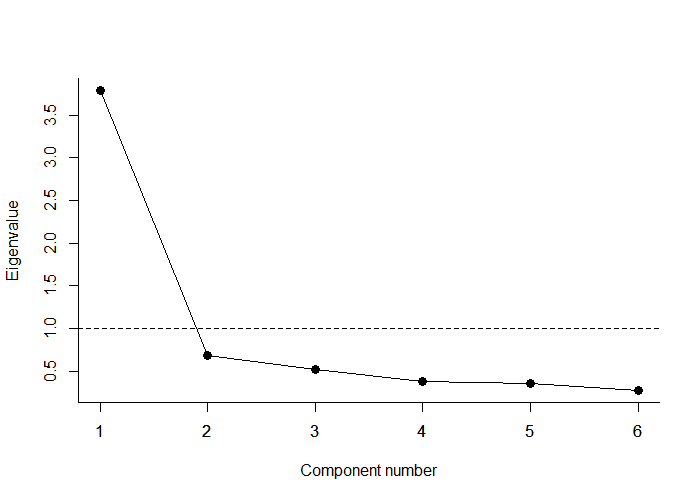
Twin Research and Human Genetics

The Association between Dyslexia and Developmental Speech and Language Disorder Candidate Genes and Reading and Language Abilities in Adults

Catherine Doust, Scott D. Gordon, Natalie Garden, Simon E. Fisher, Nicholas G. Martin, Timothy C. Bates & Michelle Luciano

Supplementary Material



1

2

3

4

5

6

0.5

1.0

1.5

2.0

2.5

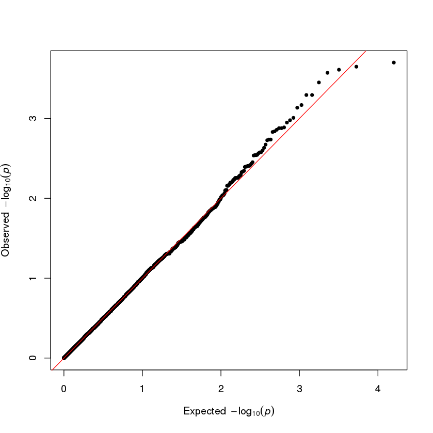
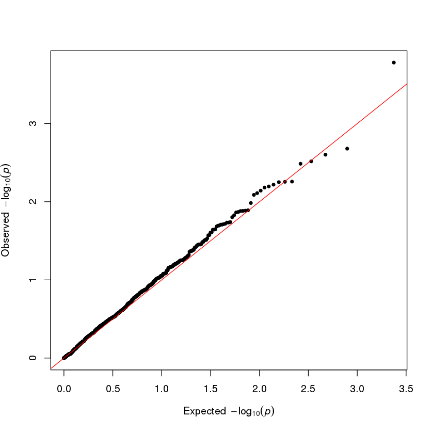
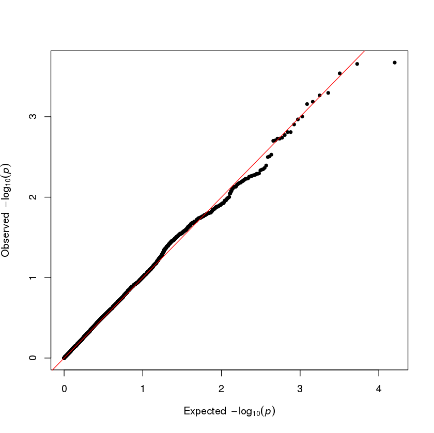
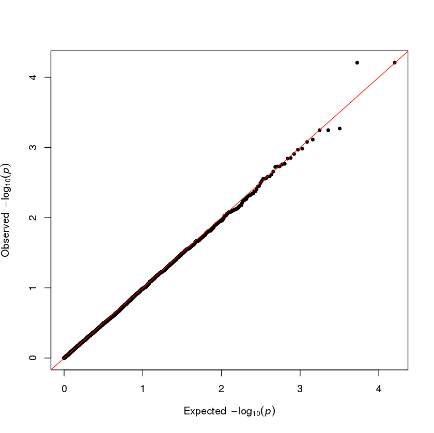
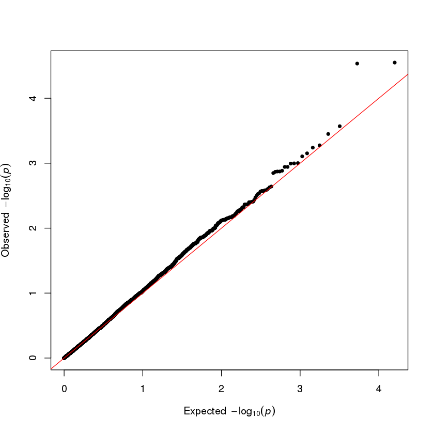
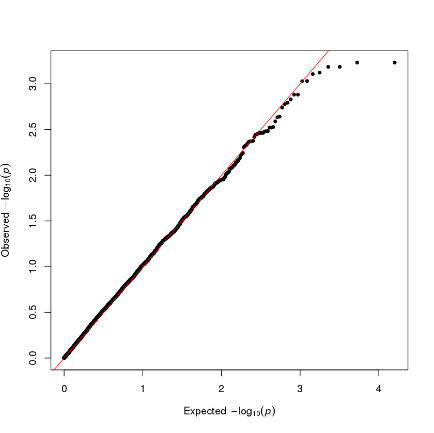
3.0

3.5

Component number

Eigenvalue

*Supplementary Figure S1.*Scree plot of eigenvalues from a principal component analysis of regular and irregular word reading and spelling, nonword reading and phonetic spelling. The first principal component explains 63.07% of the variance.



(a)

Observed -log10(*p*)

Expected -log10(*p*)

2

1.5

(b)

(c)

2.0

2.5

1.0

3.0

0.5

0.0

0

4

1

3

Expected -log10(*p*)

Expected -log10(*p*)

Expected -log10(*p*)

2

0

4

1

3

0

1

2

3

Observed -log10(*p*)

Expected -log10(*p*)

Expected -log10(*p*)

2

0

4

1

3

2

0

4

1

3

2

0

4

1

3

2.0

0.0

3.5

1.0

3.0

0.5

1.5

2.5

Observed -log10(*p*)

Observed -log10(*p*)

0

1

2

3

4

0

1

2

3

4

Observed -log10(*p*)

Observed -log10(*p*)

0

1

2

3

0

1

2

3

(d)

(e)

(f)

*Supplementary Figure S2.* Quantile-quantile (Q-Q) plot of observed versus expected *p* values for associations of SNPs within a dyslexia candidate gene set (*N* = 7,968) with (a) nonword reading, (b) phonetic spelling, (c) a reading and spelling principal component, (d) self-reported reading impairment and (e) nonword repetition; and an DLD candidate gene set (*N* = 10,126) with (f) nonword repetition. The red line is the distribution of *p* values under the null hypothesis.

Supplementary Table S1

*Multiple Regression Analyses to Predict the Effect of Age, Sex and Hearing Difficulties on Reading, Spelling, and Language Measures*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model | *t* | *p* | β | *SE* | *F* | *df* | *p* | Adjusted *R2* |
| Regular word reading |  |  |  |  | 3.63 | 1352 | .01 | .01 |
| Intercept | 48.65 | < .001 | 52.11 | 1.07 |  |  |  |  |
| Age | -0.38 | .71 | -0.01 | 0.04 |  |  |  |  |
| Age2 | 0.97 | .33 | 0.00 | 0.00 |  |  |  |  |
| Sex | -2.75 | .006 | -0.45 | 0.17 |  |  |  |  |
| Hearing difficulties | -1.04 | .30 | -0.38 | 0.36 |  |  |  |  |
| Irregular word reading | |  |  |  | 5.32 | 1352 | < .001 | .01 |
| Intercept | 24.67 | < .001 | 45.37 | 1.84 |  |  |  |  |
| Age | -0.16 | .87 | -0.01 | 0.07 |  |  |  |  |
| Age2 | 1.08 | .28 | 0.00 | 0.00 |  |  |  |  |
| Sex | -1.33 | .18 | -0.38 | 0.28 |  |  |  |  |
| Hearing difficulties | -2.18 | .029 | -1.36 | 0.62 |  |  |  |  |
| Nonword reading |  |  |  |  | 3.64 | 1352 | .01 | .01 |
| Intercept | 14.90 | < .001 | 43.18 | 2.90 |  |  |  |  |
| Age | 0.54 | .59 | 0.06 | 0.10 |  |  |  |  |
| Age2 | -0.28 | .78 | -0.00 | 0.00 |  |  |  |  |
| Sex | -1.47 | .14 | -0.66 | 0.45 |  |  |  |  |
| Hearing difficulties | -3.30 | < .001 | -3.23 | 0.98 |  |  |  |  |
| Nonword repetition |  |  |  |  | 39.45 | 1351 | < .001 | .10 |
| Intercept | 14.73 | < .001 | 31.66 | 2.15 |  |  |  |  |
| Age | 0.91 | .36 | 0.07 | 0.08 |  |  |  |  |
| Age2 | -2.04 | .042 | -0.00 | 0.00 |  |  |  |  |
| Sex | -2.90 | .004 | -0.96 | 0.33 |  |  |  |  |
| Hearing difficulties | -10.13 | < .001 | -7.36 | 0.73 |  |  |  |  |
| Regular word spelling |  |  |  |  | 12.84 | 1350 | < .001 | .03 |
| Intercept | 18.15 | < .001 | 0.82 | 0.05 |  |  |  |  |
| Age | 0.60 | .55 | 0.00 | 0.00 |  |  |  |  |
| Age2 | 0.70 | .48 | 0.00 | 0.00 |  |  |  |  |
| Sex | -4.23 | < .001 | -0.03 | 0.00 |  |  |  |  |
| Hearing difficulties | -2.28 | .023 | -0.04 | 0.02 |  |  |  |  |
| Irregular word spelling | |  |  |  | 8.55 | 1352 | < .001 | .02 |
| Intercept | 15.07 | < .001 | 11.68 | 0.78 |  |  |  |  |
| Age | 0.61 | .55 | 0.02 | 0.03 |  |  |  |  |
| Age2 | 0.07 | .94 | 0.00 | 0.00 |  |  |  |  |
| Sex | -5.14 | < .001 | -0.61 | 0.12 |  |  |  |  |
| Hearing difficulties | -0.94 | .35 | -0.25 | 0.26 |  |  |  |  |
| Phonetic spelling |  |  |  |  | 1.76 | 1351 | .14 | .00 |
| Intercept | 6.90 | < .001 | 0.60 | 0.09 |  |  |  |  |
| Age | 0.89 | .38 | 0.00 | 0.00 |  |  |  |  |
| Age2 | -0.48 | .63 | 0.00 | 0.00 |  |  |  |  |
| Sex | -1.05 | .29 | -0.01 | 0.01 |  |  |  |  |
| Hearing difficulties | -1.65 | .10 | -0.05 | 0.03 |  |  |  |  |

Supplementary Table S2

Associations of SNPs Previously Associated with Reading or Language Ability or Disability with Nonword Reading

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chr | Gene | SNP | Effect allele | Freq | *b* | *SE* | *p* | Significant in previous studies |
| 1 | *KIAA0319L* | rs7523017 | A | .07 | 0.12 | 0.08 | .12 | Couto et al. (2008) |
| 3 | *ROBO1* | rs12495133 | A | .37 | -0.05 | 0.04 | .21 | Tran et al. (2014) |
| 3 | *ROBO1* | rs331142 | A | .74 | -0.01 | 0.04 | .87 | Tran et al. (2014) |
| 3 | *ROBO1* | rs333491 | A | .55 | 0.07 | 0.04 | .085 | Mascheretti et al. (2014) |
| 3 | *ROBO1* | rs4535189 | A | .49 | 0.06 | 0.04 | .13 | Sun et al. (2017) |
| 6 | *DCDC2* | rs1091047 | C | .84 | 0.07 | 0.05 | .17 | Lind et al. (2010) |
| 6 | *DCDC2* | rs1419228 | A | .82 | 0.05 | 0.05 | .33 | Lind et al. (2010) |
| 6 | *DCDC2* | rs2274305 | C | .66 | 0.07 | 0.04 | .067 | Chen, Zhao, Zhang, and Zuo (2017); Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs4599626 | A | .24 | 0.00 | 0.05 | .97 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6922023 | A | .17 | -0.03 | 0.05 | .53 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6937665 | A | .82 | 0.02 | 0.05 | .69 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs7765678 | C | .07 | -0.09 | 0.07 | .21 | Lind et al. (2010); Müller et al. (2016) |
| 6 | *DCDC2* | rs793862 | A | .27 | -0.07 | 0.04 | .11 | Scerri et al. (2011); Schumacher et al. (2006) |
| **6** | ***DCDC2*** | **rs807701** | **A** | **.66** | **0.08** | **0.04** | **.045** | **Newbury et al. (2011); Scerri et al. (2011)** |
| 6 | *DCDC2* | rs807724 | C | .22 | -0.08 | 0.04 | .061 | Chen et al. (2017); Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs9467075 | A | .14 | -0.05 | 0.05 | .31 | Chen et al. (2017); Lind et al. (2010) |
| 6 | *DCDC2* | rs9467076 | C | .11 | -0.08 | 0.06 | .19 | Lind et al. (2010) |
| 6 | *KIAA0319* | rs2038137 | G | .63 | 0.01 | 0.04 | .78 | Carrion-Castillo et al. (2017); Cope et al. (2005); Harold et al. (2006); Müller et al. (2016) |
| 6 | *KIAA0319* | rs2179515 | C | .65 | 0.01 | 0.04 | .74 | Francks et al. (2004); Cope et al. (2005) |
| 6 | *KIAA0319* | rs4504469 | C | .59 | 0.03 | 0.04 | .44 | Francks et al. (2004); Cope et al. (2005); Harold et al. (2006); Shao et al. (2016); Venkatesh, Siddaiah, Padakannaya, and Ramachandra (2013) |
| 6 | *KIAA0319* | rs6935076 | C | .63 | 0.04 | 0.04 | .31 | Carrion-Castillo et al. (2017); Cope et al. (2005); Couto et al. (2010); Harold et al. (2006); Müller et al. (2016); Scerri et al. (2011) |
| 6 | *KIAA0319* | rs761100 | A | .43 | 0.00 | 0.04 | .95 | Carrion-Castillo et al. (2017); Harold et al. (2006); Newbury et al. (2011) |
| 6 | *KIAA0319* | rs9461045 | C | .82 | -0.05 | 0.05 | .34 | Scerri et al. (2011); Shao et al. (2016) |
| 7 | *CNTNAP2* | rs10246256 | C | .32 | 0.04 | 0.04 | .39 | Vernes et al. (2008) |
| **7** | ***CNTNAP2*** | **rs17236239** | **A** | **.65** | **0.12** | **0.04** | **.003** | **Carrion-Castillo et al. (2017); Vernes et al. (2008); Whitehouse, Bishop, Ang, Pennell, and Fisher (2011)** |
| **7** | ***CNTNAP2*** | **rs2538976** | **C** | **.50** | **-0.09** | **0.04** | **.024** | **Vernes et al. (2008)** |
| **7** | ***CNTNAP2*** | **rs2538991** | **A** | **.49** | **0.09** | **0.04** | **.025** | **Vernes et al. (2008)** |
| **7** | ***CNTNAP2*** | **rs2710102** | **A** | **.49** | **0.09** | **0.04** | **.022** | **Vernes et al. (2008); Whitehouse et al. (2011)** |
| 7 | *CNTNAP2* | rs2710117 | A | .64 | -0.03 | 0.04 | .42 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs4431523 | C | .32 | -0.08 | 0.04 | .065 | Vernes et al. (2008) |
| **7** | ***CNTNAP2*** | **rs759178** | **A** | **.49** | **0.09** | **0.04** | **.022** | **Vernes et al. (2008); Whitehouse et al. (2011)** |
| 7 | *CNTNAP2* | rs851715 | C | .32 | 0.03 | 0.04 | .46 | Vernes et al. (2008) |
| 7 | *FOXP2* | rs10230558 | A | .56 | 0.05 | 0.04 | .19 | Peter et al. (2011) |
| 7 | *FOXP2* | rs12533005 | C | .43 | 0.00 | 0.04 | .97 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs2253478** | **A** | **.41** | **0.08** | **0.04** | **.043** | **Tolosa et al. (2010)** |
| 7 | *FOXP2* | rs6980093 | A | .60 | 0.01 | 0.04 | .72 | Mozzi et al., 2017 |
| 7 | *FOXP2* | rs7782412 | C | .42 | 0.02 | 0.04 | .57 | Peter et al. (2011) |
| 7 | *FOXP2* | rs923875 | A | .60 | -0.02 | 0.04 | .56 | Peter et al. (2011) |
| 7 | *FOXP2* | rs936146 | C | .47 | 0.05 | 0.04 | .18 | Peter et al. (2011) |
| 15 | *CYP19A1* | rs2289105 | C | .53 | -0.01 | 0.04 | .87 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs17819126 | C | .93 | -0.13 | 0.07 | .073 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743204 | G | .79 | -0.02 | 0.05 | .73 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743205 | C | .94 | 0.04 | 0.08 | .65 | Taipale et al. (2003) |
| 15 | *DYX1C1* | rs57809907 | A | .09 | -0.10 | 0.07 | .16 | Brkanac et al. (2007); Dahdouh et al. (2009); Scerri et al. (2004); Taipale et al. (2003); Wigg et al. (2004) |
| **15** | ***DYX1C1*** | **rs600753** | **C** | **.50** | **0.09** | **0.04** | **.023** | **Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015)** |
| 15 | *DYX1C1* | rs7174102 | A | .35 | -0.03 | 0.04 | .39 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8037376 | C | .33 | 0.00 | 0.04 | 1.00 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8040756 | A | .15 | -0.07 | 0.06 | .19 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8043049 | C | .35 | 0.00 | 0.04 | .94 | Paracchini et al. (2011) |
| 16 | *ATP2C2* | rs16973771 | C | .40 | -0.04 | 0.04 | .36 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs2875891 | C | .65 | 0.04 | 0.04 | .32 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8045507 | A | .40 | -0.03 | 0.04 | .38 | Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8053211 | A | .54 | 0.02 | 0.04 | .70 | Müller et al. (2017) |
| 16 | *CMIP* | rs12927866 | C | .59 | 0.00 | 0.04 | .93 | Scerri et al. (2011) |
| 16 | *CMIP* | rs16955705 | A | .54 | 0.02 | 0.04 | .64 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs4265801 | G | .54 | 0.02 | 0.04 | .54 | Newbury et al. (2009) |
| 16 | *CMIP* | rs6564903 | C | .53 | 0.01 | 0.04 | .84 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs7201632 | C | .46 | -0.01 | 0.04 | .72 | Newbury et al. (2009) |
| 21 | *DIP2A* | rs11702704 | C | .27 | -0.02 | 0.04 | .70 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs17302525 | A | .94 | 0.00 | 0.08 | .96 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs1892692 | A | .40 | 0.02 | 0.04 | .54 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2070435 | A | .33 | 0.03 | 0.04 | .44 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2255526 | A | .72 | 0.03 | 0.04 | .47 | Kong et al. (2016) |
| 21 | *DIP2A* | rs2839282 | C | .92 | 0.01 | 0.07 | .88 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839299 | C | .69 | 0.04 | 0.04 | .30 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839308 | A | .77 | -0.02 | 0.05 | .66 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs762254 | A | .08 | 0.03 | 0.07 | .65 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs8132320 | A | .18 | 0.01 | 0.05 | .90 | Poelmans et al. (2009)a |
| 21 | *MCM3AP* | rs2839193 | A | .29 | -0.02 | 0.04 | .58 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839227 | A | .87 | 0.03 | 0.06 | .61 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839232 | A | .19 | -0.03 | 0.05 | .57 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839259 | C | .07 | 0.00 | 0.07 | .97 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs4819241 | C | .88 | 0.03 | 0.06 | .62 | Poelmans et al. (2009)a |
| 21 | *PRMT2* | rs9982863 | A | .55 | -0.04 | 0.04 | .29 | Poelmans et al. (2009)a |
| 21 | *S100B* | rs9722 | A | .10 | 0.02 | 0.06 | .77 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |

*Note.* Chr = chromosome, Freq = frequency, boldface indicates nominal significance.

aMicroarray analysis of a small deletion co-segregating with dyslexia in a family.

Supplementary Table S3

Associations of SNPs Previously Associated with Reading or Language Ability or Disability with Phonetic Spelling

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chr | Gene | SNP | Effect allele | Freq | *b* | *SE* | *p* | Significant in previous studies |
| 1 | *KIAA0319L* | rs7523017 | A | .07 | 0.13 | 0.08 | .091 | Couto et al. (2008) |
| 3 | *ROBO1* | rs12495133 | A | .37 | -0.02 | 0.04 | .67 | Tran et al. (2014) |
| 3 | *ROBO1* | rs331142 | A | .74 | 0.01 | 0.05 | .89 | Tran et al. (2014) |
| 3 | *ROBO1* | rs333491 | A | .55 | 0.02 | 0.04 | .64 | Mascheretti et al. (2014) |
| 3 | *ROBO1* | rs4535189 | A | .49 | -0.01 | 0.04 | .89 | Sun et al. (2017) |
| 6 | *DCDC2* | rs1091047 | C | .84 | -0.05 | 0.06 | .33 | Lind et al. (2010) |
| 6 | *DCDC2* | rs1419228 | A | .82 | 0.06 | 0.05 | .20 | Lind et al. (2010) |
| 6 | *DCDC2* | rs2274305 | C | .66 | -0.01 | 0.04 | .74 | Chen et al. (2017); Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs4599626 | A | .24 | 0.06 | 0.05 | .18 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6922023 | A | .17 | 0.03 | 0.05 | .58 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6937665 | A | .82 | -0.05 | 0.05 | .38 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs7765678 | C | .07 | 0.05 | 0.08 | .55 | Lind et al. (2010); Müller et al. (2016) |
| 6 | *DCDC2* | rs793862 | A | .27 | 0.03 | 0.04 | .53 | Scerri et al. (2011); Schumacher et al. (2006) |
| 6 | *DCDC2* | rs807701 | A | .66 | -0.02 | 0.04 | .64 | Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs807724 | C | .22 | -0.01 | 0.05 | .90 | Chen et al. (2017); Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs9467075 | A | .14 | -0.10 | 0.06 | .074 | Chen et al. (2017); Lind et al. (2010) |
| 6 | *DCDC2* | rs9467076 | C | .11 | -0.04 | 0.06 | .51 | Lind et al. (2010) |
| 6 | *KIAA0319* | rs2038137 | G | .63 | -0.07 | 0.04 | .081 | Carrion-Castillo et al. (2017); Cope et al. (2005); Harold et al. (2006); Müller et al. (2016) |
| **6** | ***KIAA0319*** | **rs2179515** | **C** | **.65** | **-0.08** | **0.04** | **.045** | **Francks et al. (2004); Cope et al. (2005)** |
| 6 | *KIAA0319* | rs4504469 | C | .59 | -0.05 | 0.04 | .17 | Francks et al. (2004); Cope et al. (2005); Harold et al. (2006); Shao et al. (2016); Venkatesh et al. (2013) |
| 6 | *KIAA0319* | rs6935076 | C | .63 | 0.03 | 0.04 | .41 | Carrion-Castillo et al. (2017); Cope et al. (2005); Couto et al. (2010); Harold et al. (2006); Müller et al. (2016); Scerri et al. (2011) |
| 6 | *KIAA0319* | rs761100 | A | .43 | 0.07 | 0.04 | .062 | Carrion-Castillo et al. (2017); Harold et al. (2006); Newbury et al. (2011) |
| 6 | *KIAA0319* | rs9461045 | C | .82 | 0.06 | 0.05 | .26 | Scerri et al. (2011); Shao et al. (2016) |
| 7 | *CNTNAP2* | rs10246256 | C | .32 | 0.01 | 0.04 | .85 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs17236239 | A | .65 | 0.05 | 0.04 | .23 | Carrion-Castillo et al. (2017); Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2538976 | C | .50 | -0.05 | 0.04 | .17 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2538991 | A | .49 | 0.05 | 0.04 | .22 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2710102 | A | .49 | 0.05 | 0.04 | .22 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2710117 | A | .64 | -0.04 | 0.04 | .32 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs4431523 | C | .32 | -0.08 | 0.04 | .058 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs759178 | A | .49 | 0.05 | 0.04 | .22 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs851715 | C | .32 | 0.01 | 0.04 | .74 | Vernes et al. (2008) |
| 7 | *FOXP2* | rs10230558 | A | .56 | 0.03 | 0.04 | .40 | Peter et al. (2011) |
| 7 | *FOXP2* | rs12533005 | C | .43 | -0.03 | 0.04 | .52 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs2253478** | **A** | **.41** | **0.10** | **0.04** | **.018** | **Tolosa et al. (2010)** |
| 7 | *FOXP2* | rs6980093 | A | .60 | -0.01 | 0.04 | .83 | Mozzi et al., 2017 |
| 7 | *FOXP2* | rs7782412 | C | .42 | 0.06 | 0.04 | .12 | Peter et al. (2011) |
| 7 | *FOXP2* | rs923875 | A | .60 | 0.03 | 0.04 | .42 | Peter et al. (2011) |
| 7 | *FOXP2* | rs936146 | C | .47 | -0.02 | 0.04 | .64 | Peter et al. (2011) |
| 15 | *CYP19A1* | rs2289105 | C | .53 | -0.03 | 0.04 | .45 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs17819126 | C | .93 | 0.05 | 0.08 | .54 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743204 | G | .79 | 0.00 | 0.05 | 1.00 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743205 | C | .94 | -0.16 | 0.09 | .063 | Taipale et al. (2003) |
| 15 | *DYX1C1* | rs57809907 | A | .09 | 0.09 | 0.07 | .18 | Brkanac et al. (2007); Dahdouh et al. (2009); Scerri et al. (2004); Taipale et al. (2003); Wigg et al. (2004) |
| 15 | *DYX1C1* | rs600753 | C | .50 | 0.04 | 0.04 | .37 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs7174102 | A | .35 | -0.06 | 0.04 | .15 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8037376 | C | .33 | -0.06 | 0.04 | .14 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8040756 | A | .15 | 0.00 | 0.06 | .98 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8043049 | C | .35 | -0.07 | 0.04 | .11 | Paracchini et al. (2011) |
| 16 | *ATP2C2* | rs16973771 | C | .40 | 0.05 | 0.04 | .24 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs2875891 | C | .65 | -0.07 | 0.04 | .089 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8045507 | A | .40 | 0.06 | 0.04 | .13 | Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8053211 | A | .54 | -0.05 | 0.04 | .25 | Müller et al. (2017) |
| 16 | *CMIP* | rs12927866 | C | .59 | 0.00 | 0.04 | .93 | Scerri et al. (2011) |
| 16 | *CMIP* | rs16955705 | A | .54 | -0.02 | 0.04 | .55 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs4265801 | G | .54 | 0.02 | 0.04 | .61 | Newbury et al. (2009) |
| 16 | *CMIP* | rs6564903 | C | .53 | 0.01 | 0.04 | .76 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs7201632 | C | .46 | 0.02 | 0.04 | .53 | Newbury et al. (2009) |
| 21 | *DIP2A* | rs11702704 | C | .27 | -0.04 | 0.04 | .35 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs17302525 | A | .94 | 0.05 | 0.09 | .56 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs1892692 | A | .40 | 0.02 | 0.04 | .65 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2070435 | A | .33 | 0.00 | 0.04 | .92 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2255526 | A | .72 | -0.02 | 0.04 | .62 | Kong et al. (2016) |
| 21 | *DIP2A* | rs2839282 | C | .92 | -0.10 | 0.07 | .14 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839299 | C | .69 | 0.00 | 0.04 | .98 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839308 | A | .77 | 0.01 | 0.05 | .80 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs762254 | A | .08 | -0.10 | 0.07 | .18 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs8132320 | A | .18 | -0.03 | 0.05 | .63 | Poelmans et al. (2009)a |
| 21 | *MCM3AP* | rs2839193 | A | .29 | -0.01 | 0.04 | .90 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839227 | A | .87 | 0.03 | 0.06 | .59 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839232 | A | .19 | -0.05 | 0.05 | .32 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839259 | C | .07 | -0.02 | 0.08 | .76 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs4819241 | C | .88 | 0.05 | 0.06 | .46 | Poelmans et al. (2009)a |
| **21** | ***PRMT2*** | **rs9982863** | **A** | **.55** | **0.08** | **0.04** | **.043** | **Poelmans et al. (2009)a** |
| **21** | ***S100B*** | **rs9722** | **A** | **.10** | **-0.13** | **0.06** | **.040** | **Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015)** |

*Note.* Chr = chromosome, Freq = frequency, boldface indicates nominal significance.

aMicroarray analysis of a small deletion co-segregating with dyslexia in a family.

Supplementary Table S4

Associations of SNPs Previously Associated with Reading or Language Ability or Disability with a Reading and Spelling Principal Component

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chr | Gene | SNP | Effect allele | Freq | *b* | *SE* | *p* | Significant in previous studies |
| 1 | *KIAA0319L* | rs7523017 | A | .07 | 0.05 | 0.08 | .53 | Couto et al. (2008) |
| 3 | *ROBO1* | rs12495133 | A | .37 | 0.00 | 0.04 | .95 | Tran et al. (2014) |
| 3 | *ROBO1* | rs331142 | A | .74 | 0.00 | 0.05 | .97 | Tran et al. (2014) |
| 3 | *ROBO1* | rs333491 | A | .55 | 0.01 | 0.04 | .87 | Mascheretti et al. (2014) |
| 3 | *ROBO1* | rs4535189 | A | .49 | 0.02 | 0.04 | .69 | Sun et al. (2017) |
| 6 | *DCDC2* | rs1091047 | C | .84 | -0.10 | 0.06 | .079 | Lind et al. (2010) |
| 6 | *DCDC2* | rs1419228 | A | .82 | 0.09 | 0.05 | .092 | Lind et al. (2010) |
| 6 | *DCDC2* | rs2274305 | C | .66 | -0.01 | 0.04 | .75 | Chen et al. (2017); Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs4599626 | A | .24 | 0.08 | 0.05 | .074 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6922023 | A | .17 | 0.05 | 0.05 | .37 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6937665 | A | .82 | -0.08 | 0.05 | .11 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs7765678 | C | .07 | -0.01 | 0.08 | .94 | Lind et al. (2010); Müller et al. (2016) |
| 6 | *DCDC2* | rs793862 | A | .27 | 0.00 | 0.04 | .97 | Scerri et al. (2011); Schumacher et al. (2006) |
| 6 | *DCDC2* | rs807701 | A | .66 | -0.01 | 0.04 | .82 | Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs807724 | C | .22 | -0.05 | 0.05 | .23 | Chen et al. (2017); Newbury et al. (2011); Scerri et al. (2011) |
| **6** | ***DCDC2*** | **rs9467075** | **A** | **.14** | **-0.13** | **0.06** | **.023** | **Chen et al. (2017); Lind et al. (2010)** |
| 6 | *DCDC2* | rs9467076 | C | .11 | -0.09 | 0.06 | .15 | Lind et al. (2010) |
| 6 | *KIAA0319* | rs2038137 | G | .63 | 0.00 | 0.04 | .91 | Carrion-Castillo et al. (2017); Cope et al. (2005); Harold et al. (2006); Müller et al. (2016) |
| 6 | *KIAA0319* | rs2179515 | C | .65 | -0.01 | 0.04 | .89 | Francks et al. (2004); Cope et al. (2005) |
| 6 | *KIAA0319* | rs4504469 | C | .59 | 0.03 | 0.04 | .39 | Francks et al. (2004); Cope et al. (2005); Harold et al. (2006); Shao et al. (2016); Venkatesh et al. (2013) |
| 6 | *KIAA0319* | rs6935076 | C | .63 | 0.02 | 0.04 | .57 | Carrion-Castillo et al. (2017); Cope et al. (2005); Couto et al. (2010); Harold et al. (2006); Müller et al. (2016); Scerri et al. (2011) |
| 6 | *KIAA0319* | rs761100 | A | .43 | 0.00 | 0.04 | .96 | Carrion-Castillo et al. (2017); Harold et al. (2006); Newbury et al. (2011) |
| 6 | *KIAA0319* | rs9461045 | C | .82 | -0.04 | 0.05 | .43 | Scerri et al. (2011); Shao et al. (2016) |
| 7 | *CNTNAP2* | rs10246256 | C | .32 | -0.02 | 0.04 | .66 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs17236239 | A | .65 | 0.02 | 0.04 | .70 | Carrion-Castillo et al. (2017); Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2538976 | C | .50 | -0.01 | 0.04 | .84 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2538991 | A | .49 | 0.01 | 0.04 | .85 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2710102 | A | .49 | 0.01 | 0.04 | .85 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2710117 | A | .64 | 0.01 | 0.04 | .74 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs4431523 | C | .32 | -0.01 | 0.04 | .74 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs759178 | A | .49 | 0.01 | 0.04 | .85 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs851715 | C | .32 | -0.01 | 0.04 | .74 | Vernes et al. (2008) |
| 7 | *FOXP2* | rs10230558 | A | .56 | 0.06 | 0.04 | .15 | Peter et al. (2011) |
| 7 | *FOXP2* | rs12533005 | C | .43 | 0.00 | 0.04 | .91 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs2253478** | **A** | **.41** | **0.09** | **0.04** | **.020** | **Tolosa et al. (2010)** |
| 7 | *FOXP2* | rs6980093 | A | .60 | -0.02 | 0.04 | .66 | Mozzi et al., 2017 |
| 7 | *FOXP2* | rs7782412 | C | .42 | 0.03 | 0.04 | .41 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs923875** | **A** | **.60** | **0.08** | **0.04** | **.038** | **Peter et al. (2011)** |
| 7 | *FOXP2* | rs936146 | C | .47 | 0.00 | 0.04 | .93 | Peter et al. (2011) |
| 15 | *CYP19A1* | rs2289105 | C | .53 | -0.01 | 0.04 | .75 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs17819126 | C | .93 | 0.04 | 0.08 | .63 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743204 | G | .79 | 0.02 | 0.05 | .76 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743205 | C | .94 | -0.09 | 0.09 | .30 | Taipale et al. (2003) |
| 15 | *DYX1C1* | rs57809907 | A | .09 | 0.02 | 0.07 | .74 | Brkanac et al. (2007); Dahdouh et al. (2009); Scerri et al. (2004); Taipale et al. (2003); Wigg et al. (2004) |
| 15 | *DYX1C1* | rs600753 | C | .50 | 0.04 | 0.04 | .28 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs7174102 | A | .35 | -0.06 | 0.04 | .12 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8037376 | C | .33 | -0.08 | 0.04 | .066 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8040756 | A | .15 | -0.01 | 0.06 | .85 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8043049 | C | .35 | -0.06 | 0.04 | .14 | Paracchini et al. (2011) |
| 16 | *ATP2C2* | rs16973771 | C | .40 | 0.05 | 0.04 | .20 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs2875891 | C | .65 | -0.05 | 0.04 | .24 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8045507 | A | .40 | 0.06 | 0.04 | .18 | Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8053211 | A | .54 | -0.05 | 0.04 | .25 | Müller et al. (2017) |
| 16 | *CMIP* | rs12927866 | C | .59 | 0.01 | 0.04 | .75 | Scerri et al. (2011) |
| 16 | *CMIP* | rs16955705 | A | .54 | -0.02 | 0.04 | .69 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs4265801 | G | .54 | 0.02 | 0.04 | .53 | Newbury et al. (2009) |
| 16 | *CMIP* | rs6564903 | C | .53 | 0.00 | 0.04 | .92 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs7201632 | C | .46 | 0.02 | 0.04 | .62 | Newbury et al. (2009) |
| 21 | *DIP2A* | rs11702704 | C | .27 | -0.05 | 0.04 | .30 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs17302525 | A | .94 | 0.01 | 0.09 | .86 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs1892692 | A | .40 | -0.02 | 0.04 | .55 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2070435 | A | .33 | -0.02 | 0.04 | .62 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2255526 | A | .72 | -0.05 | 0.04 | .23 | Kong et al. (2016) |
| 21 | *DIP2A* | rs2839282 | C | .92 | -0.05 | 0.07 | .46 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839299 | C | .69 | 0.00 | 0.04 | .93 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839308 | A | .77 | -0.02 | 0.05 | .72 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs762254 | A | .08 | 0.00 | 0.07 | .95 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs8132320 | A | .18 | 0.02 | 0.05 | .72 | Poelmans et al. (2009)a |
| 21 | *MCM3AP* | rs2839193 | A | .29 | -0.04 | 0.04 | .41 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839227 | A | .87 | 0.01 | 0.06 | .85 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839232 | A | .19 | -0.01 | 0.05 | .77 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839259 | C | .07 | 0.01 | 0.08 | .88 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs4819241 | C | .88 | 0.02 | 0.06 | .71 | Poelmans et al. (2009)a |
| **21** | ***PRMT2*** | **rs9982863** | **A** | **.55** | **0.08** | **0.04** | **.048** | **Poelmans et al. (2009)a** |
| **21** | ***S100B*** | **rs9722** | **A** | **.10** | **-0.15** | **0.06** | **.017** | **Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015)** |

*Note.* Chr = chromosome, Freq = frequency, boldface indicates nominal significance.

aMicroarray analysis of a small deletion co-segregating with dyslexia in a family.

Supplementary Table S5

Associations of SNPs Previously Associated with Reading or Language Ability or Disability with Self-Reported Reading Impairment

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chr | Gene | SNP | Effect allele | Freq | *b* | *SE* | *p* | Significant in previous studies |
| 1 | *KIAA0319L* | rs7523017 | A | .07 | -0.01 | 0.02 | .74 | Couto et al. (2008) |
| 3 | *ROBO1* | rs12495133 | A | .37 | -0.01 | 0.01 | .30 | Tran et al. (2014) |
| 3 | *ROBO1* | rs331142 | A | .74 | 0.00 | 0.01 | .61 | Tran et al. (2014) |
| 3 | *ROBO1* | rs333491 | A | .55 | 0.01 | 0.01 | .32 | Mascheretti et al. (2014) |
| 3 | *ROBO1* | rs4535189 | A | .49 | -0.01 | 0.01 | .22 | Sun et al. (2017) |
| 6 | *DCDC2* | rs1091047 | C | .84 | 0.00 | 0.01 | .95 | Lind et al. (2010) |
| 6 | *DCDC2* | rs1419228 | A | .82 | 0.00 | 0.01 | .72 | Lind et al. (2010) |
| 6 | *DCDC2* | rs2274305 | C | .66 | 0.00 | 0.01 | .59 | Chen et al. (2017); Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs4599626 | A | .24 | 0.00 | 0.01 | .96 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6922023 | A | .17 | -0.01 | 0.01 | .49 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6937665 | A | .82 | -0.01 | 0.01 | .51 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs7765678 | C | .07 | 0.00 | 0.02 | .86 | Lind et al. (2010); Müller et al. (2016) |
| 6 | *DCDC2* | rs793862 | A | .27 | 0.00 | 0.01 | .87 | Scerri et al. (2011); Schumacher et al. (2006) |
| 6 | *DCDC2* | rs807701 | A | .66 | 0.00 | 0.01 | .65 | Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs807724 | C | .22 | 0.01 | 0.01 | .57 | Chen et al. (2017); Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs9467075 | A | .14 | 0.01 | 0.01 | .53 | Chen et al. (2017); Lind et al. (2010) |
| 6 | *DCDC2* | rs9467076 | C | .11 | 0.01 | 0.01 | .61 | Lind et al. (2010) |
| 6 | *KIAA0319* | rs2038137 | G | .63 | 0.01 | 0.01 | .42 | Carrion-Castillo et al. (2017); Cope et al. (2005); Harold et al. (2006); Müller et al. (2016) |
| 6 | *KIAA0319* | rs2179515 | C | .65 | 0.01 | 0.01 | .35 | Francks et al. (2004); Cope et al. (2005) |
| 6 | *KIAA0319* | rs4504469 | C | .59 | 0.00 | 0.01 | .88 | Francks et al. (2004); Cope et al. (2005); Harold et al. (2006); Shao et al. (2016); Venkatesh et al. (2013) |
| 6 | *KIAA0319* | rs6935076 | C | .63 | -0.01 | 0.01 | .39 | Carrion-Castillo et al. (2017); Cope et al. (2005); Couto et al. (2010); Harold et al. (2006); Müller et al. (2016); Scerri et al. (2011) |
| 6 | *KIAA0319* | rs761100 | A | .43 | -0.01 | 0.01 | .12 | Carrion-Castillo et al. (2017); Harold et al. (2006); Newbury et al. (2011) |
| 6 | *KIAA0319* | rs9461045 | C | .82 | -0.01 | 0.01 | .52 | Scerri et al. (2011); Shao et al. (2016) |
| 7 | *CNTNAP2* | rs10246256 | C | .32 | 0.01 | 0.01 | .38 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs17236239 | A | .65 | 0.02 | 0.01 | .059 | Carrion-Castillo et al. (2017); Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2538976 | C | .50 | -0.01 | 0.01 | .21 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2538991 | A | .49 | 0.01 | 0.01 | .49 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2710102 | A | .49 | 0.01 | 0.01 | .48 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2710117 | A | .64 | -0.01 | 0.01 | .36 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs4431523 | C | .32 | -0.01 | 0.01 | .35 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs759178 | A | .49 | 0.01 | 0.01 | .48 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs851715 | C | .32 | 0.01 | 0.01 | .36 | Vernes et al. (2008) |
| 7 | *FOXP2* | rs10230558 | A | .56 | 0.00 | 0.01 | .58 | Peter et al. (2011) |
| 7 | *FOXP2* | rs12533005 | C | .43 | 0.00 | 0.01 | .95 | Peter et al. (2011) |
| 7 | *FOXP2* | rs2253478 | A | .41 | -0.01 | 0.01 | .27 | Tolosa et al. (2010) |
| 7 | *FOXP2* | rs6980093 | A | .60 | 0.01 | 0.01 | .49 | Mozzi et al., 2017 |
| 7 | *FOXP2* | rs7782412 | C | .42 | 0.00 | 0.01 | .64 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs923875** | **A** | **.60** | **-0.02** | **0.01** | **.038** | **Peter et al. (2011)** |
| 7 | *FOXP2* | rs936146 | C | .47 | 0.01 | 0.01 | .51 | Peter et al. (2011) |
| 15 | *CYP19A1* | rs2289105 | C | .53 | 0.01 | 0.01 | .52 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs17819126 | C | .93 | -0.02 | 0.02 | .34 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743204 | G | .79 | 0.00 | 0.01 | .97 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743205 | C | .94 | 0.02 | 0.02 | .24 | Taipale et al. (2003) |
| 15 | *DYX1C1* | rs57809907 | A | .09 | -0.01 | 0.01 | .45 | Brkanac et al. (2007); Dahdouh et al. (2009); Scerri et al. (2004); Taipale et al. (2003); Wigg et al. (2004) |
| 15 | *DYX1C1* | rs600753 | C | .50 | -0.01 | 0.01 | .39 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs7174102 | A | .35 | 0.01 | 0.01 | .13 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8037376 | C | .33 | 0.02 | 0.01 | .074 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8040756 | A | .15 | -0.01 | 0.01 | .65 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8043049 | C | .35 | 0.01 | 0.01 | .16 | Paracchini et al. (2011) |
| 16 | *ATP2C2* | rs16973771 | C | .40 | 0.00 | 0.01 | .78 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs2875891 | C | .65 | 0.00 | 0.01 | .86 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8045507 | A | .40 | 0.00 | 0.01 | .74 | Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8053211 | A | .54 | 0.00 | 0.01 | .70 | Müller et al. (2017) |
| 16 | *CMIP* | rs12927866 | C | .59 | 0.00 | 0.01 | .66 | Scerri et al. (2011) |
| 16 | *CMIP* | rs16955705 | A | .54 | 0.00 | 0.01 | .58 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs4265801 | G | .54 | 0.01 | 0.01 | .46 | Newbury et al. (2009) |
| 16 | *CMIP* | rs6564903 | C | .53 | 0.00 | 0.01 | .60 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs7201632 | C | .46 | 0.00 | 0.01 | .67 | Newbury et al. (2009) |
| 21 | *DIP2A* | rs11702704 | C | .27 | 0.01 | 0.01 | .30 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs17302525 | A | .94 | -0.01 | 0.02 | .67 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs1892692 | A | .40 | 0.00 | 0.01 | .91 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2070435 | A | .33 | 0.01 | 0.01 | .27 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2255526 | A | .72 | -0.01 | 0.01 | .33 | Kong et al. (2016) |
| 21 | *DIP2A* | rs2839282 | C | .92 | 0.02 | 0.01 | .11 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839299 | C | .69 | 0.01 | 0.01 | .16 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839308 | A | .77 | -0.02 | 0.01 | .059 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs762254 | A | .08 | 0.01 | 0.02 | .67 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs8132320 | A | .18 | 0.02 | 0.01 | .06 | Poelmans et al. (2009)a |
| 21 | *MCM3AP* | rs2839193 | A | .29 | 0.00 | 0.01 | .68 | Poelmans et al. (2009)a |
| **21** | ***PCNT*** | **rs2839227** | **A** | **.87** | **-0.03** | **0.01** | **.038** | **Poelmans et al. (2009)a** |
| **21** | ***PCNT*** | **rs2839232** | **A** | **.19** | **0.02** | **0.01** | **.036** | **Poelmans et al. (2009)a** |
| 21 | *PCNT* | rs2839259 | C | .07 | 0.02 | 0.02 | .22 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs4819241 | C | .88 | -0.02 | 0.01 | .13 | Poelmans et al. (2009)a |
| 21 | *PRMT2* | rs9982863 | A | .55 | 0.00 | 0.01 | .70 | Poelmans et al. (2009)a |
| **21** | ***S100B*** | **rs9722** | **A** | **.10** | **0.03** | **0.01** | **.024** | **Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015)** |

*Note.* Chr = chromosome, Freq = frequency, boldface indicates nominal significance.

aMicroarray analysis of a small deletion co-segregating with dyslexia in a family.

Supplementary Table S6

Associations of SNPs Previously Associated with Reading or Language Ability or Disability with Nonword Repetition

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Chr | Gene | SNP | Effect allele | Freq | *b* | *SE* | *p* | Significant in previous studies |
| 1 | *KIAA0319L* | rs7523017 | A | .07 | -0.02 | 0.08 | .79 | Couto et al. (2008) |
| 3 | *ROBO1* | rs12495133 | A | .37 | 0.00 | 0.04 | .99 | Tran et al. (2014) |
| 3 | *ROBO1* | rs331142 | A | .74 | 0.03 | 0.05 | .52 | Tran et al. (2014) |
| 3 | *ROBO1* | rs333491 | A | .55 | 0.01 | 0.04 | .86 | Mascheretti et al. (2014) |
| 3 | *ROBO1* | rs4535189 | A | .49 | 0.02 | 0.04 | .62 | Sun et al. (2017) |
| **6** | ***DCDC2*** | **rs1091047** | **C** | **.84** | **-0.11** | **0.06** | **.043** | **Lind et al. (2010)** |
| 6 | *DCDC2* | rs1419228 | A | .82 | 0.06 | 0.05 | .21 | Lind et al. (2010) |
| 6 | *DCDC2* | rs2274305 | C | .66 | -0.03 | 0.04 | .46 | Chen et al. (2017); Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| **6** | ***DCDC2*** | **rs4599626** | **A** | **.24** | **0.10** | **0.05** | **.023** | **Chen et al. (2017)** |
| 6 | *DCDC2* | rs6922023 | A | .17 | 0.06 | 0.05 | .29 | Chen et al. (2017) |
| 6 | *DCDC2* | rs6937665 | A | .82 | -0.07 | 0.05 | .18 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 6 | *DCDC2* | rs7765678 | C | .07 | 0.03 | 0.08 | .73 | Lind et al. (2010); Müller et al. (2016) |
| 6 | *DCDC2* | rs793862 | A | .27 | 0.00 | 0.04 | .91 | Scerri et al. (2011); Schumacher et al. (2006) |
| 6 | *DCDC2* | rs807701 | A | .66 | -0.02 | 0.04 | .55 | Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs807724 | C | .22 | -0.04 | 0.05 | .43 | Chen et al. (2017); Newbury et al. (2011); Scerri et al. (2011) |
| 6 | *DCDC2* | rs9467075 | A | .14 | -0.10 | 0.06 | .058 | Chen et al. (2017); Lind et al. (2010) |
| 6 | *DCDC2* | rs9467076 | C | .11 | -0.09 | 0.06 | .13 | Lind et al. (2010) |
| 6 | *KIAA0319* | rs2038137 | G | .63 | -0.01 | 0.04 | .81 | Carrion-Castillo et al. (2017); Cope et al. (2005); Harold et al. (2006); Müller et al. (2016) |
| 6 | *KIAA0319* | rs2179515 | C | .65 | -0.01 | 0.04 | .75 | Francks et al. (2004); Cope et al. (2005) |
| 6 | *KIAA0319* | rs4504469 | C | .59 | 0.04 | 0.04 | .35 | Francks et al. (2004); Cope et al. (2005); Harold et al. (2006); Shao et al. (2016); Venkatesh et al. (2013) |
| 6 | *KIAA0319* | rs6935076 | C | .63 | 0.04 | 0.04 | .30 | Carrion-Castillo et al. (2017); Cope et al. (2005); Couto et al. (2010); Harold et al. (2006); Müller et al. (2016); Scerri et al. (2011) |
| 6 | *KIAA0319* | rs761100 | A | .43 | 0.02 | 0.04 | .68 | Carrion-Castillo et al. (2017); Harold et al. (2006); Newbury et al. (2011) |
| 6 | *KIAA0319* | rs9461045 | C | .82 | -0.02 | 0.05 | .68 | Scerri et al. (2011); Shao et al. (2016) |
| 7 | *CNTNAP2* | rs10246256 | C | .32 | 0.03 | 0.04 | .54 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs17236239 | A | .65 | 0.03 | 0.04 | .47 | Carrion-Castillo et al. (2017); Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2538976 | C | .50 | -0.02 | 0.04 | .65 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2538991 | A | .49 | 0.02 | 0.04 | .63 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs2710102 | A | .49 | 0.02 | 0.04 | .62 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs2710117 | A | .64 | -0.01 | 0.04 | .80 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs4431523 | C | .32 | -0.05 | 0.04 | .21 | Vernes et al. (2008) |
| 7 | *CNTNAP2* | rs759178 | A | .49 | 0.02 | 0.04 | .62 | Vernes et al. (2008); Whitehouse et al. (2011) |
| 7 | *CNTNAP2* | rs851715 | C | .32 | 0.03 | 0.04 | .54 | Vernes et al. (2008) |
| 7 | *FOXP2* | rs10230558 | A | .56 | 0.05 | 0.04 | .21 | Peter et al. (2011) |
| 7 | *FOXP2* | rs12533005 | C | .43 | 0.00 | 0.04 | .96 | Peter et al. (2011) |
| **7** | ***FOXP2*** | **rs2253478** | **A** | **.41** | **0.10** | **0.04** | **.014** | **Tolosa et al. (2010)** |
| 7 | *FOXP2* | rs6980093 | A | .60 | -0.02 | 0.04 | .63 | Mozzi et al., 2017 |
| 7 | *FOXP2* | rs7782412 | C | .42 | 0.04 | 0.04 | .29 | Peter et al. (2011) |
| 7 | *FOXP2* | rs923875 | A | .60 | 0.07 | 0.04 | .065 | Peter et al. (2011) |
| 7 | *FOXP2* | rs936146 | C | .47 | -0.02 | 0.04 | .61 | Peter et al. (2011) |
| 15 | *CYP19A1* | rs2289105 | C | .53 | -0.03 | 0.04 | .49 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs17819126 | C | .93 | 0.04 | 0.08 | .61 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743204 | G | .79 | 0.03 | 0.05 | .61 | Bates et al. (2010) |
| 15 | *DYX1C1* | rs3743205 | C | .94 | -0.08 | 0.09 | .34 | Taipale et al. (2003) |
| 15 | *DYX1C1* | rs57809907 | A | .09 | 0.01 | 0.07 | .85 | Brkanac et al. (2007); Dahdouh et al. (2009); Scerri et al. (2004); Taipale et al. (2003); Wigg et al. (2004) |
| 15 | *DYX1C1* | rs600753 | C | .50 | 0.04 | 0.04 | .28 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |
| 15 | *DYX1C1* | rs7174102 | A | .35 | -0.06 | 0.04 | .16 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8037376 | C | .33 | -0.06 | 0.04 | .16 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8040756 | A | .15 | 0.00 | 0.06 | .94 | Paracchini et al. (2011) |
| 15 | *DYX1C1* | rs8043049 | C | .35 | -0.04 | 0.04 | .31 | Paracchini et al. (2011) |
| 16 | *ATP2C2* | rs16973771 | C | .40 | 0.05 | 0.04 | .19 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs2875891 | C | .65 | -0.04 | 0.04 | .29 | Müller et al. (2017); Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8045507 | A | .40 | 0.06 | 0.04 | .17 | Newbury et al. (2009) |
| 16 | *ATP2C2* | rs8053211 | A | .54 | -0.07 | 0.04 | .076 | Müller et al. (2017) |
| 16 | *CMIP* | rs12927866 | C | .59 | 0.03 | 0.04 | .49 | Scerri et al. (2011) |
| 16 | *CMIP* | rs16955705 | A | .54 | -0.01 | 0.04 | .82 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs4265801 | G | .54 | 0.03 | 0.04 | .52 | Newbury et al. (2009) |
| 16 | *CMIP* | rs6564903 | C | .53 | 0.01 | 0.04 | .74 | Newbury et al. (2009); Scerri et al. (2011) |
| 16 | *CMIP* | rs7201632 | C | .46 | 0.02 | 0.04 | .69 | Newbury et al. (2009) |
| 21 | *DIP2A* | rs11702704 | C | .27 | -0.05 | 0.04 | .22 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs17302525 | A | .94 | 0.00 | 0.08 | .97 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs1892692 | A | .40 | -0.04 | 0.04 | .31 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2070435 | A | .33 | -0.03 | 0.04 | .50 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2255526 | A | .72 | -0.08 | 0.04 | .081 | Kong et al. (2016) |
| 21 | *DIP2A* | rs2839282 | C | .92 | -0.02 | 0.07 | .82 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839299 | C | .69 | -0.01 | 0.04 | .88 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs2839308 | A | .77 | -0.06 | 0.05 | .19 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs762254 | A | .08 | -0.03 | 0.07 | .67 | Poelmans et al. (2009)a |
| 21 | *DIP2A* | rs8132320 | A | .18 | 0.06 | 0.05 | .22 | Poelmans et al. (2009)a |
| 21 | *MCM3AP* | rs2839193 | A | .29 | -0.05 | 0.04 | .20 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839227 | A | .87 | -0.02 | 0.06 | .76 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839232 | A | .19 | 0.01 | 0.05 | .79 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs2839259 | C | .07 | 0.02 | 0.08 | .78 | Poelmans et al. (2009)a |
| 21 | *PCNT* | rs4819241 | C | .88 | -0.02 | 0.06 | .79 | Poelmans et al. (2009)a |
| 21 | *PRMT2* | rs9982863 | A | .55 | 0.07 | 0.04 | .057 | Poelmans et al. (2009)a |
| 21 | *S100B* | rs9722 | A | .10 | -0.11 | 0.06 | .070 | Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Körne, et al. (2015) |

*Note.* Chr = chromosome, Freq = frequency, boldface indicates nominal significance.

aMicroarray analysis of a small deletion co-segregating with dyslexia in a family.

**Supplementary discussion**

Within the dyslexia and speech/language disorder candidate gene sets, we targeted 77 SNPs that have previously been reported as associated with reading or language ability or disability. Of these, 17 SNPs were nominally associated with at least one of our five measures, and no SNP approached the threshold adjusted for multiple-testing of markers and traits of *p* = 7.28 x 10-4. Two SNPs in *FOXP2*, rs2253478 and rs923875, were collectively nominally associated with all five of our measures. There is a lack of GWAS of language ability in unselected populations, so our selection of candidate variants included those from previous family studies. The *FOXP2* variant rs2253478 was associated with the poverty of speech item of the Manchester scale in patients with schizophrenia by Tolosa et al. (2010), but they do not report the direction of effect. The A allele of rs923875 was associated with a reduced score in real word reading efficiency in a cohort of parents of children with dyslexia (Peter et al., 2011). Here, we show a positive effect of the A allele of rs2253478 and the C allele of rs923875 on test scores and a reduced likelihood of self-reporting reading impairment.

Five SNPs in *CNTNAP2* (rs17236239, rs2710102, rs759178, rs2538976, and rs2538991) were nominally associated with nonword reading (which assesses phonological processing during reading). All except rs2538976 were associated with reading in an older adult population cohort in a previous study (Luciano, Gow, Pattie, Bates, & Deary, 2018), with a consistent direction of effect, and replicating a study of language impairment in children by Vernes et al. (2008) and a population study of language development in children by Whitehouse et al. (2011). In a study of dyslexic and non-dyslexic children, rs17236239 was associated with nonword repetition, with a positive effect on scores (Carrion-Castillo et al., 2017), consistent with our findings.

SNPs in the dyslexia candidate gene *DCDC2* were nominally associated with nonword reading (rs807701), the reading and spelling composite score (rs9467075), and nonword repetition (rs4599626 and rs1091047). In a case-control study of dyslexia, probands were more likely to carry the C allele at rs807701 (Newbury et al., 2011), accordingly we found the alternative allele to confer a positive effect on nonword reading. The A alleles of rs4599626 and rs9467075 were nominally associated with nonword repetition and the reading and spelling composite score respectively in our study and with dyslexia cases by Chen et al. (2017). Whilst rs9467075 had a negative effect on the reading and spelling composite score, in line with the findings of Chen et al. (2017), rs4599626 had a positive effect on nonword repetition. Lind et al. (2010) reported an association of the G allele of rs1091047 which conferred a general reading disadvantage in unselected adult twins and we found the same variant to have a negative effect on nonword repetition in our unselected adult cohort. These data support shared genetic aetiology between reading and language ability.

Matsson, Huss, Persson, Einarsdottir, Tiraboschi, Nopola-Hemmi, Schumacher, Neuhoff, Warnke, Lyytinen, Schulte-Korne, et al. (2015) detected variants in *S100B* (rs9722) and *DYX1C1* (rs600753) in association with spelling performance in a dyslexia case-control study. We replicated the effect and direction of rs9722 for phonetic spelling, reading and spelling composite score, and self-reported reading impairment. The C allele of rs600753 in Matsson and colleagues’ study was at an increased frequency in cases although we found the same allele was nominally associated with a higher score in nonword reading.

The same SNP in *PRMT2*, rs9982863, was nominally associated with both the reading and spelling composite score and phonetic spelling. This SNP is within a deleted region at 21q22.3 which segregates with dyslexia in a father and three sons (Poelmans et al., 2009). Two further SNPs in *PCNT* (rs2839227 and rs2839232) proximal to the deletion site in this family were associated with self-reported reading impairment here. SNP rs2179515 in *KIAA0319* was associated with dyslexia cases in independent samples (Cope et al., 2005; Francks et al., 2004), and here we show an analogous nominal association with the phonetic spelling score.

**REFERENCES**

Bates, T. C., Lind, P. A., Luciano, M., Montgomery, G. W., Martin, N. G., & Wright, M. J. (2010). Dyslexia and DYX1C1: deficits in reading and spelling associated with a missense mutation. *Molecular Psychiatry, 15*(12), 1190-1196. doi:10.1038/mp.2009.120

Brkanac, Z., Chapman, N. H., Matsushita, M. M., Chun, L., Nielsen, K., Cochrane, E., . . . Raskind, W. H. (2007). Evaluation of candidate genes for DYX1 and DYX2 in families with dyslexia. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics, 144b*(4), 556-560. doi:10.1002/ajmg.b.30471

Carrion-Castillo, A., Maassen, B., Franke, B., Heister, A., Naber, M., van der Leij, A., . . . Fisher, S. E. (2017). Association analysis of dyslexia candidate genes in a Dutch longitudinal sample. *European Journal of Human Genetics, 25*(4), 452-460. doi:10.1038/ejhg.2016.194

Chen, Y., Zhao, H., Zhang, Y. X., & Zuo, P. X. (2017). DCDC2 gene polymorphisms are associated with developmental dyslexia in Chinese Uyghur children. *Neural Regen Res, 12*(2), 259-266. doi:10.4103/1673-5374.200809

Cope, N., Harold, D., Hill, G., Moskvina, V., Stevenson, J., Holmans, P., . . . Williams, J. (2005). Strong evidence that KIAA0319 on chromosome 6p is a susceptibility gene for developmental dyslexia. *American journal of human genetics, 76*(4), 581-591. doi:10.1086/429131

Couto, J. M., Gomez, L., Wigg, K., Cate-Carter, T., Archibald, J., Anderson, B., . . . Barr, C. L. (2008). The KIAA0319-like (KIAA0319L) gene on chromosome 1p34 as a candidate for reading disabilities. *Journal of neurogenetics, 22*(4), 295-313. doi:10.1080/01677060802354328

Couto, J. M., Livne-Bar, I., Huang, K., Xu, Z., Cate-Carter, T., Feng, Y., . . . Barr, C. L. (2010). Association of reading disabilities with regions marked by acetylated H3 histones in KIAA0319. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics, 153b*(2), 447-462. doi:10.1002/ajmg.b.30999

Dahdouh, F., Anthoni, H., Tapia-Paez, I., Peyrard-Janvid, M., Schulte-Korne, G., Warnke, A., . . . Zucchelli, M. (2009). Further evidence for DYX1C1 as a susceptibility factor for dyslexia. *Psychiatric Genetics, 19*(2), 59-63. doi:10.1097/YPG.0b013e32832080e1

Francks, C., Paracchini, S., Smith, S. D., Richardson, A. J., Scerri, T. S., Cardon, L. R., . . . Monaco, A. P. (2004). A 77-kilobase region of chromosome 6p22.2 is associated with dyslexia in families from the United Kingdom and from the United States. *American journal of human genetics, 75*(6), 1046-1058. doi:10.1086/426404

Harold, D., Paracchini, S., Scerri, T., Dennis, M., Cope, N., Hill, G., . . . Monaco, A. P. (2006). Further evidence that the KIAA0319 gene confers susceptibility to developmental dyslexia. *Molecular Psychiatry, 11*(12), 1085-1091. doi:10.1038/sj.mp.4001904

Kong, R., Shao, S., Wang, J., Zhang, X., Guo, S., Zou, L., . . . Song, R. (2016). Genetic variant in DIP2A gene is associated with developmental dyslexia in Chinese population. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics, 171*(2), 203-208. doi:10.1002/ajmg.b.32392

Lind, P. A., Luciano, M., Wright, M. J., Montgomery, G. W., Martin, N. G., & Bates, T. C. (2010). Dyslexia and DCDC2: normal variation in reading and spelling is associated with DCDC2 polymorphisms in an Australian population sample. *European Journal of Human Genetics, 18*(6), 668-673. doi:10.1038/ejhg.2009.237

Luciano, M., Gow, A. J., Pattie, A., Bates, T. C., & Deary, I. J. (2018). The Influence of Dyslexia Candidate Genes on Reading Skill in Old Age. *Behavior genetics, 48*(5), 351-360. doi:10.1007/s10519-018-9913-3

Mascheretti, S., Riva, V., Giorda, R., Beri, S., Lanzoni, L. F. E., Cellino, M. R., & Marino, C. (2014). KIAA0319 and ROBO1: evidence on association with reading and pleiotropic effects on language and mathematics abilities in developmental dyslexia. *Journal of Human Genetics, 59*(4), 189-197. doi:10.1038/jhg.2013.141

Matsson, H., Huss, M., Persson, H., Einarsdottir, E., Tiraboschi, E., Nopola-Hemmi, J., . . . Kere, J. (2015). Polymorphisms in DCDC2 and S100B associate with developmental dyslexia. *J Hum Genet, 60*(7), 399-401. doi:10.1038/jhg.2015.37

Matsson, H., Huss, M., Persson, H., Einarsdottir, E., Tiraboschi, E., Nopola-Hemmi, J., . . . Kere, J. (2015). Polymorphisms in DCDC2 and S100B associate with developmental dyslexia. *Journal of Human Genetics, 60*(7), 399-401. doi:10.1038/jhg.2015.37

Müller, B., Schaadt, G., Boltze, J., Emmrich, F., Consortium, L., Skeide, M. A., . . . Wilcke, A. (2017). ATP2C2 and DYX1C1 are putative modulators of dyslexia-related MMR. *Brain Behav, 7*(11), e00851-e00851. doi:10.1002/brb3.851

Müller, B., Wilcke, A., Czepezauer, I., Ahnert, P., Boltze, J., & Kirsten, H. (2016). Association, characterisation and meta-analysis of SNPs linked to general reading ability in a German dyslexia case-control cohort. *Sci Rep, 6*, 27901. doi:10.1038/srep27901

Newbury, D. F., Paracchini, S., Scerri, T. S., Winchester, L., Addis, L., Richardson, A. J., . . . Monaco, A. P. (2011). Investigation of dyslexia and SLI risk variants in reading- and language-impaired subjects. *Behavior genetics, 41*(1), 90-104. doi:10.1007/s10519-010-9424-3

Newbury, D. F., Winchester, L., Addis, L., Paracchini, S., Buckingham, L.-L., Clark, A., . . . Monaco, A. P. (2009). CMIP and ATP2C2 modulate phonological short-term memory in language impairment. *American journal of human genetics, 85*(2), 264-272. doi:10.1016/j.ajhg.2009.07.004

Paracchini, S., Ang, Q. W., Stanley, F. J., Monaco, A. P., Pennell, C. E., & Whitehouse, A. J. (2011). Analysis of dyslexia candidate genes in the Raine cohort representing the general Australian population. *Genes, Brain and Behavior, 10*(2), 158-165. doi:10.1111/j.1601-183X.2010.00651.x

Peter, B., Raskind, W. H., Matsushita, M., Lisowski, M., Vu, T., Berninger, V. W., . . . Brkanac, Z. (2011). Replication of CNTNAP2 association with nonword repetition and support for FOXP2 association with timed reading and motor activities in a dyslexia family sample. *Journal of Neurodevelopmental Disorders, 3*(1), 39-49. doi:10.1007/s11689-010-9065-0

Poelmans, G., Engelen, J. J., Van Lent-Albrechts, J., Smeets, H. J., Schoenmakers, E., Franke, B., . . . Schrander-Stumpel, C. (2009). Identification of novel dyslexia candidate genes through the analysis of a chromosomal deletion. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics, 150B*(1), 140-147. doi:10.1002/ajmg.b.30787

Scerri, T. S., Fisher, S. E., Francks, C., MacPhie, I. L., Paracchini, S., Richardson, A. J., . . . Monaco, A. P. (2004). Putative functional alleles of DYX1C1 are not associated with dyslexia susceptibility in a large sample of sibling pairs from the UK. *J Med Genet, 41*(11), 853-857. doi:10.1136/jmg.2004.018341

Scerri, T. S., Morris, A. P., Buckingham, L. L., Newbury, D. F., Miller, L. L., Monaco, A. P., . . . Paracchini, S. (2011). DCDC2, KIAA0319 and CMIP are associated with reading-related traits. *Biological Psychiatry, 70*(3), 237-245. doi:10.1016/j.biopsych.2011.02.005

Schumacher, J., Anthoni, H., Dahdouh, F., Konig, I. R., Hillmer, A. M., Kluck, N., . . . Kere, J. (2006). Strong genetic evidence of DCDC2 as a susceptibility gene for dyslexia. *American journal of human genetics, 78*(1), 52-62. doi:10.1086/498992

Shao, S., Kong, R., Zou, L., Zhong, R., Lou, J., Zhou, J., . . . Song, R. (2016). The Roles of Genes in the Neuronal Migration and Neurite Outgrowth Network in Developmental Dyslexia: Single- and Multiple-Risk Genetic Variants. *Molecular Neurobiology, 53*(6), 3967-3975. doi:10.1007/s12035-015-9334-8

Sun, X., Song, S., Liang, X., Xie, Y., Zhao, C., Zhang, Y., . . . Gong, G. (2017). ROBO1 polymorphisms, callosal connectivity, and reading skills. *Human Brain Mapping, 38*(5), 2616-2626. doi:10.1002/hbm.23546

Taipale, M., Kaminen, N., Nopola-Hemmi, J., Haltia, T., Myllyluoma, B., Lyytinen, H., . . . Kere, J. (2003). A candidate gene for developmental dyslexia encodes a nuclear tetratricopeptide repeat domain protein dynamically regulated in brain. *Proc Natl Acad Sci U S A, 100*(20), 11553-11558. doi:10.1073/pnas.1833911100

Tolosa, A., Sanjuán, J., Dagnall, A. M., Moltó, M. D., Herrero, N., & de Frutos, R. (2010). FOXP2 gene and language impairment in schizophrenia: association and epigenetic studies. *BMC medical genetics, 11*, 114-114. doi:10.1186/1471-2350-11-114

Tran, C., Wigg, K. G., Zhang, K., Cate-Carter, T. D., Kerr, E., Field, L. L., . . . Barr, C. L. (2014). Association of the ROBO1 gene with reading disabilities in a family-based analysis. *Genes, Brain and Behavior, 13*(4), 430-438. doi:10.1111/gbb.12126

Venkatesh, S. K., Siddaiah, A., Padakannaya, P., & Ramachandra, N. B. (2013). Lack of association between genetic polymorphisms in ROBO1, MRPL19/C2ORF3 and THEM2 with developmental dyslexia. *Gene, 529*(2), 215-219. doi:10.1016/j.gene.2013.08.017

Vernes, S. C., Newbury, D. F., Abrahams, B. S., Winchester, L., Nicod, J., Groszer, M., . . . Fisher, S. E. (2008). A functional genetic link between distinct developmental language disorders. *New England Journal of Medicine, 359*(22), 2337-2345. doi:10.1056/NEJMoa0802828

Whitehouse, A. J. O., Bishop, D. V. M., Ang, Q. W., Pennell, C. E., & Fisher, S. E. (2011). CNTNAP2 variants affect early language development in the general population. *Genes, Brain and Behavior, 10*(4), 451-456. doi:10.1111/j.1601-183X.2011.00684.x

Wigg, K. G., Couto, J. M., Feng, Y., Anderson, B., Cate-Carter, T. D., Macciardi, F., . . . Barr, C. L. (2004). Support for EKN1 as the susceptibility locus for dyslexia on 15q21. *Molecular Psychiatry, 9*(12), 1111-1121. doi:10.1038/sj.mp.4001543