*Learning in colour: Children with grapheme-colour synaesthesia show cognitive benefits in vocabulary and self-evaluated reading*

***Supplementary Information.***

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Red* | *Blue* | *Green* | *Yellow* | *Orange* | *Pink* | *Purple* | *Brown* | *Black* | *Grey* | *White* |
| *R* | *255* | *0* | *0* | *255* | *255* | *255* | *120* | *138* | *0* | *130* | *255* |
| *G* | *0* | *100* | *160* | *255* | *128* | *0* | *0* | *76* | *0* | *130* | *255* |
| *B* | *25* | *255* | *0* | *0* | *0* | *255* | *150* | *0* | *0* | *130* | *255* |

Figure 1.Figure shows the red, green, blue (RGB) coordinates for the colour patches used in our synaesthesia diagnostic consistency test. Values are taken from Berlin and Kay (1969) original RGB values for prototypical colours, with the exception of Grey and Brown which were marginally adjusted for print quality. In Berlin and Kay (1969) Grey was originally 115,115,115; and Brown was originally 110, 60, 0

**Sensitivity (power) analysis of prior results from** (Simner & Bain, 2018)

Here we consider the data collected by (Simner & Bain, 2018) to establish whether they had sufficient power to detect differences between synaesthetes and non-synaesthete controls in their receptive vocabulary task. Using the power analysis statistical program G\*Power (Faul, Erdfelder, Lang, & Buchner, 2007) we estimated sensitivity in terms of the size of effect required with the sample sizes (n=5). Simner & Bain (2018) used a Wilcoxon signed rank one sample test to assess any significant differences between a population mean (M = 100), and their sample mean. At .80 power (p<.05 significance, two tailed significance), a sample size of 5 would require an Effect size of 1.8, to get a significant effect (actual ES = 0.7).

**Models split by synaesthesia type**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | *Receptive Vocabulary* | |
|  |  | Estimate (*SE*) | *d* (95% CI) |
| Intercept |  | 10.77 (0.22) |  |
| Age~ |  | 0.06 (0.02)\*\* | 0.19 (0.08,0.29) |
| Gender: Boys (vs Girls) |  | 0.75 (0.09)\*\* | 0.43 (0.31,0.52) |
| Highest household qualification (vs degree) | None | -1.76 (0.29) \*\* | -1.01 (-1.35,-0.58) |
| Other | -0.17 (0.73) | -0.09 (-0.71,0.55) |
| Lower | -0.66 (0.29)\* | -0.38 (-0.71,-0.01) |
| Upper | -0.80 (0.14)\*\* | -0.46 (-0.65,-0.24) |
| Higher | -0.20 (0.11)# | -0.12 (-0.21,-0.02) |
| Number only (vs high performing) |  | 1.00 (0.56)\* | 0.58 (0.06,0.99) |
| Letter only (vs high performing) |  | 0.19 (0.45) | 0.11 (-0.42,0.57) |
| Number and Letter (vs high performing) |  | 0.78 (0.46) | 0.45 (-0.19,0.99) |
| Average performing (vs high performing) |  | -0.30 (0.21) | -0.17 (-0.40,0.02) |
| Random: PSU  Random: Child  N |  | 0.21 (0.08)  3.04 (0.12)\*\*  1531 |  |

**SI Table 1**: Mixed Linear effects models for Receptive Vocabulary at Sweep 8 (parentheses show standard error) comparing three synaesthesia sub-types to average performing controls. \*p<0.05 \*\*p<0.01 \*\*\* p<0.001, ~grand centred mean, nf not fitted. d Cohen’s d (size of effect only); Bootstrapped significance and CI values shown

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | *Sentence Comprehension* | |
|  |  | B (*SE*)\* | *OR (95% CI)* |
| Intercept |  | -0.41 (0.27)\*\*\* |  |
| Age~ |  | nf |  |
| Gender: Boys (vs Girls) |  | -0.39 (0.12)\*\* | 0.68 (0.53,0.86) |
| Highest household qualification (vs degree) | None | -0.71 (0.46) | 0.49 (0.20,1.21) |
| Other | 0.06 (0.90) | 1.06 (0.18,6.20) |
| Lower | -0.67 (0.46) | 0.51 (0.21,1.27) |
| Upper | -0.18 (0.18) | 0.84 (0.59,1.19) |
| Higher | -0.34 (0.14)\* | 0.71 (0.54,0.94) |
| Number only (vs high performing) |  | 0.66 (0.65) | 1.94 (0.54,6.97) |
| Letter only (vs high performing) |  | -0.74 (0.63) | 0.48 (0.14,1.65) |
| Number and Letter (vs high performing) |  | 0.16 (0.56) | 1.17 (0.39,3.51) |
| Average performing (vs high performing) |  | -0.30 (0.27) | 0.74 (0.44,1.25) |
| Random: PSU  Random: Child  N |  | 0.26 (0.09)\*\*  ---  1531 |  |

**SI Table 2**: Mixed Binary logistic effects for Sentence Comprehension at Sweep 8 (parentheses show standard error) comparing three synaesthesia sub-types to average performing controls. \*p<0.05 \*\*p<0.01 \*\*\* p<0.001, ~grand centred mean, nf not fitted. d Cohen’s d

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | *Expressive Vocabulary* | |
|  |  | Estimate (*SE*) | *d* (95% CI) |
| Intercept |  | 8.60 (0.26)\*\*\* |  |
| Age~ |  | 0.10 (0.02)\*\*\* | 0.25 (0.15,0.35) |
| Gender: Boys (vs Girls) |  | nf |  |
| Highest household qualification (vs degree) | None | -1.72 (0.35)\*\*\* | -0.84 (-1.17,-0.51) |
| Other | -1.27 (0.86) | -0.62 (-1.45,0.20) |
| Lower | -0.80 (0.35)\* | -0.39 (-0.72,-0.06) |
| Upper | -0.78 (0.16)\*\*\* | -0.38 (-0.54,-0.23) |
| Higher | -0.50 (0.12)\*\*\* | -0.24 (-0.36,-0.13) |
| Number only (vs high performing) |  | 1.80 (0.65)\*\* | 0.88 (0.25,1.50) |
| Letter only (vs high performing) |  | 0.42 (0.53) | 0.21 (-0.30,0.71) |
| Number and Letter (vs high performing) |  | 1.01 (0.54)# | 0.49 (-0.02,1.01) |
| Average performing (vs high performing) |  | -0.32 (0.25) | -0.16 (-0.40,0.08) |
| Random: PSU  Random: Child  N |  | 0.38 (0.10)\*\*\*  4.19 (0.16)\*\*\*  1531 |  |

**SI Table 3**: Mixed Linear effects models/Binary logistic effects for Expressive Vocabulary at Sweep 8 (parentheses show standard error) comparing three synaesthesia sub-types to average performing controls. \*p<0.05 \*\*p<0.01 \*\*\* p<0.001, ~grand centred mean, nf not fitted. d Cohen’s d

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | *Academic Self-Concept: Reading* | | *Academic Self-Concept: Number work* | |
|  |  | Estimate (*SE*) | *OR (95% CI)* | Estimate (*SE*) | *OR (95% CI)* |
| Intercept |  | -0.30 (0.25) |  | -0.62 (0.25)\* |  |
| Age~ |  | Nf |  | nf |  |
| Gender: Boys (vs Girls) |  | Nf |  | 0.75 (0.10)\*\*\* | 2.12 (1.73,2.60) |
| Highest household qualification (vs degree) | None | -0.96 (0.39)\* | 0.38 (0.18,0.82) | nf |  |
| Other | 0.09 (0.83) | 1.09 (0.21,5.61) | nf |  |
| Lower | -0.85 (0.38)\* | 0.43 (0.20,0.89) | nf |  |
| Upper | -0.75 (0.17)\*\*\* | 0.47 (0.34,0.66) | nf |  |
| Higher | -0.31 (0.12)\*\* | 0.73 (0.58,0.93) | nf |  |
| Number only (vs high performing) |  | 0.33 (0.63) | 1.38 (0.40,4.74) | -0.17 (0.64) | 0.84 (0.24,2.97) |
| Letter only (vs high performing) |  | 1.04 (0.53)\* | 2.83 (1.00,7.99) | -0.14 (0.52) | 0.87 (0.31,2.42) |
| Number and Letter (vs high performing) |  | 1.00 (0.54)# | 2.72 (0.94,7.84) | -0.07 (0.53) | 0.93 (0.33,2.64) |
| Average performing (vs high performing) |  | 0.06 (0.25) | 1.06 (0.65,1.73) | -0.02 (0.25) | 0.98 (0.61,1.59) |
| Random: PSU  n |  | nf  1531 | | nf  1531 | |

**SI Table 4**: Binary logistic effects for Academic self-concept in Reading and Number Work at Sweep 8 (parentheses show standard error) comparing three synaesthesia sub-types to average performing controls.\*p<0.05 \*\*p<0.01 \*\*\* p<0.001, ~grand centred mean, nf not fitted. d Cohen’s d AM Average performing

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | *Expressive Vocabulary* | |
|  |  | Coefficient (SE) | d (95% CI) |
| Intercept |  | 64.04 (1.21)\*\*\* |  |
| Age~ |  | nf |  |
| Gender: Boys (vs Girls) |  | -1.42 (0.49)\*\* | -0.15 (-0.26,-0.05) |
| Highest household qualification (vs degree) | None | -10.36 (1.53)\*\*\* | -1.11 (-1.43,-0.79) |
| Other | -2.30 (3.90) | -0.25 (-1.07,0.57) |
| Lower | -6.53 (1.56)\*\*\* | -0.70 (-1.03,-0.37) |
| Upper | -4.20 (0.73)\*\*\* | -0.45 (-0.60,-0.30) |
| Higher | -2.67 (0.57) | -0.29 (-0.41,-0.17) |
| Synaesthete (vs high performing) |  | 0.53 (1.76) | 0.06 (-0.31,0.43) |
| Average performing (vs high performing) |  | -1.50 (1.17) | -0.16 (-0.41,0.09) |
| Random: PSU  Random: Child  n |  | 3.77 (1.52)\*  87.25 (3.35)\*\*\*  1486 | |

**SI Table 5.** Mixed effects Linear regression model for Expressive vocabulary at Sweep 5 (parentheses show standard error). \*p<0.05 \*\*p<0.01 \*\*\* p<0.001, ~grand centred mean. Synaesthetes and average performing controls are compared to high performing controls. d Cohen’s d (size of effect only)

**References**

Berlin, B., & Kay, P. (1969). *Basic color terms : their universality and evolution*. University of California Press.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. http://doi.org/10.3758/BF03193146

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