Many adults and children with dyslexia also have problems with lower-level sensory, attentional, or motor tasks. In particular, there may be problems with auditory processing\(^1\), visual motion processing\(^1\), visual-spatial attention\(^1\), and motor control\(^2\). However, whether these low-level sensory or motor problems underlie dyslexia, or merely co-exist with remains a topic of much debate\(^3\). If these sensorimotor problems do underlie dyslexia, they should be demonstrable in young children, before they learn to read. Early identification of dyslexia is important because targeted interventions appear to be most effective when introduced early in childhood; however, there is currently little evidence from longitudinal studies to explore the antecedents of dyslexia in children. The few longitudinal studies published on this topic do indeed suggest that low-level sensory deficits may predict later reading difficulties in young children\(^4\).

**Aims**

- We have developed a simple tablet-based “dot-to-dot” (DdT) task which we believe taps into the visual-spatial attention and visual-motor integration systems, and which may help identify children at higher risk of dyslexia earlier and more quickly than existing tests. Unlike existing tests, our DdT does not depend on any phonological or general knowledge; as such, it could be developed for use in young children before they fail to learn to read, from a wide range of cultural backgrounds, and in whom English may not be the first language.
- Here, we present preliminary data from the first phase of a new longitudinal study of pre-school and primary aged children in Edinburgh, UK, to explore whether performance on our DdT task can be used to predict later reading success.

**Methods**

**Participants**

So far, 70 children (36 females, 34 males) aged between 4 yrs, 10 months and 8 yrs, 4 months (mean = 6 yrs 4 m; SD = 1 yr 1 m) have taken part from a single primary school in Edinburgh. Future testing will encompass pre-school children (ages 4-5 yrs), and schools with different demographic profiles to ensure the sample is representative of the wider population.

46 adults (12 females, 34 males), aged between 17 and 46 years (mean = 23.6 yrs; SD = 6.50) were recruited from the staff and student population of Edinburgh Napier University. Of these, 19 had been identified as dyslexic by the University’s Student Support team, and 27 stated they were not dyslexic.

**Tests**

Visual-Spatial-Motor Skills were measured using our “dot-to-dot” task (see below). In addition, children completed a short battery of tests to measure phonological and other cognitive abilities, including: (1) the Child’s test of dyslexia screening tasks; (2) phonological awareness (DEST-2 / DST-1); (3) a rapid automated naming (DEST-2 / DST-1); (4) working memory (digit span; WISC/WPPSI-IV); (5) verbal reasoning (similarities; WISC/WPPSI-IV); (6) fluid/perceptual reasoning (block design & matrix reasoning; WISC/WPPSI-IV); (7) fine motor skills (bead threading; DEST-2). Data collection in adults for equivalent tests is currently underway.

**Procedure**

All data collection in children was carried out by authors BP and ABB. Children were tested individually over two sessions, lasting 20-30 min each, in a quiet room at their school. During the first session, children completed the dot-to-dot task and LUCID screening test; during the second, they completed the rest of the cognitive tasks. Test order was randomized across participants.

All the adults’ data were collected by IMK. The dot-to-dot task was completed by all participants, in a single session lasting 50 - 60 minutes: data collection for the other cognitive tests is ongoing.

**The Dot-To-Dot Task**

Participants were asked to look at a sequence of dots on a display monitor and draw a line as quickly and accurately as possible between them on an adjacent touch-screen tablet using a stylus (see Figure 1). Single dots were presented sequentially at a random order, as soon as the stylus moved sufficiently close to the previous dot. Participants completed three trials for each of 8 and 9 dot displays, using both the dominant and non-dominant hand. The sequence of trials was randomized.

We measured: (1) the maximum error between the drawn line and the line of best fit in the first sector of the pattern (DdT First Sector Max Error); (2) the total error between the drawn line compared to the line of best fit over the whole pattern (DdT Total Error); and (3) the time taken to complete the task (DdT Time).

**Results & Discussion**

1. **Adults: Dot-to-Dot (DdT) Task**

Performance on our dot-to-dot task in adults with and without dyslexia are shown in Figure 2, for the dominant sector, and Table 1. Dyslexic adults made significantly greater mean errors in the first sector of the pattern, on average, compared with non-dyslexic (t(22) = 2.62; p < 0.01; 2a). Adults with dyslexia also made more errors over the pattern as a whole (2b), and took less time to complete the task (2c), on average, compared those without dyslexia, but these differences were not significant.

These results suggest that accuracy on our dot-to-dot task is lower in adults with identified dyslexia – at least in the first sector of the pattern – and suggest value in exploring young children’s performance on this task to see if it can predict reading success.

2. **Children: Dot-to-Dot and Other Tasks**

In children, the First Sector Max Error measure of performance on our dot-to-dot task was significantly correlated with both Phonological Awareness and Rapid Automated Naming (RAN), arguably the two most powerful predictors of reading success in children, as well as both working memory (Digit Span) and perceptual reasoning (Matrix Reasoning).

Table 1: Pearson’s correlations. * indicates that the correlation is significant at the two-tailed test.

Groups of children classified as “high” (n=18) and “low” (n=32) risk of dyslexia on the basis of their scores on LUCID-Rapid were compared for each of the tasks (see Figure 3). Independent-samples t-tests revealed that children deemed at high risk of dyslexia made significantly greater maximum errors in the first sector of the pattern (DdT First Sector Max Error) and made more errors over the whole pattern (DdT Total Error), compared with low-risk children; however, there was no significant difference in time taken to complete the task.

The findings that DdT First Sector Max Error was significantly greater in both adults with identified dyslexia and children at high risk of dyslexia, and correlated robustly with phonological awareness being strong, suggests the task may be useful in predicting reading success. We will revisit these children in future years to examine whether or not the DdT task can reliably predict reading and writing success, and whether poor performance on the DdT task is best explained by problems in the underlying visual-spatial-motor system(s) that may underlie dyslexia in many individuals, or by factors such as poor motor or cognitive skills alone.

**Conclusions**

- Both adults with dyslexia, and children deemed at high risk of dyslexia, performed significantly worse than their non-dyslexic / low-risk counterparts on our dot-to-dot task – especially in the first sector.
- Performance on our dot-to-dot task is significantly correlated with phonological awareness and RAN, which suggests the task may be useful in predicting reading success.
- Longitudinal data will explore whether or not deficits in performance on the dot-to-dot task precede dyslexia difficulties; so, if we establish that low performance on this task is suggestive of dyslexia, we may use it as a screening tool in children and adults from a range of linguistic backgrounds.

**References**


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