

# Supporting Information

## Green Spaces and Cognitive Development in Primary Schoolchildren

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## Appendix I: Sensitivity Analyses

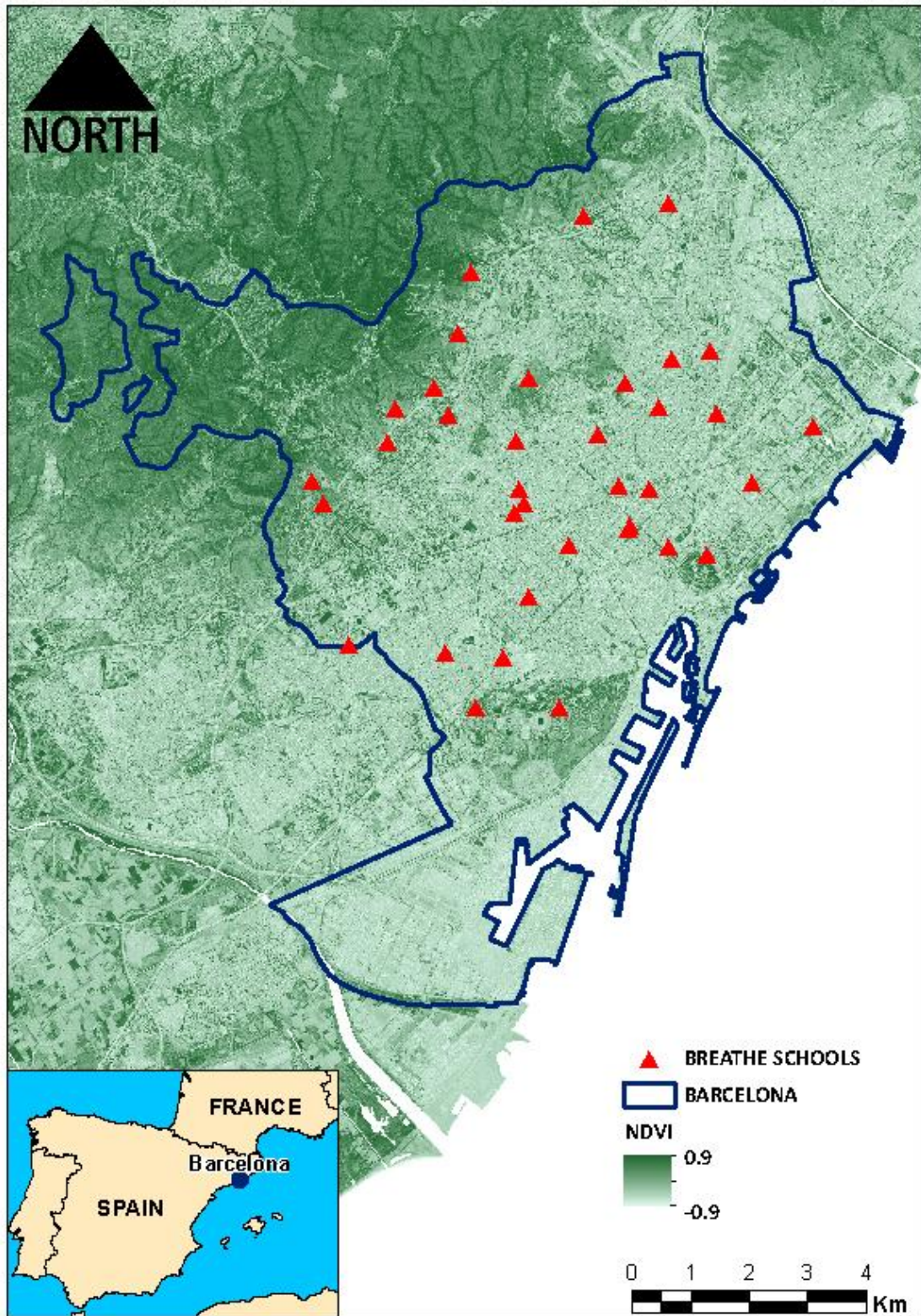
- 1- To explore the robustness of our findings to the weights used to abstract total surrounding greenness index, we developed a new measure of total surrounding greenness index by simply averaging the residential, commuting, and school greenness (i.e. equal weights). We repeated the analyses using this alternative measure which did not result in a notable change in our findings.
- 2- Further adjustment of analyses for (one at a time) ethnicity, maternal smoking during pregnancy, preterm birth, low birth weight, breastfeeding, exposure to environmental tobacco smoke, parental employment status, parental marital status, school type (public vs. private), school neighborhood socioeconomic status, and use of computer games did not result in a notable change in interpretation of our findings. However, the estimates for 12-month progress in superior working memory associated with commuting greenness became statistically significant after adjustment of analysis for ethnicity (regression coefficient (95% CI) for greenness exposure: 3.1 (0.02, 6.2)), low birth weight (3.2 (0.1, 6.3)), and paternal employment status 3.3 (0.22, 6.5)). On the other hand, the estimates for 12-month change in inattentiveness associated with greenness surrounding the schools became marginally statistically significant after further adjustment of analyses for ethnicity (-3.6 (-7.2, 0.0)) and marital status (-3.4 (-7.0, 0.2)). Also further adjustment of the association between school surrounding greenness and inattention for the school neighborhood socioeconomic status made the association slightly weaker and marginally significant (-3.5 (-7.1, 0.1), p-value=0.056).
- 3- For assessing commuting greenness, we used the shortest route between the home and school depending on the reported mode of transport which might not necessarily be the route chosen by participants. We carried out a sensitivity analysis using NDVI average over a rectangle covering possible routes between home and school to assess commuting greenness for each participant. We repeated the main analyses for this alternative measure of commuting greenness which did not show any notable difference with findings of main analyses.

- 4- In the main analyses, we used a 250 m buffer to assess residential surrounding greenness. This was chosen to represent the likely distance children might walk from home. Recent studies suggest for children 10-12 years old, the average activity space ranges from 250-1600 m, depending on several factors, with age and self mobility being important (1). Because our children are younger we chose the smallest neighborhood size for our main analysis. To explore the sensitivity of our findings against this selection of buffer size, we used buffers of 100 m, 500 m, and 1000 m to abstract residential surrounding greenness. Repeating the analyses for this alternative set of exposures did not result in a notable change in our findings for residential surrounding greenness.
  
- 5- To evaluate a potential momentary impact of having a view towards green spaces as well as other conditions at the time of cognitive tests on our findings, we further adjusted (one at a time) our analyses for having a view towards green spaces during the tests (yes/no), the timing of test (morning (8-11)/midday (11-13)/afternoon (13-15)), weather condition during the test (sunny/non-sunny), thermal comfort at the test room (comfortable/non-comfortable), and perceived noise level at the time of test (noisy/non-noisy). These adjustments did not result in a notable change in our findings with the exception of the association between school surrounding greenness and inattentiveness that after further adjustment for the timing of the test became slightly weaker with borderline statistical significance (regression coefficient (95% CI) of -3.3 (-6.9, 0.3), p-value=0.07).

## References

1. Villanueva K, *et al.* (2012) How far do children travel from their homes? Exploring children's activity spaces in their neighborhood. *Health place* 18(2):263-273.

**Figure S1:** Schools participating in BREATHE study and Normalized Difference Vegetation Index (NDVI) over Barcelona, July 23<sup>rd</sup>, 2012. Source: RapidEye (5 m × 5 m resolution).



**Table S1.** Characteristics of the study participants.

<b>Variable</b>	<b>N</b>	<b>%</b>
<b>Ethnicity</b>		
Spanish	1760	84.4
Non-Spanish	325	15.6
<b>Maternal employment status</b>		
Self-employed	377	18.1
Employee	1453	69.7
Unemployed	255	12.2
<b>Paternal employment status</b>		
Self-employed	686	32.9
Employee	1274	61.1
Unemployed	125	6
<b>Single parent</b>		
No	1830	87.8
Yes	255	12.2
<b>Maternal smoking during pregnancy</b>		
No	1879	90.1
Yes	206	9.88
<b>Preterm birth</b>		
No	1929	92.5
Yes	156	7.48
<b>Low birth weight</b>		
No	1892	90.7
Yes	193	9.26
<b>Breastfeeding (<math>\geq 6</math> months)</b>		
Yes	1496	71.8
No	589	28.2
<b>Exposure to environmental tobacco smoke</b>		
No	1812	86.9
Yes	273	13.1

**Table S2.** Description (median (IQR)) of the outcomes and greenness exposure (NDVI average) by maternal educational level.

	Non-University (n=1034)	University (n=1419)	p-value <sup>a</sup>
<b>Working memory (WM)</b>			
(2-back Numbers, d <sup>2</sup> )			
At baseline (1 <sup>st</sup> visit)	196 (199)	221 (239)	<0.01
Change (4 <sup>th</sup> - 1 <sup>st</sup> visit)	19 (224)	0 (219)	0.84
<b>Superior WM</b>			
(3-back Numbers, d <sup>2</sup> )			
At baseline (1 <sup>st</sup> visit)	109 (127)	128 (126)	<0.01
Change (4 <sup>th</sup> - 1 <sup>st</sup> visit)	19 (172)	17 (177)	0.78
<b>Inattentiveness</b>			
(HRT-SE, ms)			
At baseline (1 <sup>st</sup> visit)	279 (136)	260 (131)	<0.01
Change (4 <sup>th</sup> - 1 <sup>st</sup> visit)	-31 (113)	-45 (109)	0.01
<b>NDVI average</b>			
Home <sup>b</sup>	0.090 (0.046)	0.091 (0.057)	0.12
<b>School</b>			
Within	0.076 (0.086)	0.11 (0.089)	<0.01
Surrounding <sup>c</sup>	0.096 (0.088)	0.10 (0.15)	<0.01
Commuting	0.091 (0.057)	0.11 (0.069)	<0.01
Total surrounding greenness index	0.087 (0.061)	0.101 (0.080)	<0.01

<sup>a</sup> p-value for Mann–Whitney U test.

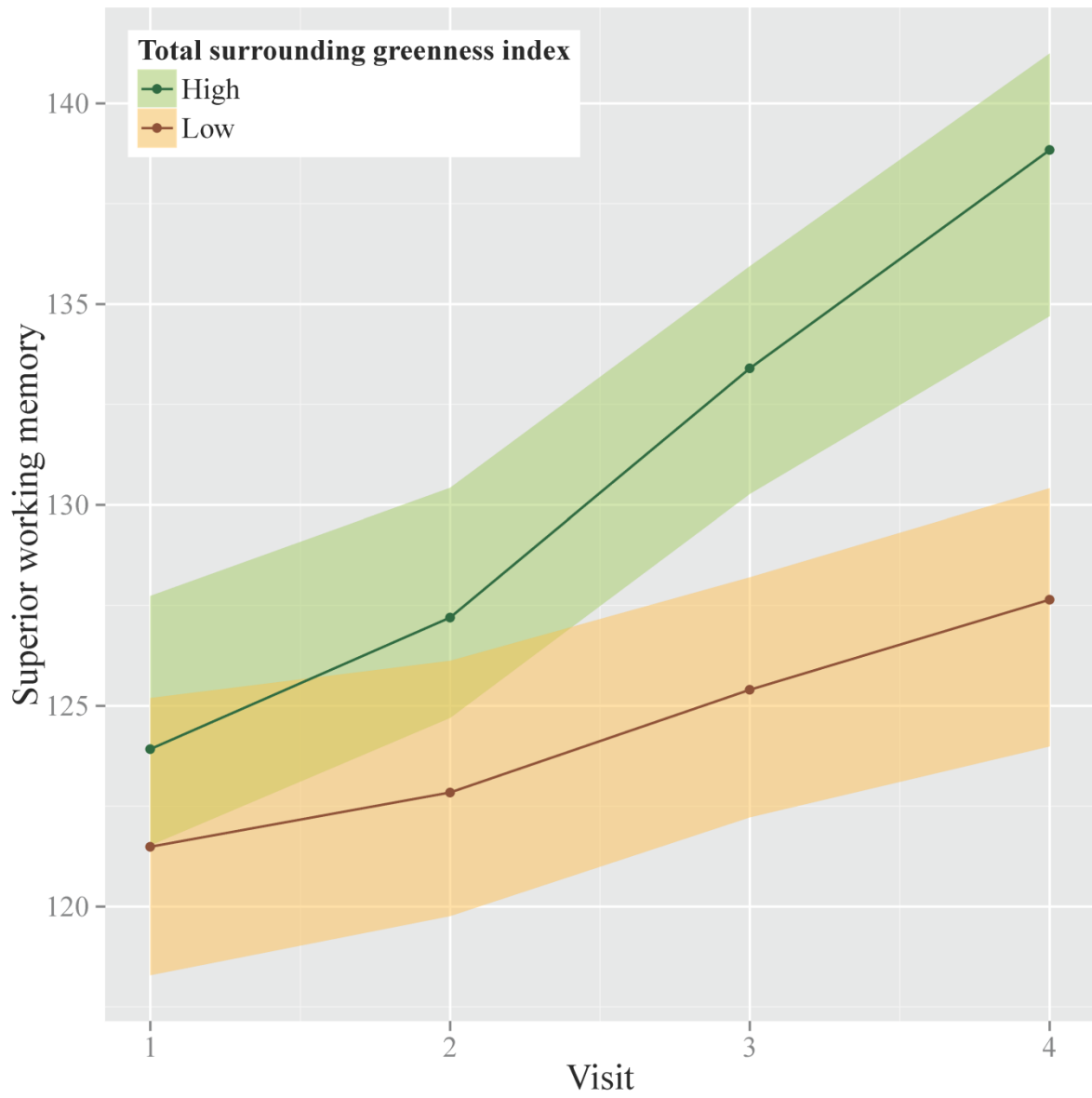
<sup>b</sup>250m buffer around home.

<sup>c</sup>50m buffer around school boundaries.

**Table S3.** Median (IQR) and Spearman’s correlation coefficient between estimates of greenness.

	Median (IQR)	Home	Within School	Surrounding School	Commuting
Home	0.091 (0.053)	1			
Within School	0.094 (0.085)	0.46	1		
Surrounding School	0.100 (0.120)	0.48	0.75	1	
Commuting	0.100 (0.062)	0.69	0.73	0.80	1

**Figure S2:** 12-month progress (with 95% confidence bands) in cognitive development for participants with the first (low greenness) and third (high greenness) tertiles of total surrounding greenness index.





**Table S4:** Difference (95% confidence interval)<sup>a</sup> in cognitive development using word stimuli, at baseline and 12-month progress, per one interquartile range (IQR) change in greenness in 2,593 children and 9,357 tests from 36 schools, Barcelona.

Surrounding Greenness	Median(IQR)	Working memory (2-back Words, d')		Superior Working memory (3-back Words, d')	
		Baseline	Progress	Baseline	Progress
<b>Home<sup>b</sup></b>					
250m buffer	0.091 (0.053)	-1.5 (-5.5, 2.5)	3.0 (-0.32, 6.3)	2.8 (-0.3, 5.8)	0.3 (-2.3, 2.9)
<b>School</b>					
Within	0.094 (0.085)	2.8 (-4.6, 10.0)	6.5 (2.0, 11.0)*	1.5 (-3.5, 6.4)	6.1 (2.6, 9.6)*
Surrounding <sup>b</sup>	0.100 (0.120)	3.8 (-4.2, 12.0)	5.2 (0.2, 10.0)*	1.3 (-4.1, 6.7)	5.2 (1.3, 9.2)*
<b>Commuting</b>	0.100 (0.062)	1.9 (-3.1, 6.9)	4.9 (1.0, 8.7)*	2.2 (-1.6, 6.0)	3.3 (0.3, 6.4)*
<b>Total surrounding greenness index</b>	0.094 (0.073)	1.9 (-5.2, 9.0)	8.5 (3.7, 13.0)*	2.9 (-2.3, 8.1)	6.5 (2.7, 10.0) *

\* p-value <0.05

<sup>a</sup> Difference adjusted for age, sex, maternal education, residential neighborhood socioeconomic status; school and subject as nested random effects.

<sup>b</sup>250m buffer around home.

<sup>c</sup>50m buffer around school boundaries.

**Table S5:** Difference (95% confidence interval)<sup>a</sup> in alerting, orienting, and executive processing derived from attentional network test (ANT), at baseline and 12-month progress, per one interquartile range (IQR) change in greenness in 2,593 children and 9,357 tests from 36 schools, Barcelona.

Surrounding Greenness	Median(IQR)	Executive processing		Orienting		Alerting	
		Baseline	Progress	Baseline	Progress	Baseline	Progress
<b>Home<sup>b</sup></b>	0.091 (0.053)	43 (-110, 190)	-96 (-230, 32)	34 (-140, 210)	-15 (-170, 140)	120 (-64, 300)	17 (-150, 180)
<b>School</b>							
Within	0.094 (0.085)	-180 (-420, 58)	24 (-150, 190)	-110 (-360, 150)	120 (-92, 330)	-160 (-420, 100)	130 (-82, 350)
Surrounding <sup>c</sup>	0.100 (0.120)	-180 (-430, 81)	-75 (-270, 120)	-230 (-510, 53)	190 (-47, 420)	-240 (-520, 34)	140 (-100, 380)
<b>Commuting</b>	0.100 (0.062)	-34 (-220, 150)	-100 (-250, 44)	-110 (-320, 91)	10 (-170, 190)	4 (-210, 220)	88 (-100, 280)
<b>Total surrounding greenness index</b>	0.094 (0.073)	-75 (-320, 170)	-41 (-220, 140)	-100 (-360, 160)	100 (-130, 330)	-37 (-310, 240)	64 (-170, 300)

\* p-value <0.05

<sup>a</sup> Difference adjusted for age, sex, maternal education, residential neighborhood socioeconomic status; school and subject as nested random effects.

<sup>b</sup>250m buffer around home.

<sup>c</sup>50m buffer around school boundaries.

**Table S6.** Difference (and 95% confidence interval) in 12-month cognitive development per one interquartile range change in greenness estimated by main analyses (adjusted for age, sex, maternal education, and neighborhood SES) and no-SES models (adjusted for age and sex).

Greenness	Working memory (2-back Numbers, d')		Superior Working memory (3-back Numbers, d')		Inattentiveness (HRT-SE, ms)	
	Main analyses	No-SES	Main analyses	No-SES	Main analyses	No-SES
<b>Home<sup>a</sup></b>						
250 m buffer	0.7 (-2.6, 4.1)	0.7 (-2.6, 4.1)	-0.1 (-2.7, 2.6)	0.0 (-2.6, 2.7)	-0.7 (-3.1, 1.7)	-0.7 (-3.1, 1.7)
<b>School</b>						
Within	9.8 (5.2, 14.0)*	11.0 (6.2, 15.0) *	6.9 (3.4, 10.0)*	7.8 (4.3, 11) *	-3.4 (-6.6, -0.2)*	-3.9 (-7.1, -0.7) *
Surrounding <sup>b</sup>	9.5 (4.5, 15.0)*	10.0 (5.2, 15.0) *	6.3 (2.3, 10.0)*	6.7 (2.7, 11) *	-3.7 (-7.3, -0.1)*	-3.9 (-7.6, -0.3) *
<b>Commuting</b>	4.9 (1.0, 8.8) *	5.2 (1.3, 9.2) *	3.1 (0.0, 6.1)	3.7 (0.6, 6.8) *	-1.2 (-4.0, 1.7)	-1.8 (-4.6, 1.1)
<b>Total surrounding greenness index</b>	9.8 (5.0, 15.0)*	11.0 (5.7, 16.0)*	6.7 (2.8, 11.0)*	7.5 (3.6, 11.0)*	-3.9 (-7.4, -0.4)*	-4.5 (-8.0, -1.0)*

\* p-value <0.05

<sup>a</sup>250m buffer around home.

<sup>b</sup>50m buffer around school boundaries.