WEB MATERIAL

Early-Life Exposure to Green Space and Mid-Childhood Cognition in the Project Viva Cohort, Massachusetts

Marcia P. Jimenez, Jessica Shoaff, Marianthi-Anna Kioumourtzoglou, Susan Korrick, Sheryl L. Rifas-Shiman, Marie-France Hivert, Emily Oken, and Peter James

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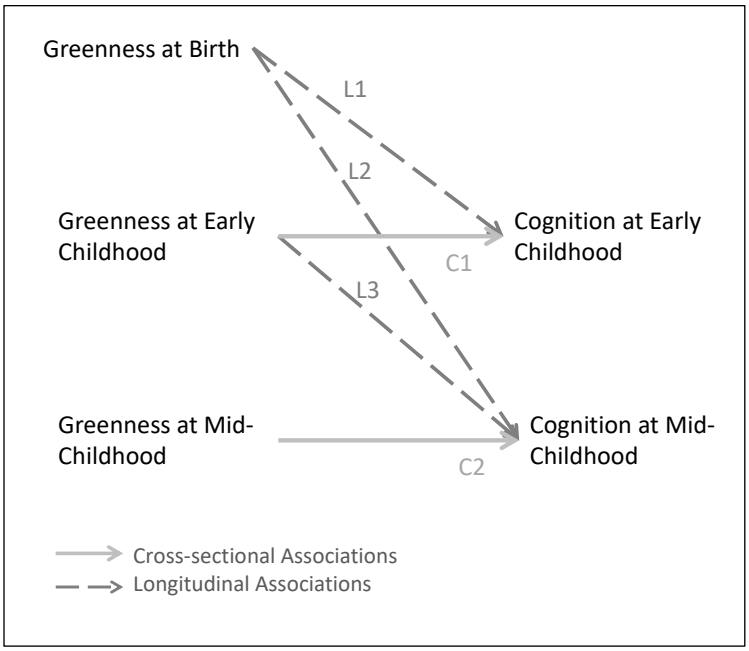
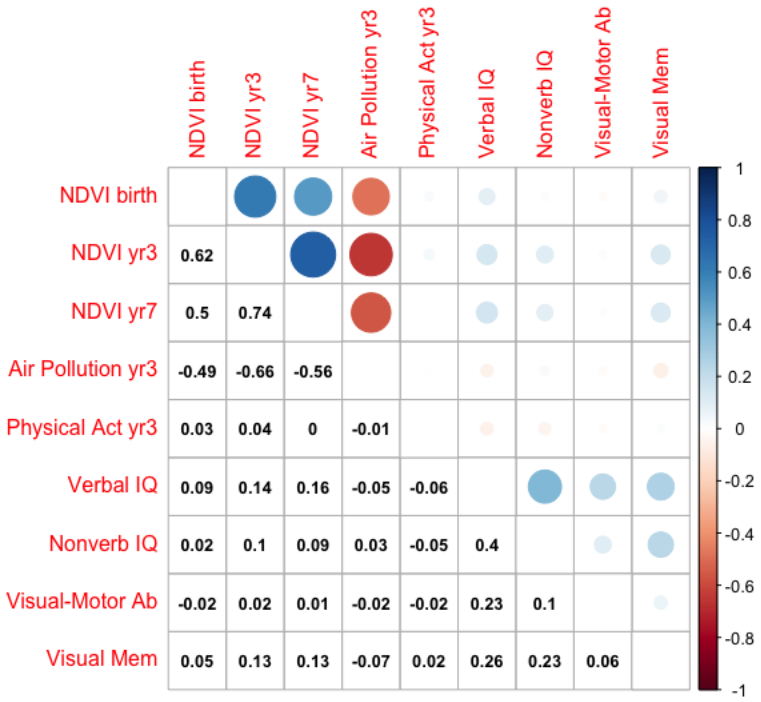
Web Table 1. Neurobehavioral functional domains measured by cognitive assessments.

Domain	Verbal IQ (KBIT-2)	Non0verbal IQ (KBIT-2)	Visual Motor (WRAVMA)	Design Memory (WRAML2)	Picture Memory (WRAML2)
Crystallized intelligence	X	X			
Word knowledge	X				
Executive function	X	X		X	X
Fine motor skills			X		
Visuospatial perception		X	X	X	
Visual Memory				X	X

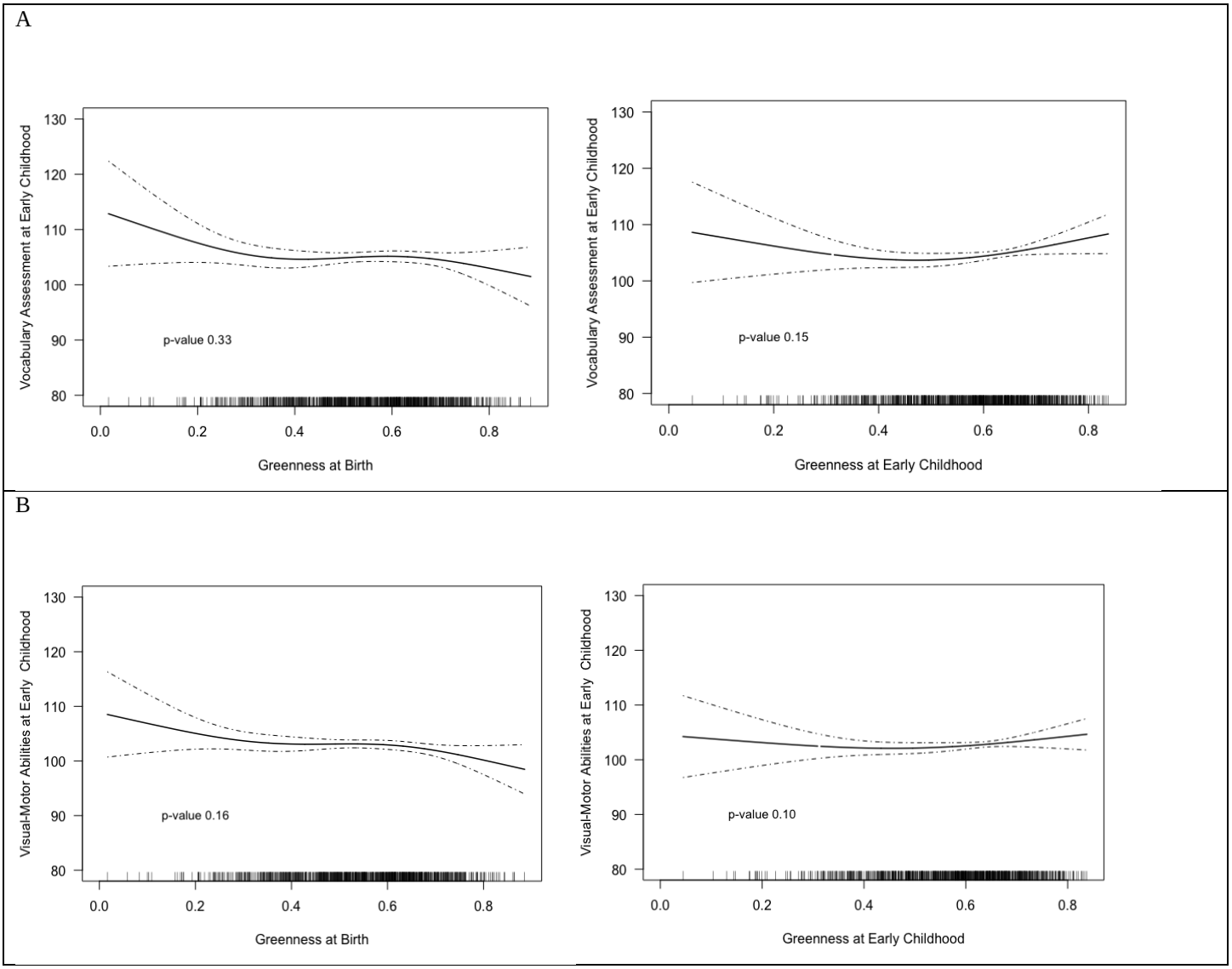
Web Figure 1. Cross-sectional and longitudinal associations examined in this study.



Web Figure 2. Pearson correlation coefficients between exposure (greenness at different ages), potential mediators (Black carbon and physical activity at age 3) and outcomes (at age 7).



Web Figure 3. Nonlinear Relationships Between Greenness and Cognitive Assessments at Early Childhood: (A) Vocabulary Comprehension, and (B) Visual-Motor Abilities.



Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], father's education (high school degree, some college, or ≥college graduate), household [annual income at enrollment in early pregnancy (<40,000, 40,000-70,000, > $70,000), neighborhood median annual income at birth, and greenness exposure in all preceding age-periods, but not in subsequent age-periods.
P-values correspond to spline terms for greenness exposure at each time point.

Web Table 2. Difference in average outcome scores with one interquartile range (IQR) increase in NDVI at birth, early childhood or mid-childhood with cognition assessments in early childhood and mid-childhood, fully adjusted.

Variable	Birth Estimate (95% CI)	Early childhood Estimate (95% CI)	Mid-childhood Estimate (95% CI)
Early Childhood Assessments			
Vocabulary	-1.37 (-2.95, 0.21)	0.71 (-1.02, 2.44)	
Motor Abilities	-1.29 (-2.62, 0.04)	0.48 (-0.96, 1.92)	
Mid-childhood Assessments			
Verbal IQ	-0.16 (-1.64, 1.32)	0.37 (-1.26, 2)	0.64 (-1.13, 2.41)
Non-verbal IQ	-0.77 (-2.69, 1.15)	1.66 (-0.44, 3.77)	0.25 (-2.04, 2.54)
Motor Abilities	-0.93 (-2.94, 1.08)	0.03 (-2.18, 2.25)	-0.56 (-2.97, 1.84)
Visual Memory	0.04 (-0.48, 0.57)	0.76 (0.19, 1.34)	0.35 (-0.27, 0.97)

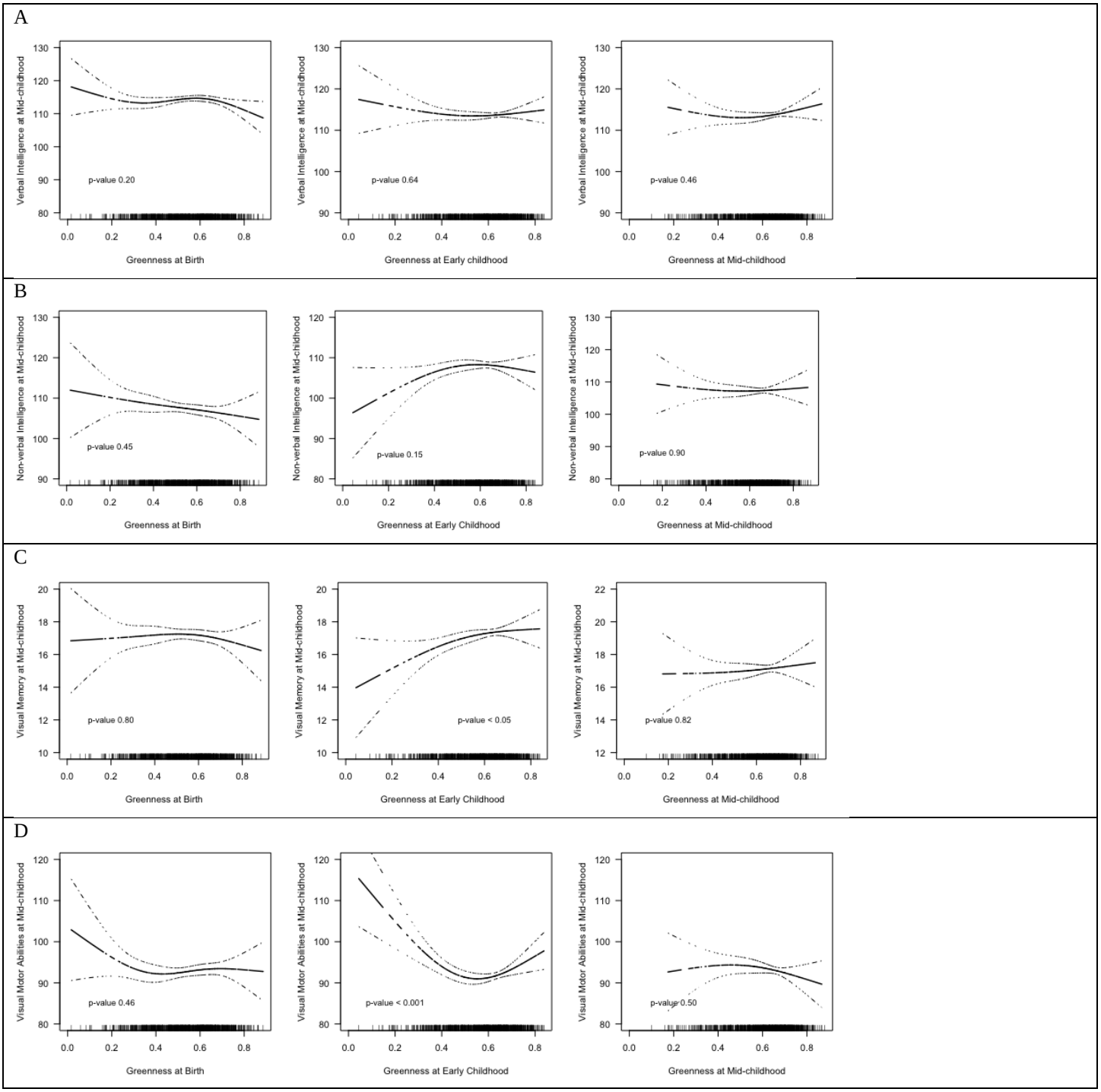
Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], father's education (high school degree, some college, or ≥college graduate), household [annual income at enrollment in early pregnancy (<40,000, 40,000-70,000, > $70,000), neighborhood median annual income at birth, and greenness exposure in all preceding age-periods, but not in subsequent age-periods.

Web Table 3. Difference in average outcome scores with one interquartile range (IQR) increase in NDVI at birth, early childhood or mid-childhood with cognition assessments in early childhood and mid-childhood, adjusted by a minimal set of confounders.

Variable	Birth Estimate (95% CI)	Early childhood Estimate (95% CI)	Mid-childhood Estimate (95% CI)
Early Childhood Assessments			
Vocabulary	-0.97 (-2.47, 0.53)	1.14 (-0.47, 2.76)	
Motor Abilities	-1.42 (-2.69, -0.15)	0.77 (-0.58, 2.12)	
Mid-childhood Assessments			
Verbal IQ	0.41 (-0.99, 1.81)	0.69 (-0.81, 2.2)	0.84 (-0.8, 2.48)
Non-verbal IQ	-1.14 (-2.94, 0.66)	1.52 (-0.42, 3.46)	0.31 (-1.81, 2.43)
Motor Abilities	-0.26 (-2.15, 1.62)	-0.44 (-2.46, 1.59)	-0.84 (-3.05, 1.37)
Visual Memory	0.08 (-0.41, 0.57)	**0.92 (0.4, 1.45)**	0.16 (-0.41, 0.73)

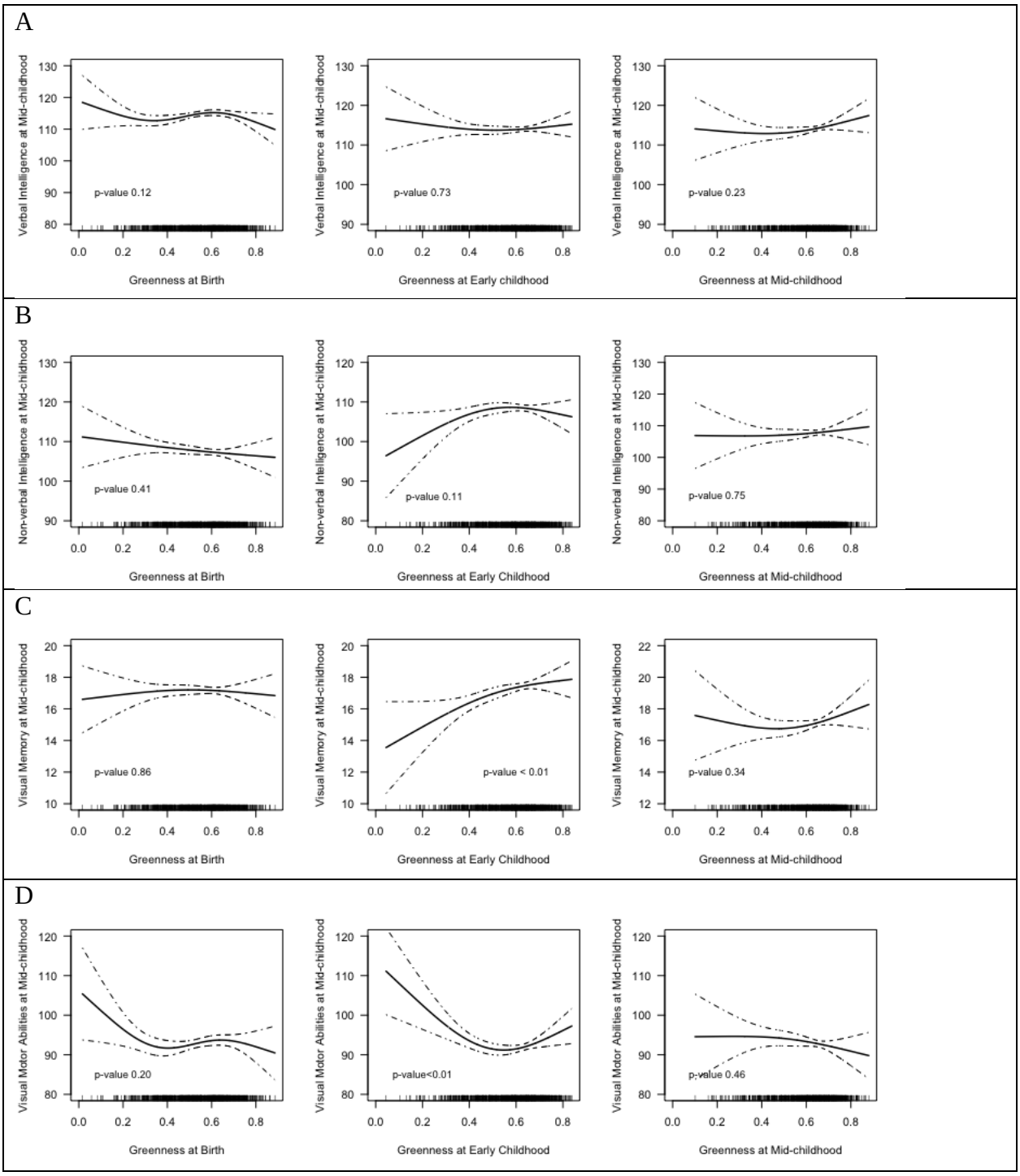
Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], neighborhood median annual household income at birth, and greenness exposure in all preceding age-periods, but not in subsequent age-periods.

Web Figure 4. Nonlinear Relationship between Greenness at 90 m and Cognitive Assessments at Mid-childhood (A): Verbal IQ, (B) Non-verbal IQ, (C) Visual Memory, and (D) Visual-Motor Abilities; further adjusting for early childhood cognitive assessments.



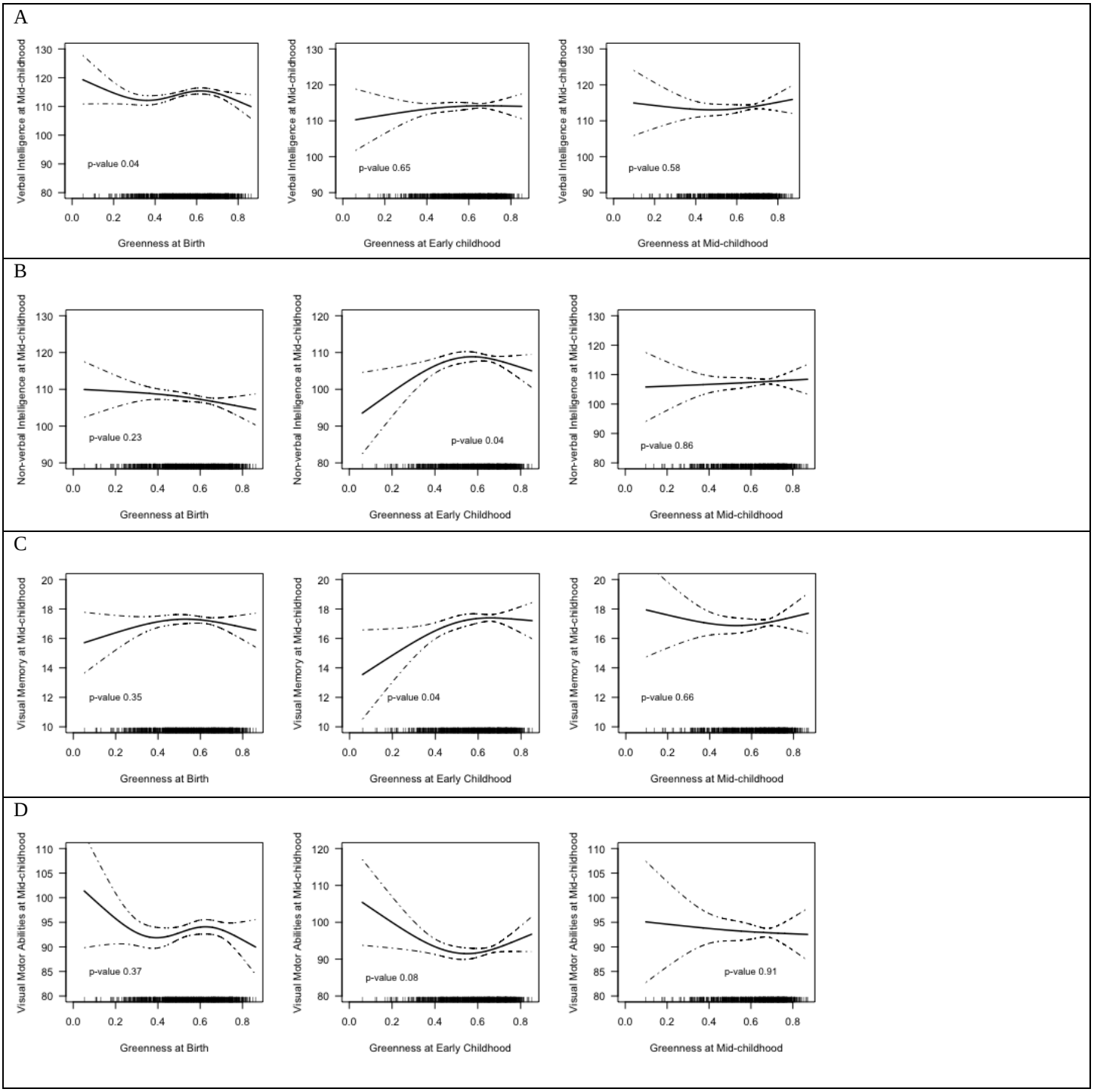
Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], father's education (high school degree, some college, or ≥college graduate), household [annual income at enrollment in early pregnancy (<40,000, 40,000-70,000, > $70,000), neighborhood median annual income at birth, and early childhood cognitive assessment. Later exposure timepoints additionally adjusted for early exposure timepoints. For example, NDVI in mid-childhood adjusted for NDVI at birth, and early childhood.
P-values correspond to spline terms for greenness exposure at each time point.

Web Figure 5. Sensitivity analysis without outliers. Nonlinear Relationship between Greenness at 90m and Cognitive Assessments at Mid-childhood: (A) Verbal IQ, (B) Non-verbal IQ, (C) Visual Memory, and (D) Visual-Motor Abilities.



Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], father's education (high school degree, some college, or ≥college graduate), household [annual income at enrollment in early pregnancy (<40,000, 40,000-70,000, > $70,000), and neighborhood median annual income at birth.
Later exposure timepoints additionally adjusted for early exposure timepoints. For example, NDVI in mid-childhood adjusted for NDVI at birth, and early childhood.
P-values correspond to spline terms for greenness exposure at each time point.

Web Figure 6. Nonlinear Relationship between Greenness at 270 m and Cognitive Assessments at Mid-childhood: (A) Verbal IQ, (B) Non-verbal IQ, (C) Visual Memory, and (D) Visual-Motor Abilities.



Note: Analyses were adjusted for sex, age at cognitive testing, maternal characteristics [IQ, education (high school degree, some college, or ≥college graduate), race (white, non-white)], father's education (high school degree, some college, or ≥college graduate), household [annual income at enrollment in early pregnancy (<40,000, 40,000-70,000, > $70,000), and neighborhood median annual income at birth.

Later exposure timepoints additionally adjusted for early exposure timepoints. For example, NDVI in mid-childhood adjusted for NDVI at birth, and early childhood.

P-values correspond to spline terms for greenness exposure at each time point.

Web Table 4. Demographic characteristics and green space exposure of final analysis sample (N=857) and full cohort (N=2128) of Project Viva participants.

Variable	**Final analysis sample (N=857)**	**Full cohort (N=2128)**
Child's age at mid-childhood, years (mean ± SD)	7.85 ± 0.77	7.96 ± 0.85
Child's sex % female	51.34	48.5
Child's race % White	71.3	63.06
Mother's education % >=college graduate	74.68	64.64
Father's education % >=college graduate	68.73	64.55
Household income at enrollment in early pregnancy % >US$70,000 per year	66.63	61.15
Census tract median household income at birth (US$) (mean ± SD)	59,355 ± 21,004	57,010 ± 21,368
NDVI at birth (mean ± SD)	0.54 ± 0.15	0.52 ± 0.15
NDVI at early childhood (mean ± SD)	0.57 ± 0.14	0.56 ± 0.14
NDVI at mid-childhood (mean ± SD)	0.60 ± 0.13	0.59 ± 0.14
Verbal IQ at mid-childhood (mean ± SD)	113.87 ± 13.92	111.83 ± 15.11
Non-verbal IQ at mid-childhood (mean ± SD)	107.46 ± 16.55	106.31 ± 16.96
Motor Abilities at mid-childhood (mean ± SD)	93.07 ± 16.92	91.99 ± 16.73
Visual Memory at mid-childhood (mean ± SD)	17.1 ± 4.4	16.9 ± 4.4

Web Table 5. Distribution [mean (standard deviation)] of cognitive measures by effect modifiers among 857 Project Viva participants.

Effect Modifier	Verbal IQ	Non-verbal IQ	Motor Abilities	Visual Memory
Sex				
Males (N=417)	112.53 (14.75)	105.9 (16.88)	91.15 (17.49)	16.9 (4.62)
Females (N=440)	115.14 (12.97)	108.94 (16.11)	94.89 (16.17)	17.29 (4.18)
Parental education				
Low parental education (N=333)	107.93 (14.34)	103.5 (15.99)	90.76 (17.08)	16.57 (4.35)
High parental education (N=524)	117.64 (12.25)	109.98 (16.42)	94.54 (16.67)	17.44 (4.4)
Neighborhood socio-economic status based on median household income at birth				
Low NSES (N=285)	110.08 (14.91)	105.66 (15.68)	92.52 (17.25)	16.6 (4.13)
Medium NSES (N=284)	114.11 (12.86)	106.79 (16.6)	92.55 (16.37)	17.24 (4.56)
High NSES (N=285)	117.37 (13.03)	109.98 (17.1)	94.23 (17.11)	17.44 (4.5)
Population density				
Low population density (N=284)	114.48 (11.99)	106.94 (16.2)	92.65 (16.69)	17.25 (4.31)
Medium population density (N=284)	115.48 (13.54)	108.16 (17.26)	93.46 (17.48)	17.24 (4.64)
High population density (N=284)	111.58 (15.83)	107.34 (16.28)	93.11 (16.61)	16.78 (4.28)