

Extreme Heat and Cognitive Decline

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Supplementary Appendix 1.

$$\begin{aligned} \text{Cognitive function}_{ij} = & \gamma_{00} + \gamma_{10} \text{Age}_{ij} + \gamma_{20} \text{Age}_{ij}^2 + \\ & \gamma_{01} \text{Heat}_i + \gamma_{02} \text{Group}_i + \gamma_{03} (\text{Heat}_i \times \text{Group}_i) + \beta_{yx} X_{ij} + \beta_{yz} Z_i + \\ & \gamma_{11} \text{Heat}_i \text{Age}_{ij} + \gamma_{12} \text{Group}_i \text{Age}_{ij} + \gamma_{13} (\text{Heat}_i \times \text{Group}_i) \text{Age}_{ij} + \\ & \beta_{yxt} X_{ij} \text{Age}_{ij} + \beta_{yzt} Z_i \text{Age}_{ij} + \zeta_{0i} + \zeta_{1i} \text{Age}_{ij} + \varepsilon_{ij} \end{aligned}$$

where subscripts j represents measurement occasion (survey wave) and i represents individual. Cognitive function $_{ij}$ is the value of cognitive scores for individual i at occasion j . γ_{00} is the average intercept, γ_{10} and γ_{20} are the average effects for the linear and quadratic terms of age. γ_{01} , γ_{02} , and γ_{03} represent the effects of extreme heat exposure, a subgroup (i.e., race/ethnicity, neighbourhood socioeconomic status), and their interactions on the intercept. γ_{11} , γ_{12} , and γ_{13} are the effects of extreme heat exposure, a subgroup, and their interactions with the linear term of age. X_{ij} is a vector of time-varying covariates (living arrangement and household wealth) for the individual i at observation j , while Z_i is a vector of time-constant covariates (sex, education, region of residence, urbanicity, and years of follow-up) for the individual i . β_{yx} and β_{yz} denote vectors of coefficients for the effects of covariates X_{ij} and Z_i on the intercept. β_{yxt} and β_{yzt} are vectors of coefficients for the effects of covariates X_{ij} and Z_i on the rate of change with age. ζ_{0i} and ζ_{1i} are a random intercept and linear slope of age. ε_{ij} is the occasion-specific error term.

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Supplementary Table 1. Differences in Extreme Heat Exposure Across Subgroups

	% High exposure	Group comparison
<i>Race/ethnicity</i>		
White	16.9	vs. Black ($p < .001$)
Black	32.5	vs. Hispanic ($p < .001$)
Hispanic	11.0	vs. White ($p = .01$)
<i>Neighborhood SES</i>		
Average	18.9	vs. Disadvantaged ($p = .36$)
Disadvantaged	22.1	vs. Affluent ($p = 0.01$)
Affluent	11.7	vs. Average ($p = 0.005$)

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Supplementary Table 2. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories, U.S. Health and Retirement Study, 2006-2018

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
<i>Fixed effects</i>												
Age (centred at age 65)	-0.12	<0.001			-0.12	<0.001			-0.12	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	-0.03	0.83	0.002	0.85	-0.04	0.77	0.01	0.23	-0.06	0.70	0.01	0.29
Heat × Non-Hispanic Black^a					-0.04	0.91	-0.08	<0.001				
Heat × Hispanic ^a					0.15	0.78	0.003	0.93				
Heat × Disadvantaged neighbourhood^b									0.14	0.66	-0.07	0.002
Heat × Affluent neighbourhood ^c									0.04	0.91	-0.00	0.98
Female	0.99	<0.001	-0.02	0.01	0.99	<0.001	-0.02	0.01	0.99	<0.001	-0.02	0.006
Race/ethnicity (ref: White)												
Black	-2.41	<0.001	-0.02	0.03	-2.41	<0.001	0.00	0.99	-2.41	<0.001	-0.02	0.03
Hispanic	-1.99	<0.001	-0.002	0.85	-2.01	<0.001	-0.002	0.87	-1.99	<0.001	-0.01	0.64
Neighbourhood SES (ref: average)												
Disadvantaged neighbourhood	-0.61	<0.001	0.01	0.29	-0.60	<0.001	0.01	0.32	-0.64	<0.001	0.03	0.02
Affluent neighbourhood	0.65	<0.001	-0.01	0.12	0.65	<0.001	-0.01	0.13	0.65	<0.001	-0.01	0.17
Living alone, not married/partnered	-0.01	0.86	0.01	0.03	-0.01	0.88	0.01	0.02	-0.01	0.87	0.01	0.03
≥ Some college education	2.05	<0.001	-0.01	0.08	2.05	<0.001	-0.01	0.07	2.05	<0.001	-0.01	0.07
Household wealth	0.02	<0.001	0.002	<0.001	0.02	<0.001	0.002	<0.001	0.02	<0.001	0.002	<0.001
Region of residence (ref: Northeast)												
Midwest	-0.04	0.79	0.002	0.86	-0.04	0.79	0.001	0.89	-0.04	0.79	0.001	0.88
South	-0.20	0.17	0.002	0.79	-0.19	0.17	0.001	0.89	-0.19	0.18	0.001	0.88
West	-0.13	0.41	-0.004	0.69	-0.12	0.42	-0.004	0.74	-0.12	0.42	-0.01	0.65
Urbanicity	0.20	0.05	0.01	0.30	0.20	0.06	0.007	0.35	0.20	0.06	0.01	0.33

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Length of follow-up (ref: 2 years)

4 years	0.19	0.41	-0.01	0.78	0.19	0.42	-0.004	0.81	0.19	0.42	-0.004	0.80
6 years	0.02	0.94	-0.004	0.82	0.01	0.95	-0.004	0.82	0.02	0.95	-0.003	0.87
8 years	0.59	0.01	-0.03	0.07	0.59	0.006	-0.03	0.07	0.58	0.01	-0.03	0.08
10 years	0.45	0.03	-0.01	0.42	0.45	0.03	-0.01	0.43	0.45	0.03	-0.01	0.44
12 years	1.10	<0.001	0.05	<0.001	1.10	<0.001	0.05	<0.001	1.10	<0.001	0.05	<0.001
<i>Random effects</i>	Variance		95% CI		Variance		95% CI		Variance		95% CI	
Intercept	6.62		6.23, 7.04		6.62		6.22, 7.03		6.62		6.23, 7.04	
Linear slope	0.01		0.007, 0.011		0.01		0.007, 0.010		0.01		0.007, 0.010	
Residual	6.49		6.32, 6.66		6.49		6.32, 6.66		6.49		6.33, 6.66	

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood.

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Supplementary Table 3. Interaction Models with Both Race and Neighbourhood Interactions

	Intercept		Rate of change	
	b	p value	b	p value
Age (centred at age 65)	-0.12	<0.001		
Age squared	-0.01	<0.001		
Heat	-0.06	0.71	0.02	0.15
Heat × Non-Hispanic Black^a	-0.08	0.81	-0.06	0.007
Heat × Hispanic ^a	0.07	0.90	0.02	0.53
Heat × Disadvantaged neighbourhood^b	0.16	0.65	-0.05	0.03
Heat × Affluent neighbourhood ^b	0.03	0.93	-0.002	0.93
Female	0.99	<0.001	-0.02	0.01
Race/ethnicity (ref: White)				
Black	-2.40	<0.001	-0.05	0.69
Hispanic	-2.00	<0.001	-0.01	0.59
Neighbourhood SES (ref: average)				
Disadvantaged neighbourhood	-0.64	<0.001	0.02	0.06
Affluent neighbourhood	0.65	<0.001	-0.01	0.17
Living alone, not married/partnered	-0.01	0.88	0.01	0.02
≥ Some college education	2.05	<0.001	-0.01	0.06
Household wealth	0.02	<0.001	0.002	<0.001
Region of residence (ref: Northeast)				
Midwest	-0.04	0.79	0.001	0.91
South	-0.19	0.18	0.001	0.92
West	-0.12	0.43	-0.004	0.72
Urbanicity	0.20	0.06	0.01	0.37
Length of follow-up (ref: 2 years)				
4 years	0.19	0.42	-0.004	0.81
6 years	0.01	0.96	-0.003	0.86
8 years	0.58	0.006	-0.03	0.08
10 years	0.45	0.03	-0.01	0.44
12 years	1.10	<0.001	0.05	<0.001

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood.

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Supplementary Table 4. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function Trajectories, U.S. Health and Retirement Study, 2006-2018, Continuous Measure of Extreme Heat Exposure

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.13	<0.001			-0.13	<0.001			-0.13	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.03	0.25	-0.002	0.20	0.02	0.51	-0.001	0.69	0.02	0.53	-0.001	0.51
Heat × Non-Hispanic Black^a					-0.02	0.71	-0.01	0.001				
Heat × Hispanic ^a					0.12	0.11	-0.001	0.85				
Heat × Disadvantaged neighbourhood^b									0.08	0.12	-0.01	0.02
Heat × Affluent neighbourhood ^c									-0.01	0.80	0.003	0.34

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.

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Supplementary Table 5. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive FunctionTrajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, 99th Threshold for Extreme Heat

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.12	<0.001			-0.12	<0.001			-0.12	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.02	0.84	-0.002	0.81	0.02	0.88	0.01	0.40	0.02	0.88	0.01	0.27
Heat × Non-Hispanic Black^a					-0.17	0.59	-0.09	<0.001				
Heat × Hispanic ^a					0.28	0.63	0.003	0.93				
Heat × Disadvantaged neighbourhood^b									0.01	0.98	-0.08	<0.001
Heat × Affluent neighbourhood ^c									-0.01	0.97	0.01	0.81

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.

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Supplementary Table 6. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, Completers

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.08	<0.001			-0.08	<0.001			-0.08	<0.001		
Age squared	-0.004	<0.001			-0.004	<0.001			-0.004	<0.001		
Heat	0.14	0.39	-0.01	0.57	0.20	0.29	0.004	0.74	0.22	0.22	0.002	0.85
Heat × Non-Hispanic Black^a					-0.31	0.43	-0.07	0.01				
Heat × Hispanic ^a					-0.24	0.70	-0.01	0.72				
Heat × Disadvantaged neighbourhood^b									-0.63	0.19	-0.07	0.03
Heat × Affluent neighbourhood ^c									-0.03	0.96	-0.01	0.87

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.

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Supplementary Table 7. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Stratified by Race/ethnicity, U.S. Health and Retirement Study, 2006-2018

	Stratified Model 1: Whites				Stratified Model 2: Black				Stratified Model 3: Hispanic			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
Fixed Effects	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Age (centred at age 65)	-0.12	<0.001			-0.14	0.001			-0.21	<0.001		
Age squared	-0.01	<0.001			-0.004	<0.001			-0.01	<0.001		
Heat	-0.09	0.55	0.01	0.19	0.19	0.54	-0.06	0.004	-0.13	0.81	-0.004	0.90
Female	1.14	<0.001	-0.02	<0.001	0.74	0.002	0.01	0.66	-0.57	0.01	0.01	0.53
Neighbourhood SES (ref: average)												
Disadvantaged neighbourhood	-0.19	0.39	0.01	0.36	-0.37	0.12	-0.01	0.68	-1.62	<0.001	0.01	0.66
Affluent neighbourhood	0.68	<0.001	-0.01	0.21	0.79	0.12	-0.02	0.45	1.15	0.003	-0.03	0.42
Living alone, not married/partnered	-0.05	0.62	0.02	0.03	0.19	0.28	-0.001	0.93	-0.002	0.99	0.02	0.31
≥ Some college education	1.90	<0.001	-0.01	0.13	3.21	<0.001	-0.03	0.13	2.13	<0.001	0.02	0.38
Household wealth	0.02	<0.001	0.002	<0.001	0.02	0.08	0.001	0.16	0.03	0.006	0.001	0.19
Region of residence (ref: Northeast)												
Midwest	-0.13	0.38	0.01	0.52	0.27	0.50	-0.05	0.046	1.98	0.006	-0.11	0.01
South	-0.20	0.21	0.003	0.79	-0.57	0.13	-0.01	0.67	1.22	0.01	-0.01	0.69
West	-0.22	0.18	0.002	0.86	-0.11	0.80	-0.03	0.45	1.12	0.01	-0.04	0.26
Urbanicity	0.16	0.17	0.003	0.74	0.29	0.42	0.06	0.004	0.60	0.24	0.02	0.50
Length of follow-up (ref: 2 years)												
4 years	0.33	0.21	-0.01	0.64	-0.07	0.90	-0.03	0.43	-0.87	0.26	0.10	0.11
6 years	-0.03	0.93	-0.001	0.97	0.26	0.66	-0.07	0.12	-0.38	0.56	0.08	0.09
8 years	0.54	0.02	-0.03	0.08	1.07	0.10	-0.04	0.39	-0.01	0.99	0.04	0.45
10 years	0.43	0.06	-0.02	0.26	1.19	0.048	0.01	0.84	-0.27	0.66	0.03	0.42
12 years	1.15	<0.001	0.04	0.001	1.23	0.008	0.04	0.26	0.26	0.63	0.13	<0.001

Supplementary Table 8. Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, Persistent Extreme Heat Exposure

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.13	<0.001			-0.13	<0.001			-0.13	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.02	0.43	-0.01	0.007	0.02	0.48	-0.004	0.08	0.02	0.55	-0.01	0.04
Heat × Non-Hispanic Black^a					-0.01	0.94	-0.02	<0.001				
Heat × Hispanic ^a					-0.02	0.86	0.01	0.37				
Heat × Disadvantaged neighbourhood^b									-0.03	0.75	-0.01	0.27
Heat × Affluent neighbourhood ^c									0.04	0.56	0.001	0.77

Note. ^a Reference group = non-Hispanic White; ^b Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up. Persistent exposure to extreme heat was measured with a score representing the proportion of each HRS participant's follow-up period spent in census tracts with high heat exposure. This score, ranging from 0 to 10, a score of 1 signifies that 10% of the follow-up period was spent in such conditions, while a score of 10 indicates a consistent, or 100%, exposure to extreme heat throughout the follow-up period.