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Visual attention span deficits and assessing causality in developmental dyslexia

Usha Goswami

In my recent Opinion article (Sensory theories of developmental dyslexia: three challenges for research. *Nature Rev. Neurosci.* **16**, 43–54 (2015))[1], I described the challenges in establishing causality for each of the main sensory-deficit theories of developmental dyslexia. In their comment (Visual attention deficits in developmental dyslexia cannot be ascribed solely to poor reading experience. *Nature Rev. Neurosci.* http://dx.doi.org/10.1038/nrn3836-c1 (2015))[2], Lobier and Valdois bring together 12 of their studies to argue that a visual attention (VA) span deficit meets the criteria that are required to demonstrate causality in developmental dyslexia[3–14]. Unfortunately, all of the studies that were discussed used letters to assess VA span; thus, the demonstrated deficit only affects letters and is causally ambiguous[1]. Lobier and Valdois do not address my key point — that a VA span deficit disappears if non-alphanumeric stimuli are used[15,16] (FIG. 1). Furthermore, Lobier and Valdois rely on studies with adults and chronological age controls. Such research designs are ambiguous with respect to causality[1], as the individuals with dyslexia and control individuals that were studied differed dramatically in their experience of recoding letters to sound.

Here, I focus on the reading level (RL) match and training data presented by Lobier and Valdois (see Table 1 in my Opinion article[1]), and a chronological-age match study using unfamiliar visual stimuli. Lobier and Valdois report an RL match study with 10-year-old children with dyslexia and 7-year-old typically developing children[7]. The VA span deficit (in letter report) was significant, but the younger children were markedly poorer at identifying single letters, which were the stimuli used in the VA span task. Consequently, this difference in identification accuracy could have caused the VA span difference[7]. Furthermore, the individuals with VA span dyslexia showed markedly worse pseudoword reading than those with 'phonological' dyslexia, indicating that they have very severely reduced experience in phonological recoding. This reduced practice in phonological recoding could explain the reduced VA span[1]. Lobier and Valdois also cite an RL match study that compared 11-year-old children with dyslexia (RL = 7 years) to 8-year-old typically developing children[8]. Unfortunately, the VA span task again used letters, but letter identification skills were not measured. Hence, the group difference in VA span could again arise from poorer letter identification skills in younger children.

In addition, Lobier and Valdois cite a training study that followed one 8-year-old child for 17 months[9]. The child received VA span training in months 3–6 and gained 4 months in reading age. Unfortunately, no control children who received a different type of training were tested, so the gain is impossible to interpret. Indeed, this child was not impaired in VA span when compared with RL match controls. Finally, a visual categorization study involving 10-year-old children was discussed[11]. Children were shown unfamiliar visual stimuli (FIG. 2), with strings of five stimuli from two categories displayed on any one trial. Children had to decide whether one, two or three stimuli were present from one of the two categories, which was visually cued before and after each trial. This task and stimuli are very similar to those used in a series of studies of visual processing in dyslexia by Vellutino[17]. Vellutino comprehensively established that, with unfamiliar visual stimuli, recognition and retention is affected by verbal labelling. Hence, a labelling (that is, phonological) difficulty could explain poorer categorization in individuals with dyslexia. Note that this was not a standard VA span study and that an RL match comparison was not included.

Clearly, the evidence presented does not critically touch on the challenges for sensory theories of dyslexia that are posed in my Opinion article[1]. Currently missing are studies measuring VA span before reading tuition commences, using both alphanumeric and non-alphanumeric stimuli, showing a reduced span in at-risk children. Studies of illiterate adults could also be informative, as no VA span difference should be found for letters versus symbols[15]. When verbal labels are overlearned, as for coloured dots, the VA span of individuals with dyslexia

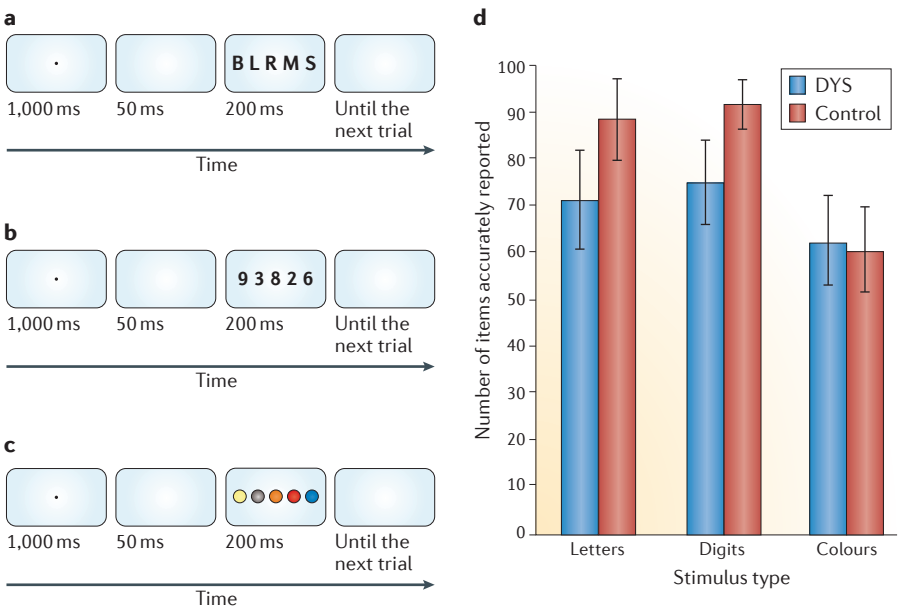

Figure 1 | **The visual attention span task.** Variations on the visual attention span task using alphanumeric stimuli (parts **a** and **b**) and dots (part **c**) are shown. Compared with 10-year-old control children (control), French-speaking 10-year-old children with dyslexia (DYS) showed a reliable deficit in the accurate reporting of letters and digits but not in reporting the colour of the dots (part **d**). Adapted with permission from REF. 16, © 2012 John Wiley & Sons, Ltd.

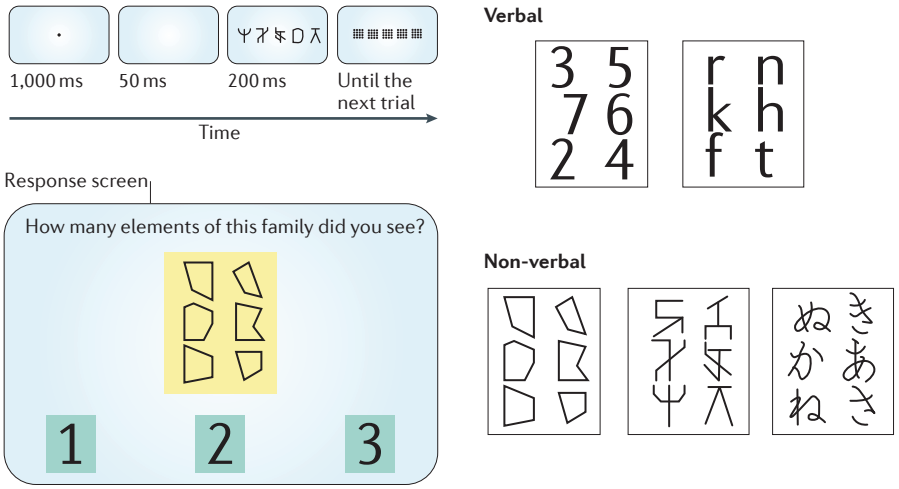

Figure 2 | **Visual attention span task using non-verbal stimuli.** The unfamiliar (that is, non-verbal) visual stimuli that are used to assess visual categorization skills in dyslexia are shown. The categories include abstract shapes, pseudoletters and Japanese Hiragana characters. Children were asked to remember which category was presented visually in a pre-trial cue. They then saw a string of five stimuli for 200 ms (top panel) and had to decide how many were in the cued category. They were then cued again with the category (middle panel) and had to respond. Figure reprinted from *Cortex*, **48**, Lobier, M., Zoubrinetzky, R. & Valdois, S., The visual attention span deficit in dyslexia is visual and not verbal, 768–773, Copyright (2012), with permission from Elsevier.

is equivalent to chronological age controls (FIG. 1). This fatally undermines the argument that the VA span deficit is a visually driven and independent cause of dyslexia[11].

Usha Goswami is at the Centre for Neuroscience in Education, Department of Psychology, University of Cambridge, Downing Street, Cambridge, CB2 3EB, UK.

e-mail: ucg10@cam.ac.uk

doi:10.1038/nrn3836-c2
Published online 20 March 2015

1. Goswami, U. Sensory theories of developmental dyslexia: three challenges for research. *Nature Rev. Neurosci.* **16**, 43–54 (2015).
2. Lobier, M. & Valdois, S. Visual attention deficits in developmental dyslexia cannot be ascribed solely to poor reading experience. *Nature Rev. Neurosci.* http://dx.doi.org/10.1038/nrn3836-c1 (2015).
3. Bosse, M.-L., Tainturier, M. J. & Valdois, S. Developmental dyslexia: the visual attention span deficit hypothesis. *Cognition* **104**, 198–230 (2007).
4. Germano, G. D., Reilhac, C., Capellini, S. A. & Valdois, S. The phonological and visual basis of developmental dyslexia in Brazilian Portuguese reading children. *Front. Psychol.* **5**, 1169 (2014).
5. Valdois, S. *et al.* Phonological and visual processing deficits can dissociate in developmental dyslexia: evidence from two case studies. *Read. Writ.* **16**, 541–572 (2003).
6. Peyrin, C. *et al.* Neural dissociation of phonological and visual attention span disorders in developmental dyslexia: FMRI evidence from two case reports. *Brain Lang.* **120**, 381–394 (2012).
7. Zoubrinetzky, R., Bielle, F. & Valdois, S. New insights on developmental dyslexia subtypes: heterogeneity of mixed reading profiles. *PloS ONE* **9**, e99337 (2014).
8. Bosse, M. L. & Valdois, S. Patterns of developmental dyslexia according to a multi-trace memory model of reading. *Curr. Psychol. Lett.* **1**, 10 (2003).
9. Valdois, S. *et al.* Dyslexia in a French–Spanish bilingual girl: behavioural and neural modulations following a specific visual-attention span intervention program. *Cortex* **53**, 120–145 (2014).
10. Lallier, M., Valdois, S., Lassus-Sangosse, D., Prado, C. & Kandel, S. Impact of orthographic transparency on typical and atypical reading development: evidence in French–Spanish bilingual children. *Res. Dev. Disabil.* **35**, 1177–1190 (2014).
11. Lobier, M., Zoubrinetzky, R. & Valdois, S. The visual attention span deficit in dyslexia is visual and not verbal. *Cortex* **48**, 768–773 (2012).
12. Lobier, M., Peyrin, C., Pichat, C., Le Bas, J. F. & Valdois, S. Visual processing of multiple elements in the dyslexic brain: evidence for a superior parietal dysfunction. *Front. Hum. Neurosci.* **8**, 479 (2014).
13. Ans, B., Carbonnel, S. & Valdois, S. A connectionist multiple-trace memory model for polysyllabic word reading. *Psychol. Rev.* **105**, 678–723 (1998).
14. Lobier, M., Dubois, M. & Valdois, S. The role of visual processing speed in reading speed development. *PLoS ONE* **8**, e58097 (2013).
15. Ziegler, J. C. *et al.* Rapid processing of letters, digits and symbols: what purely visual-attentional deficit in developmental dyslexia? *Dev. Sci.* **13**, F8–F14 (2010).
16. Valdois, S., Lassus-Sangosse, D. & Lobier, M. Impaired letter string processing in developmental dyslexia: what visual-to-phonology code disorder? *Dyslexia* **18**, 77–93 (2012).
17. Vellutino, F. R. *Dyslexia: Theory and Research* (MIT Press, 1979).

Competing interests statement
The author declares competing interests: see Web version for details.