# An investigation of task constraints on attentional orienting in adults with dyslexia

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## Introduction

Attentional processes have been shown to be necessary for the development of the reading system, and also for competent reading. Individuals with dyslexia have generally been reported to respond more slowly than those without dyslexia to targets on spatial cueing tasks (e.g., Brannan & Williams, 1987; Facoetti et al., 2000; Roach et al., 2004). Reduced sensitivity to cueing suggests that cues are not efficient at attracting attentional resources. However, poor use of cues has not always been reported. On a detection task, Buchholz and Aimola Davies (2005) found that adults with dyslexia showed a lack of cue effect in the periphery (6.5° from fixation), but there was a cue effect in the parafovea (3° from fixation). On a discrimination task, Buchholz and Aimola Davies (2006) found that the ability of these same adults with dyslexia to orient attention in the fovea (1° from fixation) was impaired. In contrast, Bednarek & colleagues (2004) found children with dyslexia had no difficulty orienting at this location. These seemingly contradictory findings may relate to differences in methodology.

## Aims

This study aims to extend previous research examining attentional abilities in dyslexia. Characteristics of stimuli (cue type and size, SOA, visual field, eccentricity) are manipulated within spatial cueing tasks to examine the effect of change on performance, and therefore limitations of attention. No study has previously examined all these variables in one sample.

Furthermore, both group and individual-case to control-group comparisons are made to examine the nature and distribution of individual differences.

## Experiment 1

*Participants*
Five adults who currently met the criteria of dyslexia (ADys) participated in this study. Phonological difficulties were shown by all. The control group consisted of sixteen adults with no history of reading difficulties.

*Procedures*
Detection of a 0.5° target, with and without a 1.0° spatial cue, is examined at three eccentricities along the horizontal and vertical meridians.

Participants were instructed to maintain fixation throughout each block of trials, and trials were repeated if they contained an eye movement greater than 1° of visual angle (VA).

A novel spatial cueing task was presented (see Figure 1). There were 5 blocks of trials with 144 trials per block, divided into: 10% catch trials (cue with no target), 80% valid (cue and target in same location), 10% nocue (target with no cue).

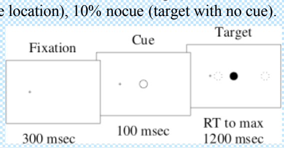


**Fig 1:** *An example of the valid cue procedure for stimuli presented on the right of fixation. Broken circles represent possible locations for stimulus presentation.*

### Results

•Main effect of visual field: $F(3,57) = 7.1$, $p < 0.001$, indicating slower RTs along the vertical meridian.

• Cue type x eccentricity x group interaction was significant ($F(2,38) = 3.6$, $p < 0.05$). The ability to detect the target improved with cueing for both groups at all eccentricities.

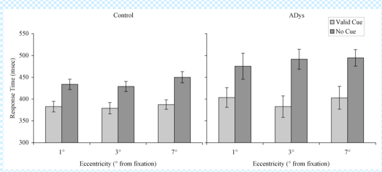

**Fig 2:** *RTs for the control and ADys groups as a function of eccentricity for each cue condition. Vertical bars represent SEM.*

- No cue : main effect of eccentricity ($F(1,19) = 5.8$, $p < 0.05$) indicating that RT increased as eccentricity increased.
- Valid cue : eccentricity x group interaction ($F(1,19) = 8.9$, $p < 0.01$). RTs decreased across 1° and 3° eccentricities for the ADys group (25 ms, $t(4) = 7.3$, $p < 0.01$, and all cases) but not for the control group (4 ms, $t(15) = 1.3$, $p < 0.2$). A significant increase in RTs occurred across 3° and 7° for both groups.

## Experiment 2

*Procedures*
SOA and cue size were varied at three eccentricities, along the horizontal and vertical meridians, to examine the effect of these changes on adjusting and maintaining attentional focus.

Three sessions separated by a 30 minute break were conducted, with each session testing a single cue size (0.5°, 1.0°, 3.0°). There were 5 blocks of trials with 232 trials per block, divided into 32 catch trials and 200 valid trials). The 3.0° cue size was only presented at 3.0° and 7.0° eccentricities.

### Results

*•At 1° and 3° eccentricities*
Interactions:
SOA x eccentricity x VF x group, $F(3,57) = 5.8$, $p < 0.01$.

LVF, RVF and TVF: RTs faster at long SOA, but improvement greater for the controls than ADys group
BVF: same degree improvement for both groups at long SOA.

Eccentricity x cue size x group, $F(1,19) = 10.1$, $p < 0.01$. (Fig 3).
ADys:
- 1° eccentricity, RT slower with increased cue size (21 ms, $t(4)=5.4$, $p < 0.0$).
- 1° cue, RT faster with increased eccentricity (12 ms, $t(4)=4.3$, $p < 0.01$).

Controls: no significant change in performance at either eccentricity or for either cue size.

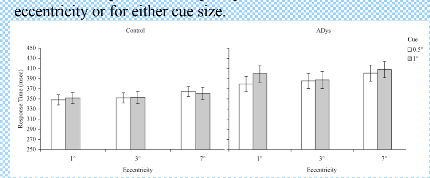

**Fig 3:** *RTs for the control and ADys groups as a function of eccentricity for each cue condition.*

*•At 3° and 7° eccentricities*
Interactions
SOA x eccentricity x VF x group, $F(3,57) = 3.5$, $p < 0.05$

LVF and BVF: same degree improvement at the long SOA.
RVF and TVF: As for 1° and 3° eccentricities.
RVF only:RTs slower for the ADys group at 7° (14 ms, $t(19)=2.8$, $p < 0.05$).

Eccentricity x group, $F(1,19) = 6.7$, $p < 0.05$. (Fig 3)

ADys only: increase in RTs across 3° and 7°.

## Experiment 3

The ability to reduce, maintain and shift attentional focus (**Attentional Orienting**) is explored by introducing an uninformative (invalid) cue condition.

*Participants*
Same dyslexia group and 11 control participants from Experiment 1.

*Procedures*
As for Experiment 2 with these exceptions: invalid cueing condition included, stimuli only presented in LVF and RVF, and cue size randomly presented within each session.

Three sessions separated by approximately 10 minute breaks were conducted, with each containing 3 blocks of 324 trials: 60% valid, 30% invalid and 10% catch. For the two smaller cue sizes (0.5° and 1°) presented at 3° there were two possible invalid target positions: 1° and 7° eccentricity.

### Results

*•At 1° and 3° eccentricities*:
Interactions
SOA x cue size x group, $F(1,14) = 7.5$, $p < 0.05$ (Fig 4).

ADys group: orienting performance only comparable to controls at 100 ms SOA for 1° cue, $t(14)=1.2$, $p > 0.2$.

Cue size x eccentricity x group, $F(1,14) = 14.0$, $p < 0.01$ (Fig 5). ADys group: orienting performance only comparable to controls at 1° eccentricity for 1° cue, $t(14)=1.5$, $p > 0.1$.

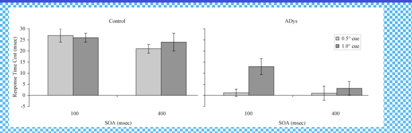

**Fig 4:** *RT costs for the control and ADys groups as a function of SOA and cue size.*

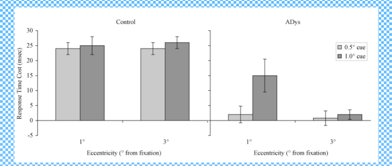

**Fig 5:** *RT costs for the control and ADys groups as a function of eccentricity and cue size.*

*•At 3° and 7° eccentricities*
Interactions
Eccentricity x cue size x SOA x group, $F(2,28) = 4.7$, $p < 0.05$, (Fig 6).
ADys: orienting performance only comparable to controls in the 100 ms SOA condition, with a 1° or 3 ° cue size at 3° eccentricity, and with a 3° cue size at 7° eccentricity ($p > 0.1$).

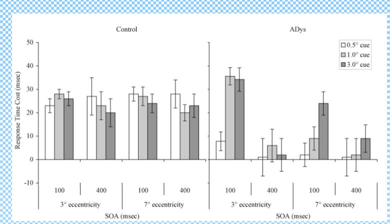

**Fig 6:** *RT costs for the control and ADys groups as a function of eccentricity, SOA and cue size.*

•VF x cue size x group, $F(2,28) = 4.7$, $p < 0.05$, (Fig 7).
ADys: orienting performance only comparable to controls for the 1° and 3° cue sizes in the LVF, and the 3° cue size in the RVF ($p > 0.1$).

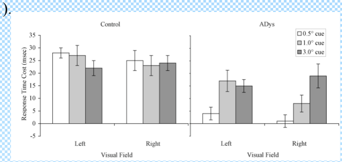

**Fig 7:** *RT costs for the control and ADys groups as a function of VF and cue size.*

*Attention drift shown with 1° cue: (Fig 8)*
ADys: Attentional focus seems to 'drift' toward fixation, requiring a change in direction for target detection at 7° eccentricity (thus a high RT cost = 36 ms), while the drift encompasses the target at 1° eccentricity (thus a low RT cost = 2 ms).

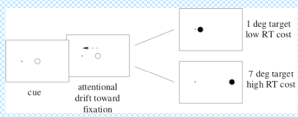


**Fig 8:** *Diagram of attentional drift from 3° eccentricity for the 1° cue.*

## Discussion

Attentional difficulties in dyslexia appear related to the process of orienting, specifically to reducing and maintaining attentional focus. These difficulties appear worse in the periphery, particularly in the right visual field. A larger focus is suggested by the presence of orienting only with larger cues, and the poorer performance with the 1° cue closer to fixation, possibly due to increased interference from the fixation cross. Poor maintenance is suggested by performance deficits at long SOA, and an apparent drift with the 1° cue at short SOA. Reading may be compromised since a difficulty in automatic orienting may affect the planning of eye movements, while a difficulty reducing and maintaining attention may hinder decoding due to increased distraction from nearby text. This research also indicates that finding an orienting deficit in dyslexia depends on stimulus characteristics.

**References**
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