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EXAMINING THE IMPACT OF DISCRETE AND CONTEXTUAL STRESS FACTORS ON MEMORY

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THESIS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the College of Arts and Sciences at the University of Kentucky

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ABSTRACT OF THESIS

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Stress is a complex and multifaceted process which is often not perceived as such. Therefore, given the unidimensional conceptualization of stress in previous research the current understanding of the associations between stress and memory are not well understood. This study investigates the association between stress and memory by capturing the complexity of stress through discrete and contextual stress factors. The current study used ecological momentary assessment (EMA) and geocoded indices (i.e., zip codes) of population density (i.e., urbanicity) and deprivation (socioeconomic disadvantage) in a large and diverse sample of U.S. participants ($N = 8817$) to examine the relationship between markers of daily stress (i.e., detection and intensity) and contextual factors (i.e., urbanicity and deprivation) on a well-established assessment of memory recall. Analyses examined models of cumulative stress reports and event-based stress reports. Results revealed significant main effects and interactions between our discrete and contextual stress factors highlighting that both factors contribute to the relationship between stress and memory. Additionally, examining the cumulative impact of stress across several days on a single memory test revealed to be more effective in assessing the impact of stress on memory compared to examining stress occurring at the same instance of test. Overall, this study provided new evidence in the way stress impacts memory thus suggesting the importance of examining cumulative stress over time and examining contextual factors of stress.

KEYWORDS: Stress, memory, urbanicity, rurality, social deprivation

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CHAPTER 1. LITERATURE REVIEW

Stress—a mobilization of biological resources in response to a set of conditions that prompts psychological evaluation and behavioral response (Crosswell & Lockwood, 2020)—can impact every aspect of how we form memories. For instance, stress affects how information is stored, which can influence what we remember and how well we remember it (Schwabe et al., 2022). Stress can also impair or enhance memory. Given that memories of the past help shape our thoughts, actions, and even identity in present and future contexts, it is important to comprehensively understand the intimate connection between stress and memory. The current research investigates the intimate connection between stress and memory by conceptualizing stress and memory as complex and multifaceted processes that are interrelated. However, to begin unpacking the complex relationship between stress and memory, we need to reexamine how researchers understand stress.

1.1 The Dissociation Between Disciplinary Stress Definitions and its Impact on Memory Research

Few memory studies have examined stress in a way that captures its complexity. For example, social epidemiologists define stress as social (e.g., social roles, culture) and/or economic contextual factors (e.g., geographic location, poverty, neighborhood deprivation). On the other hand, psychologists have traditionally conceptualized stress as exposures to discrete events (e.g., acute psychosocial or physiological laboratory events, daily hassles, traumatic events). As such, most research studies examining the impact of stress on memory are limited to event-based experiences that are either induced in the lab or prompted by survey questions. Importantly, the integration of stress frameworks has rarely been used to examine how memory processing may vary within a person due to transient stressful experiences (e.g., daily hassles) as well as between individuals because of more persistent contextual factors (e.g., poverty). Therefore, we will be investigating these interactions under a stress framework which integrates various conceptualizations of stress across disciplines.

1.2 The Need to Examine Stress in Context to Improve Our Understanding of Memory

Recent work has conceptualized stress as a multifaceted process that depends on *context*, including individual characteristics (e.g., demographics), environmental factors (e.g., geographic location), and sociocultural factors (e.g., societal role), yet this understanding has yet to be incorporated in traditional memory research. Such contextual factors capture information that is often not conveyed in self-reports. For instance, Epel and colleagues (2018) argue environments that are physically dangerous or impoverished are not usually considered by respondents when asked "how stressful is your life." The authors argue that lay understandings of stress do not include physical danger or basic survival. By extension, we argue neighborhood residents may not consider their neighborhood's impoverished characteristics to be stressors if their socioeconomic status does not reflect poverty status. Nevertheless, the physical environment (e.g., urban vs. rural, resource accessibility) may still influence how people experience stress (Evans et al., 2020). Additionally, by examining contextual factors at the individual level and the environmental level, we are acknowledging that people may be engaging with stressors differently given these contextual factors and that may lead to differing impacts on memory.

1.3 Physical Environment Impacts Biological Stress Response.

One way to examine environmental contextual stress factors is by assessing the urbanicity of an area. Urban vs. rural areas are classified as densely populated areas of 50,000 or more people (*Population, Urban and Rural (Market Profile Data 2020)*, 2020). Previous research has associated living in urban areas with a dysregulated functioning of the stress response (Evans et al., 2020; Steinheuser et al., 2014). Typically, the human brain activates two systems in response to stress. The first system—the sympathetic nervous system—is activated quickly and prepares the body for fight or flight (Schwabe et al., 2022). The second system (i.e. hypothalamic pituitary axis) is activated more slowly and sustains the stress response to allow the brain to contextualize stressful information. These two systems release numerous hormones, peptides, and neurotransmitters in waves that reach the brain at different times and regulate adaptive responses to environmental conditions (Schwabe et al., 2022). Lack of balance or prolonged activation of either system can have negative consequences. For instance, in one study conducted with college students ($N = 248$) urban upbringing was associated with the prolonged release of cortisol, one hormone released by the hypothalamic pituitary axis and known to mobilize biological resources in response to psychological and physiological stressors (Steinheuser et al., 2014). Other work finds urban upbringings to be associated with blunted stress reactivity during a stressful event revealing insufficient cortisol secretion (Evans et al., 2020). Importantly, prolonged cortisol elevation or insufficient cortisol secretion can lead to memory deficits (Evans et al., 2020). Although research connecting urbanicity to memory is limited, we infer that urbanicity is associated with memory impairment because of the links between urbanicity and stress.

1.4 Social Deprivation Impacts Stress Burden

The previous research comparing differences across urbanicity has ignored the characteristics unique to a neighborhood. For instance, a neighborhood defined as urban (or rural) can also be impoverished whereas a different urban (or rural) neighborhood can be wealthy. Therefore, comparisons across urbanicity without considering factors like poverty may convolute our understanding of this relationship as there are significant differences within urban (or rural) neighborhoods. Social deprivation, the disadvantages an individual faces in accessing material and social resources (Wang et al., 2021), is one way to conceptualize unique neighborhood characteristics. Indices of social deprivation often include the cumulation of aversive living environments including poverty, housing quality, education attainment, and employment opportunities (Zuelsdorff et al., 2020). Previous research has evaluated the association between social deprivation and stress burden (Guidi et al., 2021). In a meta-analysis, 12 out of 14 studies found significant associations between neighborhood deprivation and stress burden (measured by a variety of stress-related biomarkers – e.g., cortisol) even after controlling for individual characteristics (Ribeiro et al., 2018). In the 12 studies, living in areas with higher deprivation was associated with higher stress burden (Ribeiro et al., 2018). These studies provide evidence for the inclusion of social deprivation as an environmental contextual stress factor. When considering urbanicity and ignoring deprivation we are not privy to the potential exacerbated impacts on the stress response from individuals coming from urban and highly deprived environments.

Altogether, the inclusion of both environmental contextual stress factors along with self-reported stress exposures allows stress to be conceptualized as a multifaced process and embraces new theories of stress and behavior. As indicated previously, the inclusion of environmental contextual factors provides insight to stress exposures, participants typically neglect to self-report. Even more, how these contextual factors influence memory has been neglected by much of the existing research considering previous stress and memory literature has focused on singular stress reports.

1.5 Stress and Memory are Interconnected

1.5.1 Acute and Chronic Stress on Memory

Whether *acute*—immediate and short-term—stress enhances or impairs memory depends on the stage of memory processing that is occurring during the onset of the stressor (Hidalgo et al., 2019; Shields et al., 2017; Vogel & Schwabe, 2016). Stress occurring immediately before (i.e., within 30 minutes) the initial learning of information—or encoding—can enhance memory formation (Allen et al., 2017; Kirschbaum et al., 1992; Smith et al., 2019; Zoladz et al., 2011). The stress systems prioritize processing and storing stress-relevant information. Therefore, stress occurring up to 30 minutes or more before learning (encoding), and during storing (consolidation) for earlier learned material, often impairs memory formation (Sandi, 2013; Smeets et al., 2009; Vogel & Schwabe, 2016; Zoladz et al., 2011). Further, stress that occurs before retrieval, which is recalling stored information, impairs people's ability to recall information learned before the onset of the stressor (Smeets, 2011; Smeets et al., 2009; Vogel & Schwabe, 2016). However, capturing the temporal impact of acute stress on memory in a real world-setting is often difficult due to the lack of control over when a stressor occurs.

Some research has linked the impact of *chronic*—reoccurring, overwhelming, and prolonged—stress on memory, but such studies focus on older adults or unhealthy samples. In one study, of older Black and White adults with a mean age of 60, experiencing a higher quantity of stress exposures led to poorer memory performance (Morris et al., 2021). In this study, Black adults reported experiencing a higher number of stress exposures compared to White participants. Black adults also appraised individual stressors as less upsetting, or less intense, compared to White participants. As a result, Black participants' poorer memory performance, in comparison to White participants, was linked to the number of stressors they experienced, and not the intensity of the stressor (Morris et al., 2021). This provided evidence that the appraisal of a stressor as less upsetting or less intense may not prevent the negative impact of self-reported high frequency of stress exposures. Other work done with caregivers demonstrates a relationship between chronic stress (from taking care of a loved one) and impaired memory relative to matched controls (Falzarano & Siedlecki, 2021; Mackenzie et al., 2007; 2009)

1.6 The Stress Response and Changes to Memory

The memory process is highly susceptible to alterations in the brain when under stress. As mentioned previously, when experiencing stress, the brain prioritizes processing information relevant to the stressful event while reducing the processing of stress-irrelevant information. This results in impairments to memory retrieval, goal directed learning, memory updating, and generalization of memories. After the stressor, storing information most relevant to the stressor is prioritized as it can assist with coping with similar stressors in the future (Schwabe et al., 2022). Furthermore, the changes that occur in the brain during a stress response were not meant to be sustained for long periods and can lead to dysregulation of the stress response leading to memory impairment (Glei et al., 2007; Kim et al., 2015; McEwen, 2017; Ouellet-Morin et al., 2011; Schwabe et al., 2022; Souza-Talarico et al., 2011). However, our understanding of the biological impact of the stress response on memory in humans is confined to event-based time intervals and does not inform the complexity of these two systems.

Taken together, the relationship between stress, both *acute* and *chronic*, and memory processing is complex and multifaceted. Extant research, however, has not yet comprehensively captured this complexity. Indeed, findings from carefully controlled laboratory experiments that standardize stressor type and timing have gleaned valuable insights that elucidate the relationship between acute stress and memory. Their lack of external validity, however, is a challenge because such laboratory studies do not account for complex—and more realistic—scenarios like multiple stressors occurring in rapid succession or the global nature of how stress can permeate without a specific stressful event occurring. Understanding this type of nuance requires investigating stress and memory in real-world settings. Conversely, research investigating chronic stress and memory has typically been conducted outside of laboratory settings with induced stressors. Chronic stress is also conceptualized as lifetime stress exposures which sum stress exposures across a lifetime. However, this metric assumes different events are more stressful than others but does not consider differences in individual stress reactivities and/ or subjective stress intensities to the same stress exposures (e.g., car accident). Furthermore, much of this research relies on a unidimensional understanding of stress as an event or occurrence, which ignores the role contextual stressors such as geographic location or socioeconomic deprivation may play in memory processing. In sum, though there is a long-standing literature examining stress on memory few have attempted to utilize an interdisciplinary approach to investigate the interaction of daily stress exposures and environmental contextual factors to determine how their combined impact relates to memory. The current study used ecological momentary assessment (EMA) and geocoded indices (i.e., zip codes) of population density (i.e., urbanicity) and deprivation (socioeconomic disadvantage) in a large and diverse sample of U.S. participants to examine the relationship between markers of daily stress (i.e., detection and intensity) and contextual factors (i.e., urbanicity and deprivation) on a well-established assessment of memory recall.

1.7 Current Study

To address the complex relationship between stress and memory the current study leveraged a 21-day EMA to investigate the impact of *contextual* stress exposures (geographic location and social deprivation) and *daily* stress responses (stress detection and intensity) on memory. We collected daily reports of participants' stress responses and assessed their performance on a memory task. We examined geographic region (rural vs. urban) and social deprivation from participant-provided zip codes. Informed by previous research, we predict: (a) *higher acute stress intensity is associated with memory impairment* (b) *reports of higher global stress is associated with poorer memory* (c) *living in areas with higher deprivation is associated with poorer memory, and* (d) *living in more urban environments is associated with poorer memory*. When examining the dual role of global stress and contextual factors we further predict: (e) *reports of higher global stress intensity and living in areas of higher social deprivation is associated with memory* *impairment*, (f) *living in more urban environments and having higher reports of global stress intensity is associated with poorer memory, and* (g) *higher reports of global stress intensity from participants living in more urban environments with higher social deprivation is associated with poorer memory.* Given the relationship between acute stressors and memory is complex, we will also investigate how environmental factors influence this relationship. We predict (h) *reports of higher acute stress intensity and living in areas of higher social deprivation is associated with poorer memory*, (i) *living in more urban environments and having higher reports of acute stress intensity is associated with poorer memory, and* (j) *higher reports of acute stress intensity from participants living in more urban environments with higher social deprivation is associated with poorer memory.*

CHAPTER 2. METHOD

2.1 Participants

Participants (*N* = 8817) downloaded the phone application, MyBPLab, through the U.S. Google Playstore and completed at least one test of the memory task, between March 2019 – December 2021. Participants were included in this study if they were fluent in English, at least 18 years of age, had a compatible phone (Samsung S9 or Note 9), and reported residence in the United States. The sample was 79% White, 8% Black, 6% Asian, 1% Indian, 1% Pacific Islander, 3% Native, 61% male, 39% female, 83% lived in more urban areas, 11% lived in rural areas and had a mean age of 47(*SD* = 12.52). All demographic characteristics are displayed in Table 1.

2.2 Procedure

After downloading the app, and confirming age and English fluency, participants completed the consent form, basic demographics (race, ethnicity, age, sex, education, zip code, body mass index, subjective social status, and tobacco use) and received authorization to participate in the study via email. Once enrolled in the study, participants were instructed to complete up to three daily check-ins during set time windows (Morning: 7am–10am; Afternoon: 10am–4pm; Evening: 8pm–11pm). Each check-in included questions about the participant's stress experiences (stress detection and acute stress intensity or global stress intensity). Starting on Day 2 of the 21-day study, participants were provided the opportunity to complete a paired-associates memory task, which started directly after their regular morning check-in. The app was designed to be a 21-day study, but participants could continue participating after 21 days or could drop out of the study before the 21 days.

2.3 Measures

2.3.1 Stress Assessment

To assess stress levels, participants were asked if they experienced anything stressful since their last check-in (check-ins were scheduled three times a day for participants to access the study via the app). If participants answered yes (acute stress detection), participants were asked to rate (1) "How stressful was it," (2) "How much did it impact your life," (3) "Do you feel like you handled it/are handling it well [reverse-scored]" on a five-point Likert-type scale ranging from 1(*not at all*) to 5 (*extremely*). The three questions were averaged to create an acute stress intensity score ranging from 1 to

5. Participants received a unique score for every check-in they completed the acute stress intensity questions.

If participants answered no to experiencing anything stressful since their last check-in then they received a different subset of questions. Here participants were asked to rate a series of questions identifying their current stress level. Participants rated how much they felt (1) “stressed, anxious, overwhelmed [reverse scored],” (2) “in control, coping well, on top things,” and (3)” joyful, glad, happy*,”* on a five-point Likert-type scale ranging from 1(*not at all*) to 5 (*extremely*). The three questions were averaged to create a global stress intensity score ranging from 1 to 5. Participants received a unique score for every check-in they completed the global stress intensity questions.

2.3.2 Paired-Associates Memory Task

Participants were instructed to view a list of 20 unrelated word and picture pairs. Each picture and word were presented together on the phone screen. Participants were instructed to remember the picture and word together as a pair and told they would receive subsequent tests. Each pair was presented on the phone screen for five seconds. Participants were tested on subsets of the picture-word pairs three times, directly after encoding, three days after encoding, and six days after encoding During each recall test, participants were shown the picture from initial acquisition and asked to recall the word that was paired with that image. Three days after test 3, participants were presented with a new list of 20 unrelated word and picture pairs to encode and followed the same procedures described above. Participants received a memory score from each test they completed. Scores were calculated by dividing the number of correct responses by the sum of the number of correct, missed, and skipped responses.

2.3.3 Urbanicity

While in the study participants provided their four-digit zip codes for their place of residence. Data from the United States population density data were obtained from Social Explorer, a mapping and geospatial online data tool, using their 2020 Market Profile Database to determine county-level urbanicity scores (*Population, Urban and Rural (Market Profile Data 2020)*, 2020). The participant provided zip codes were adjusted to the county level and were merged with the Market Profile Database to provide every participant with an urbanicity score. To rectify the issue of zip codes overlapping more than one county, we set the county with the most zip code overlaps to be the county designation.

2.3.4 Subjective Social Status

Subjective Social Status was measured using the MacArthur Scale of Subjective Social Status (Adler & Stewart, 2007). Participants were shown an image of a 10-rung ladder and presented with the following instructions: "*Think of the ladder below as representing where people stand in your country. At the top of the ladder (1) are the wealthiest people make the most money. At the bottom (10) are the poorest people who make the least money. The higher up you are on this ladder, the more money you have; the lower you are, the less money you have. Where would you place yourself on this ladder, compared to others in your country?*" Participants were then instructed to select the ladder rung that best represents their social status compared to others in the United States.

2.3.5 Social Deprivation Index

The Social Deprivation Index (SDI) is a composite measure of geographic deprivation calculated from seven subscales collected from the American Community survey (Butler et al., 2013). The factors include (a) the percent population with < 100% Federal Poverty Level (FPL), (b) percent population with less than 12 years of education, (c) percent non-employed, (d) percent population living in renter-occupied housing units, (e) percent population living in crowded housing units, (f) percent single-parent households, and (g) percent population with no personal transportation. The SDI total score ranges from 0 to 100 where higher scores suggest higher deprivation.

2.4 Statistical Analysis Plan

SPSS and R were used to clean the data and conduct analyses. Three separate models were examined using Generalized Linear Mixed Effects Models (to account for fixed and random effects) with a model specification of binomial logistic regression. For each model, the demographic variables (race/ethnicity, age, sex, education, body mass index, and tobacco use) were entered into the model first. Second, the variables of interest (event and contextual stress variables) were entered. Next, the two-way interactions were entered into the model and the three-way interactions were entered into the model last. The first set of analyses (Model 1) examined the impact of stress events for the days leading up to the memory task. Specifically, the averages were gathered for acute and global stress intensity ratings for the three days before each memory task. Each stress rating average was entered as a unique predictor of memory performance. We utilized Generalized Linear Mixed Effects Models with a model specification of binomial logistic regression (*N* = 6454) and included a random effect to account for those repeated memory outcomes nested within each individual. Given our forced-choice methodological approach used to assess acute and global stress (i.e., individuals could only respond to either the acute or global stress questions) and previous literature suggesting that stress exposures near memory retrieval may result in poorer memory, we additionally wanted to assess the impact of acute and global stress ratings directly before the memory assessment. The next set of analyses (Model 2) focused solely on individuals who reported experiencing an acute stressor directly before completing the memory task. Again, we used Generalized Linear Mixed Effects Models with a model specification of binomial logistic regression (*N* = 843). In this sample, acute stress events were rare. As such, 10% of this sample had repeated outcome measurements associated with a simultaneous acute stress report. In Model 2, like Model 1, we included a random effect, however, we note that we may have underestimated fixed effects considering the small percentage of repeated outcomes for each individual. The final set of analyses (Model 3) focused on individuals who reported no acute stress but provided global stress ratings at the same instance of completing the memory task. Generalized Linear Mixed Effects Models with a model specification of binomial logistic regression (*N* = 8817) were used here as well. Again, a random effect was included to account for repeated observations. For all three models, we first entered social deprivation using the SDI total score (score summed across all the 7 subscales). In addition, to assessing which aspects of social deprivation were notable, we also assessed statistical models where each subscale was entered as a unique predictor (Model 1.1, Model 2.1, and Model 3.1).

CHAPTER 3. RESULTS

3.1 Sample Characteristics

Sample demographics are presented in table 1. Overall, the sample reported relatively low levels of acute 1.05 (*SD* =1.67) and global 1.74 (*SD* = 0.74) stress intensities when averaging across check-ins. However, stress intensities were higher when examining separate models (Model 2 and Model 3), acute 3.09 (*SD* = 0.87) and global 3.86 (*SD* = 0.77) stress intensities. The average SDI for models 1, 2, and 3 was 42.29 (*SD* = 26.74), 43.96 (*SD* = 26.85), and 42.58 (*SD* = 26.70) respectively. The participant average memory task scores for models 1, 2, and 3 were 0.45 (*SD* = 0.35), 0.37 (*SD* = 0.37), and 0.36 (*SD* = 0.36) respectively. Descriptive statistics and correlations for all study variables are presented in Table 3.2. The stress indicators: acute stress intensity, r(6452) = -.19, $p < 0.01$ and global stress intensity, r(6452) = .09, $p <$ 0.01, were significantly correlated with memory. The urbanicity indicator was also significantly correlated with several of the SDI subscales: living below the federal poverty line, single-parent family, living in renter-occupied housing units, crowding, no employment, high needs, (*r*s range -.12 to .18, $p < .01$) but was not correlated with the SDI total score, r(6367) = -0.02, $p = .19$. Similarly, global stress was significantly correlated with two SDI subscales; living in renter-occupied housing units r(6369) = 0.03, $p =.03$ and having no personal transportation r(6369) = 0.03, $p =.03$ but not the SDI total score, r(6367) = 0.02, $p = .21$. Acute stress intensity was not significantly correlated with any SDI subscales nor the SDI total score, r(6367) = 0.01, $p = .42$.

3.2 Model 1: The Cumulative Impact of Stress Events on Memory

Results of the mixed effects binomial regressions for Model 1 which examined average acute stress intensity and global stress intensity across check-ins leading up to a memory task are presented in Table 3.3. The first step examined demographic factors of gender, race, education, BMI, and subjective social status. Results revealed that male participants performed worse on the memory task ($\beta = -0.23$ $p < .001$). Those with a high school diploma ($\beta = -0.25$, $p = .001$) performed poorer on the memory task. Participants with graduate-level education displayed better memory performance ($\beta = 0.15$, $p = 0.02$). Older adults performed poorer on memory tasks ($\beta = -0.35$, $p < .001$), and participants identifying as Native Americans displayed better memory performance ($\beta = -0.29$, $p = .02$). Participants with higher subjective social status displayed poorer memory performance ($\beta = -0.05$, $p = .02$). Tobacco use and other racial groups did not show significant relations with the memory task. Next, we examined the contribution of our variables of interest, acute stress intensity, global stress, urbanicity, and SDI. All previously reported demographic factors were statistically significant in the step. Higher acute stress intensity led to poorer memory ($\beta = -0.30$, $p < .001$), and contrary to hypotheses, higher global stress intensity led to better memory ($\beta = 0.20$, $p < .001$). Higher urbanicity scores led to better memory ($\beta = 0.25$, $p = .02$), and higher SDI lead to poorer memory; however, the relationship between SDI and memory did not meet statistical thresholds ($\beta = -0.03$, $p = .20$). We also examined two- and three-way interactions between acute stress intensity, global stress intensity, SDI, and urbanicity. A noteworthy interaction emerged between urbanicity and acute stress intensity ($\beta = -0.14$, $p =.002$) revealing that as urbanicity and acute stress intensity increased, memory performance declined supporting our hypothesis. No other two- or three-way interactions met significance thresholds contrary to our predictions.

3.3 Model 1.1: The Cumulative Impact of Stress Events and SDI subscales on Memory

Results of the mixed effects binomial regressions for Model 2.1 are presented in Table 4. The first step in this model was the same as in Model 2 which just examined demographic factors. Next, we examined the influence of our variables of interest, acute stress intensity, global stress intensity, urbanicity, and SDI subscales. Here, like Model 1, higher acute stress intensity led to poorer memory ($\beta = -0.30$, $p < .001$), and higher global stress intensity led to better memory ($\beta = 0.20$, $p < .001$). In the next step we examined interactions between our variables of interest. A significant interaction between acute stress intensity and high needs score revealed that as high needs scores and acute stress intensities increased memory performance decreased ($\beta = -0.10$, $p = .03$). Additionally, another interaction emerged revealing as single parent family scores and acute stress intensities increased memory performance declined ($\beta = -0.14$, $p = .02$). In the final step we tested three-way interactions between our variables of interest which yielded three noteworthy interactions. First, the interaction between single parent family scores and global stress intensities varies across levels of urbanicity ($\beta = -0.33$, $p = .04$). For lower urbanicity, memory performance declined faster for individuals living in areas with higher single parent family scores as global stress intensities increased. However, memory performance decline did not differ across urbanicity in the higher urban group. The next three-way interaction revealed that for individuals living in areas with lower urbanicity, memory performance declined faster for higher crowding scores as acute stress intensities increased. The opposite trend appeared for the more urban group such that memory performance declined faster for lower crowding scores ($\beta = 0.60$, $p < .001$). Finally, the interaction between unemployment scores, urbanicity, and acute stress intensity revealed that memory performance declined faster in areas with higher unemployment rates with more urban areas showing the fastest memory performance decline ($\beta = -0.42$, $p = .01$).

3.4 Model 2: Event-based Acute Stress Intensity before a Memory Task

Results of the mixed effects binomial regressions for Model 2 are presented in Table 5. For the demographic factors, results revealed that female participants performed better on the memory task ($\beta = 0.48$, $p = 0.02$), older adults performed poorer on the memory task ($\beta =-0.04$, $p < .000$), Pacific Islanders displayed poorer memory performance ($\beta = -2.69$, $p =.002$), and participants who smoke tobacco displayed poorer memory performance ($\beta = -0.63$, $p =.04$. All other racial categories and demographic factors were not statistically significant in this step. Next, we examined the contribution of our variables of interest, acute stress intensity, urbanicity, and SDI. Previous demographic associations remained steady after the inclusion of variables of interest. Here, higher SDI led to poorer memory performance ($\beta = -0.35$, $p =.004$). Neither acute stress intensity nor urbanicity significantly impacted memory in this model and no interactions emerged contrary to our predictions.

3.5 Model 2.1: Event-based Acute Stress Intensity with SDI Subcales before a Memory Task

Results of the mixed effects binomial regressions for Model 2.1 are presented in Table 6. The first step in this model was the same as in Model 2 which just examined demographic factors. Next, we examined the influence of our variables of interest, acute stress intensity, urbanicity, and SDI subscales. Here, higher FPL scores yielded better memory performance (β = 0.49, p =.03), and higher high school dropout rates yielded poorer memory performance (β = -0.38, p =.04). The next, step revealed a significant interaction between high school dropout rates and acute stress intensity (β = -2.33, p =.003), indicating that as high school dropout rates and stress intensities increased, memory performance declined. A significant interaction also emerged between no personal transportation and acute stress intensity (β = 1.90, p =.005) revealing that as stress intensities increased and no transportation scores decreased, memory performance declined. In the final step, two significant three-way interactions emerged. An interaction between high school dropout rates, acute stress intensity, and urbanicity (β = -1.89, p =.009), revealed as high school dropout rates and stress intensities increased, memory performance declined across level of urbanicity. However, higher urbanicity displayed the fastest memory performance decline. The three-way interaction between no personal transportation, acute stress intensity, and urbanicity (β = 1.67, p =.008), revealed that as no personal transportation decreased and acute stress intensities increased, memory performance declined. The rate of decline was fastest for the higher urbanicity group. Additionally, as no personal transportation increased and acute stress intensities increased, memory performance improved across levels of urbanicity but at a faster rate for the lower urbanicity group.

3.6 Model 3: Event-based Global Stress Intensity before a Memory Task

Results of the mixed effects binomial regressions for Model 3 are presented in Table 7. The first step examined demographic factors of gender, race, education, BMI, and subjective social status. Female participants performed better on the memory tasks compared to males (β = 0.32, $p < .001$) and older participants performed poorer on the memory task (β = -0.43, $p < .001$). Interestingly, participants with lower subjective social status displayed better memory β = -0.07, $p = .002$). Participants who reported using tobacco performed worse on the memory task (β = -2.70, $p = .04$), and participants identifying as White (β = 0.23, $p = .003$) or Pacific Islander performed better on the memory task (β = 0.62, $p = .01$). All other demographic factors and racial categories did not show significant relations with memory. The second step included our variables of interest: global stress (β = -0.01, $p = .55$), urbanicity (β = 0.01, $p = .68$), and SDI (β = -0.02, $p = .47$) revealing no statistically significant effects on memory performance which was not aligned with our predictions. No interactions emerged in the third step also in contrast with our previous predictions.

3.7 Model 3.1: Event-based Global Stress Intensity with SDI subscales before a Memory Task

Results of the mixed effects binomial regressions for Model 3.1 are presented in Table 8. The first step in this model was the same as in Model 2 which just examined demographic factors. Next, we examined the influence of our variables of interest, global stress intensity, urbanicity and SDI subscales which yielded no significant results other than the demographic factors. The next step examined two-way interactions between our variables of interest. Here, a significant interaction emerged revealing that as FPL scores and global stress intensities increased, memory performance improved (β = 0.54, $p = .01$). Another interaction revealed that as no personal transportation scores and global stress intensities increased, memory performance decreased (β = -.40, $p = .01$). The final step tested three-way interactions yielding an interaction between high needs scores, global stress intensity, and urbanicity (β = -0.22, p =.04). In this interaction as high needs scores increased, and global stress intensities increased memory performance improved across level of urbanicity. However, higher urbanicity revealed the fastest rates for improved memory performance.

Table 3.1 Sample Demographics

Variable	Total Sample Model 1	Total Sample Model 2	Total Sample Model 3
N	6454	843	8817
Gender			
Female	2515 (39%)	374 (44.4%)	3204 (36.3%)
Male	3939 (61%)	461 (54.7%)	5589 (63.4%)
Age	46.96 *SD* 1.67	44.87 *SD* 11.50	47.73 *SD* 12.52
Education			
Some HS	83 (1.3%)	11 (1.3%)	98 (1.1%)
HS Diploma / GED	762 (11.8%)	93 (11%)	1016 (11.5%)
Some college	2412 (37.4%)	237 (28.1%)	2210 (25.1%)
4-year	1801 (27.9%)	237 (28.1%)	2511 (28.5%)
Graduate school	1396 (21.6%)	158 (18.7)	1910 (21.7%)
Ethnicity			
Black	503 (7.8%)	75 (8.9%)	670 (7.6%)
White	5134 (79.5%)	624 (74%)	6982 (79.2%)
Asian	388 (6.0%)	61 (7.2%)	526 (5.9%)
Indian	90 (1.4%)	19 (2.3%)	115 (1.3%)
Pacific Islander	59 (0.9%)	15 (1.8%)	77 (0.9%)
Native	196 (3%)	42 (5%)	249 (2.8%)
Tobacco use			
Yes	640 (9.9%)	101 (12%)	847 (9.6%)
No	5814 (90.1%)	742 (88%)	7968 (90.4%)
Urbanicity			
More Urban	5761 (89.3%)	503 (59.7)	6077 (68.9%)
Less Urban	693 (10.7%)	58 (6.9%)	690 (7.8%)
SDI	42.29 *SD* 26.74	43.96 *SD* 26.85	42.58 *SD* 26.70
Stress Intensity			
Acute Stress Intensity	1.05 *SD* 1.67	3.09 *SD* 0.80	-
Global Stress Intensity	1.74 *SD* 0.74	-	3.86 *SD* 0.77
Memory Score	0.45 *SD* 0.35	0.37 *SD* 0.37	0.36 *SD* 0.36

Table 3.2 Descriptive Statistics and Correlations for Study Variables

Variables	***n***	***M***	***SD***	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1. Acute SI	6454	1.05	1.67	-											
2. Global SI	6454	1.74	.74	.16**	-										
3. Urbanicity	6454			-.00	.01	-									
4. Memory Score	6454	.45	.35	-.19**	.09**	.01	-								
5. SDI Total Score	6369	42.29	26.74	.01	.02	-.02	-.01	-							
6. Federal Poverty Line	6369	43.14	27.31	.02	.02	-.18**	-.01	.91**	-						
7. Single Parent Family	6369	43.99	26.99	.01	.20	.10**	.01	.84**	.71**	-					
8. No transportation	6369	43.58	27.81	.01	.03*	.01	.01	.73**	.63**	.55**	-				
9. HS dropout	6369	44.70	27.98	.01	.03*	.25**	.01	.75**	.60**	.64**	.66**	-			
10. Crowding	6369	44.61	27.30	-.01	-.01	.18**	-.01	.62**	.46**	.46**	.28**	.49**	-		
11. No employment	6369	44.88	27.14	.02	-.01	-.04**	-.01	.67**	.62**	.52**	.42**	.32**	.37**	-	
12. High Needs	6369	48.26	29.46	.01	.02	-.09**	-.01	.33**	.36**	.20**	.46**	.36**	.04**	.20**	-

Note. H.S. = High School, Subjective S.S. = Subjective Social Status, Acute SI = Acute Stress Intensity, Global SI = Global Stress Intensity FPL = Federal Poverty Line.

*p<.05, **p<.01, ***p<.001

Table 3.3 Memory Performance Regressed on Study Variables in the Cumulative Impact of Stress Events Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Fixed E.																
Gender	-0.23***	0.05	-0.32	-0.14	-0.28***	0.05	-0.38	-0.19	-0.28***	0.05	-0.38	-0.19	-0.28***	0.05	-0.38	-0.19
Some HS	-0.39	0.20	-0.79	0.01	-0.39	0.21	-0.79	0.02	-0.39	0.21	-0.79	0.02	-0.39	0.21	-0.79	0.02
HS diploma/ GED	-0.25**	0.08	-0.40	-0.09	-0.27***	0.08	-0.43	-0.11	-0.27***	0.08	-0.43	-0.11	-0.27***	0.08	-0.43	-0.11
Some college	-0.02	0.06	-0.14	0.09	-0.02	0.06	-0.14	0.09	-0.02	0.06	-0.14	0.09	-0.02	0.06	-0.14	0.09
Graduate school	0.15*	0.07	0.02	0.28	0.13	0.07	0.00	0.26	0.13	0.07	0.00	0.26	0.13	0.07	0.00	0.26
Tobacco use	-0.15	0.07	-0.29	0.00	-0.15*	0.08	-0.30	0.00	-0.15	0.08	-0.30	0.00	-0.15	0.08	-0.30	0.00
Age	-0.35***	0.02	-0.39	-0.30	-0.33***	0.02	-0.38	-0.28	-0.33***	0.02	-0.38	-0.28	-0.33***	0.02	-0.38	-0.28
BMI	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.08	0.01
Subjective S.S.	-0.06*	0.02	-0.10	-0.01	-0.05*	0.02	-0.10	0.00	-0.05*	0.02	-0.09	0.00	-0.05	0.02	-0.09	0.00
White	0.15	0.08	-0.01	0.30	0.11	0.08	-0.05	0.28	0.11	0.08	-0.05	0.28	0.11	0.08	-0.05	0.27
Black	0.00	0.10	-0.20	0.21	-0.02	0.11	-0.23	0.19	-0.03	0.11	-0.24	0.18	-0.03	0.11	-0.24	0.18
Asian	-0.12	0.11	-0.34	0.10	-0.16	0.12	-0.39	0.07	-0.16	0.12	-0.39	0.07	-0.16	0.12	-0.39	0.07
Indian	0.26	0.20	-0.13	0.64	0.18	0.20	-0.21	0.57	0.16	0.20	-0.23	0.55	0.16	0.20	-0.24	0.55
Pacific Islander	0.15	0.23	-0.31	0.61	0.28	0.25	-0.21	0.77	0.29	0.25	-0.21	0.78	0.28	0.25	-0.21	0.78
Native	0.29*	0.13	0.04	0.54	0.42**	0.13	0.16	0.67	0.41**	0.13	0.16	0.67	0.42**	0.13	0.16	0.67
Acute SI					-0.30***	0.01	-0.32	-0.27	-0.22***	0.04	-0.30	-0.14	-0.22***	0.04	-0.30	-0.14

Table 3.3 continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Global SI					0.20***	0.03	0.15	0.26	0.11	0.10	-0.09	0.32	0.11	0.10	-0.09	0.31
Urbanicity					0.25*	0.10	0.04	0.45	0.14	0.24	-0.33	0.61	0.14	0.24	-0.33	0.61
SDI					-0.03	0.02	-0.08	0.02	0.07	0.06	-0.04	0.18	0.07	0.06	-0.04	0.18
SDI x Acute SI									-0.02	0.02	-0.06	0.03	-0.03	0.11	-0.24	0.18
Urbanicity x Acute SI									-0.09*	0.05	-0.19	0.00	-0.10	0.05	-0.19	0.00
SDI x Global SI									-0.10	0.05	-0.20	0.01	-0.02	0.12	-0.26	0.22
Urbanicity x Global SI									0.11	0.12	-0.13	0.35	0.11	0.12	-0.13	0.36
SDI x Acute SI x Urbanicity													0.02	0.11	-0.19	0.22
SDI x Global SI x Urbanicity													-0.08	0.11	-0.30	0.14
Random E.	Variance				Variance				Variance				Variance			
Health Code	1.35				1.40				1.40				1.40			

Note. Model degrees of freedom: step 1 = 6108, step 2 = 6021, step 3 = 6017, step 4 = 6015

H.S. = High School, Subjective S.S. = Subjective Social Status, SDI = Social Deprivation Index Total score. Acute SI = Acute Stress Intensity, Global SI = Global Stress Intensity, Random E = Random Effect.

*p<.05, **p<.01, ***p<.001

Table 3.4 Memory Performance Regressed on Study Variables and SDI Subscales in the Cumulative Impact of Stress Events Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Gender	-0.23***	0.05	-0.32	-0.14	-0.29***	0.05	-0.39	-0.19	-0.29***	0.05	-0.38	-0.19	-0.28***	0.05	-0.38	-0.19
Some HS	-0.39	0.20	-0.79	0.01	-0.37	0.21	-0.77	0.04	-0.36	0.21	-0.77	0.04	-0.35	0.21	-0.75	0.06
HS Diploma/ GED	-0.25**	0.08	-0.40	-0.09	-0.27**	0.08	-0.43	-0.11	-0.26**	0.08	-0.42	-0.10	-0.25**	0.08	-0.41	-0.09
Some college	-0.02	0.06	-0.14	0.09	-0.02	0.06	-0.14	0.09	-0.02	0.06	-0.13	0.10	-0.02	0.06	-0.14	0.10
Graduate school	0.15*	0.07	0.02	0.28	0.12	0.07	-0.01	0.25	0.12	0.07	-0.01	0.25	0.12	0.07	-0.01	0.25
Tobacco use	-0.15	0.07	-0.29	0.00	-0.15*	0.08	-0.30	0.00	-0.15*	0.08	-0.30	0.00	-0.17*	0.08	-0.32	-0.01
Age	-0.35***	0.02	-0.39	-0.30	-0.33***	0.02	-0.38	-0.28	-0.33***	0.02	-0.38	-0.28	-0.33***	0.02	-0.38	-0.29
BMI	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.08	0.01	-0.03	0.02	-0.07	0.02
Subjective S.S.	-0.06*	0.02	-0.10	-0.01	-0.05	0.02	-0.09	0.00	-0.05	0.02	-0.09	0.00	-0.05	0.02	-0.09	0.00
White	0.15	0.08	-0.01	0.30	0.11	0.08	-0.06	0.27	0.10	0.08	-0.06	0.26	0.10	0.08	-0.06	0.26
Black	0.00	0.10	-0.20	0.21	-0.02	0.11	-0.23	0.19	-0.03	0.11	-0.24	0.18	-0.02	0.11	-0.24	0.19
Asian	-0.12	0.11	-0.34	0.10	-0.17	0.12	-0.41	0.06	-0.19	0.12	-0.42	0.05	-0.20	0.12	-0.43	0.04
Indian	0.26	0.20	-0.13	0.64	0.16	0.20	-0.23	0.55	0.16	0.20	-0.23	0.55	0.15	0.20	-0.24	0.55
Pacific Islander	0.15	0.23	-0.31	0.61	0.28	0.25	-0.22	0.77	0.29	0.25	-0.21	0.78	0.26	0.25	-0.24	0.75
Native	0.29*	0.13	0.04	0.54	0.42**	0.13	0.17	0.68	0.42**	0.13	0.16	0.67	0.43**	0.13	0.17	0.68
Acute SI					-0.30***	0.01	-0.32	-0.27	-0.20***	0.06	-0.31	-0.09	-0.13	0.14	-0.41	0.15
Global SI					0.20***	0.03	0.14	0.26	0.20	0.14	-0.07	0.47	0.01	0.21	-0.39	0.42

Table 3.4 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Urbanicity					0.22	0.12	-0.01	0.46	0.17	0.29	-0.39	0.73	0.13	0.29	-0.44	0.70
FPL					0.01	0.04	-0.07	0.10	0.05	0.11	-0.17	0.26	0.04	0.11	-0.18	0.25
HS Dropout					-0.05	0.04	-0.13	0.02	0.05	0.09	-0.13	0.23	0.05	0.09	-0.13	0.23
High needs					-0.02	0.03	-0.07	0.03	-0.05	0.06	-0.17	0.08	-0.06	0.06	-0.18	0.06
Employment					0.00	0.03	-0.06	0.06	-0.07	0.07	-0.22	0.07	-0.07	0.07	-0.21	0.07
Crowding					0.01	0.03	-0.05	0.07	0.03	0.07	-0.10	0.17	0.05	0.07	-0.09	0.19
Single Parent Family					-0.06	0.04	-0.13	0.02	0.01	0.09	-0.16	0.18	0.00	0.09	-0.17	0.17
Transportation					0.06	0.03	0.00	0.13	0.02	0.08	-0.13	0.17	0.04	0.08	-0.11	0.19
Urbanicity x Acute SI									-0.09	0.08	-0.26	0.08				
FPL x Acute SI									0.12	0.07	-0.02	0.26	-0.21*	0.24	-0.67	0.25
HS Dropout x Acute SI									0.01	0.06	-0.12	0.13	0.42	0.20	0.02	0.82
High needs x Acute SI									-0.10*	0.05	-0.19	-0.01	-0.16	0.20	-0.56	0.24
Employment x Acute SI									-0.08	0.05	-0.19	0.02	0.06	0.16	-0.25	0.37
Crowding x Acute SI									0.02	0.05	-0.07	0.12	0.28**	0.17	-0.05	0.61

Table 3.4 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Single Parent Family* x Acute SI									-0.14*	0.06	-0.27	-0.02	-0.52	0.16	-0.84	-0.20
Transportation x Acute SI									0.08	0.05	-0.02	0.19	-0.32	0.21	-0.74	0.10
Urbanicity x Global SI									0.05	0.11	-0.17	0.27	0.21	0.18	-0.13	0.55
FPL x Global SI									-0.08	0.12	-0.33	0.16	-0.14	0.20	-0.53	0.26
HS Dropout x Global SI									-0.13	0.11	-0.34	0.08	-0.04	0.18	-0.39	0.31
High needs x Global SI									0.07	0.07	-0.07	0.22	0.29*	0.13	0.03	0.55
Employment x Global SI									0.13	0.08	-0.04	0.29	-0.01	0.14	-0.28	0.27
Crowding x Global SI									-0.05	0.08	-0.21	0.11	-0.13	0.14	-0.41	0.15
Single Parent Family* x Global SI									-0.04	0.10	-0.23	0.16	0.25	0.18	-0.10	0.60
Transportation x Global SI									0.02	0.09	-0.15	0.19	-0.06	0.16	-0.36	0.25

Table 3.4 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
FPL Score x Acute SI x Urbanicity													-0.33	0.21	-0.74	0.08
HS Dropout x Acute SI x Urbanicity													0.13	0.21	-0.27	0.54
High needs x Acute SI x Urbanicity													-0.17	0.16	-0.48	0.14
Employmentx Acute SI x Urbanicity													-0.42*	0.18	-0.77	-0.07
Crowding x Acute SI x Urbanicity													0.60***	0.17	0.26	0.94
Single Parent Family x Acute SI x Urbanicity													0.24	0.23	-0.21	0.68

Table 3.4 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Transportation x Acute SI x Urbanicity													0.28	0.17	-0.06	0.62
FPL Score x Global SI x Urbanicity													0.10	0.18	-0.27	0.46
HS Dropout x Global SI x Urbanicity													-0.11	0.16	-0.42	0.21
High needs x Global SI x Urbanicity													-0.22	0.12	-0.46	0.02
Employmentx Global SI x Urbanicity													0.16	0.13	-0.10	0.41
Crowding x Global SI x Urbanicity													0.09	0.14	-0.18	0.36
Single Parent Family x													-0.33*	0.17	-0.66	0.00

Table 3.4 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Global SI x Urbanicity																
Transportation x Global SI x Urbanicity													0.06	0.15	-0.22	0.35
Random E.	Variance				Variance				Variance				Variance			
Health Code	1.36				1.40				1.40				1.40			

Note. Model degrees of freedom: step 1 = 6110, step 2 = 6017, step 3 = 6001, step 4 = 5987.

The SDI subscales were used in place of the SDI total score. H.S. = High School, Subjective S.S. = Subjective Social Status, Acute SI = Acute Stress Intensity, Global SI = Global Stress Intensity, FPL = Federal Poverty Line, Random E = Random Effect.

*p<.05, **p<.01, ***p<.001

Table 3.5 Memory Performance Regressed on Study Variables in the Acute Stress Intensity before a Memory Task Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Gender	0.49*	0.21	0.08	0.89	0.55*	0.24	0.08	1.01	0.56*	0.24	0.10	1.03	0.57*	0.24	0.10	1.03
Some HS	-2.12	2.91	-7.82	3.59	1.23	1.52	-1.74	4.20	1.29	1.52	-1.69	4.28	1.29	1.52	-1.69	4.27
HS diploma/ GED	-2.17	2.76	-7.58	3.25	0.05	0.47	-0.87	0.96	1.29	1.52	-0.84	1.00	0.08	0.47	-0.84	1.00
Some college	-2.42	2.75	-7.60	3.23	-0.36	0.39	-1.12	0.40	-0.35	0.39	-1.11	0.41	-0.35	0.39	-1.12	0.41
4-year	-2.26	2.75	-7.65	3.13	-0.58	0.39	-1.34	0.19	-0.59	0.39	-1.36	0.17	-0.60	0.39	-1.36	0.17
Graduate school	-1.62	2.75	-7.01	3.77	0.39	0.42	-0.44	1.22	0.36	0.43	-0.48	1.19	0.36	0.43	-0.48	1.19
Tobacco use	-0.63*	0.31	-1.24	-0.02	-0.66	0.36	-1.37	0.05	-0.68	0.37	-1.40	0.03	-0.69	0.37	-1.40	0.03
Age	-0.04***	0.01	-0.06	-0.02	-0.04***	0.01	-0.06	-0.02	-0.04***	0.01	-0.06	-0.02	-0.45***	0.12	-0.69	-0.21
BMI	0.01	0.01	-0.02	0.04	0.01	0.02	-0.02	0.04	0.00	0.02	-0.03	0.04	0.03	0.12	-0.20	0.27
Subjective S.S.	-0.05	0.10	-0.26	0.15	0.08	0.12	-0.15	0.32	0.09	0.12	-0.15	0.33	0.09	0.12	-0.15	0.33
White	-0.19	0.33	-0.84	0.45	-0.43	0.44	-1.29	0.42	-0.40	0.44	-1.26	0.47	-0.40	0.44	-1.26	0.46
Black	-0.23	0.43	-1.06	0.60	-0.25	0.53	-1.29	0.80	-0.20	0.54	-1.25	0.86	-0.19	0.54	-1.25	0.86
Asian	0.02	0.47	-0.91	0.95	-0.20	0.58	-1.33	0.94	-0.21	0.58	-1.35	0.93	-0.21	0.58	-1.35	0.93
Indian	0.36	0.68	-0.97	1.68	0.29	0.89	-1.45	2.03	0.30	0.89	-1.45	2.04	0.30	0.89	-1.45	2.04
Pacific Islander	-2.69**	0.88	-4.43	-0.96	-2.57*	1.17	-4.87	-0.27	-2.56*	1.17	-4.86	-0.25	-2.56*	1.18	-4.86	-0.26
Native	0.83	0.45	-0.06	1.72	0.66	0.52	-0.36	1.67	0.66	0.52	-0.36	1.68	0.66	0.52	-0.36	1.68

Table 3.5 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Acute SI					-0.14	0.10	-0.34	0.07	0.41	0.42	-0.43	1.24	0.38	0.47	-0.55	1.30
Urbanicity					0.22	0.13	-0.03	0.47	0.57	0.45	-0.32	1.46	0.58	0.46	-0.31	1.48
SDI					-0.35**	0.12	-0.59	-0.10	0.18	0.43	-0.65	1.02	0.18	0.43	-0.65	1.02
SDI x Acute SI									-0.45	0.56	-1.59	0.33	-0.54	0.81	-2.12	1.05
Urbanicity x Acute SI									-0.63	0.49	-1.56	0.65	-0.41	0.63	-1.65	0.82
SDI x Acute SI x Urbanicity													-0.10	0.66	-1.40	1.20
Random E.	Variance				Variance				Variance				Variance			
Health Code	4.95				4.16				4.20				4.20			

Note. Model degrees of freedom: step 1 = 778, step 2 = 511, step 3 = 509, step 4 = 498.

H.S. = High School, Subjective S.S. = Subjective Social Status, SDI = Social Deprivation Index Total score. Acute SI = Acute Stress Intensity, Random E = Random Effect.

*p<.05, **p<.01, ***p<.001

Table 3.6 Memory Performance Regressed on Study Variables and SDI Subscales in the Acute Stress Intensity before a Memory Task Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Gender	0.49*	0.21	0.08	0.89	0.56*	0.24	0.09	1.02	0.54*	0.24	0.07	1.01	0.52*	0.24	0.05	0.99
Some HS	-2.12	2.91	-7.82	3.59	1.52	1.53	-1.48	4.52	1.17	1.60	-1.96	4.30	1.46	1.59	-1.65	4.57
HS Diploma/ GED	-2.17	2.76	-7.58	3.25	-0.03	0.47	-0.95	0.88	-0.20	0.47	-1.13	0.73	-0.11	0.47	-1.03	0.81
Some college	-2.42	2.75	-7.60	3.23	-0.45	0.39	-1.21	0.31	-0.66	0.40	-1.43	0.12	-0.58	0.39	-1.35	0.19
4-year	-2.26	2.75	-7.65	3.13	-0.65	0.39	-1.42	0.11	-0.78*	0.40	-1.56	-0.01	-0.76	0.39	-1.53	0.01
Graduate school	-1.62	2.75	-7.01	3.77	0.17	0.44	-0.69	1.02	0.08	0.44	-0.79	0.95	0.02	0.44	-0.84	0.88
Tobacco use	-0.63*	0.31	-1.24	-0.02	-0.67	0.36	-1.38	0.03	-0.70	0.37	-1.41	0.02	-0.73*	0.36	-1.45	-0.02
Age	-0.04***	0.01	-0.06	-0.02	-0.04***	0.01	-0.06	-0.02	-0.04***	0.01	-0.06	-0.02	-0.03**	0.01	-0.05	-0.01
BMI	0.01	0.01	-0.02	0.04	0.01	0.02	-0.02	0.04	0.00	0.02	-0.03	0.03	0.00	0.02	-0.03	0.03
Subjective S.S.	-0.05	0.10	-0.26	0.15	0.08	0.12	-0.15	0.32	0.10	0.12	-0.14	0.34	0.12	0.12	-0.12	0.36
White	-0.19	0.33	-0.84	0.45	-0.52	0.44	-1.38	0.33	-0.60	0.44	-1.47	0.27	-0.57	0.44	-1.43	0.29
Black	-0.23	0.43	-1.06	0.60	-0.16	0.53	-1.20	0.88	-0.11	0.54	-1.17	0.94	-0.16	0.53	-1.21	0.88
Asian	0.02	0.47	-0.91	0.95	-0.23	0.59	-1.38	0.93	-0.34	0.60	-1.51	0.84	-0.49	0.60	-1.66	0.69

Table 3.6 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Indian	0.36	0.68	-0.97	1.68	0.12	0.88	-1.61	1.85	0.17	0.89	-1.58	1.92	0.24	0.88	-1.49	1.98
Pacific Islander	-2.69**	0.88	-4.43	-0.96	-2.62*	1.18	-4.93	-0.31	-3.05*	1.25	-5.49	-0.61	-3.23**	1.24	-5.65	-0.81
Native	0.83	0.45	-0.06	1.72	0.70	0.52	-0.31	1.71	0.84	0.52	-0.19	1.86	0.85	0.52	-0.16	1.87
Acute Stress Intensity					-0.16	0.13	-0.41	0.10	0.84	0.52	-0.17	1.85	0.86	0.65	-0.41	2.12
Urbanicity					1.17	0.63	-0.07	2.41	1.25*	0.54	0.19	2.31	1.42*	0.55	0.34	2.50
FPL					0.49*	0.23	0.04	0.95	1.69*	0.75	0.22	3.15	1.53	0.80	-0.05	3.10
HS Dropout					-0.38*	0.19	-0.75	-0.00	1.55*	0.71	0.17	2.93	1.95**	0.73	0.53	3.37
High needs					0.10	0.14	-0.16	0.37	-0.57	0.49	-1.53	0.39	-0.42	0.49	-1.39	0.55
Employment					-0.29	0.15	-0.59	0.01	-0.36	0.55	-1.43	0.71	-0.23	0.54	-1.30	0.84
Crowding					-0.05	0.15	-0.34	0.24	0.60	0.54	-0.46	1.66	0.22	0.55	-0.85	1.29
Single Parent Family					-0.29	0.19	-0.66	0.07	-1.58*	0.64	-2.84	-0.33	-1.54*	0.65	-2.82	-0.27
Transportation					-0.06	0.17	-0.39	0.27	-1.71	0.63	-2.94	-0.48	-2.01**	0.65	-3.28	-0.74
Urbanicity x Acute SI									-1.31	0.68	-2.91	0.35	-1.45	0.88	-3.16	0.27
FPL x Acute SI									-1.29	0.83	-3.89	-0.78	-2.07*	0.97	-3.97	-0.16

Table 3.6 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
HS Dropout x Acute SI									-2.33**	0.79	-0.32	1.72	-1.12	0.98	-3.04	0.81
High needs x Acute SI									0.70	0.52	-1.00	1.35	0.97	0.70	-0.39	2.33
Employment x Acute SI									0.17	0.60	-1.89	0.38	-0.19	0.75	-1.65	1.28
Crowding x Acute SI									-0.76	0.58	-0.01	2.84	-0.66	0.79	-2.22	0.90
Single Parent Family* x Acute SI									1.42	0.73	0.56	3.24	2.48*	0.97	0.59	4.37
Transportation x Acute SI									1.90**	0.68	-2.65	0.02	0.73	0.83	-0.91	2.36
FPL Score x Acute SI x													1.00	0.78	-0.53	2.54

Table 3.6 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Urbanicity																
HS Dropout x Acute SI x Urbanicity													-1.89**	0.73	-3.31	-0.47
High needs x Acute SI x Urbanicity													-0.53	0.52	-1.56	0.50
Employment x Acute SI x Urbanicity													0.28	0.58	-0.87	1.42
Crowding x Acute SI x													0.52	0.63	-0.72	1.75

Table 3.6 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Urbanicity																
Single Parent Family x Acute SI x Urbanicity													-1.24	0.85	-2.90	0.43
Transportation x Acute SI x Urbanicity													1.68**	0.63	0.43	2.92
Random E.	Variance				Variance				Variance				Variance			
Health Code	4.95				4.08				4.13				3.96			

Note. Model degrees of freedom: step 1 = 725, step 2 = 505, step 3 = 497, step 4 = 490.

The SDI subscales were used in place of the SDI total score. H.S. = High School, Subjective S.S. = Subjective Social Status, Acute SI = Acute Stress Intensity, FPL = Federal Poverty Line, Random E = Random Effect.

*$p<.05$, **$p<.01$, ***$p<.001$

Table 3.7 Memory Performance Regressed on Study Variables in the Global Stress Intensity before a Memory Task Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Gender	0.32***	0.05	0.22	0.41	0.21***	0.05	0.11	0.31	0.21***	0.05	0.11	0.31	0.21***	0.05	0.11	0.31
Some HS	-0.04	0.62	-1.26	1.19	-0.05	0.24	-0.52	0.42	-0.06	0.24	-0.53	0.41	-0.06	0.24	-0.53	0.41
HS Diploma/ GED	0.13	0.59	-1.03	1.28												
Some college	0.36	0.59	-0.79	1.51	0.21*	0.08	0.05	0.37	0.21*	0.08	0.05	0.37	0.20*	0.08	0.04	0.36
4-year	0.44	0.59	-0.71	1.59	0.19*	0.09	0.02	0.36	0.19*	0.09	0.02	0.36	0.19*	0.09	0.02	0.36
Graduate school	0.59	0.59	-0.56	1.74	0.34***	0.09	0.16	0.52	0.34***	0.09	0.16	0.52	0.34***	0.09	0.16	0.52
Tobacco use	-0.09	0.08	-0.24	0.06	-0.09	0.08	-0.25	0.06	-0.09	0.08	-0.25	0.07	-0.09	0.08	-0.25	0.07
Age	-0.43***	0.02	-0.48	-0.39	-0.42***	0.03	-0.47	-0.36	-0.41	0.03	-0.47	-0.36	-0.42***	0.03	-0.47	-0.36
BMI	-0.01	0.02	-0.06	0.03	-0.04	0.02	-0.09	0.01	-0.04***	0.02	-0.09	0.01	-0.04	0.02	-0.09	0.01
Subjective S.S.	-0.07**	0.02	-0.12	-0.03	-0.05*	0.03	-0.10	0.00	-0.05*	0.03	-0.10	0.00	-0.05*	0.03	-0.10	0.00
White	0.23**	0.08	0.08	0.39*	0.21	0.09	0.04	0.38	0.21*	0.09	0.04	0.38	0.21*	0.09	0.04	0.37
Black	0.08	0.11	-0.13	0.28	0.08	0.11	-0.14	0.30	0.08	0.11	-0.14	0.30	0.07	0.11	-0.15	0.30
Asian	0.01	0.12	-0.22	0.24	-0.07	0.13	-0.32	0.18	-0.07	0.13	-0.32	0.18	-0.07	0.13	-0.32	0.18
Indian	0.20	0.20	-0.20	0.60	0.35	0.23	-0.10	0.80	0.35	0.23	-0.10	0.80	0.34	0.23	-0.11	0.79
Pacific Islander	0.62*	0.24	0.15	1.10	0.36	0.26	-0.15	0.88	0.36	0.26	-0.16	0.87	0.35	0.26	-0.16	0.87
Native	0.22	0.13	-0.04	0.49*	0.29	0.14	0.01	0.56	0.28*	0.14	0.01	0.56	0.28*	0.14	0.01	0.56

Table 3.7 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Global SI					-0.01	0.02	-0.05	0.03	0.00	0.09	-0.17	0.17	-0.04	0.09	-0.22	0.14
Urbanicity					0.01	0.03	-0.07	0.03	0.10	0.11	-0.11	0.31	0.10	0.11	-0.11	0.31
SDI					-0.02	0.02	-0.04	0.06	-0.18	0.11	-0.40	0.03	-0.18	0.11	-0.40	0.03
SDI x Global SI									0.18	0.11	-0.04	0.40	0.29	0.16	-0.03	0.60
Urbanicity x Global SI									-0.11	0.13	-0.37	0.15	-0.05	0.15	-0.34	0.24
SDI x Global SI x Urbanicity													-0.12	0.13	-0.37	0.13
Random E.	Variance				Variance				Variance				Variance			
Health Code	1.86				1.47				1.47				1.47			

Note. Model degrees of freedom: step 1 = 8308, step 2 = 6319, step 3 = 6317, step 4 = 6316.

High School Diploma/GED variable was ranked deficient and was dropped out of Models 2-4. H.S. = High School, Subjective S.S. = Subjective Social Status, SDI = Social Deprivation Index Total score, Global SI = Global Stress Intensity, Random E = Random Effect.

*p<.05, **p<.01, ***p<.001

Table 3.8 Memory Performance Regressed on Study Variables and SDI Subscales in the Global Stress Intensity before a Memory Task Model

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Gender	0.32***	0.05	0.22	0.41	0.21	0.05	0.11	0.31	0.21***	0.05	0.11	0.31	0.21***	0.05	0.11	0.31
Some HS	-0.04	0.62	-1.26	1.19	-0.05	0.24	-0.52	0.42	-0.06	0.24	-0.53	0.41	-0.05	0.24	-0.52	0.42
HS Diploma/ GED	0.13	0.59	-1.03	1.28												
Some college	0.36	0.59	-0.79	1.51	0.21**	0.08	0.05	0.37	0.21**	0.08	0.05	0.37	0.21*	0.08	0.05	0.37
4-year	0.44	0.59	-0.71	1.59	0.19*	0.09	0.02	0.36	0.20*	0.09	0.03	0.37	0.19*	0.09	0.02	0.36
Graduate school	0.59	0.59	-0.56	1.74	0.34***	0.09	0.16	0.52	0.34***	0.09	0.16	0.52	0.34***	0.09	0.16	0.52
Tobacco use	-0.09	0.08	-0.24	0.06	-0.10	0.08	-0.25	0.06	-0.09	0.08	-0.25	0.07	-0.10	0.08	-0.26	0.06
Age	-0.43***	0.02	-0.48	-0.39	-0.42***	0.03	-0.47	-0.37	-0.41***	0.03	-0.47	-0.36	-0.42***	0.03	-0.47	-0.36
BMI	-0.01	0.02	-0.06	0.03	-0.04	0.02	-0.09	0.01	-0.04	0.02	-0.09	0.01	-0.04	0.02	-0.09	0.01
Subjective S.S.	-0.07**	0.02	-0.12	-0.03	-0.05*	0.03	-0.10	0.00	-0.05*	0.03	-0.10	0.00	-0.05*	0.03	-0.10	0.00
White	0.23**	0.08	0.08	0.39*	0.21*	0.09	0.04	0.38	0.20*	0.09	0.04	0.37	0.20*	0.09	0.03	0.37
Black	0.08	0.11	-0.13	0.28	0.08	0.11	-0.14	0.30	0.07	0.11	-0.15	0.29	0.07	0.11	-0.16	0.29
Asian	0.01	0.12	-0.22	0.24	-0.08	0.13	-0.33	0.17	-0.08	0.13	-0.34	0.17	-0.09	0.13	-0.35	0.16
Indian	0.20	0.20	-0.20	0.60	0.34	0.23	-0.11	0.79	0.35	0.23	-0.10	0.80	0.33	0.23	-0.13	0.78
Pacific Islander	0.62*	0.24	0.15	1.10	0.36	0.26	-0.16	0.87	0.37	0.26	-0.14	0.89	0.37	0.26	-0.15	0.88

Table 3.8 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Native	0.22	0.13	-0.04	0.49*	0.29*	0.14	0.02	0.57	0.28*	0.14	0.01	0.56	0.28*	0.14	0.01	0.55
Global SI					-0.01	0.02	-0.05	0.03	-0.06	0.10	-0.26	0.14	-0.14	0.12	-0.37	0.09
Urbanicity					0.01	0.03	-0.04	0.07	-0.04	0.13	-0.29	0.21	-0.03	0.13	-0.28	0.22
FPL					-0.02	0.05	-0.11	0.07	-0.52*	0.20	-0.91	-0.12	-0.51*	0.20	-0.90	-0.12
HS Dropout					0.00	0.04	-0.08	0.08	-0.21	0.17	-0.55	0.14	-0.20	0.17	-0.55	0.14
High needs					-0.02	0.03	-0.07	0.04	0.11	0.12	-0.13	0.35	0.11	0.12	-0.13	0.35
Employment					0.02	0.03	-0.05	0.08	0.13	0.14	-0.14	0.40	0.13	0.14	-0.14	0.40
Crowding					-0.01	0.03	-0.07	0.05	0.03	0.14	-0.23	0.30	0.03	0.14	-0.24	0.30
Single Parent Family					-0.04	0.04	-0.11	0.04	0.02	0.17	-0.31	0.34	0.01	0.17	-0.31	0.34
Transportation					0.04	0.03	-0.03	0.11	0.40**	0.14	0.12	0.68	0.40**	0.14	0.12	0.68
Urbanicity x Global SI									0.07	0.16	-0.23	0.38	0.20	0.18	-0.15	0.56
FPL x Global SI									0.54*	0.21	0.12	0.95	0.62*	0.26	0.11	1.14
HS Dropout x Global SI									0.23	0.18	-0.13	0.59	0.31	0.23	-0.14	0.75
High needs x Global SI									-0.13	0.13	-0.38	0.12	0.07	0.16	-0.25	0.38
Employment x Global SI									-0.12	0.15	-0.41	0.17	-0.24	0.18	-0.59	0.12

Table 3.8 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Crowding x Global SI									-0.05	0.14	-0.33	0.24	-0.07	0.18	-0.42	0.28
Single Parent Family x Global SI									-0.06	0.17	-0.40	0.28	-0.06	0.21	-0.47	0.36
Transportation x Global SI									-0.39**	0.15	-0.69	-0.10	-0.37*	0.19	-0.74	0.00
FPL x Global SI x Urbanicity													-0.10	0.17	-0.44	0.24
HS Dropout x Global SI x Urbanicity													-0.10	0.15	-0.39	0.20
High needs x Global SI x Urbanicity													-0.22*	0.11	-0.44	-0.01
Employmentx Global SI x Urbanicity													0.13	0.12	-0.11	0.37

Table 3.8 Continued

Variable	Step 1				Step 2				Step 3				Step 4			
	Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI		Estimate	SE	95% CI	
			LL	UL			LL	UL			LL	UL			LL	UL
Crowding x Global SI x Urbanicity													0.03	0.13	-0.22	0.28
Single Parent Family x Global SI x Urbanicity													0.01	0.15	-0.29	0.30
Transportatio n x Global SI x Urbanicity													-0.01	0.13	-0.27	0.25
Random E.	Variance				Variance				Variance				Variance			
Health Code	1.86				1.48				1.47				1.47			

Note. Model degrees of freedom: step 1 = 8308, step 2 = 6313, step 3 = 6303, step 4 = 6298.

High School Diploma/GED variable was ranked deficient and was dropped out of Models 2-4. H.S. = High School, Subjective S.S. = Subjective Social Status, Global SI = Global Stress Intensity, FPL = Federal Poverty Line, Random E = Random Effect.

*p<.05, **p<.01, ***p<.001

CHAPTER 4. DISCUSSION

The results of this study highlight the intricate nature of stress and how it may impact memory in a real-world setting. Here, we captured daily stress responses and contextual stress exposures to better conceptualize the impact of stress on memory performance. First, we examined the cumulative impact of stress across several days on a single memory test. Aligned with our hypothesis, acute stress intensity, averaged over multiple days, was related to worse memory performance. However, contrary to our hypothesis, global stress intensity was associated with better memory. Additionally, we investigated the impact of environmental contextual factors and found that living in more urban environments was related to better memory outcomes. However, higher acute stress intensities moderated this relationship such that those in urban environments with higher acute stress had poorer memory performance. Next, we examined the impact of event-based stress ratings on memory performance. For this, we focused exclusively on the stress ratings people provided directly before they completed a memory test. We found that when people reported experiencing an acute stressor, contextual factors were important. Specifically, for those who reported an acute stressor, higher social deprivation was related to poorer memory performance. Taken together, these results rebut traditionally memory approaches and suggest that it is important to account for stress accumulation over days as that may provide greater insight into stress and memory relationships. Further, considering the complex nature of environmental contextual factors and how they interact with daily stress events may be a more thorough approach to assessing stress and memory links.

As predicted, reports of higher acute stress intensities averaged across multiple days were associated with poorer memory. Previous research established the importance of assessing when a stressor occurs in relation to memory stages as it can yield memory impairment or enhancement. This finding extends this body of work by revealing that multiple acute stressors occurring before memory recall can lead to memory impairment. This work also adds to the minimal body of research that examines stress outside of a controlled laboratory environment and assesses the intensity of an acute stressor rather than just evaluating the occurrence of a stress event. Taken together, these results highlight the importance of and provide a framework for examining the cumulative impact of stress and its intensity on memory in real-world settings.

Little research has examined chronic stress in mid-life healthy adults. Additionally, chronic stress literature is inundated by research examining the summation of lifetime traumatic events or focused on those who are navigating a persistently stressful situation (e.g., caregivers). Contrary to these traditional approaches, we characterize chronic stress as self-reported stress intensities (i.e., global stress intensity) that were independent of a traumatic or acute stress event and further did not delineate people with objectively stressful conditions. As a result, our hypothesis was informed by research inconsistent with our sample and study design. We found that higher levels of average global stress led to better memory performance. Our findings suggests that previous understandings of the relationship between chronic stress and memory may not be representative of everyday stress and memory relationships. Instead, in some cases, higher chronic stress may lead to memory benefits. Given that the association in our study between global stress and memory were not aligned with our prediction, we also concede that our assessment of global stress may tap into other aspects of psychological function. Chronic stress is typically defined as the summation of stressful life events or prolonged psychological responses to a past trauma. Here, global stress intensity was measured by asking participants to rate their feelings of anxiety, in control, and happiness independent of any stressful or traumatic experience. We captured this indicator at multiple time points across multiple days in the study and found similar variance in the acute and global stress rating in Models 2 and 3. This suggests that both acute and global stress facets may be fluid and subject to change over short time intervals. Yet, because the global stress rating was not linked to an event, these ratings may be also capturing an individual's general psychological arousal. Considering previous literature has indicated that higher arousal near memory recall is linked with memory enhancement (Cahill et al., 2003; Goldfarb et al., 2019; Segal et al., 2014; Wichmann et al., 2012), our results may be better explained by this interpretation.

Another major component of this study was investigating the impact of environmental contextual factors. We found living in more urban environments was related to better memory, which contradicted our hypothesis. However, experiencing higher acute stress intensities in more urban locations was associated with poorer memory. This finding was aligned with our predictions and suggests the association between urbanicity and memory changes direction with the inclusion of acute stress intensity. These findings suggest experiencing acute stress may be more impactful for individuals living in urban environments and could eventually place them at risk for significant memory impairment. Additionally, exploratory analyses examining the impact of SDI subscales revealed significant interactions with our discrete stress indicators and urbanicity across our event and model-based indices. The inclusion of these subscales provided evidence for how different characteristics across levels of urbanicity differentially impact memory performance. For instance, high school dropout rates interacted differently with acute stress intensities across levels of urbanicity with the more urban areas showing the biggest impact on memory performance. Findings like this support the notion that the environment engages with stressful events to significantly impact memory. Thus, highlighting the importance of using a stress framework that captures both discrete stress events and contextual stress factors in future work.

We were able to compare two models of stress on memory performance – cumulative or the average stress across days leading up to a memory task, and event-based, the direct impact of momentary stress on memory. This comparison revealed that cumulative approaches may be more effective to assess the impact of stress on memory. In the event-based vs cumulative models, participants reported higher stress intensities. However, this did not predict their memory score. On the other hand, the cumulative stress rating over days may be a better assessment of the individuals stress condition as this was more closely related to their cognitive ability. This suggests that multiple stress ratings over time, even if at lower intensities, may be more impactful to memory and a better way to assess stress's impact on memory, than using an event-based model.

Importantly, we also found that for those who reported an acute stressor directly prior to their memory test social deprivation was a valuable predictor of their memory performance. This suggest that it may be important to consider how contextual factors inform cognition, including memory, to impact the relationship between stress and behavior. However, this finding should be interpreted with caution as we only found a role for deprivation in the event-based acute stress model. Specifically, our sample size in this model was limited and the demographic factors of this Model's sample may have been less representative of the population.

4.1 Limitations & Future Directions

This study is not without limitations. One limiting factor of this study is the inability to capture both types of self-reported stress indicators at each check-in. Due to the design of the study, participants only responded to one of the self-reported stress questions preventing further analyses on how these factors interact and combined to impact memory. Furthermore, far fewer participants reported an acute stressor decreasing the sample size in that Model. Another limitation of this study was capturing zip-code level data to examine social deprivation. Because there is variety in levels of deprivation across one zip code this limited us from conducting a more in-depth analysis of deprivation at the neighborhood level. Examining deprivation across consensus-level neighborhood blocks would provide a better depiction of the deprivation across neighborhoods. Additionally, what is perceived as a socially deprived area by a resident may not coincide with the ranking of such an area. Future research would benefit from examining social deprivation by self-report and comparing such reports to established indices.

4.2 Conclusion

Overall, this study was able to provide new evidence in the way stress impacts memory, highlighting the importance of capturing stress over time and capturing contextual factors of stress in a real-world setting. We highlight the need to use an interdisciplinary approach to capture the multifaceted essence of stress. Additionally, we highlight important critical factors in the relationship between stress and memory. For instance, the experience of multiple acute stressors prior to a memory task seem to impair memory whereas a singular acute stress report prior to memory did not have an impact in this study. Furthermore, investigating the impact of environmental contextual stress factors added value in that daily stress reports varied based on environmental factors. The implications of our results highlight a need for research to go beyond the traditional methods of examining stress and memory. When capturing stress, we suggest looking at the possibility of co-occurring stressors as well as contextual factors of the environment. Including such factors allow for a better understanding of the interactive effects that occur naturally in everyday life, providing a more informative description of how stress permeates the body to impact memory.

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