Good-poor reader accuracy differences in four-dot masking

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ABSTRACT

Good and poor readers differ on a variety of visual processes related to visual attention and rate of visual processing. Poor readers show increased visual attentional dwell time, evidence of left visual field "minineglect," differences on measures related to visual magnocellular processes (higher dot motion coherence threshold, contrast sensitivity for low spatial and high temporal frequency stimuli), and lower accuracy on measures of visual masking. The current study examined reader group differences in performance on one form of backward masking that is related to visual attention – four dot masking. 104 children in Grade 1, 46 at risk of reading disability, and 58 typically developing readers matched on age, gender, and home language, were administered a four-dot masking task in which target location (left and right visual fields), eccentricity (central, peripheral), and mask duration (48, 96, and 192 ms) were varied. Poor readers consistently scored lower than good readers. Poorer performance was found at the 192 ms duration condition, showing that the expected four-dot masking effect was obtained, and stronger masking was found for peripheral targets compared with central targets. Although no location effect was found in the good readers, the group of poor readers, scoring below average on a standardized reading measure, showed anomalous performance for targets in the left visual field, but not for targets in the right visual field. Results are discussed in relation to visual attentional development in good and poor readers.

HYPOTHESES

- **Four-dot (FD) accuracy will improve with age.**
- **FD accuracy influenced by mask duration and location, and by reader group (poorer performance for left field targets by poor readers)**
- **Significant relationships between FD accuracy reading ability right from Grade 1.**
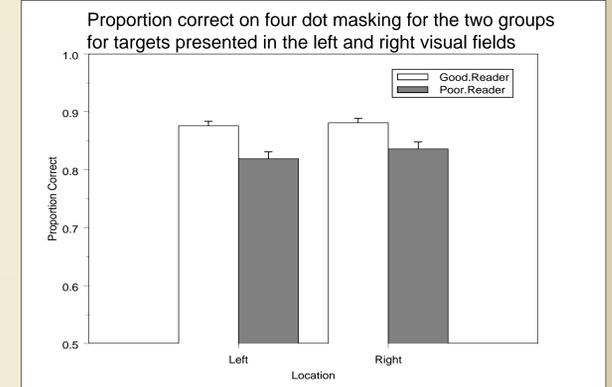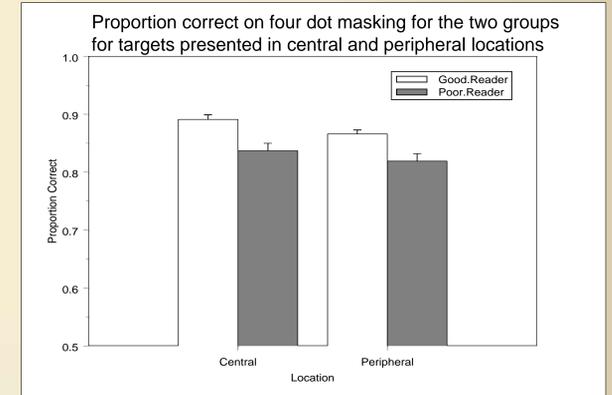- **Reader group differences persist across ages tested**

500 ms

48 ms

0, 48, or 144 ms
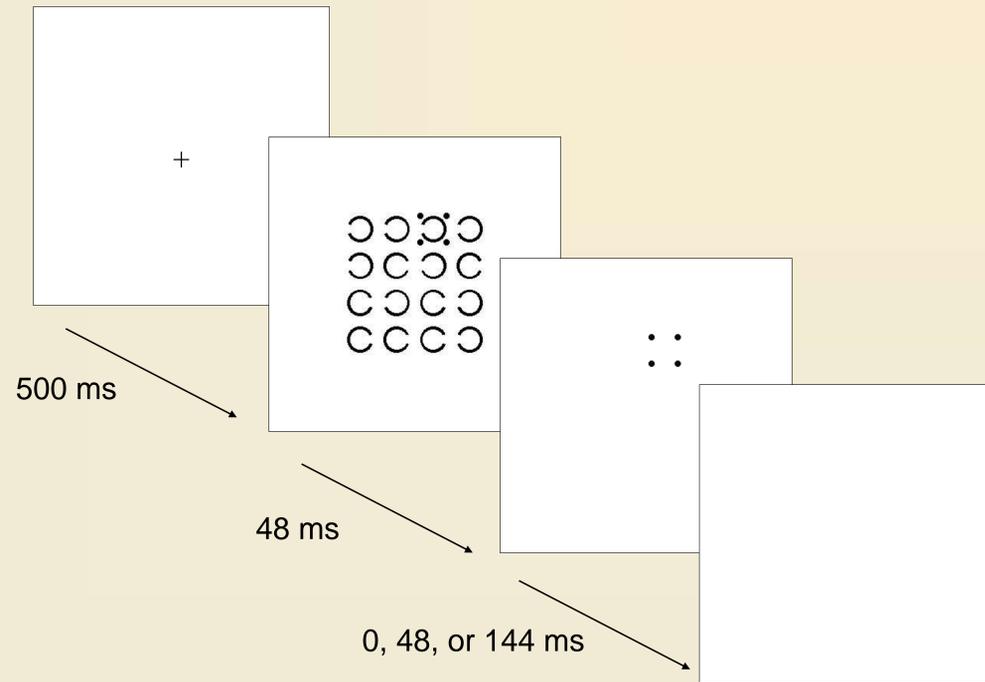
RESULTS

- Lower accuracy by poor readers overall
- Improved accuracy across waves for both groups
- Decreased accuracy with longer mask duration
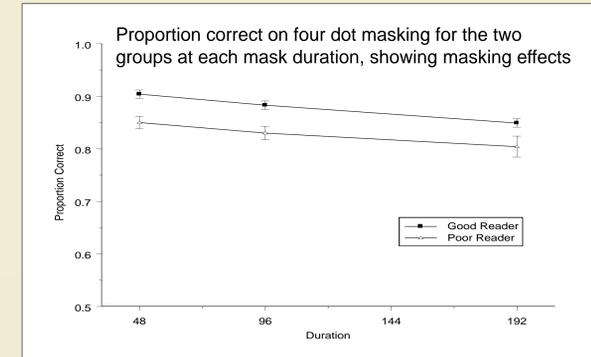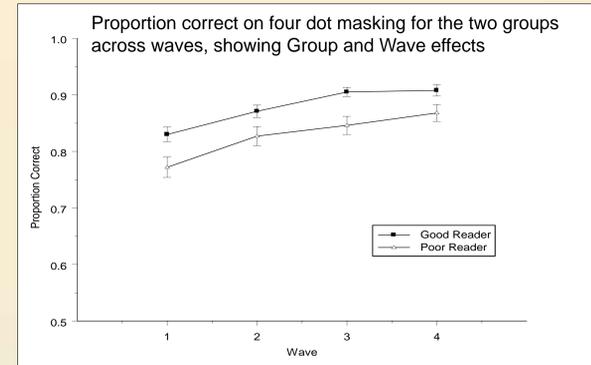
RESULTS

- Higher accuracy for central than peripheral targets
- Lower accuracy for left side targets than right side targets, for poor readers only

Proportion correct on four dot masking for the two groups across waves, showing Group and Wave effects

Proportion correct on four dot masking for the two groups at each mask duration, showing masking effects

Proportion correct on four dot masking for the two groups for targets presented in central and peripheral locations

Proportion correct on four dot masking for the two groups for targets presented in the left and right visual fields

BACKGROUND

1. Four-dot masking[1]:
  a. Target and mask onset simultaneously
  b. Mask temporally trails target
  c. Reduced target visibility from substitution of mask object for target

2. Attentional involvement[1]:
  a. Modulates masking effect - focused attention at appropriate location reduces masking, achieves perception of target
  b. Stronger masking at non-focused locations
  c. Efficiency of attention allocation reflected in four-dot masking accuracy

3. Relation to emerging readers:
  a. Motion detection ability improves to age 7 - possible influence on attentional processes[7, 8]
  b. Attentional deficit in some disbled readers[3, 4]
  c. "Left mini-neglect" in some disabled readers[2] (expect poorer four dot masking performance for targets in left compared to right visual field)

Questions

How does visual attention, indicated by masking accuracy, develop in emerging readers, and does visual attention, indicated by 4-dot masking, predict reading skills in emerging readers?

METHOD

Participants: 104 Grade One children (58 Male, 46 Female) recruited from 12 public schools in Winnipeg, Canada. Four waves of testing conducted:

Wave 1: Spring Grade 1   Wave 3: Spring Grade 2
Wave 2: Fall Grade 2   Wave 4: Fall Grade 3

Measures:

Four Dot Masking: (gap location discrimination accuracy)

Targets: 4 X 4 matrix of variously oriented C shapes (left, right gap)
- black (7 cd/m^2) on white (30 cd/m^2); each shape subtended $1.0°$ visual angle

Mask: Four dots surrounding target; simultaneous onset with targets; each dot $0.1°$ visual angle, dot distance $0.9°$ visual angle

Varied target location relative to fixation point (central vs. peripheral; left vs right visual fields); Mask duration (48 - simultaneous offset, 96, 192 ms)

Reading: Woodcock Reading Mastery Test-Revised (WRMT-R) Total Reading standard score, comprised of combined

decoding (pseudoword and single word), and

comprehension (words - antonym, synonym, analogies and CLOZE passages)

Phonological Awareness (PA): Composite score involving Elision (omitting phoneme in orally presented word) and Blending Words subtests of Comprehensive Test of Phonological Processes (CTOPP)

Table 1

Means and standard deviations in WRMT-R total reading, Wave 1 IQ, and CTOPP phonological awareness composite[a] performance for Good and Poor reader groups at each Wave of Testing (N=58 and 46 respectively)

	Good Reader	Poor Reader	Correlations:
Reading	M (SD)	M (SD)	Reading & FD[d]
Wave			
1	112.74 (8.58)	96.89 (8.62)[b]	.09 (-.05)
2	107.80 (9.39)	94.76 (7.95)[b]	.30 (.20[b])
3	111.93 (9.39)	95.17 (8.63)[b]	.42 (.38[b])
4	107.00 (9.81)	88.11 (11.57)[b]	.25 (.03)
IQ[c]			
1	102.93 (12.14)	91.59 (1.46)[b]	
PA			
1	105.88 (9.10)	96.07 (7.56)[b]	
2	101.38 (11.86)	91.78 (7.23)[b]	
3	98.76 (12.45)	90.67 (7.93)[b]	
4	100.95 (12.37)	89.43 (8.98)[b]	

Notes. a. Standard scores with population M=100 and SD=15; b. p<.001
c. Vocabulary and Matrix Reasoning composite on the WASI, p<.001, all group effects maintained after covarying IQ; d. partial correlations (controlling for PA) in parentheses

CONCLUSIONS

As children mature, four dot masking performance improves
Reading ability is related to four dot masking accuracy: poor readers are consistently worse than good readers
  - indicates a developmental deficit[4]
  - inconsistent partial correlations across waves indicates mediation via PA
   - Lower four-dot masking performance by poor readers likely a marker of neurological difference rather than causally related to reading difficulty[5], or letter-order encoding[6]
   - Evidence suggestive of "left mini neglect" in poor readers[2]: poorer performance for left- vs right-field targets for poor readers only

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