

# DYSLEXICS ARE IMPAIRED ON IMPLICIT HIGHER-ORDER SEQUENCE LEARNING, BUT NOT ON IMPLICIT CONTEXT LEARNING



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## Background

Developmental dyslexia is an unexpected reading disability characterized by poor phonological awareness skills (Bradley and Bryant, 1983) and perceptual abnormalities (Stein and Walsh, 1997). Whilst the most prominent weakness involves the acquisition of reading and reading-related skills, little is known about other domains of learning, particularly those that rely less on language. There is evidence that implicit sequence learning, using the serial reaction time task (SRTT), is impaired in dyslexia (Vicari et al., 2003), but other studies have not confirmed this finding (Kelly et al., 2002; Waber et al., 2003). The present study compared dyslexic and non-dyslexic college students on two implicit learning tasks, an alternating SRTT in which sequential dependences exist across non-adjacent elements (Howard & Howard, 1997; Howard et al., 2004) and a spatial context learning task in which the global configuration of a display cues the location of a search target (Chun & Jiang, 1998). These tasks rely on different brain regions -- higher-order sequence learning on fronto-striatal-cerebellar circuitry and contextual learning on medial temporal lobe structures. Hence, their comparison provides an opportunity to test the cerebellar theory of dyslexia (Nicolson et al 2001).

## Participants

|                               | Control        | Dyslexic       |
|-------------------------------|----------------|----------------|
| Gender                        | 8 F, 4 M       | 5 F, 6 M       |
| Age                           | 20.25 (1.14)   | 20.59 (1.46)   |
| Handedness*                   | 93.82 (11.80)  | 61.34 (52.25)  |
| Real Word Reading (W-J WI)*** | 133.00 (17.04) | 102.09 (14.61) |
| Non Word Reading (W-J WA)**   | 116.67 (15.23) | 98.54 (8.85)   |
| Digit Span Combined (WMS-III) | 108.33 (14.82) | 99.09 (10.44)  |
| Spelling (TWS)***             | 119.58 (10.41) | 99.18 (9.68)   |
| Phoneme Awareness® (TAAS)*    | 12.75 (.45)    | 11.73 (1.42)   |
| Rapid Automatized Naming*     | 102.00 (10.32) | 88.00 (16.05)  |
| WASI Vocabulary*              | 70.00 (8.15)   | 59.18 (10.84)  |

p < .05 \*  
 p < .01 \*\*  
 p < .001 \*\*\*  
 @ raw score, others standard scores

## Interpretation and Conclusions

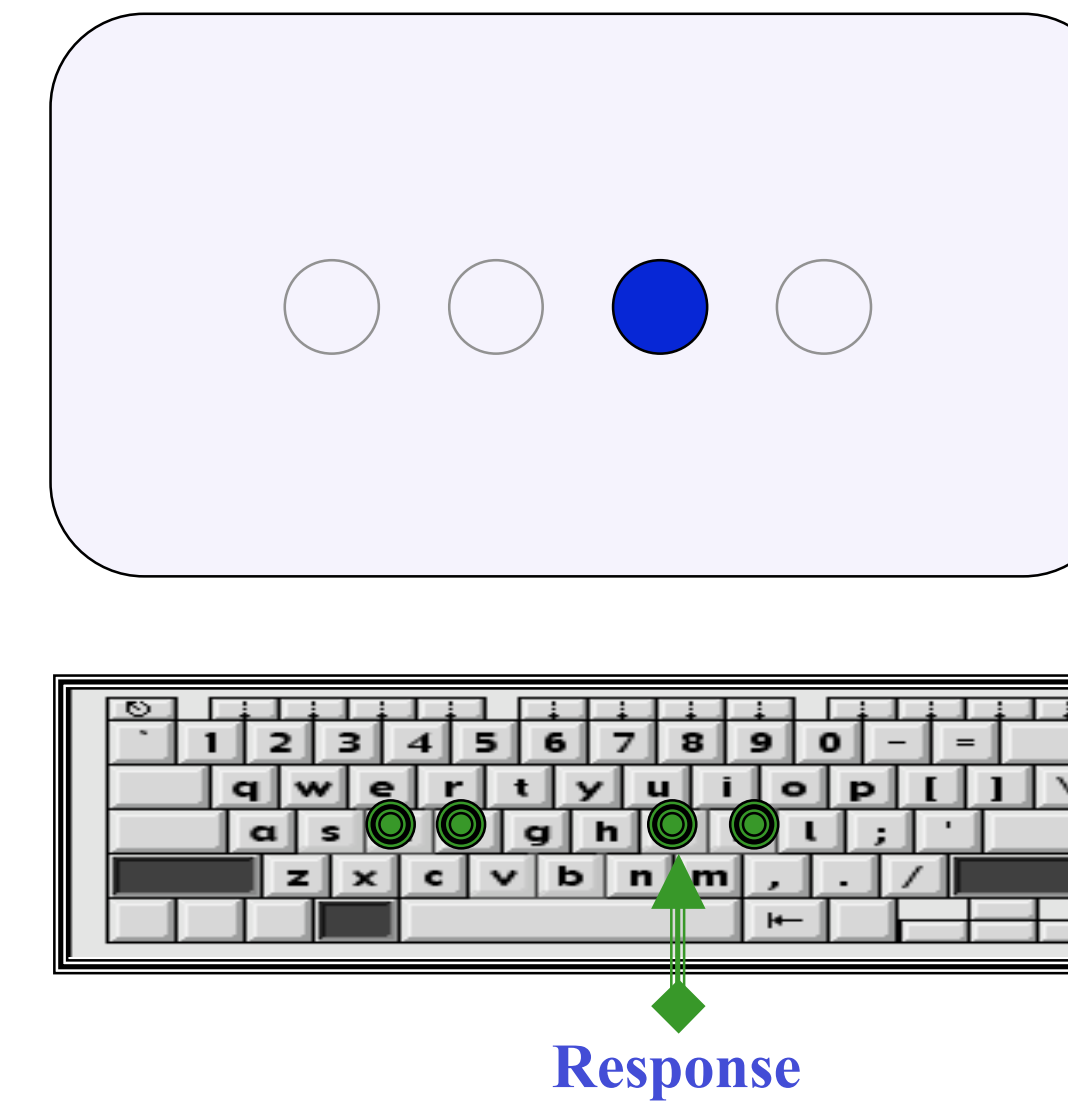
Results revealed a double dissociation: dyslexics showed impaired sequence learning, but a clear trend toward superior spatial context learning. Consistent with this group difference, there was a significant positive correlation between reading skill measures (single real and nonword reading) and sequence learning, but a significant negative correlation between these measures and spatial context learning. Tests of explicit knowledge confirmed that learning was implicit for both groups on both tasks. These findings are consistent with previous evidence that these implicit learning tasks are based on different underlying brain systems and that sequence learning, a task outside of the domain of reading, is impaired in dyslexia.

Society for Neuroscience, San Diego, CA 10.26.2004  
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 Supported by NIH Grants R37-AG15450 and HD40095

## Alternating Serial Reaction Time Task

### Learning

- Repeating sequence
- Alternates with random events (e.g. 1r2r3r4r...)
- 8 epochs of 20 blocks each
- Push key under stimulus

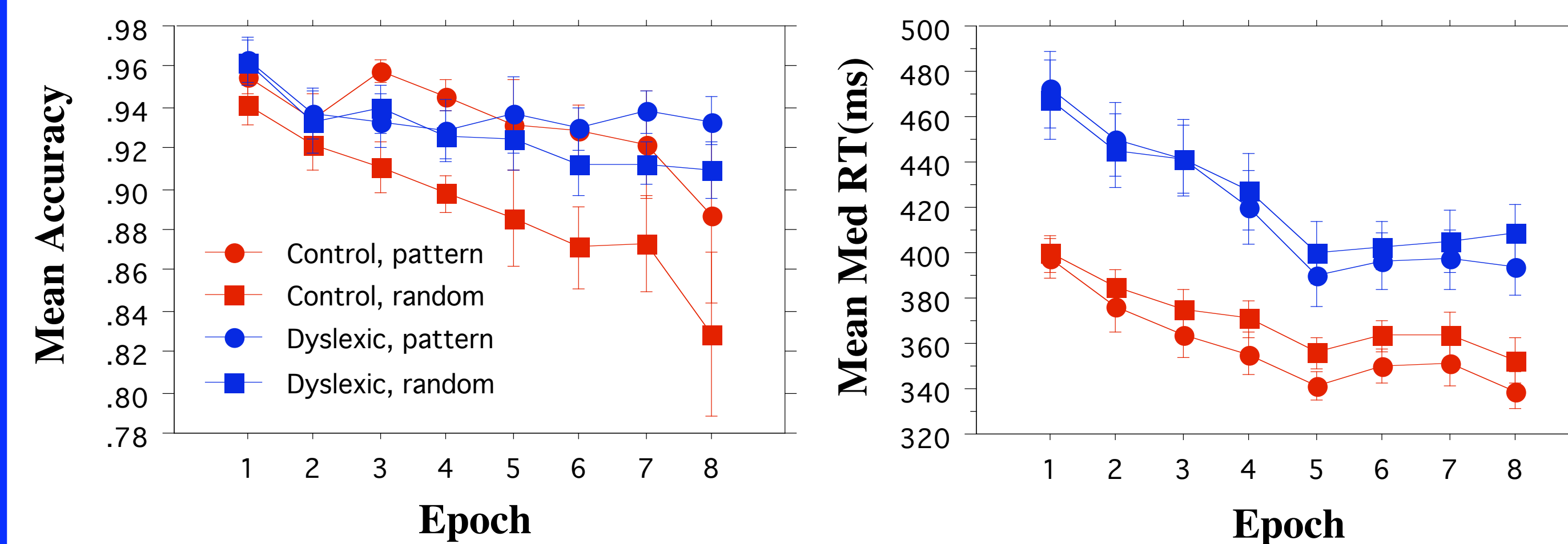


### Explicit Tests

- Recognition test
- Card sorting
- Interview

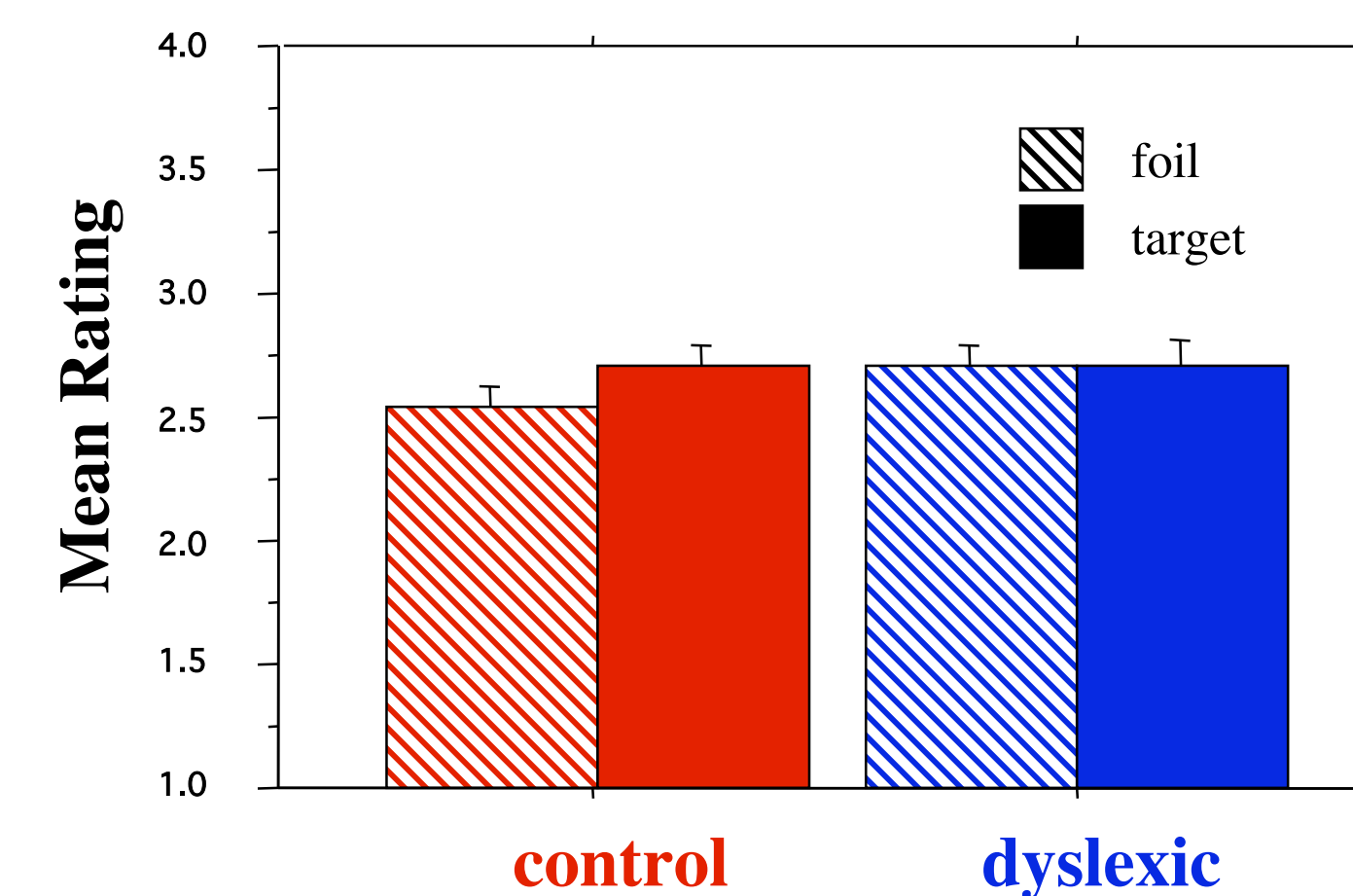
### Learning:

- Both groups learn regularity
- But *less* learning in dyslexic group



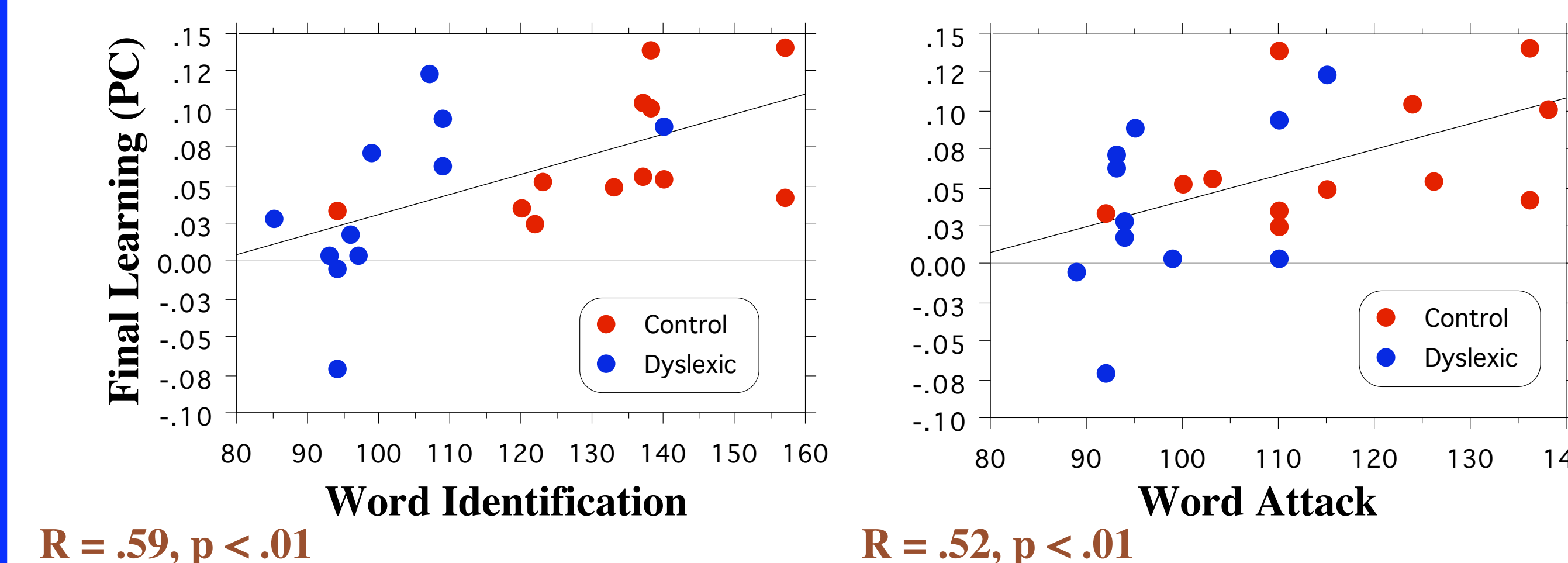
### Explicit Recognition:

- Learning is implicit



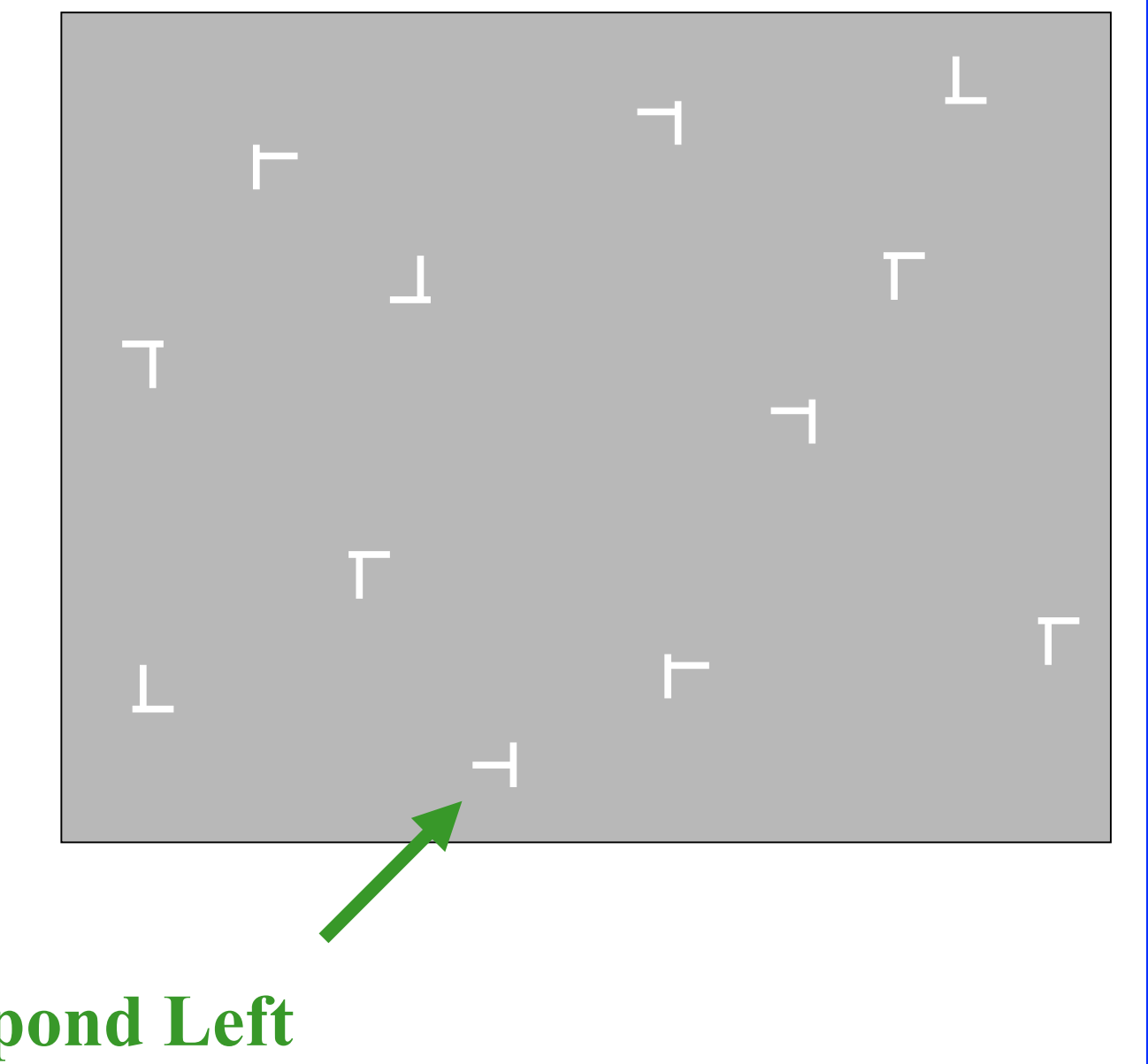
### Individual correlations:

- *Positive* correlation between single word reading and learning



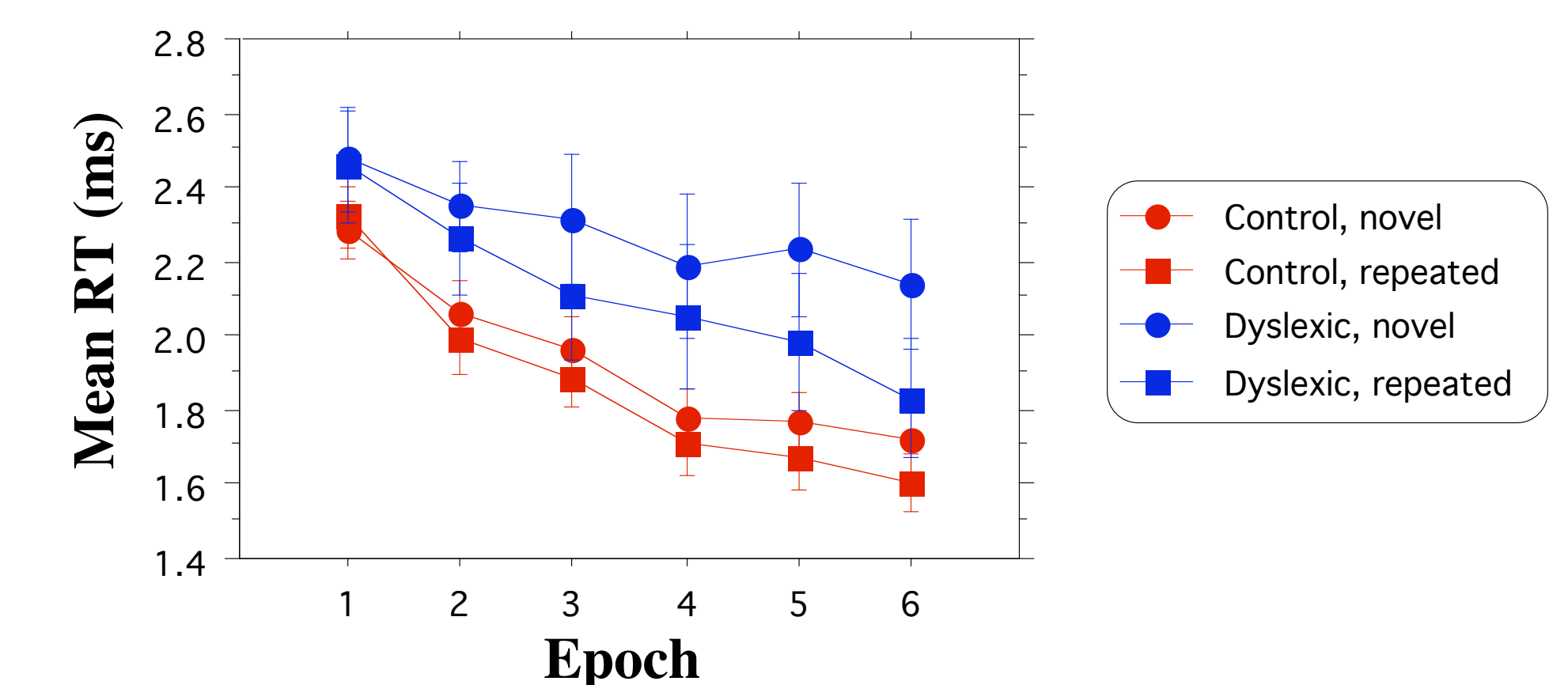
## Contextual Cueing Task

- Fixation dot
- Visual array of 12 items
  - 11 distractors (L's--orientation varies)
  - 1 target (horizontal T)
- Task to find T, respond **direction**
- Auditory feedback
- 24 trials/block
  - 12 **repeated** configurations
  - 12 **new** configurations
- On repeated trials
  - Configuration predicts **location** of T
  - NOT direction of T
- Six epochs of 5 blocks



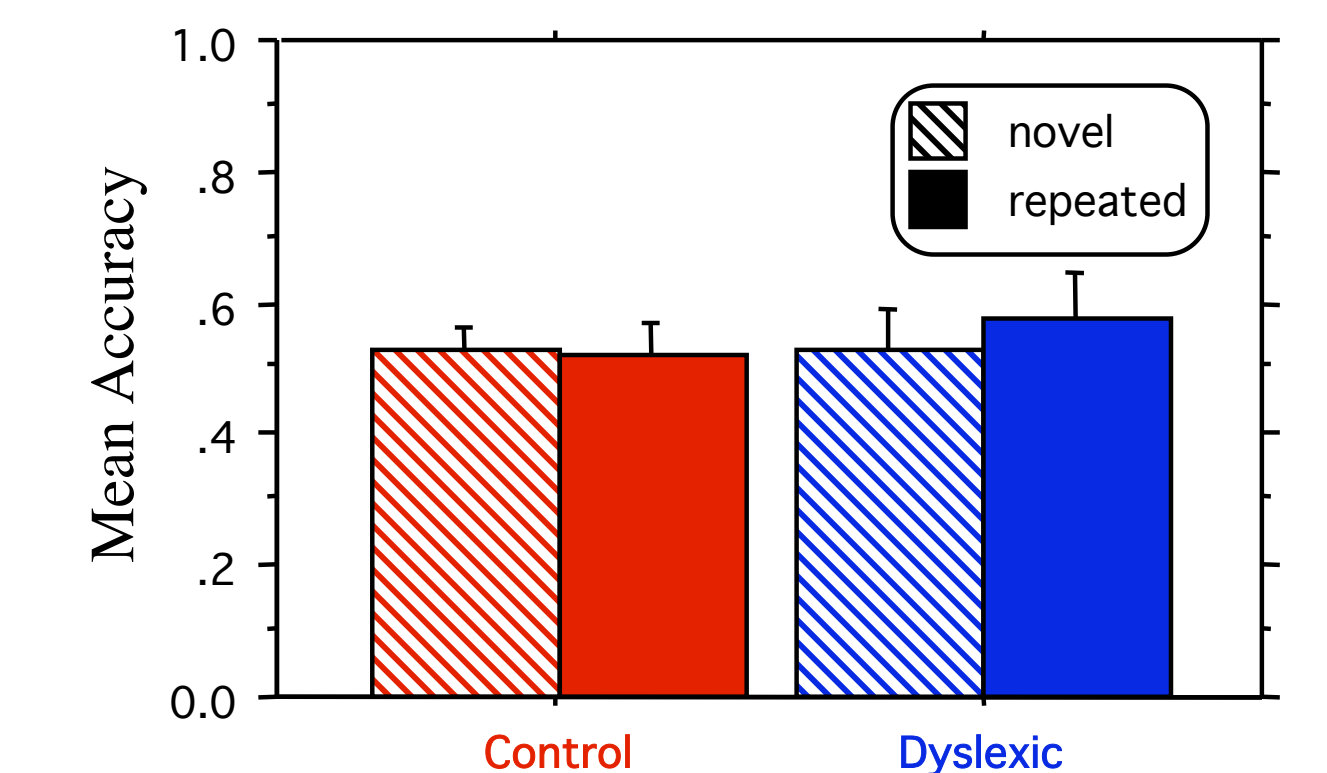
### Learning:

- Both groups learn regularity
- Trend for *more* learning in dyslexic group



### Explicit Recognition:

- Learning is implicit



### Individual correlations:

- *Negative* correlation between single word reading and learning

