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Neighborhood Disadvantage and Cognitive Disparities: A Community-Centered Investigation of Processing Speed Effects Across Racial and Ethnic Groups in Older Adults

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ABSTRACT

Background. Neighborhood disadvantage is associated with cognitive decline, but whether this effect differs by race/ethnicity is unclear.

Methods. Data from participants in the Health and Aging Brain Studies were analyzed using linear regression to test whether race/ethnicity moderates the relationship between Area Deprivation Index and processing speed (Trail Making Test Part A, Digit Symbol Substitution Test), adjusting for age. Analyses were conducted for Non-Hispanic White (NHW, n=1,271) vs Hispanic/Latino (n=1,264) and Non-Hispanic Black (NHB, n=1,346) vs Hispanic/Latino participants.

Results. The ADI x ethnicity interaction was significant for both Non-Hispanic White vs Hispanic/Latino (Trails A p=0.0194; DSST p=0.001) and Non-Hispanic Black vs Hispanic/Latino (Trails A p<0.001; DSST p<0.001), but stronger for the Non-Hispanic White comparison. Hispanic/Latino adults showed 3.4X stronger effects of neighborhood disadvantage on Trails A compared to Non-Hispanic White Adults.

Discussion. These findings suggest that structural inequities compound to shape cognitive outcomes. While neighborhood disadvantage affects processing speed across all racial/ethnic groups, Hispanic/Latino older adults experience disproportionate effects. This differential vulnerability may reflect the intersection of marginalized identities and structural inequities, including educational attainment and environmental stressors, as well as limited access to protective resources. Educational disparities between groups suggest systemic inequities in opportunity and access begin long before older age, with downstream effects on cognition.

Health Equity Implications. Structural inequities in education and neighborhood conditions intersect to amplify cognitive health disparities for Hispanic/Latino older adults. Interventions addressing neighborhood disadvantage must be paired with efforts to reduce educational disparities to effectively reduce cognitive health inequities.

Keywords: *Area Deprivation Index, Processing speed, Cognitive disparities, Health equity, Neighborhood disadvantage, Social Determinants of Health, Cognitive Aging, Neuropsychological assessment, Environmental stressor*

INTRODUCTION

Social determinants of health, particularly neighborhood disadvantage measured via the Area Deprivation Index (ADI), plays a key role in shaping cognitive aging trajectories. While neighborhood deprivation is broadly linked to accelerated cognitive decline, significant gaps remain regarding whether environmental stressors differentially impact cognitive processing speed, an area highly vulnerable to early neurodegenerative changes, across distinct racial and ethnic cohorts. Older adults navigate distinct socio-structural contexts across the lifespan. Hispanic/Latino older adults face unique vulnerabilities, including disproportionate exposure to neighborhood deprivation and systemic barriers to educational attainment. Early-life educational disparities reduce cognitive reserve, potentially heightening vulnerability to late-life environmental disadvantage. This study utilizes data from the Health and Aging Brain Study –Health Disparities (HABS-HD) to address a primary research question: To what extent does neighborhood disadvantage, as measured by ADI, differentially affect processing speed performance among Hispanic/Latino, Non-Hispanic Black (NHB), and Non-Hispanic White (NHW) older adults? Cognitive processing speed performance was evaluated using the Trail Making Test Part A (Trails A) and the Digit Symbol Substitution Test (DSST). By testing whether race/ethnicity moderates the relationship between ADI and processing speed, while controlling for age, sex, and educational attainment, this study clarifies how lifespan structural inequities compound to drive ethnic disparities in cognitive health

METHODS

Study Design and Setting

Data were obtained from the Health and Aging Brain Study–Health Disparities (HABS-HD) [3], an ongoing longitudinal study designed to investigate cognitive aging and Alzheimer's disease among ethnically diverse older adults in the United States. Access to the HABS-HD dataset was granted through the Laboratory of Neuro Imaging (LONI) following approval of a data access request and completion of required data use agreements.

Participants and Recruitment

Participants were included in this analysis if they identified as Non-Hispanic White (NHW), Non-Hispanic Black (NHB), or Hispanic/Latino and had complete data for all study variables. Individuals with missing data for Area Deprivation Index (ADI) national rank or age were excluded from analyses. A total of 2,535 participants (1,271 NHW, 1,264 Hispanic/Latino) were included in the primary analysis comparing NHW to Hispanic/Latino participants.

Ethics Approval

All members of the research team completed Collaborative Institutional Training Initiative (CITI) Human Subjects Research training before accessing and working with participant data.

Measures

Neighborhood socioeconomic disadvantage was assessed using the Area Deprivation Index (ADI) [4] National Rank, with higher values indicating greater neighborhood disadvantage. Processing speed was evaluated using two standardized neuropsychological measures: the Trail Making Test Part A (Trails A) [5], for which longer completion times reflect poorer performance, and the Digit Symbol Substitution Test (DSST)[6], in which higher scores indicate better cognitive performance. Age and education were included as covariates in sensitivity analyses because of their established association with cognitive function. Ethnicity was coded as a categorical variable with NHW serving as the reference group.

Statistical Analysis

All statistical analyses were conducted in RStudio. Descriptive statistics, including means and standard deviations, were calculated for demographic and cognitive variables by ethnic group. Prior to hypothesis testing, model assumptions were evaluated through visual inspection of histograms, scatterplots, residual diagnostic plots, and Levene's tests for homogeneity of variance.

Separate linear regression models were fit for Trails A and DSST outcomes. For each cognitive measure, a main-effects model including ADI, ethnicity, and age was first estimated. A second model added an ADI × Ethnicity interaction term to examine whether ethnicity moderated the association between neighborhood disadvantage and processing speed. For significant interactions, simple slopes analyses were conducted, and interaction effects were visualized using predicted regression lines with 95% confidence intervals. Statistical significance was defined as $p < .05$.

RESULTS

Sample Characteristics

The final sample consisted of 2,553 participants (1,275 Non-Hispanic White [NHW] and 1,278 Hispanic/Latino) for the primary comparison. For the Non-Hispanic Black comparison, the sample consisted of 2,314 participants (1,036 Non-Hispanic Black [NHB] and 1,278 Hispanic/Latino). Multiple linear regression analyses were conducted to examine whether neighborhood disadvantage, measured by Area Deprivation Index (ADI), was associated with processing speed and if this relationship differed by ethnicity while controlling for age.

Primary Outcomes: Processing Speed

Trail Making Test Part A

The ADI × Ethnicity interaction was significant for the Non-Hispanic White vs. Hispanic/Latino comparison ($p = 0.0194$), indicating the association between neighborhood disadvantage and processing speed differed between groups. Simple slopes analyses showed higher ADI scores were associated with slower processing among NHW adults ($b = 0.07$, $p = 0.01$). This relationship was considerably stronger among Hispanic/Latino adults ($b = 0.24$, $p < .001$), representing a slope approximately 3.4 times greater than observed for NHW participants. See Figures 1 and 2.

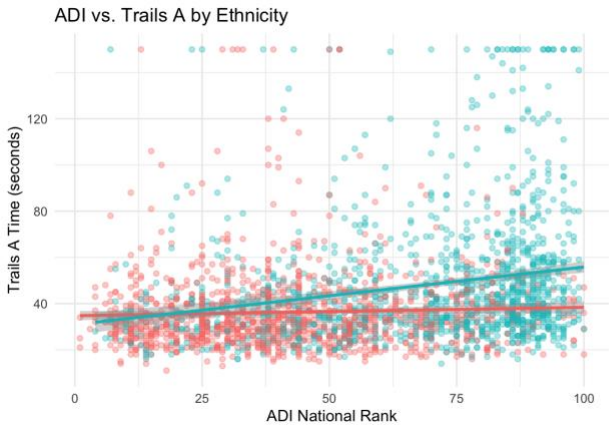

Figure 1. *Relationship between ADI National Rank and Trails A performance by ethnicity (NHW vs. Hispanic/Latino) with age-adjusted regression lines.*

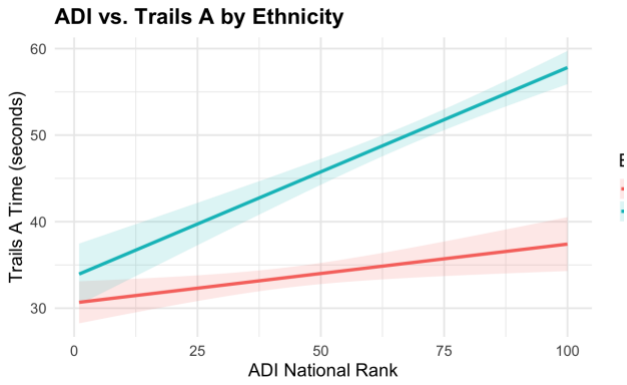

Figure 2. *ADI × Ethnicity moderation effect on Trails A: differential slopes demonstrating stronger effects of neighborhood disadvantage for Hispanic/Latino compared to Non-Hispanic White older adults.*

Digit Symbol Substitution Test

The ADI × Ethnicity interaction was significant for the Digit Symbol Substitution Test for the Non-Hispanic White vs. Hispanic/Latino comparison (DSST; $p < .001$), demonstrating that neighborhood disadvantage divergently predicted processing speed across ethnic groups. For NHW adults, higher ADI scores were associated with lower DSST performance ($b = -0.09$, $p < .001$). This negative association was significantly stronger among Hispanic/Latino adults ($b = -0.18$, $p < .001$), representing approximately twice the magnitude of the association observed in NHW participants. See Figures 3 and 4.

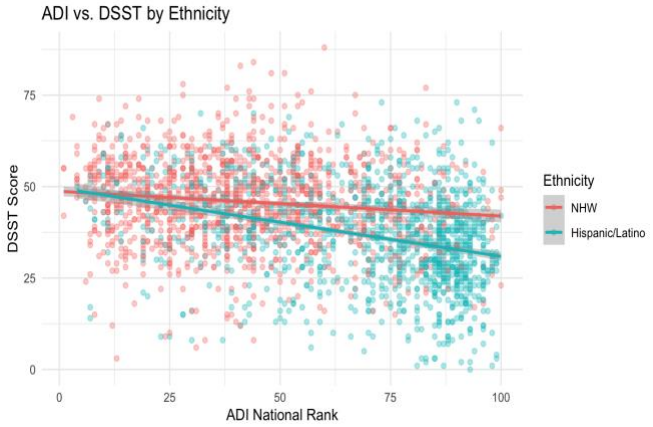

Figure 3. *Relationship between ADI National Rank and DSST performance by ethnicity (NHW vs. Hispanic/Latino) with age-adjusted regression lines.*

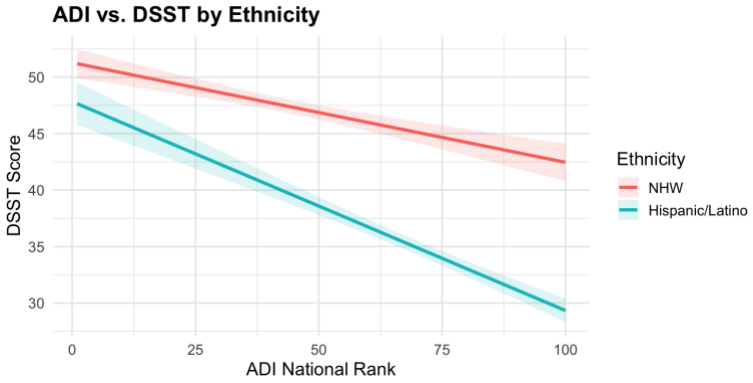

Figure 4. *ADI × Ethnicity moderation effect on DSST: differential slopes showing steeper decline in processing speed for Hispanic/Latino compared to Non-Hispanic White older adults as neighborhood disadvantage increases.*

Non-Hispanic Black vs Hispanic Latino

The ADI × Ethnicity interaction was also statistically significant when comparing Non-Hispanic Black (NHB) to Hispanic/Latino participants for both Trails A ($p < .001$) and DSST ($p < .001$). For Trails A, NHB adults showed an

ADI slope of 0.11 ($p < .001$), while Hispanic/Latino adults showed a slope of 0.24 ($p < .001$), representing approximately a 2.2-fold difference. For DSST, NHB adults showed an ADI slope of -0.11 ($p < .001$), while Hispanic/Latino adults showed a slope of -0.18 ($p < .001$), representing approximately a 1.6-fold difference.

Comparison of effect sizes between the two ethnic comparisons reveals that the ADI × Ethnicity interaction is stronger for the Non-Hispanic White vs. Hispanic/Latino comparison. For Trails A, the difference in slopes between the two ethnic groups is 0.17 points (NHW: 0.07 vs. Latino: 0.24) compared to 0.13 points for the Non-Hispanic Black comparison (NHB: 0.11 vs. Latino: 0.24). Similarly, for DSST, the Non-Hispanic White comparison shows a slope difference of 0.09 points (NHW: −0.09 vs. Latino: −0.18) compared to 0.07 points for the Non-Hispanic Black comparison (NHB: −0.11 vs. Latino: −0.18). See Figures 5 and 6.

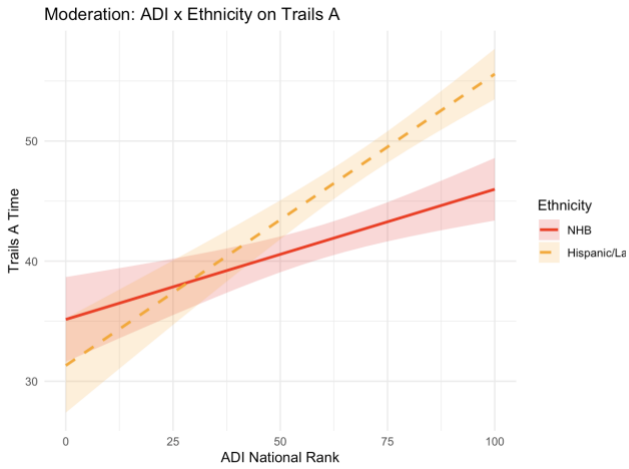

Figure 5. *ADI × Ethnicity moderation effect on Trails A (NHB vs. Hispanic/Latino): statistically significant interaction demonstrating differential effects of neighborhood disadvantage on processing speed between Non-Hispanic Black and Hispanic/Latino older adults.*

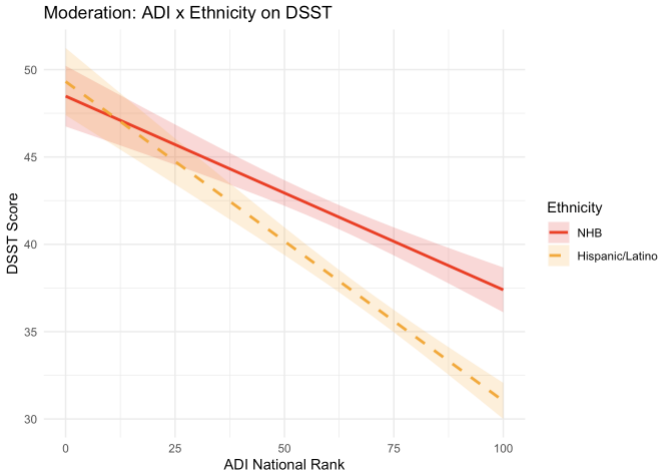

Figure 6. *ADI × Ethnicity moderation effect on DSST (NHB vs. Hispanic/Latino): statistically significant interaction showing differential effects of neighborhood disadvantage on processing speed between Non-Hispanic Black and Hispanic/Latino older adults.*

Covariates

Age was a significant predictor of processing speed across both models ($p < .001$), with older age associated with poorer processing speed performance. Overall, these findings supported the hypothesis that neighborhood disadvantage has a stronger negative association with processing speed among Hispanic/Latino older adults than among Non-Hispanic White older adults.

DISCUSSION

The results of this analysis reveal a critical intersection between neighborhood socioeconomic context and race/ethnicity in shaping cognitive aging patterns. Our finding that the relationship between neighborhood disadvantage and processing speed differs significantly across racial and ethnic groups challenges the notion of uniform neighborhood effects and instead points to the salience of structural racism in determining cognitive health outcomes. For Hispanic/Latino

older adults specifically, increasing neighborhood disadvantage appears to carry a steeper cognitive cost compared to their Non-Hispanic White peers, a pattern consistent with weathering theory, which posits that chronic exposure to discrimination and socioeconomic adversity accelerates biological aging.

The magnitude of the ADI × Ethnicity interaction for both Trails A and DSST suggests that neighborhoods are not simply economic spaces but are racialized environments embedded within broader systems of inequality. Hispanic/Latino communities are disproportionately concentrated in neighborhoods with high deprivation indices, yet the steeper cognitive decline observed in these contexts may also reflect compounding exposures: limited access to preventive healthcare, lower educational attainment opportunities, employment precarity, linguistic isolation from health information, and reduced access to cognitive-stimulating activities. Additionally, immigration-related stressors, including legal status uncertainty, family separation, and cultural displacement, may amplify the negative effects of neighborhood disadvantage on cognitive function in ways not captured by standard socioeconomic indicators.

From a health equity perspective, these findings underscore the importance of moving beyond individual risk factor modification toward structural interventions that address the root causes of neighborhood disadvantage. Community-based cognitive health promotion must be grounded in the lived experiences and strengths of Hispanic/Latino older adults, incorporating cultural values, family systems, and community networks as protective factors. Simultaneously, advocacy efforts must target upstream policy changes including fair housing enforcement, equitable education funding, workforce development, and healthcare expansion in underserved neighborhoods. Without addressing the structural inequities that create and perpetuate neighborhood disadvantage, individual-level interventions will remain insufficient.

Future research should employ longitudinal designs to track whether differential cognitive aging trajectories persist over time and to identify critical periods of vulnerability. Mechanistic investigations examining stress-related biomarkers, social isolation, access to environmental enrichment, and health service utilization could illuminate pathways through which neighborhood context "gets under the skin" to affect cognition. Community-engaged research that centers the voices and expertise of older Hispanic/Latino adults and other historically marginalized groups will be essential to developing interventions that are culturally relevant, feasible, and sustainable.

Limitations

Neighborhood disadvantages are a direct driver of health inequity that greatly impairs speed processing and cognitive function in older adults of all backgrounds. Populations that have been minoritized face a larger burden of environmental inequalities

HEALTH EQUITY IMPLICATIONS

These findings speak directly to the structural conditions that shape health outcomes for underserved populations [2]. Older Mexican adults were more likely to reside in deprived areas, whereas older non-Hispanic White adults resided in areas

with higher advantages [2]. Neighborhood disadvantage disproportionately impacts cognitive function among Hispanic/Latino older adults, suggesting that place-based interventions must be paired with efforts to address educational and economic inequities. Findings may also be influenced by social capital of residents and specific cognitive protection methods that are derived from ethnic culture [1]. Practitioners and policymakers may find these results useful when designing culturally-tailored interventions intended to reach populations historically excluded from mainstream health systems. Community-centered scholarship and participatory approaches remain central to advancing equitable cognitive health outcomes for all older adults.

STATEMENTS AND DECLARATIONS

Ethics Approval. This secondary data analysis used de-identified data from the Health and Aging Brain Studies: Health Disparities (HABS-HD). All team members completed CITI (Collaborative Institutional Training Initiative) certification in research ethics and human subjects protection prior to data analysis.

Consent to Participate. Written informed consent was obtained from all HABS-HD participants at the time of original data collection.

Consent for Publication. Not applicable — no individually identifying data are included.

Declaration of Conflicting Interests. The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data Availability. Data supporting the findings of this study are from the Health and Aging Brain Studies: Health Disparities (HABS-HD), available through LONI with submission of a Data Use Agreement.

AI Use Disclosure. No generative AI tools were used in the preparation of this manuscript.

Author Contributions. Nina Mananu, Aya Oulida, Nika Jalali, Chiamaka Okafor and Samir Gulati, contributed to conceptualization, analysis, and manuscript preparation. India Ratha contributed to final edits. Dr. Michelle Chen supervised the project, provided methodological guidance, and reviewed all drafts.

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