

Atypical Dyslexia: Visual Deficits and Literacy Development

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Abstract

We explore the visual and written language development of dizygous male twins, (AB and BB), in the initial phase of a pair of longitudinal cognitive neuropsychological case studies. Though the twins share a diagnosis of phonological dyslexia, each has another domain of difficulty. One twin, BB, demonstrates significant difficulties in visual working memory and visual orientation. The other twin, AB, has been diagnosed with ADHD with manifestations of impulsivity and hyperactivity. An attempt is made to assess the separate impacts these visual, attentional and phonological difficulties on the development of reading and writing. We consider the implications of these cases for theories of normal visual development and its pathologies and for our understanding of the complex process of acquiring written language. Finally, we describe compensatory strategies these children have adopted and consider the implications of such cases for diagnostic and instructional practice.

Introduction

Throughout its history, research on developmental disorders of written language has included work exploring the impact of visual processing deficits on reading performance (e.g., *Breitmeyer & Ganz, 1976; Lovegrove et al., 1986; Orton, 1925, Stein & Talcott, 1999*). Though the preponderance of evidence suggest that most cases of reading impairment can be attributed to language-related causes rather than to visual ones (e.g., *Hulme, 1988; Ramus, Rosen, Dakin et al. 2003; Vellutino & Fletcher, 2005*), there is no doubt that visual processing deficits can also interfere with literacy development (e.g., *McCloskey & Rapp, 2000a,b; McCloskey, Valtonen & Sherman 2006; Pirozzolo & Rayner, 1978*). Given the heterogeneity of atypical forms of reading-related disorders, their relative rarity, and the complexity of the cognitive systems they affect, they represent a good domain for exploration by means of longitudinal cognitive neuropsychological case studies.

This report summarizes the initial phase of a longitudinal case study that will track the development of literacy in 9 year-old male dyzygous twins, AB and BB. These twins share a diagnosis of developmental phonological dyslexia, but each has an additional area of difficulty. One (AB) has been identified with a disorder of attention. The other (BB) shows a number of signs suggesting some form of anomalous visual-spatial processing.

The goals of the initial phase of this longitudinal project include:

1. Conducting an initial assessment of aspects of *visual processing* in both children in order to identify probable neurocognitive origins of visual difficulties.
2. Compiling initial profiles of the children's *written language performance* that can be used to identify probable neurocognitive origins literacy problems.
3. Developing initial hypotheses about the interaction of these specific impairments.

Histories

Medical and Developmental Background: Both boys.

- Were born at 30 weeks gestation, but did not require NICU care
- Repeated kindergarten due to motor weaknesses, difficulty acquiring academic skills, and adjustment issues secondary to events within the family
- Had occupational therapy evaluations documenting fine motor weaknesses, but did not participate in therapy
- Have diagnoses of ADHD, for which they have taken various medications
- Received psychoeducational evaluations at age 6-11, documenting average measured intelligence, above average oral language skills and academic knowledge, and significant weaknesses in phonological awareness, decoding and word identification, and written language skills

AB:

- Received brief speech therapy for articulation problems in preschool
- Began Orton-Gillingham tutoring once a week during summer 2007

BB:

- Participated in swimming therapy to address poor muscle tone in early childhood
- Began Orton-Gillingham tutoring twice a week in October, 2006

Individual profiles

One twin (**BB**) has shown consistent signs of visually based developmental difficulties. Manifestations have included:

- History of preferring to view a variety of visual inputs (text, pictures, television) in an inverted orientation
- Frequent letter orientation errors in reading and writing.
- Informal history of difficulty with visual search that suggests the possibility of some degree of visual neglect or visual search impairment.

The other twin (**AB**) is not reported to suffer from the same visual processing difficulties, but has been diagnosed with attention-related problems that include:

- Unsystematic visual search and visual analysis
- Difficulty sustaining attention
- Impulsive response style in task performance

As noted above, the twins also differ in the interventions they have received to address their literacy development. This intervention appears to have assisted BB in acquiring a significant degree of compensatory skill for his phonological dyslexia and has also influenced the impact of his visual orientation difficulties in reading.

General profiles

BB

- BB manifests a systematic difficulty with the orientation of written symbols. Letter reversals are very common in his writing and spelling. Reading errors also include mis-identification of words due to misperceptions of letter identity.
- BB has, until recently, professed a preference for viewing a variety of stimuli in mis-oriented form. For example, he would rotate books and magazines 90-180 degrees for reading or viewing and would position himself for viewing television with his head at 19-180 degrees to the screen.
- He has recently said that he no longer finds it more comfortable to read inverted text. This may be a product of the systematic multisensory reading intervention that he has received over the last year.
- BB has also been diagnosed with a classic phonological dyslexia.

AB

- AB has been diagnosed with attention deficit disorder with primary manifestations in hyperactivity and inattention. He is also noted to be prone to hyperfocusing.
- His mother notes that he seems to have a marked talent in visual awareness, possibly linked to enhanced acuity in peripheral vision.
- AB has been diagnosed with a classic phonological dyslexia.

Our initial explorations of visual processing have included formal assessment instruments and informal experimental measures.

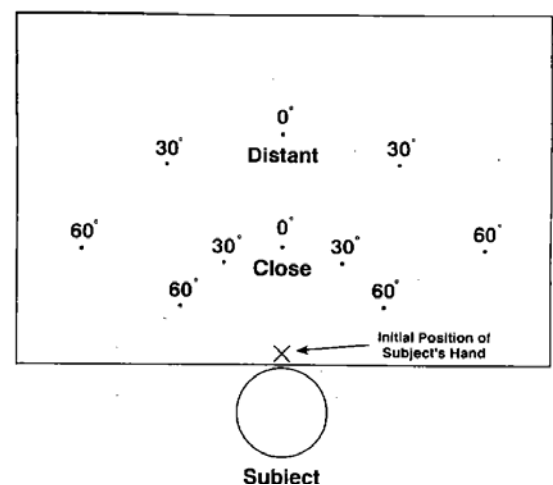
Preliminary assessment of visual processing includes a number of standardized measures of visual processing and visual memory along with selected experimental measures.

Visual Processing

Visual Localization. Both boys were assessed for their ability to localize objects in space by means of a ballistic reaching task (after McCloskey et al. 1995).

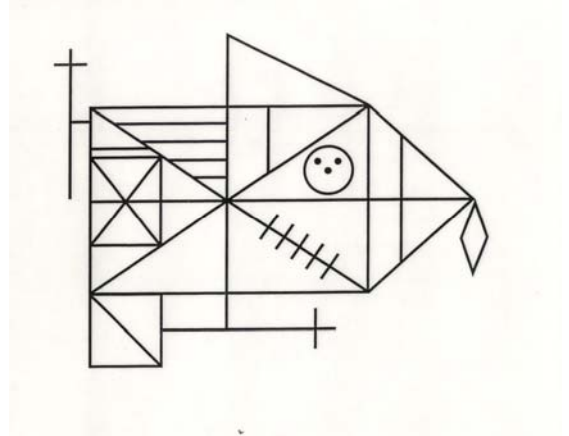
- Though BB showed signs of mirror reflection displacements on initial screening, a systematic assessment of his performance on this task did not reveal evidence of difficulty with visual-spatial object localization.
- AB was also accurate in his localizations but chose to keep his eyes pointed directly ahead, identifying and reaching for objects guided by his peripheral vision.

Conclusion: BB does not appear to suffer from an impairment of visual localization.

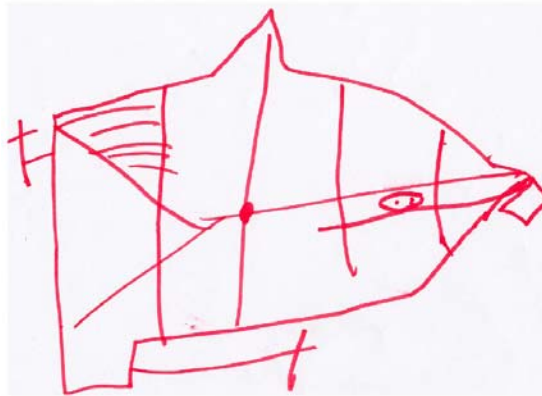


Rey Complex Figure Task. Both boys were administered the direct copy and immediate recall portions of the RCFT. Their productions are included below.

- AB's performance was essentially normal for his age. He approached the figure in a 'big picture' manner. He executed his copy rapidly, completing the task in three and a half minutes. His delayed reproduction included the primary outline but was relatively sparse with respect to internal detail. This is consistent with his weaknesses in visual working memory. [Color Sequence: Green, Blue, Black, Orange, Red].

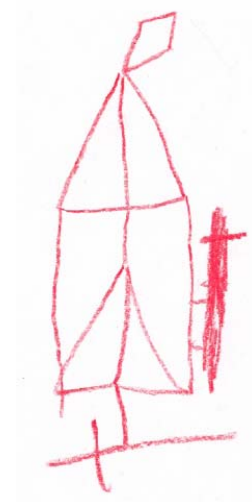
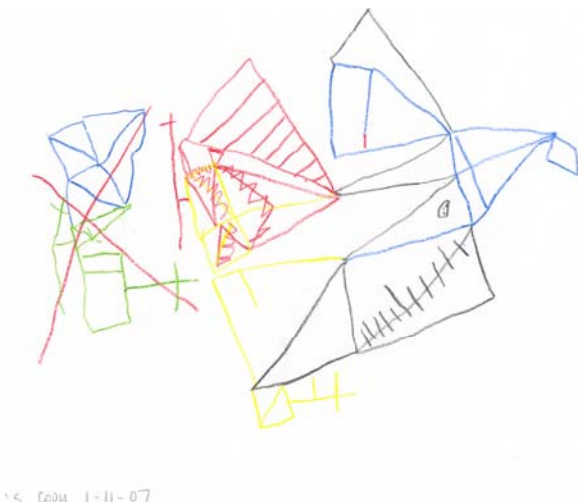


AB Copy and Recall of the RCF



- BB's performance on this task was markedly different from his brother's and reveals some of his difficulties with visual orientation. First, his production was very labored. He required more than fifteen minutes (average performance for a child his age is approximately four minute). He asked to be able to rotate the figure by 90 degrees (which was not permitted). During the copy he attempted to rotate his paper (also not permitted). He used almost constant verbal self-instruction during the copy effort. [Sequence: Green, Blue, Black, Yellow, Red]

BB. Copy and Recall of the RCF



Standardized Visual Testing

A variety of standardized tests of visual function were administered, including the motor-free TVPS-R, the Copying and Recall of Designs subtests from the DAS, and the VMI. The following tables report their scores.

Test of Visual Perceptual Skills (Revised)

	AB		BB	
	Standard Score	Percentile Rank	Standard Score	Percentile Rank
Visual Discrimination	115	84	121	92
Visual Memory	118	88	89	23
Visual-Spatial Relations	114	82	121	92
Visual Sequential Memory	99	47	86	18
Visual Closure	109	73	115	84

Differential Ability Scales (DAS)

	AB		BB	
	T Score	Percentile Rank	T Score	Percentile Rank
Copying*	47	38	38	12
Recall of Designs	40	16	35	5

* Out of level

VMI

	AB		BB	
	Standard Score	Percentile Rank	Standard Score	Percentile Rank
Visual Motor Integration	94	35	79	8
Visual Perception	102	53	119	90
Motor Coordination	60	0.8	87	20

Visual-Orthographic Processing

Letter Orientation Judgment

Lower case letters are shown in one of four orientations. Subject judges whether it is 'right' (normal orientation) or 'wrong' (mirror and/or inverted).

BB has difficulty discriminating normal from mirror reflected upright letters.

Vertical	Horizontal	AB Percent (N)	BB Percent (N)
<i>Upright</i>	<i>Normal</i>	94 (15/16)	94 (15/16)
<i>Upright</i>	<i>Mirror</i>	94 (15/16)	56 (9/16)
<i>Inverted</i>	<i>Normal</i>	94 (15/16)	100 (16/16)
<i>Inverted</i>	<i>Mirror</i>	100 (16/16)	100 (16/16)

Delayed Orthographic Copying (lower case letters)

Lower case letters are shown briefly (5 sec). Subject is asked to draw them as they were shown.

Note BB's difficulty with upright mirror reflected items.

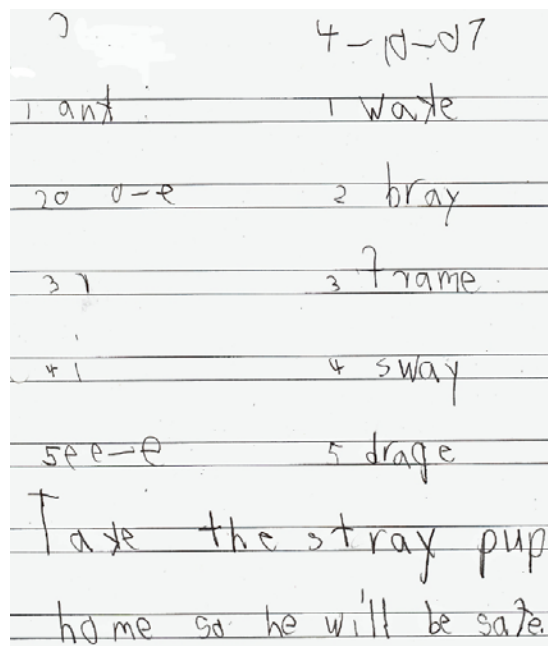
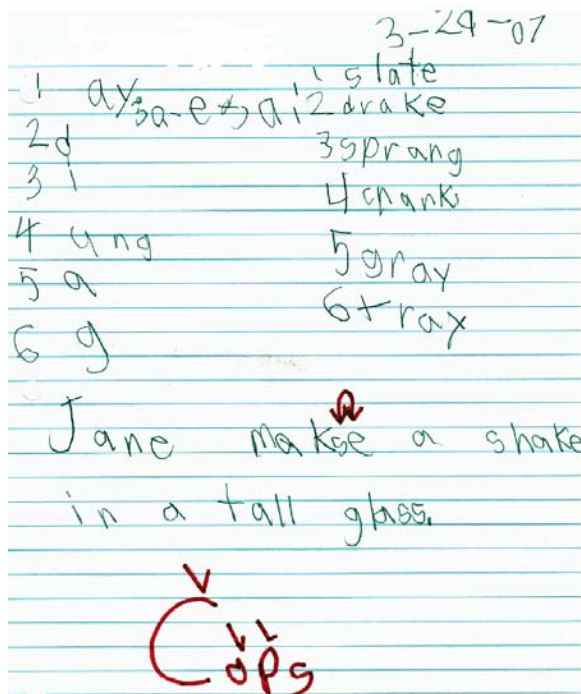
Vertical	Horiz	AB % (N)	Error Or Inv	BB % (N)	Error Or Inv
<i>Upright</i>	<i>Normal</i>	100 (6/6)	0 0	100 (6/6)	0 0
<i>Upright</i>	<i>Mirror</i>	83 (5/6)	1 0	17 (1/6)	2 2
<i>Inverted</i>	<i>Normal</i>	67 (4/6)	1 1	67 (4/6)	0 1
<i>Inverted</i>	<i>Mirror</i>	83 (5/6)	1 0	83 (5/6)	0 1

Conclusions: Both boys show evidence of focal difficulties in the visual perceptual and visual motor domains, but they appear to include some differences in origin. BB's are the more significant and include clear difficulties with visual working memory. AB shows similar difficulties on visual working memory tasks, but the origins may be somewhat different. AB's more marked attentional issues appear to affect his retention of visual details. BB, in contrast, seems to have difficulty in encoding and retrieving specific kinds of information, particularly information regarding spatial orientation.

Written Language

As mentioned, both boys have been diagnosed with a phonologically based reading disorder that has an impact on their phonological awareness, decoding, word recognition, fluency and comprehension skills.

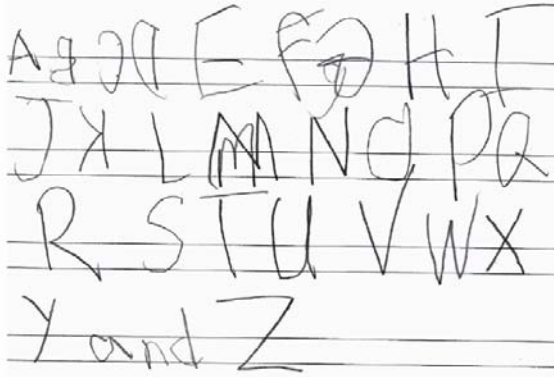
BB: This condition appears to have been most severe in BB's case. However, he has made significant progress in phonological awareness, decoding and word recognition over the past year as a result of the focused Orton-Gillingham intervention he has received. He has become very systematic in his analytic approach to written words and credits his improved reading skills with reducing his inclination to read at atypical orientations. Still, his writing is frequently marked by letter reversals. Instructional effects on the frequency of such reversals is demonstrated in a comparison of work samples before and after a two and a half week break in tutoring.



AB: The extent of AB's literacy difficulty was recognized somewhat later than BB's, due in part to AB's ability to exploit context and memory to approximate the content of written material. His overall profile is much more uneven than his brother's.

BB: Sample Alphabet

AB: Sample Alphabet



Standardized Tests of Literacy

Phonemic Awareness Test (PAT)

	AB		BB	
	Standard Score	Percentile Rank	Standard Score	Percentile Rank
Rhyming	109	72	109	72
Segmentation	92	30	88	23
Isolation	89	17	102	41
Deletion	67	1	52	1
Substitution	73	5	87	17
Blending	102	45	112	79
Graphemes	99	39	114	83
Decoding	86	17	96	32

Woodcock-Johnson III: Reading Measures

	AB		BB	
	Standard Score	Percentile Rank	Standard Score	Percentile Rank
Word Attack	98	44	102	54
Letter-Word Identification	88	21	84	14
Basic Reading cluster	92	30	91	28

TOWRE

	AB		BB	
	Standard Score	Percentile Rank	Standard Score	Percentile Rank
Sight Word Efficiency	84	14	87	19
Phonological Decoding	92	29	90	25
Total Reading Efficiency	86	17	86	17

GORT 4

	AB		BB	
	Scaled/Std Score	Percentile Rank	Scaled/Std Score	Percentile Rank
Rate	6	9	6	9
Accuracy	5	5	7	16
Fluency	5	5	6	9
Comprehension	8	25	11	63
Oral Reading Quotient	79	8	91	27

Orientation-Specific Passage Reading: Both participants were asked to read a number of short (approx. 100 word) passages under normal, inverted and mirror-reflected presentations. The results reveal similar reading rates for AB and BB for both normally oriented passages and those presented in mirror reflection. BB was less affected by inverted text. This may be residual evidence of his reported preference for reading upside down.

Text Condition	AB			BB		
	Time	Words	WPM	Time	Word	WPM
Normal	642	694	64.86	610	694	68.26
Inverted	604	465	46.19	508	465	54.92
Mirror	638	465	43.73	683	465	40.80

Conclusions

Visual Processing: Though both twins show evidence of limitations in specific areas of visual spatial and visual memory performance, the origins of that difficulty appear to be different – at least at this preliminary stage of investigation. BB’s consistent difficulty with letter orientation is associated with a marked difficulty in encoding specific orientation information. In contrast, AB’s performance appears to be accounted for in terms of visual inattention and (on occasion) impulsivity. He may also rely significantly on parafoveal vision to perform some visual tasks (e.g., ballistic reaching, design copying). This aspect of his function will be examined more carefully in the next phase of the project.

Written Language Processing: Both boys are securely diagnosed with phonological dyslexia. Their underlying impairments in this area are roughly similar in severity, but manifest rather differently for a number of interesting reasons. One of those reasons is the nature of the interventions they have received. The more intensive and systematic Orton-Gillingham tutoring that BB has received over the last year has significantly improved his performance on phonological awareness, decoding and word identification tasks. Interestingly, we also see a consistent impact of that tutoring on his accuracy in letter production, though all indications are that these improvements represent a relatively fragile compensatory skill. AB is much less proficient in decoding and much more reliant on orthographic and semantic context to guess word identities. His attentional challenges also factor into his performance profile.

The Next Phase. In the next phase of this longitudinal case study, we will be gathering comparison data from age- and grade-matched control groups and making use of experimental measures of visual and written language processing to begin to identify the specific cognitive underpinnings of the twins’ visual and literacy difficulties.

Applications: Detailed case studies based on empirically supported models of cognitive architecture are essential for developing diagnostic and instructional programs that can cope with the degree of individual variation present in our classrooms. A vital part of this approach is to develop an appreciation for the important distinctions between performance (‘behavior’) and the specific cognitive processes that give rise to that performance (Morton, 2004; Morton & Frith, 1995). A framework such as Morton’s Causal Modeling is essential for (e.g.) distinguishing compensatory skills from true fluent competence.

Atypical forms of specific cognitive disorders may not be amenable to traditional group study methodologies until they are sufficiently well understood to be able to identify individuals whose cognitive processing profiles are comparable. The case study methodology of cognitive neuropsychology is an essential technique for developing that critical understanding.

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