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APPENDIX A: Processing Speed

Kail (2000) described *information processing speed* as a “key element in people’s ability to think, to reason and remember” (Kail, 2000, p. 52). Information processing speed increases exponentially during childhood (e.g., Kail, 1991) and decreases in older age (e.g., Salthouse, 1996). In much of the scientific literature, the term *information processing speed* is used interchangeably with *cognitive* and *mental processing speed* or just *processing speed*. The term *efficiency*, that implies work done, sometimes replaces the term *speed* that can imply distance travelled over time.

Processing Speed and Intelligence

Central to some concepts of general intelligence is the g factor. Galton (1883) held that there were heritable individual differences in mental ability. Spearman (1904, 1927) reinforced Galton’s concepts with factor analysis and introduced the concept of g. Spearman’s evidence came from a *positive manifold,* a term for tests that correlate positively between the results of a wide range of tests, which included sensory discrimination. He proposed a two-factor theory in which tests reflect g and another test-specific variable, s. Subsequently, Thurstone (1938) identified Perceptual Speed as one of seven primary mental abilities, of which the others were Word Fluency, Verbal Comprehension, Spatial Visualization, Number Facility, Associative Memory and Reasoning. Later, Raymond Cattell (1963) proposed two broad abilities that contributed to g. These were Gc and Gf. Gc was acquired knowledge dependent on cultural factors, often assessed by culturally weighted verbal tasks. Gf was biological and neurological factors that interact with the environment; enable the individual to think and act *quickly*, solve problems and encode in short-term memory. Horn (1976) extended Cattell’s framework to form The Cattell-Horn model. This model included Gs, speed of processing, ability to perform automatic cognitive tasks under time pressure over minutes; and Gt, decision and reaction time. The Cattell-Horn-Carroll (CHC) model is Carroll's (1993, 1997) revision of the Cattell-Horn model. Carroll factor analysed many psychometric and chronometric tests. He ordered cognitive abilities into three *strata* or levels. Level III of the CHC model contains g. Level II has eight abilities that contribute to g, these include Gs and Gt; and Level 1 has 70 narrow abilities. Indeed, there have been some suggestions that g *is* information processing speed or even nerve conduction velocity (e.g., Brand, 1996). Carroll thought that there was "generally a low or even zero correlation with levels of intelligence" (Carroll, 1993). Others have come to the same conclusion (e.g., Rabbitt, 1996). In their critique, entitled "Mental Speed is not the 'Basic' Process of Intelligence", Stankov and Roberts (1999) explored and summarised reasons for doubting a central role for speed in intelligence. Indeed these authors provided evidence for a cognitive speed factor related to Gf alone. As with Carroll, the relatively small, uncorrected correlations between diverse tests of processing speed and intelligence was among their doubts. Sheppard and Vernon's (2008) review of cognitive speed's relationship to intelligence, across 1146 correlations (172 studies), between 1955 and 2005, showed a mean correlation of r (53,541) = − .24, s = .07. A recently revised CHC model has a flexible approach to g: "users are encouraged to ignore it [g] if they do not believe that theoretical g has merit particularly in applied clinical assessment contexts" (Schneider & McGrew, 2012, p. 111). Table A1 summarises some influential works since the late 1800s that have integrated speed into theories of human cognitive abilities.

Schneider and McGrew's (2012) revised CHC model maintains Speed and Efficiency (Table A2) as one of its six conceptually grouped broad abilities. In Speed and Efficiency, items for Gt are presented one at a time, whereas for Gs items belong to a series that require sustained concentration, fluency and attention. This difference is important and may be why Gs correlates more strongly with g than does Gt (Schneider & McGrew, 2012). Gt contains inspection time in this framework although inspection time has an affinity with Gs (Section 2.3.1; O'Connor & Burns, 2003).

Table A1

Speed in Theories of Human Cognitive Abilities

Date	Author	Concept
1927	Spearman	High correlation between general intelligence (g) and RT.
1938	Thurstone	Speed is one of seven primary mental abilities.
1941, 1963	Raymond Cattell	Crystallised intelligence (Gc) and fluid intelligence (Gf) comprise g. Gf represents factors that include *quick* thinking.
1965, 1976	Horn	Gs is speed of processing, the ability to perform automatic cognitive tasks under time pressure over minutes. Gt, includes DT and RT.
1993 1997	Carroll	Three stratum theory of which Level II contains among others: Gs, broad cognitive speediness, speed of performance based typically on timed overlearned tasks, has a fixed interval are easy and require little complex thought. Has Level I abilities of perceptual speed, correct decision speed and writing/printing speed. Gt, speed of decision to stimuli, measured in milliseconds or seconds and typically, chronometric tasks such as DT and RT.
2012	Schneider & McGrew	Cattell-Horn-Carroll model reviewed. No g but 16 broad ability factors in six groups one of which is *Speed and Efficiency,* which contains: Gs, ability to perform simple, repetitive tasks quickly and fluently Gt, simple and choice RT, semantic processing speed, mental comparison speed and inspection time; Gps, psychomotor speed, speed and fluency of physical body movements

Note. DT = decision time; RT = reaction time.

Apart from the CHC model, there are other important frameworks for intelligence testing. However, although elementary cognitive tasks (ECTs), as Gt, do not relate particularly to Gc, they often significantly correlate negatively with Gf. Gf is often assessed by visuospatial puzzles but simple verbal tasks that rely on familiar words also reflect Gf (Johnson & Deary, 2011). Furthermore, conceptual frameworks, which do not include speed as an important component, are Gardner's theory of multiple intelligences (Gardner, 1983); R.J. Sternberg's triarchic theory (R. J. Sternberg, 1985, 2003); and Goleman's theory of emotional intelligence (Goleman, 1995).

Table A2

Details of Speed and Efficiency after Schneider and McGrew (2012)

Broad ability	Narrow ability
Gs Performance for simple, repetitive cognitive tasks quickly and fluently. Predictor of individual differences once a task has been mastered.	*Perceptual speed:* The speed at which visual stimuli can be compared for similarity or difference *Rate of test-taking:* The speed and fluency with which simple cognitive tests are completed *Number facility:* The speed at which basic arithmetic operations are performed accurately *Reading fluency:* The rate of reading text with full comprehension *Writing speed:* The rate at which words or sentences can be generated or copied
Gt Decision speed, the speed of making very simple decisions or judgments for items presented one at a time.	*Simple RT:* RT to the onset of a single stimulus *Choice RT:* RT when a very simple choice has to be made *Semantic processing speed:* RT when a decision requires very simple encoding and mental manipulation of the stimulus content *Mental comparison speed:* RT where stimuli has to be compared for a particular characteristic *Inspection time:* The speed at which differences in stimuli can be perceived
Gps Psychomotor speed, the speed and fluidity of physical body movements.	*Speed of limb movements:* The speed of arm and leg movement *Writing speed:* Speed at which written words can be copied *Speed of articulation:* The ability to rapidly perform successive articulations with the speech musculature *Movement time*

Note. Number, reading and writing depend on Glr, which is long-term storage and retrieval fluency.

APPENDIX B: Case History

KK is a young woman of 19 years, very hard working, well compensated for her learning differences and about to go to university. She has a family history of dyslexia, a history of learning needs and has had extra support in a very highly academic school. An assessment, recorded in Table B1, shows that she had slow processing speed as assessed by Symbol Digit Modalities Test (SDMT; Smith, 1982). She had slow RAN and weak sight word reading efficiency. All her elementary cognitive test results were well below average. She had achieved three Grade A* 'A' levels.

Table B1

Assessment Profile of a University Student who has Below Average Processing Speed

Tests and questionnaires	Standard Score [a]	Confidence Interval 95%
Wide Range Intelligence Test: Verbal IQ	104	97–111
Visual IQ	123	114–129
Comprehensive Test of Phonological Processing-2		
Phonological awareness (elision + blending)	100	92–108
Phonological memory	**80**	74–86
Rapid naming	**< 52**	< 44–60
Wide Range Assessment of Memory and Learning		
Attention concentration index	91	82–100
Working memory index	100	91–109
Test of Memory and Learning-2		
Digit memory forwards	**70**	65–75
Digit backward	95	90–100
Abstract visual memory	90	85–95
Symbol Digit Modalities Test	**71**	
Woodcock Reading Mastery Test III: Word attack	98	83–113
Word comprehension	100	91–109
Passage comprehension	109	96–122
Oral reading fluency	99	91–107

	Listening comprehension	120	107–133
Test of Word Reading-2:	Sight Word Reading	**59**	49–69
	Phonemic Decoding Efficiency	**84**	76–90
Wide Range Assessment Test: Spelling		113	104−121
DASH 17+ Speed of handwriting		**< 65**	53–79
Wilkins Overlays Test		text settled by one purple overlay	
Pattern Glare Test		negative	
		KK's score	Median (IQR)[b]
Visual Discomfort Scale		**43**	7 (8)
ADC	Section		
	1	**8**	3 (6)
	2	**32**	14 (14)
ASRS_v.1.1			
	1	**4**	1 (2)
	2	**5**	1 (3)
Elementary cognitive tasks (ECTs) in ms			
Standard inspection time		**87**	50 (14)
Simple decision time		**679**	260 (40)
Choice decision time		**984**	345 (54)
Simple motor time		**506**	94 (31)

Note. ADC = Adult DCD/Dyspraxia Checklist (Kirby & Rosenblum, 2008); ASRS–v.1.1 = Adult ADHD Self-Report Scale (Adler, Kessler & Spencer, 2005); Comprehensive Test of Phonological Processing-2 (Wagner, Torgeson, Rashotte & Pearson, 2013); DASH 17+ = Detailed Assessment of Handwriting 17+ (DASH: Barnett, Henderson, Scheib & Schulz, 2010); Pattern Glare Test (Wilkins & Evans, 2001); Symbol Digit Modalities Test (Smith, 1982); Test of Memory & Learning-2 (Reynolds & Voress, 2007); Test of Word Reading Efficiency-2 (Torgeson, Wagner & Rashotte, 2012); Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); Wide Range Assessment of Memory & Learning (Sheslow & Adams, 2003); Wide Range Assessment Test (Wilkinson & Robertson, 2011); Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000); Wilkins Overlays Test (Wilkins, 2001); Woodcock Reading Mastery Test III (Woodcock, 2011). [a] Standard scores < 85 in bold. [b] Median (IQR = inter-quartile range) of 50 adults with typical development.

APPENDIX C: Variability in Method

Measurement of inspection time has been diverse. In response to calls for standardised inspection time tests (e.g., Anderson, 1986; Jensen, 2006), software programs have been generously shared (e.g., Preiss & Burns, 2012) but when these are used, without closely specified hardware, test conditions, or external verification of SOAs, studies can just be compared cautiously; different procedures may involve different neurophysiological processes. In this Appendix, a few of the ways in which measurement methods vary and some implications of this variability are noted. It is not an exhaustive account. Inspection time resolved quickly by using as few trials as possible, more often achieved by the method of limits, has advantages. The chief advantage is that participants do not tire or lose concentration. In children, Anderson (1986) found that the method of constant stimuli resulted in longer inspection times. Given the number of trials, it is possible that children had become tired and inaccurate.

Participant Readiness

Suggestions that design of the fixation stimulus used to alert a participant about the upcoming target stimulus affects responses were not substantiated (Chaiken & Young, 1993). Target stimuli themselves can be at regular (e.g., 3 seconds, Alcorn & Morris, 1996) or randomly varied intervals after the fixation stimulus (e.g., 700−1500 ms, Anderson, 1986; 250−1000 ms, McLean et al., 2011). If the period between the fixation stimulus and the target stimulus is variable, the time participants are required to sustain attention increases. In some investigations, participants initiated the stimulus when they were ready, at will (e.g., McLean et al., 2011) and in some investigations, they did not (e.g., Kranzler, 1994). Whether intervals between fixation and target stimuli varied or were constant; and whether external pacing was imposed on the participant or the participant controlled the start of the stimulus, were compared in children, eight and 12 years old (Anderson, 1989). In the condition that combined an external pace with a random interval, there were significantly longer inspection times (F (1, 60) = 4.43, p <.05). This effect also occurs in decision time investigations (Jensen, 2006). Participant control improves performance and Jensen (2006) suggested that participant's "subjective sense of 'readiness'" (p. 204) may be dependent upon neural oscillations (Section 2.2.3).

Stimuli

Different stimuli have been reviewed (McCrory & Cooper, 2007). Tachistoscope presentations of stimuli (e.g., Hulme & Turnbull, 1983) have been largely superseded by computer generated images on-screen (Anderson, 1986) or LEDs which deliver precise stimulus durations unrelated to frame cycle (e.g., Kranzler, 1994). Not all stimuli use left/right as the feature to be distinguished. Another similar stimulus choice was between a pi-figure with two identical vertical lines and one with lines of different length (Anderson, 1988). This design created an unbalanced choice for left/right response. Another design, was a version of the standard pi-figure with horizontal lines (N.R. Burns, Nettelbeck, McPherson & Stankov, 2007, p. 87), which risks a left/right bias. A 3 cm square, with one side missed randomly (Zhang, 1991) was used by Chinese students. In the context of the work presented here, an important design was meant to be more accessible for children. Instead of the pi-figure, length discrimination was between antennae on a, possibly distracting, space "invader" (Anderson, 1986, p. 678). There have been differences between upper and lower case letters (MacKenzie, Molly, Martin, Lovegrove & McNicol, 1991, as cited in Stokes & Bores, 2001); same different letter discrimination (Stokes & Bors, 2001); and letters: p, q, d and b, which require left/right and up/down orientation decisions and responses (Alcorn & Morris, 1996). Methods that utilise letters to explore visual processes risk contamination by phonological processes (Goswami, 2015). Discrimination difficulty is important. Inspection time increased with a discrimination difficulty for different lengths (Nicholls & Atkinson, 1993) and thicker stimuli had shorter inspection times in at least one study (Garaas & Pomplun, 2007).

Variations in stimulus shape, size, colour, distinguishing features and luminance, might tap different processes. Nevertheless, evidence that various stimuli are comparable comes from inspection times for eight various stimuli including alphanumeric characters (N. R. Burns, Nettelbeck & White, 1998). These authors argued that if the crucial decision on which inspection time depends is the resolution between mask and stimulus then inspection times would be the same for a variety of stimuli and masks, which they found to be the case. Further evidence that various stimuli tested the same psychological variable came from 90 adults. The authors noted that similar inspection times were produced between the standard pi-figure, an LED version and an alphanumeric task using 2, 3, 5, 7, F, H, U and Y (e.g., inspection time pi-figure: 64.9 ms, alphanumeric: 43.2 ms, and correlations between pi-figure and alphanumeric, r (89) = .36, p < .01; N.R. Burns & Nettelbeck, 2003). All the participants had average intelligence or above which restricts the generalisability of this work and the use of nameable stimuli was not ideal. Moreover, although significant the relationship between the different stimuli was only just at a medium level and the discrepancy between the SOAs was not inconsiderable. However, in a study of happy and sad facial expressions in adults, faces had on average shorter inspection times than the pi-figure but correlations were moderate and significant (between sad inspection time and symbol inspection time, r (71) = .46, p < .001; between happy inspection time and symbol inspection time, r (71) = .48, p < .001; Austin, 2004). McCrory and Cooper (2007), after testing young adults with a pi-figure, novel coloured circles and LED stimuli, found that while correlations were of medium strength (e.g., between circles and pi-figure, r (69) = .38, p < .05), in a hierarchical regression analysis there was little difference in their interaction with a measure of IQ (ΔR^2 = .01; F (1, 70) = .76, p > .05). Correlations are not so high that would warrant dismissal of the importance of stimulus variation.

Comparisons of inspection time stimuli or results of various inspection time stimuli to other cognitive measures have been, to date, for typical participants. It is likely that various visual stimuli share a common mechanism in inspection time, reflected by the correlations outlined above, but that each type of stimulus provides an additional test specific factor, which may affect participants differently.

Backward masks

Backward masks, usually between 200–500 ms, always exceed target stimulus intensity. Frequently used *pattern* masks that cover the target stimulus vary in design. The choice of mask shape is crucial. This is because an ineffective mask does not destroy the iconic image and if it does not then it introduces iconic memory as another variable. Some examples of masks are the lightning flash mask shown in Figure 1; five randomly scattered pi-figures (e.g., Gaaras & Pomplun, 2007), and, letters masked by different letters (Stokes & Bors, 2001). A dynamic succession of eight masks (Anderson, Reed & Nelson, 2001) risked distractibility. There have been forward, and backward masks around the same target stimulus (Anderson, 1986; Hulme & Turnbull, 1983).

Responses

Okubo and Nicholls (2005) make a case for a bimanual response in which four response buttons are used and the index and ring finger of both hands indicate either left or right hand side pi-figures. In another departure from standard procedures, participants named letters, which possibly confounded inspection time response with auditory processing, speech and phonics expertise (Alcorn & Morris, 1996). Participants in a study by Hulme and Turnbull (1983) tapped the table on the appropriate side, which was recoded as correct or incorrect, by an administrator. There may be further errors from bias towards left or right response collection. With increased SOAs there was a decreased tendency to opt for the same side in young Air Force recruits (F (5, 820) = 190.05, p <.001; Chaiken & Young, 1993). “As quickly as possible” responses to simultaneously measure decision time have been combined with inspection time evaluation (e.g., Piek, Dyck, Francis & Conwell, 2007, p. 680; see Section 3.4) but this procedure may risk errors from speed-accuracy trade-off.

Repeated Tests, Learning and Feedback

Inspection time remained constant across 20 years in a carefully copied study on another set of children from the same school, and this indicated stability across generations (Nettelbeck & Wilson, 2004). However, stability is not seen in repeated tests in the same participants; low-level improvements in inspection time have been observed in children (N. R. Burns, Nettelbeck, McPherson & Stankov, 2007, review). Bors, Stokes, Forrin and Hodder (1999) concluded, “the literature illustrates that across-occasion practice reduces the inspection times of young adults” (p. 114). Luciano et al. (2001) recorded a reduction of 26.9 ms in 16-year-old twins after a retest 3 months later. Anderson, Reid and Nelson (2001) showed in a study of 6–9 year olds that the improvement of inspection time performances from one year to the next in one group of children was more than the difference between separate six and nine year olds that was attributed to their development. Alternatively, there was no significant improvement in inspection time in older adults with a commercially available on-line cognitive training programme (Simpson, Camfield, Pipingas, Macpherson & Stough, 2012).

Some computer programs have used a familiarisation procedure that involves minimum number-correct at long stimulus durations prior to main trials (e.g., Preiss & Burns, 2012). The effects of subliminal visual priming have to be borne in mind (e.g., Bar et al., 2001). Too many practice trials risks learning, errors of habituation or loss of focus. Participants may learn at different rates, beyond familiarisation with the basic operations required for the test, adding another variable to the inspection time measure. Participants have received feedback for each trial, intended to maintain motivation but which introduces yet another variable (e.g., Bates & Eysenck, 1993). Anderson's (1986) screen lit up with a correct answer—there was the impression that the space invader stimulus had exploded. This suffusion of light could disturb evaluation of subsequent visual images, particularly for participants with Meares-Irlen Syndrome (Section 3. 3).

APPENDIX D: Specific Learning Differences

Dyslexia

Main theories of dyslexia.

Multi-deficit hypothesis. Evidence has emerged for a multi-deficit model of dyslexia (e.g., Fostick & Revah, 2018; Menghini et al., 2010) in which a core difference could manifest in multiple ways. A multi-deficit model could account for variations in dyslexia, differences in reading disabilities and the wide range of associated signs and symptoms. It could account for the evidence that has accumulated in support for a variety of theories of dyslexia. Below are reviewed briefly theories of dyslexia that could be relevant to inspection time performance.

Auditory processing and temporal sampling theory. A feature of dyslexia is a deficit in phonological awareness (Snowling & Melby-Lervag, 2016, review). The auditory processing hypothesis suggests that this deficit arises from inefficient processing of rapidly presented and sequential auditory stimuli (Leong & Goswami, 2014, review). Goswami (2015) has noted that one weakness in dyslexia is that of detecting *rise time,* time taken for a phoneme to reach its maximum amplitude. This weakness affects speech rhythms and consequently speech development. Research into rise time has led to the temporal sampling theory, which implicates neuronal rhythms. These rhythms may align to information coming from the senses (Goswami, 2015).

If slow speed of auditory processing causes dyslexia, it would not necessarily affect a visual process such as inspection time. If incoming sensory information is dependent on overarching neural rhythms that could affect both auditory and visual processes, then a weakness in these might also affect the readiness of some participants with dyslexia to take a test of inspection time.

Temporal sampling theory in visual processing. Vidyasagar (2013) proposed that, for people with dyslexia, failures in synchronous neuronal oscillations in the gamma frequency range could affect visual processes, particularly pathways between the parietal cortex and V1. These pathways, that precede coding of graphemes to phonemes, are responsible for visuospatial attentional feedback during reading. Goswami (2015) asserted that a person who reads less due to phonological difficulties would be more likely to have relative deficiencies in visual scanning, oculo-motor control and visual-attention skills.

A weakness in visuospatial attentional feedback could affect a participant's ability to focus on the inspection time image at an appropriate time to take advantage of an optimum level of efficiency. An underlying deficit in oscillatory rhythms in participants with dyslexia might affect inspection time, especially when experimental circumstances such as random delivery of the stimulus image after the introductory cross do not encourage self-alignment of neuronal oscillations.

Neural Noise. Hancock, Pugh and Hoeft (2017) proposed that "neural noise stemming from increased neural excitability in cortical networks implicated in reading" (p. 434) contributes to dyslexia. This theory suggests that neural noise affects phonological awareness in the auditory domain, sensory processes in the visual domain and integration of phonemes with graphemes. Glutamatergic signalling might generate neural noise, as might disruptions of neural migration, they suggest. Neural noise would manifest as a wider variation in accuracy of response to different stimulus durations around a mean threshold. Consequently, neural noise may cause greater inspection time variability (ITSD).

Magnocellular deficit. Evidence has accumulated for the magnocellular theory (Stein, 2012, review). The theory suggests that disordered magnocells (M cells) occur during development in dyslexia. These cellular disturbances lead to visual instability from weak oculomotor control, which in turn affects reading. An M system deficiency could reduce mask effects, and thus disturb letter sequences. The M theory has critics. Heath, Bishop, Hogben and Roach (2006) for example, found that visual and auditory psychophysical test results used as evidence for the theory wanted construct validity or predictive validity for reading. In a revised version of the M theory, that includes defective auditory M systems, Paracchini, Diaz and Stein (2016) proposed the temporal processing deficit theory. This theory suggests that temporal processes, rapid allocation of attention, and linking sounds with letters in dyslexia are explainable by deficits in the visual *and* auditory M system.

If there is an M deficit in participants with dyslexia, they may have difficulty with oculomotor control or would be less sensitive to fast stimuli and this would lead to an increase in inspection time. This is because the M system typically manages fast stimuli. On the other hand, mask effects could be less and this would lead to shorter inspection times. McLean et al. (2011) found evidence to implicate the M system in inspection time. They showed weak correlations between the M results of a chromatic flicker perception task, which distinguished M from P performance, and inspection time (r (89) = – .27, p < .01) in typically developing children and those with dyslexia. However, in that study most children with dyslexia did not have significantly weaker standard inspection times than typically developing children although four out of the 40 participants with dyslexia had very long inspection times (see Section 3.1.4).

Visual attention deficit. A visuospatial attention deficit for the number of items processed simultaneously in an array, the *span* (Bosse et al., 2009), was shown in readers with dyslexia (Stenneken et al., 2011). These authors assessed a span *full report* by reaction time to name letters of a five-letter array displayed for 200 ms. Naming single letters in certain positions provided a partial report. Reaction times and accuracy for letters positions 1, 3 and 5 were superior to letter positions 2 and 4 and this they suggested might indicate crowding effects in dyslexia. Lobier, Zoubrinetzky and Valdois (2012) proposed that visual attention span deficits in dyslexia influence upstream processes in the visual word form area (VWFA) in dyslexia. This, in turn, may cause a person to have difficulty reading. Zoubrinetsky, Collet, Serniclaes, Nguyen-Morel and

Valdois (2016) claimed that the visual attention span deficit does not co-occur with phonological deficits whereas Saskida et al. (2016) disagree.

One could expect that a visuospatial attention deficit in participants with dyslexia would only directly affect inspection time when target stimulus presentation is in the form of an array.

Specific procedural learning deficit or cerebellar deficit. Procedural learning, which partly involves the cerebellum, happens before a process has become automatic. A procedural learning deficit could affect the development and execution of literacy skills (Nicholson & Fawcett, 2007; Stoodley & Stein, 2013, reviews). Procedural learning difficulties that affect the development of cognition and movement such as eye movement control, balance and rapid pointing are associated with dyslexia (Stoodley & Stein, 2013; Vicari, Marotta, Menghini, Molinari & Petrosini*,* 2005). In participants with dyslexia there is reduced grey matter in right and left lobule VI of the cerebellum; and slow rapid automatic naming (RAN) is associated with abnormal right module VI activation (Norton et al., 2014). Evidence that implicates the cerebellum in participants with dyslexia may reflect deficits in other systems and not a core deficit (Nicolson & Fawcett, 2007).

A procedural-cerebellar deficit might affect inspection time in participants with dyslexia by the need for more practice trials. It may affect variability between the first and last inspection time test. However, as the inspection time procedure is devoid of rapid motor responses and the decision is relatively straightforward any further differences in inspection time from a procedural deficit seem improbable.

Asynchrony phenomenon. The asynchrony theory (Breznitz, 2008, review) suggests that there is a mismatch in the speed at which phonemes are processed is different to the speed at which letters are processed.

Subtypes. There have been attempts to classify dyslexia and different theories might apply to different subtypes. To take an example, Wolf and Bowers (1999) identified three types of dyslexia, which were characterised by deficits in phonological memory and discrimination; in rapid automatic naming (RAN); and thirdly, the *double-deficit*, in which these deficits co-occur (Wolf & Bowers, 1999). In another example, in German children, Heim et al., (2008) identified three cognitive profiles of phonological deficits; attentional deficits; and phonological, attentional and magnocellular (M) difficulties, matched to different neural networks activated during phonological and reading tasks. Van Ermingen-Marbach, Grande, Pape-Neumann, Sass and Heim (2013) grouped children into those with and without phonological differences. Zoubrinetzky, Collet, Serniclaes, Nguyen-Morel and Valdois (2016) found evidence to categorise participants with dyslexia into independent groups, one group of participants with a visual attention span deficit and one with a phonological deficit. A further classification has been into *deep* and *surface* dyslexia, which is based on the dual-route model of reading (e.g., Ziegler & Goswami, 2005, review). Snowling and Hulme (2012) reported deficits that manifest as reading or spelling difficulties and a type of dyslexia in which people have weak comprehension. Zoubrinetzky, Bielle and Valdois (2014) criticised attempts to classify dyslexia on reading or spelling behaviours. They provided evidence that cognitive underpinnings of dyslexia do not necessarily reflect literacy behaviour.

Nevertheless, there is evidence for visual disruption of reading in some people with dyslexia, so, any links between inspection time and participants with diagnosed dyslexia and/or weak literacy would provide supportive evidence for the extent and nature of the visual disruption seen in some participants.

Developmental coordination disorder

Main theories of developmental coordination disorder.

Internal forward modelling. The internal forward modelling theory of DCD suggests that, in advance of movement, people with DCD cannot easily visualise and estimate future positions of their limbs, a skill known as *predictive control* (Adams, Lust, Wilson & Steenbergen, 2014, review). Internal forward modelling, believed deficient in DCD, describes the constantly updated motor imagery or representations, which predict movement. These representations may be managed in the parietal cortex and cerebellum. There have been investigations of predictive control with methods such as the hand rotation task (e.g., Noten, Wilson, Ruddock & Steenbergen, 2014) and visually guided pointing (Sirigu et al., 1996). Predictive control deficits are variable according to parameters such as complexity of the task or severity of DCD (e.g., Wilson, Caeyenberghs, Dewey, Smits-Engelsman & Steenbergen, 2017).

Neural noise. More intra-individual variability, which may be because of more noise in the neural system than is typically found, has been a notable finding in studies of motor systems of children with DCD and noise is believed to contribute to inefficient acquisition of predictive control (Smits-Engelsman & Wilson, 2013). Intra-individual variability may also relate to overarching endogenous rhythms that may be different in DCD.

Cerebellar deficit and procedural learning. In a review of DCD, Zwicker et al. (2009) concluded that problems in the cerebellum were a likely cause of DCD. A cerebellar deficit in DCD would explain its frequent overlap with dyslexia. As with dyslexia, the automatization deficit hypothesis of DCD is a suggestion that people with DCD do not learn tasks to automaticity as quickly as do those without DCD. Weak development of the cerebellum and basal ganglia are responsible for the differences (Fawcett & Nicolson, 1992; Wilson et al., 2013). Not all studies support this hypothesis (e.g., Zwicker et al., 2012).

Inspection Time in Specific Learning Differences

Table D1

Details of Three Studies of Inspection Time in Children with Reading Disabilities

	Whyte, Currie & Hale, 1985
Participants	Seven boys with dyslexia, 7 age-matched boys without dyslexia, 9−11 years of age
Materials	Pi-shape stimulus, 10 mm wide, limbs 30 or 31mm in length and a 30 mm horizontal line joining the top of the vertical lines. Viewing was from 45 cm. Backward mask of random lines, remained on screen until the response. Two hands used to make left or right response. Correct or incorrect feedback given. One-up, one-down staircase method of 40 trials for each of 5 blocks and average of correct trials calculated.
Results	Boys with dyslexia had significantly longer mean inspection times. Practice effects and standard deviations were greater in the group with dyslexia.
	Kranzler, 1994
Participants	Eighteen reading disabled and 18 typically developing boys and girls, matched for age and gender, aged 9−10 years.
Materials	Two 15 cm vertical lines of LEDs, 3.50 cm apart, with 10 cm short arm on one side or the other, masked by the short arm made longer. Left/right response. Rate of stimulus presentation determined by computer. Auditory warning signal, random interval 1−3 s before LED target stimulus appears. Modified three phase Barrett (BRAT) algorithm offering 2 ms resolution. Typically, inspection time was resolved in < 100 trials. Individually administered nonverbal Raven's Coloured Progressive Matrices (RCPM) used to control IQ between groups.
Results	Children with and without reading disabilities did not show differences in inspection time. 7/18 reading disabled participants unable to resolve inspection time, from variability of responses in Phase III of BRAT algorithm, compared to 2/23 controls.
	McLean, Stuart, Coltheart & Castles, 2011

Participants	Forty children with dyslexia (25 boys) and 42 children without dyslexia (11 boys), aged 7−11 years
Materials	Tests were in a dimly lit room. Stimuli were cartoon aliens with two antennae of different lengths, 22 and 27 mm, visual angle difference of 1.15º. There was a button box, left and right corresponding to left right antennae positions. Fixation cross, 100 ms blank presentation, between 250 and 1000 ms random, target stimulus and 37 mm lighting flash backward mask, 300 ms. Staircase algorithm, inspection time was the average of last 8 of 10 reversals. Ten practice trials, 9 to be right before starting.
Results	Group differences in inspection time were not significant. Inspection time thresholds positively skewed in the group of participants with dyslexia but not in the group of participants who were typically developing. Four out of five children with very long inspection times had dyslexia.

Table D2

Mean Inspection Times and Standard Deviations From Studies of Children With Reading Disabilities

Authors	*Mean* (*Standard Deviation*)	
	Typical	Reading disabled
Whyte, Currie & Hale, 1985	63.30 (5.16)	102.11 (28.53)
Kranzler, 1994	89*.00 (47) 2/23 timed out	88*.00 (54) 7/18 timed out
McLean, Stuart, Coltheart & Castles, 2011	53.70 (20.80)	63.60 (40.80)

Note. Timed out occurred if a participant did not respond correctly to 9/10 consecutive trials in the final phase of resolution. * Adjusted for nonverbal intelligence.

Table D3

Mean Inspection Times and Standard Deviations From Studies of Children With Developmental Coordination Disorder

Authors	*Mean* (*Standard Deviation*)			
Piek et al., 2007	Typical (ms)	DCD (ms)	ADHD−I	ADHD−C
1	65.53 (52.90)	106.78 (91.03)	66.70 (27.26)	55.32 (17.81)
2	130.39 (97.94)	284.33 (315.31)	134.30 (63.69)	169.37 (87.50)
Dyck & Piek, 2010	Poor Language Skills (ss)	Poor Motor Skills (ss)	RELD (ss)	DCD (ss)
	99.10 (14.40)	99.60 (18.80)	83.40 (35.20)	83.10 (32.80)

Note. 1 = before set-shift, 2 =after set-shift; ss = standard score; ADHD = attention deficit hyperactivity disorder; I = impulsive, C = combined; DCD = developmental coordination disorder; Piek et al. = Piek, Dyck, Francis & Conwell (2007); RELD = receptive and expressive language disorder.

Summaries of studies of inspection time in attention deficit hyperactivity disorder. First, in Piek et al.'s (2007) study, children diagnosed with inattentive and hyperactive-impulsive types of ADHD did not have longer inspection times than typically developed peers from an inspection time/RT combined task (Table D3, Appendix D). Some of those children with hyperactive-impulsive type ADHD responded more quickly than typically developing peers before making a decision. They reacted more impulsively, more quickly, on incorrect responses. Piek et al. (2007) acknowledged that the "wash out" (p. 682) period from medication might have been inadequate. In ADHD, this medication normalises processing speed indexed by RT but the effects of medication on inspection time are not known.

Second, inspection time was measured in un-medicated children with ADHD between 7–12 years old (Sinn, Bryan & Wilson, 2008). There were no typically developed participants and scant details of the inspection time task. N-3 PUFA docosahexaenoic acid (DHA) administration did not improve inspection time. Inspection times were quite long in the group given PUFA (mean 101.20 ± 27.29 ms) although they improved (mean 80.88 ± 22.16 ms) over a period of 15 weeks. The results of a placebo group (mean 103.41 ± 27.32 ms) similarly improved after 15 weeks (mean 82.97 ± 21.82 ms) and after 30 weeks (mean 71.39± 15.95 ms).

Third, Shank, Kaufman, Leffard and Warschausky (2011) investigated inspection time in children with cerebral palsy and typically developed controls, aged 8–16 years. Inspection times correlated with symptoms on hyperactive-impulsive and inattentive subscales of Conner's Parent Rating Scales, a behavioural rating scale for symptoms of ADHD (r (69) = .48, $p < .01$; r (69) = .44, $p < .01$, inattentive and hyperactive-impulsive, respectively). In these experiments, the mask was unconventional and may have been inadequate as it consisted of three crosses arranged over each vertical limb of the pi-figure.

Fourth, Galloway-Long and Huang-Pollock (2018) measured inspection time and reaction time in groups of children with and without ADHD. Inspection time was not significantly different between groups, F (1, 264) = 2.65, p = .105, η^2 = 0.01.

APPENDIX E: Inspection Time Measurement and Task Development

I would like to thank Karolyn Webb and Peter Barwick for technical support.

Hardware

Computer. The computer, a Dell, Optiplex 7010 × 64 that operated with Windows 7 Professional, had a dedicated video memory card, all unnecessary programs removed and software for antialiasing was off.

Monitor . The Sony Trinitron, GDM-F520 CRT, 32-bit true colour, 16 × 12 in. (406 x 305 mm) monitor had pixel rate 175.5 MHz; spatial resolution 1024 × 768 pixels; temporal resolution 85 Hz and consequent interframe interval (IFI) of 11.76 ms. Importantly, 85 Hz is outside the range, between 3 and 70, particularly between 15 and 20 Hz, likely to provoke a photosensitive epileptic seizure in 1:4000 people or, less dramatically, visually provoked stress (Wilkins, Veitch & Lehman, 2010). Monitor *set-up*, a term for a procedure used in favour of *calibration,* which is used for a precise, expensive procedure (MacIntyre & Cowan, 1992), was adjusted from guidelines by Cowan (1995). Controls on the monitor were locked into standard, easy colour mode; brightness 50; contrast 100. The monitor was on for 60 minutes before use to *warm-up*, so that luminance levels would stabilise. Thanks are due to Dr Caterina Ripamonti of Cambridge Research Systems for advice about calibrating the CRT monitor.

Response box. De-bounce on the button up-movement, which prevented multiple signals when the button's contacts opened, was 0.1 ms and there was no de-bounce delay for the button-down. Small, self-adhesive, 4 mm furniture pads were attached to locate the centre of the buttons, which were operated by one finger of the participant's choice. Thanks are due to Dr Richard Plant of the Black Box Toolkit Company for help with the design of the response box.

Software

The parameters used in Programs 1 and 2 were:

`(Flip, 0, StimulusOnsetTime` of previous image**`, [],[],[]);`**

The operator **`[]`** denotes default arguments and are shown here although they are not strictly necessary in this line of code.

An important section of code that used PTB-3 for presentation of the image by the **`Flip()`** function (Kleiner et al., 2007) is shown below. Variables of **`testImage, mask,`** and the constant **`STIMULUS_DURATION`** were defined earlier in the program.

```
ifi = Screen('GetFlipInterval', wPtr);
Screen('PutImage',wPtr,testImage);
Screen('DrawingFinished',wPtr, [],0);
[stimVbl,stimOnset,stimFlip,stimMissed,stimBeampos]  =
                                Screen('Flip',wPtr,[],0);
Screen('PutImage',wPtr,mask);
Screen('DrawingFinished',wPtr,[],0);
[maskVbl, maskOnset, maskFlip, maskMissed, maskBeampos] =
Screen
        ('Flip',wPtr, (stimVbl + STIMULUS_DURATION –
.5*ifi),0);
```

Tables E1 and E2 explain code of particular importance for the accurate measurement of inspection time. The code used MATLAB R14a (The Mathworks Inc. Natick MA, USA)) with Psychophysics Toolbox extensions, Version 3.0.11 (PTB-3; Brainard, 1997; Kleiner et al., 2007).

Table E1

Explanation of `'Flip'` Function Input Argument, Psychophysics Toolbox

`'Flip', wPtr, when, don'tClear, don'tSync, multiflip;`	
`Flip`	Showed an image by synchronisation of screen and buffer surfaces with the vertical retrace.
`wPtr`	Identified the screen
`when`	Dictated the flip time and used previous output arguments or a `'GetSecs'` timestamp.
`don'tClear`	Directed behaviour of the back buffer after the flip, set to default position, 0, so that buffer cleared to black background of the screen after the flip.
`don'tSync`	Timestamps set to the default value of 0, synchronised flip to the vertical blank (VBL), that is a time when the stimulus is not on the screen, and paused script until completed.
`multiflip`	Set to default, 0, as this only applied to multiple screens.

Note. PTB-3 = Psychophysics Toolbox extensions, Version 3.0.11 (Brainard, 1997; Kleiner et al., 2007).

Table E2

Explanation of 'Flip' Function Output Argument, Psychophysics Toolbox

[VBLTimeStamp, StimulusOnsetTime, FlipTimestamp, MissedBeampos, VBLTimestamp] was a record of the computer system time when the vertical blank (VBL), that is a time when the stimulus was not on the screen, started. The buffer swaps and PTB-3 inactivated while the central processing unit operated. Knowledge of the beam position when the PTB-3 was reactivated enabled VBL calculation.	
StimulusOnsetTime	Measured from the first scan line of the monitor. It occurred after the VBL, recorded the moment when stimulus was on screen. The PTB-3 calculated it from VBL timestamp and knowledge of the VBL interval.
FlipTimestamp	Was a precise measure of time taken at end of the flip.
The delay between VBLTimestamp and FlipTimestamp	Was a record of the scan line, which had been reached when the PTB-3 reactivated after the buffer swap. The difference between FlipTimestamp and VBLTimestamp was an estimate of how long 'Flip' had taken when the PTB-3 was out of action.
MissedBeampos	The beam had travelled down the screen and its position found. Positive or negative indicated whether stimulus onset achieved the requested time.

Note. PTB-3 = Psychophysics Toolbox extensions, Version 3.0.11 (Brainard, 1997; Kleiner et al., 2007).

Timing Accuracy

External checks were made of the internal time reports generated from the computer.

Duration of frames that presented stimuli. Three methods checked the timing of frames and ultimately presentation of stimuli. These methods were with a video recorder, a stopwatch and an oscilloscope. Stopwatch and oscilloscope methods that checked stimulus presentation, described next, proved most satisfactory.

Stopwatch method. MATLAB/PTB-3 computer program presented one thousand repeats of a sequence of three frames. The stimuli, that each lasted for one frame, were (a) an 8-bit full white target stimulus bitmap (BMP), (b) a coded drawn randomised black and white dots mask, repeated with a BMP mask with similar results and (c) a blank black frame. A Kasper and Richter, Pure Q, model: 766120 stop watch was used to collect external times, one at the beginning and one at the end of each 1000-repeat trial, for each of Trials 1–4. The external times were compared to the times from the computer's internal clock, obtained from the difference between two `'GetSecs'` timestamps, one at the beginning and one at the end of each 1000-repeat trial. Moreover, PTB-3 enabled individual frames to be timed by using timestamps, built into the `'Flip'` function, for the VBL of the stimulus, mask and blank black frames.

There was a glitch in the program. A comparison of results from the stopwatch and computer showed that the time taken for each sequence was one third longer than expected; there were 4000 frames per 1000 sequences rather than the intended 3000. An oscilloscope recording, details of the oscilloscope shown below, confirmed this error. The program coded the repeat cycle with a `'for'` loop, and it emerged that this method probably resulted in one missed frame presentation at the end of each sequence, viz., after the blank background, before the stimulus image. PTB-3 reported unspecific missed frames.

Frame duration measured by a stopwatch and the computer compared to within a millisecond, after the unexpected frame was understood. This, albeit crude, method confirmed the computer's internal timing reports of frame duration of 11–12 ms. While the sequence did not replicate that of the inspection time program it served to externally verify frame durations given by the computer's own clock. It showed that the stopwatch method could alert the researcher to deficiencies in programs. However, human reaction time in the stopwatch method introduced error; the images presented in the programs used to collect inspection time data did not employ a repeat cycle, so replication was not exact; and target stimulus signals from the monitor, as opposed to frame behaviour, were not externally verifiable. It needed a further method to check the frame cycle. This was with an oscilloscope.

Oscilloscope method. A digital storage oscilloscope (GW Instek, GDS-1022) recorded the blue video signal of the cable between the PC and the monitor at pin 3 of the SVGA cable adapter for two-connections. The probe from the oscilloscope was attached to Pin 3 and to the case, to ground, of one male connection in the adapter. A Secure Digital (SD) card saved captured signals. The vertical scale of the screenshot was set to 50 mv. The horizontal scale was 10, 25 or 50 ms per grid square, of which there were 10 per shot. The screenshot widths represented 100, 250 and 500 ms, respectively.

A program was used that had the same basic code section as inspection time Programs 1 and 2. Every sequence was initiated individually; this program avoided a repeated sequence controlled by a `'for'` loop, previously found to be deficient. It called for a plain full screen white BMP, also either a drawn random dot mask or a BMP mask image of 25 IFIs, 295 ms, which preceded a background, which was blank and black. This background remained on the monitor screen until a button press initiated the next sequence. As an illustration, the IFI and frames are shown in an oscilloscope screenshot (Figure E2) of two consecutive full white frames with the horizontal time scale set to 10 ms. The oscilloscope was used to confirm the number of frames, their position in the cycle and durations to within 1 ms.

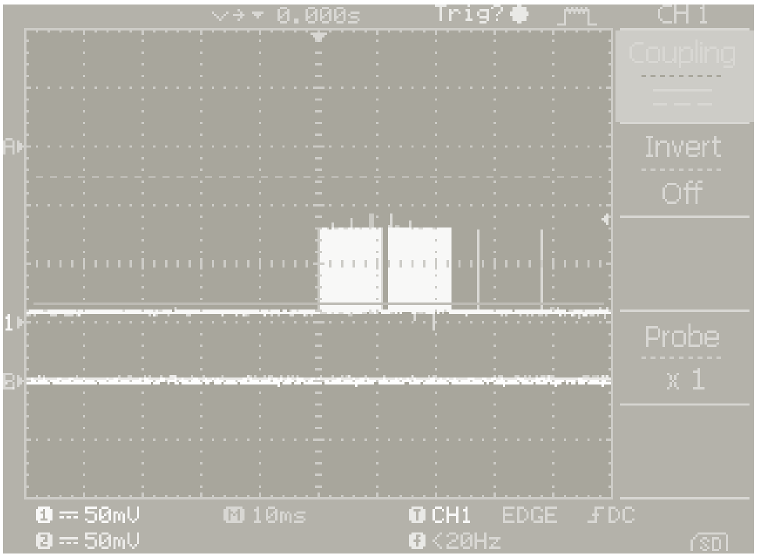


Figure E1. Oscilloscope screenshot that shows two frames of a completely white bitmap. *Note.* The vertical blanking interval is visible between them, followed by two frames of the smaller mask, which takes up about 1/10 the vertical distance of the whole screen. Horizontal axis was set at 10 ms per grid square, vertical axis to 50 mv.

The program recorded the time between successive frames by timestamps built into the PTB-3 **`Flip()`** function. The program measured (a) the IFIs between two successive VBLs, (b) target stimulus durations by use of the target *stimulus onset* and the VBL between the end of the target stimulus and the first mask frame; it thus recorded the time that the frame was scanning on the screen. The term stimulus onset can mislead. For the inspection time target stimulus, actual stimulus onset is not presented the moment scanning starts, because it is located one third from the top of the screen, but is seen by degrees after the raster scan line has reached the stimulus top. The sequence was initiated 50 times by mouse clicks, which called for each of five stimulus durations: 11.76, 23.52, 58.80, 117.64 and 176.40 ms, all rounded multiples, 1, 2, 5, 10 and 15 times the IFI, respectively.

Table E3

Timestamp Data for 50 Trials for Varying Target Stimulus Durations and a Drawn Mask of Requested Duration 295 ms (25 × IFI)

IFI Number & Duration (ms)		Target Stimulus Frame Duration (ms)	Drawn Mask Duration (ms)	Stimulus Start to Mask Start (ms)
1 11.76	*Mean*	11.19	293.68	11.74
	SD	2.06×10^{-2}	2.69×10^{-2}	2.1×10^{-2}
	Range	11.14–11.23	293.63– 293.74	11.70– 11.78
2 23.52	*Mean*	23.14	293.51	23.69
	SD	3.06×10^{-2}	3.26×10^{-2}	3.055×10^{-2}
	Range	23.08– 23.19	293.46– 293.56	23.64– 23.74
5 58.80	*Mean*	58.37	293.50	58.92
	SD	2.61×10^{-2}	2.97×10^{-2}	2.61×10^{-2}
	Range	58.33– 58.44	293.46– 293.60	58.88–58.99
10 117.64	*Mean*	117.20	293.55	117.76
	SD	1.65×10^{-2}	1.40×10^{-2}	1.65×10^{-2}
	Range	117.18–117.25	293.52–293.59	117.73–117.80
15 176.40	*Mean*	176.02	293.55	176.57
	SD	3.19×10^{-2}	3.10×10^{-2}	3.20×10^{-2}
	Range	175.90–176.08	293.50–293.61	176.45–176.64

Note. The interval between end of stimulus frame and the start of the mask frame, but not mask image, (maskonset − maskVBL) was always 0.55 ms.
IFI = interframe-interval; target stimulus frame duration = (maskVBL – stimulus onset); drawn mask duration = (lastblackVBL − maskonset); stimulus start to mask start = (mask onset – stimulus onset), SD = standard deviation.

Table E3 contains the data generated for requested stimulus durations for the trials with a drawn mask. Results show that all images were within 0.2 ms and most were nearer 0.1 ms from the requested duration. Recorded durations between stimulus frame offsets and mask frame onsets are 0.55 ms. That the mask onset was always 0.55 ms after the image, confirmed for all target stimulus durations and both BMP and drawn masks, by the oscilloscope. These times can be verified from the oscilloscope digital data of individual sequences. The oscilloscope method for repeated trials at several durations, confirmed that the code and system used for Programs 1 and 2 that measure inspection time for all the time ranges would reliably (a) deliver the target stimulus frames for the requested duration and (b) present the mask frames immediately after the target stimulus frames with no missed frames between them. The oscilloscope method indicated effectively when the code for displaying timed stimuli did not work properly. For example, in exploratory trials, although there was a 1-frame target stimulus for the requested duration, an error occurred for five frames and more. The code was subsequently adjusted to perform correctly. It was also possible to detect more easily with a full white frame, when the first mask frame did not follow directly on from the last target stimulus frame.

Pulsed nature of the stimulus. With a CRT monitor, small white images on a black background, as used for inspection time investigations, give a pulsed image. A white blocked image (Figure E2), the same outside dimensions as target stimuli used in Programs 1 and 2 was presented within the frame cycle and captured by the oscilloscope (Figure E3). Signals to the oscilloscope came directly from the computer and by-passed the screen display. Thus, it was not possible to evaluate how phosphor persistence in the CRT monitor affected the pulses. Each frame delivered a black and white cycle (Table E4), so intensity of illumination was reduced. Humans have been known to resolve flicker at 85 Hz, but the observer is usually not aware of the flicker (e.g., S. Burns, 1992).

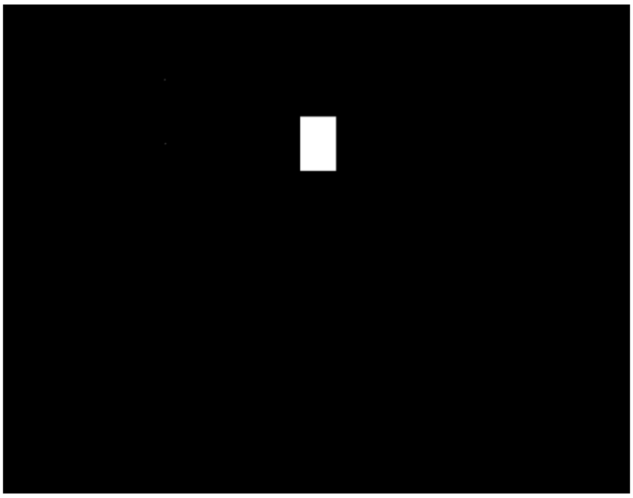


Figure E2. Solid white block on black background. *Note.* It has the same outside dimensions (31 × 20.5 mm) as pi-figure target stimuli used in investigations.

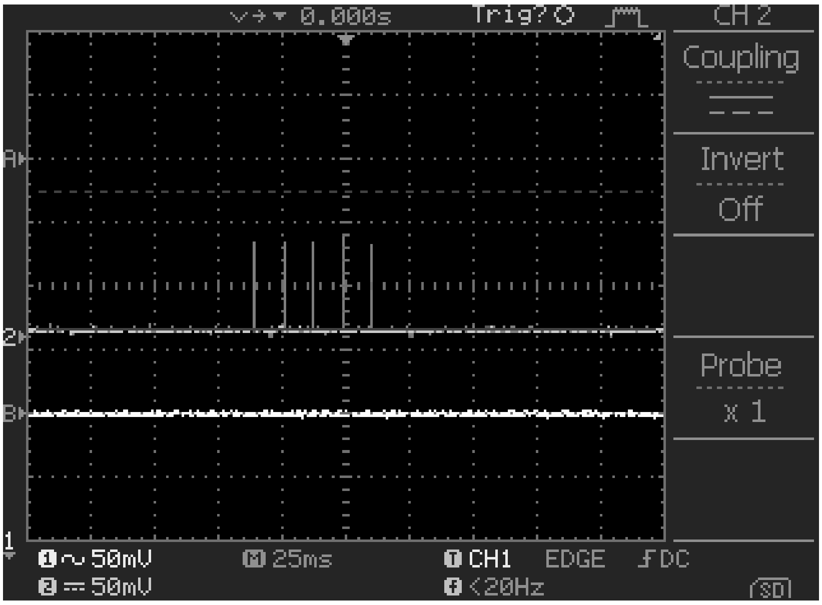


Figure E3. Screenshot for white block image on a black background shown for five interframe intervals. *Note.* This figure illustrates the pulsed nature of the signal to the monitor.

Table E4

Frame Cycle at 85 Hz for a 31 mm Image on a 304.80 mm Screen

Part of cycle	Duration (ms)
Black VBL	0.55
Black before the scan line reaches the top of the target stimulus image	3.25
White image 30.5 mm high	1.12 ms + persistence
Black starting after the scan line reaches the base of the target image + image persistence	6.84 persistence

Note. VBL = vertical blank

A photodiode to relay signals from the monitor to the oscilloscope. The pulsed character of the displayed image and how it was affected by persistence of the image on the screen was explored with a 4 mm diameter, BPX65 Silicon Pin photodiode placed against the CRT screen and built into a circuit containing a resistor and an amplifier (Figure E4, E5 & E6). On-screen events were thus transmitted to the oscilloscope. Figure E7 shows an example of an oscilloscope screenshot with the photodiode in use. Figure E8 shows a plot of the digital data of the screenshot in Figure E7.

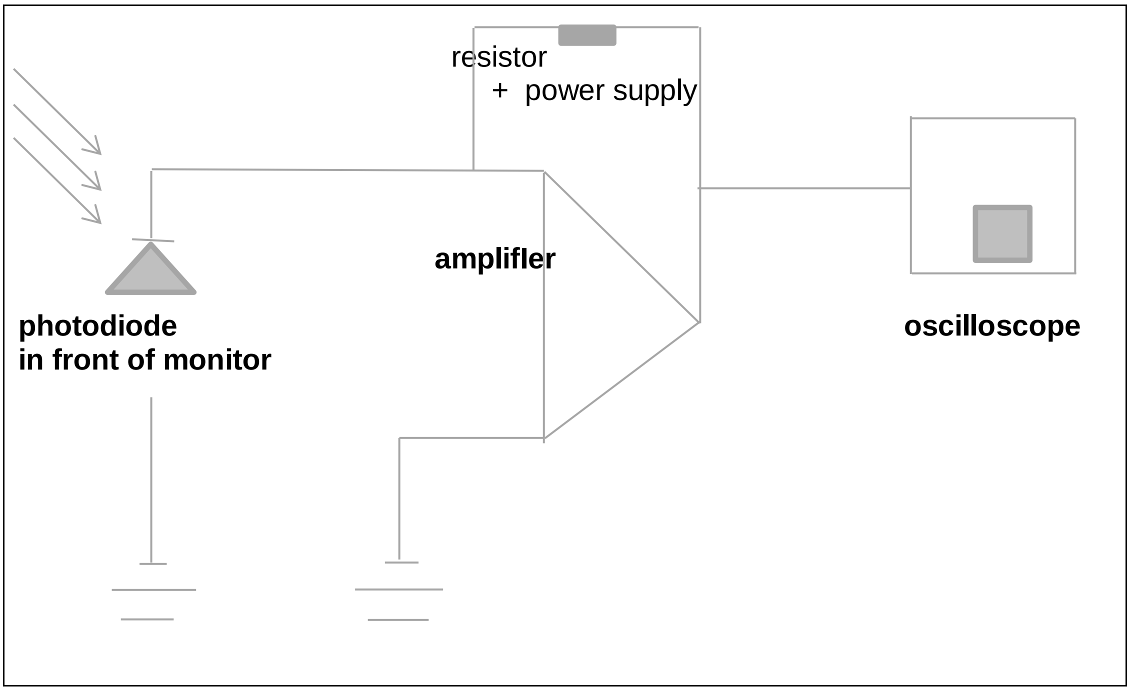
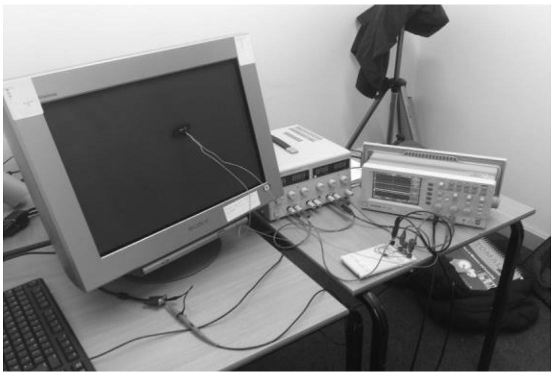


*Figure E4.*Circuit that connects photodiode to the oscilloscope.



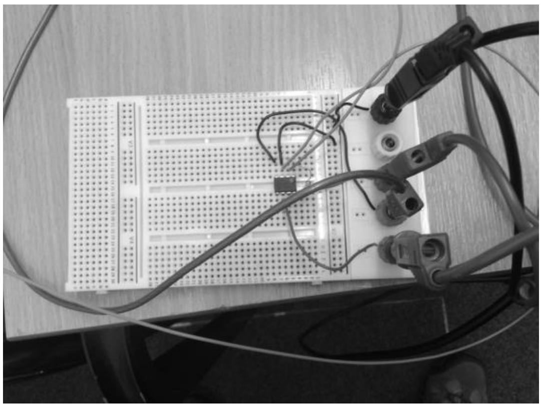


Figure E5 (left). CRT monitor with photodiode, power supply, oscilloscope, breadboard, connection of probe to SVGA connector . *Note.* The order is left to right clockwise.

Figure E6 (right). Connections to amplifier and resistor on breadboard.

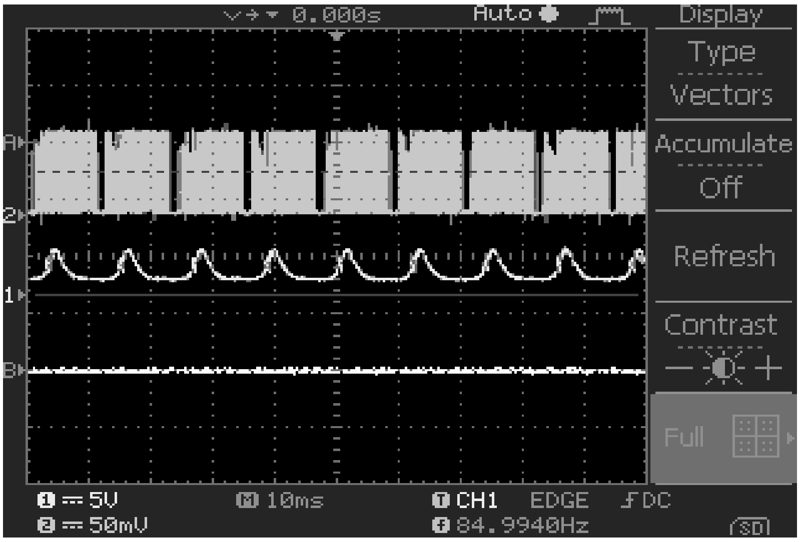


*Figure E7. S*creenshot from the photodiode that captures a section of completely white frames. *Note.* Frame rate of 85 Hz. The diode, in the target image position, was one third down the screen. Channel 1 is from the photodiode, Channel 2 shows voltage to the screen.

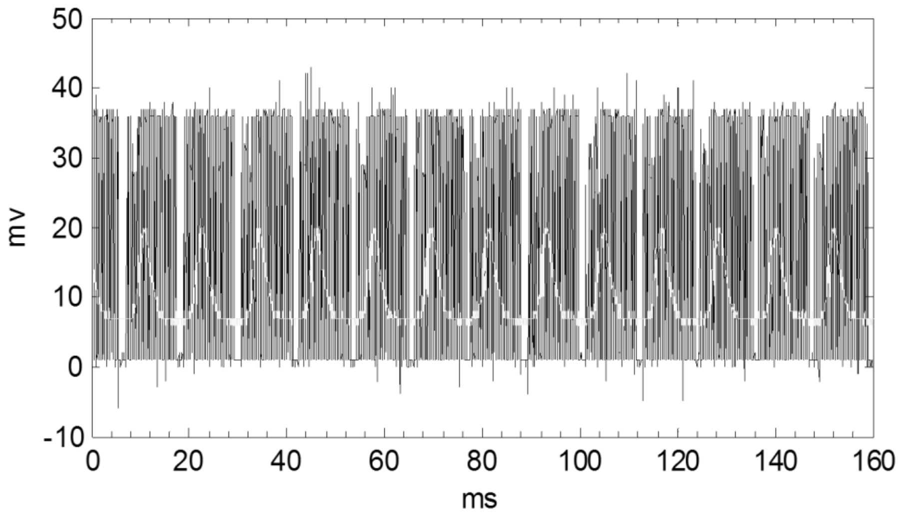


Figure E8. Digital data of the screenshot in Figure E7. *Note.* It shows direct voltage and input to light sensing diode (white line). Within each frame, after a gradual increase in signal, peak intensity can be seen at the position where the beam reaches the diode and then the signal tails off at a slightly shallower angle, indicating persistence on the screen.

Digital data presented visually in Figure E8 show that peak emission, that occurred around 4 ms into the frame cycle, was maintained for less than 1 ms, faded thereafter over 2 ms until by 8 ms into the frame cycle there was no signal. It is likely that persistence of the total image was around 2 ms. Thus for an image of height 31 mm on a screen of 304.80 mm the white image fed to the screen for 1.12 ms, 31/304.80 = 0.10; 0.10 x 11.19 = 1.12 ms) which with estimated maximum persistence of 2 ms amounted to not more than 3.12 ms (1.12 + 2). In this time, although not noticeable to a typical participant, the top had faded before the bottom appeared. At the end of the target stimulus there was an interval of black screen at least 6.84 ms duration, 11.76 – (3.12 + 3.25), before the end of the frame cycle and then another 3.80 ms, (0.55 + 3.25), before the white image was masked. Thus, a hiatus of (6.84 + 3.8) that is (10.64 ms – visible persistence) before the mask started. This allowed visible persistence to extend the image duration by perhaps some 9 or 10 ms.

Images

Luminance. Luminance of a CRT monitor will diminish with use as much as 50% over several thousand hours (Brainard & Pelli, 2002). It is therefore desirable to check monitor luminance during an investigation that continues for some moths. However, instruments that measure luminance are not designed either for a signal that pulses or for the specific spectral emissions produced by phosphors in CRT monitors (Brainard, Pelli & Pelli, 2002). Nevertheless, in the absence of more sophisticated equipment, image luminance in candelas was evaluated in a darkened room using a Tecpel 520 light meter positioned at the end of a 160 mm cardboard postal tube, diameter 80 mm, painted on the inside with matt black blackboard paint. The sensor of the light meter fitted snugly into an aperture, 12 mm diameter, drilled in the cap at the distal end of the tube. The other end was pressed against the screen at 90 º cushioned with a collar of black opaque material in the position of the stimulus image.

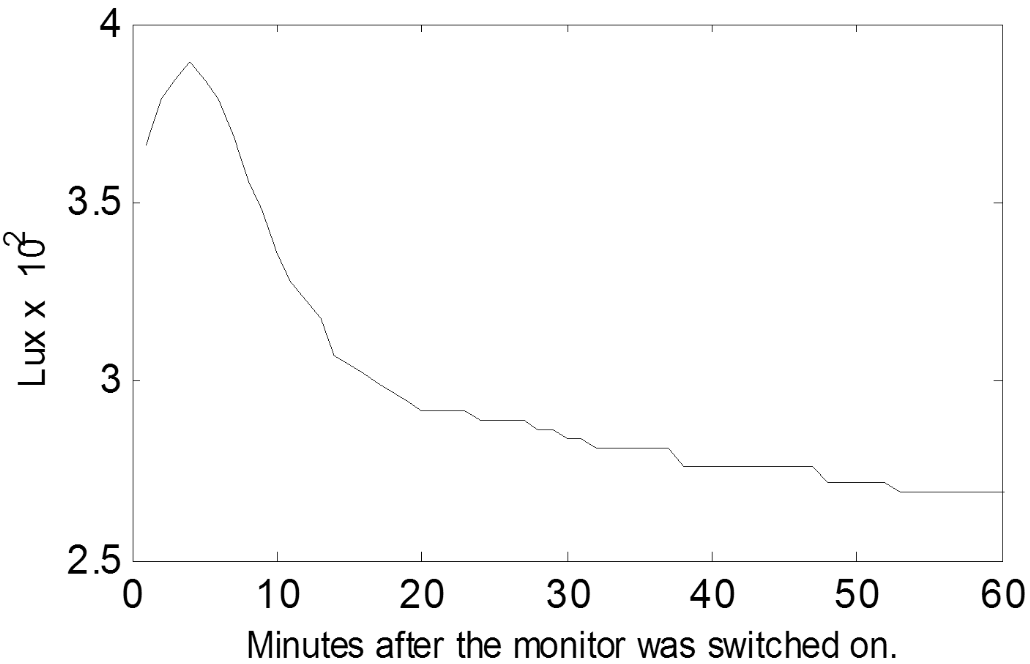


Figure E9. Graph showing luminance measured with Tecpel 520 light meter for a warm start.

With this set-up, luminance measurements were made of the small white blocked rectangle from the moment the monitor was switched on and as it warmed up. This was a *warm start* of the monitor once restarted after an off period of 20 minutes, as opposed to a cold start when the monitor had been off for more than 14 hours (Metha, Vingrys & Badcock, 1993). Results indicated that after the initial rise in luminance in the first few minutes the output steadily dropped and reached stability after 60 minutes (Figure E10). Results closely resembled those obtained with a spectro-radiometer (Metha, Vingrys & Badcock, 1993) and a photometer (National Information Display Laboratory, 2001). That changes in luminance can be shown during the warm-up period suggests that the method to measure luminance described is effective in the absence of more sophisticated equipment.

Luminance of a full white screen, a blocked image and a pi-figure at 16 cm were recorded at the start of the study and later on towards the end after 24 months. Readings (Table E5) suggested only a minor drop in luminance. The above method was not sufficiently sensitive to measure the luminance of images used in investigations at 60 cm, the distance at which the participants sat from the screen.

Table E5

Luminance Measurements

Image 0.16 m from screen	Light meter reading (Lux)	Luminance (candelas)
Pi-figure at start of study	0.30×10^{-2}	7.68×10^{-5}
Pi-figure at end of study	0.30×10^{-2}	7.68×10^{-5}
Blocked white (255 RGB) rectangle at start of study	2.64×10^{-2}	6.76×10^{-4}
Blocked white (255 RGB) rectangle at end	2.42×10^{-2}	6.20×10^{-4}
Full black screen (0 RGB) at start of study	2.00×10^{-4}	5.10×10^{-6}
Full black screen (0 RGB) at end of study	2.00×10^{-4}	5.10×10^{-6}
Full white screen (255 RGB) at start of study	17.17×10^{-2}	4.40×10^{-3}
Full white screen (255 RGB) at end	14.84×10^{-2}	3.80×10^{-3}

Note. Candelas = lux × d^2, where d = distance from light source in metres.

Calculations for pixels in target images. MATLAB measured the numbers of white (829260) and black (1244340) pixels for target stimuli, by:

```
totalPixelsInArray = numel (image variable name)
```

Answer = 691200 (which is 720 x 960 in the Paint program)

```
whitePixelvalue = sum (image variable name (:))
```

Answer = 276420

and as each white pixel has a value of 255 this amounts to 1084 white pixels .

```
blackPixelValue = (totalPixelsInArray – numberWhitePixels)
```

Answer = 1244340

Hence, 276420/ 691200 = 0.3999 (The mean value of the array).

Example Instruction Slides for Computer Program 1

The following instruction slides are adapted from those in an inspection time program kindly supplied by Preiss and Burns (2012).

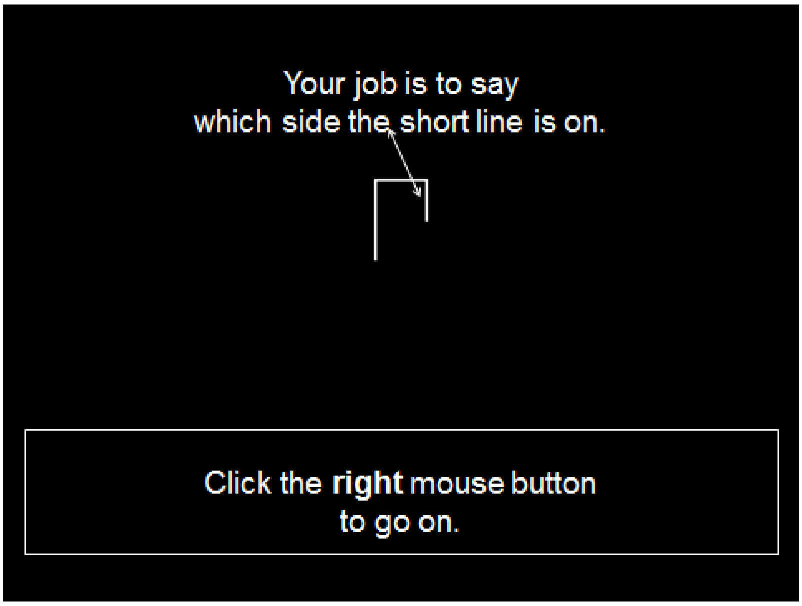


Figure E10. Instructions 1.

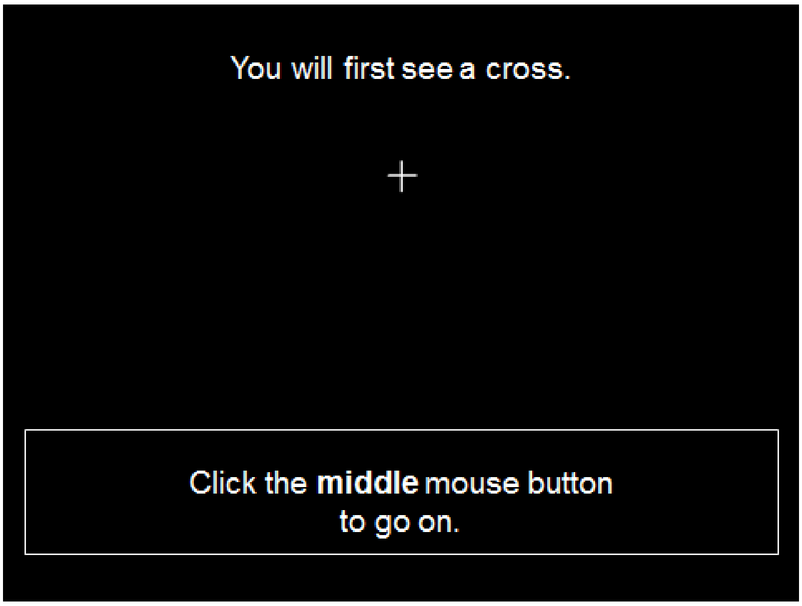


Figure E11. Instructions 2.

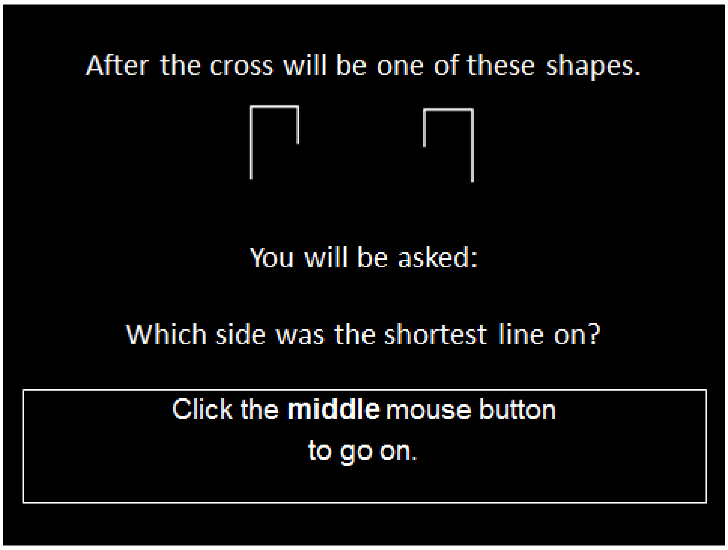


Figure E12. Instructions 3.

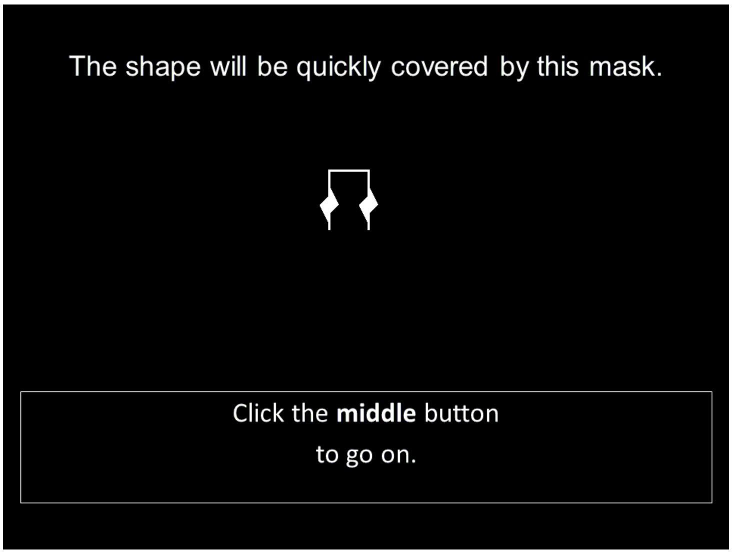


Figure E13. Instructions 4.

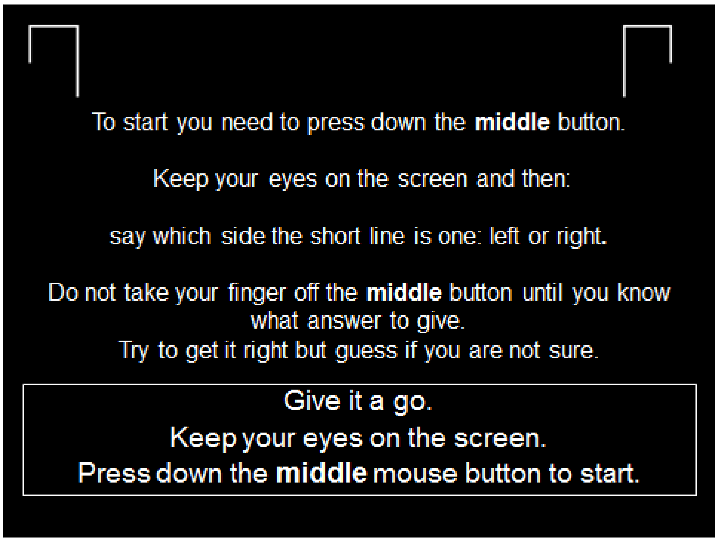


Figure E14. Instructions 5.

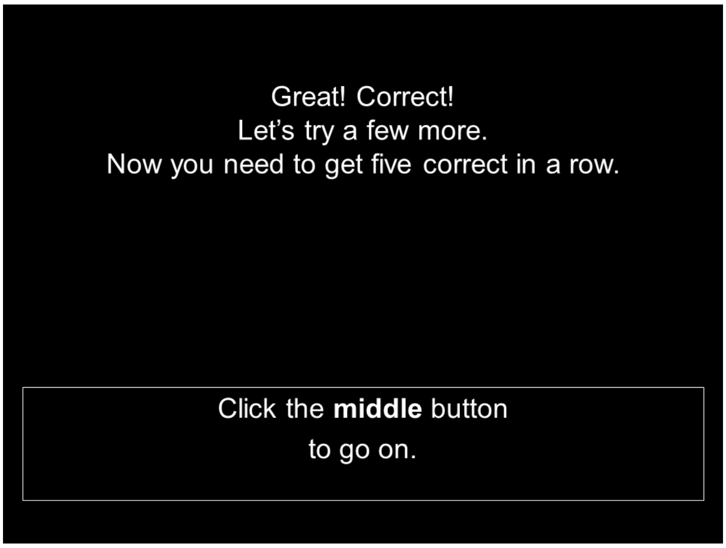


Figure E15. Instructions 6.

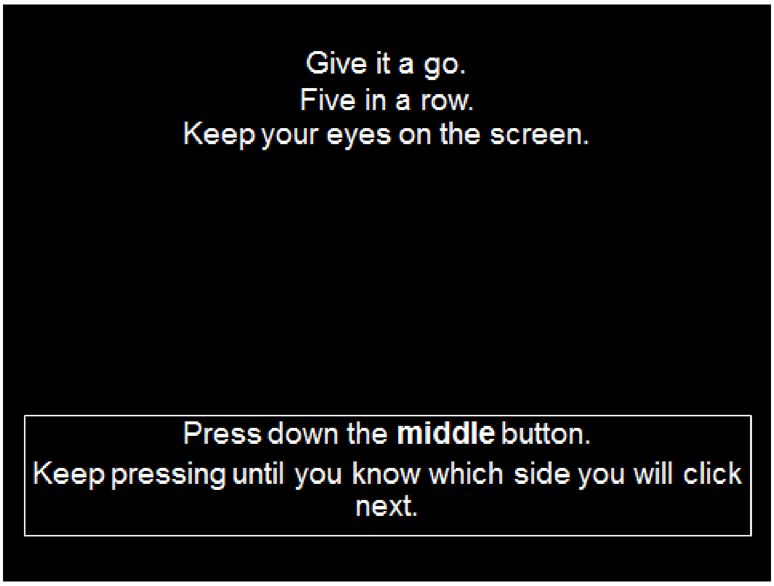


Figure E16. Instructions 7.

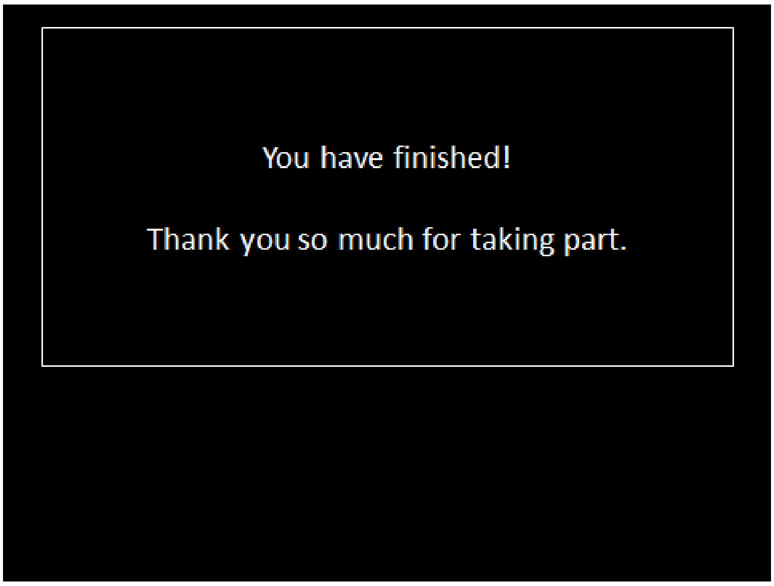


Figure E17. Final instructions.

APPENDIX F: Inspection Time Task Development: Study 1

First, Study 1 investigated Question 1.3, about spatial aspects of the target stimulus. Weak spatial judgements, known in some specific learning differences (SpLDs), could be part of a continuum in the wider population (Section 3.1). It was hypothesised that some participants would have shorter inspection times from tests that did not require left/right directional judgments, line-length discriminations or both. Second, Study 1 tackled parts of Question 2 about the nature of the relationships between inspection time and cognitive and attainment characteristics.

Method.

Participants. A group of 26 children from Year 7 (seven boys; mean age 11 years: 8 months; *SD*: 3.43 months) volunteered and all who volunteered participated. The Faculty of Science and Technology, Anglia Ruskin University Ethics Panel approved the study designs. Parents gave written consent and children gave verbal consent. Parents reported that children had normal or corrected-to-normal vision. Five children spoke an additional language to English at home and all but one child had been educated in English. Two children were left-handed. Two boys had diagnoses of Asperger's Syndrome and one girl a diagnosis of dyslexia. The mean standard score for Middle Years Information System (MidYIS) nonverbal test of ability was 114 (*SD* 17).

Materials.

Questionnaire. A parent/carer questionnaire completed at home, obtained information about English as a second language, progress with literacy and SpLDs.

QUESTIONNAIRE **My son/daughter's participant number is: xxx**		
QUESTION	**ANSWER**	**Tick ✓**
1 Was he/she a premature baby?	yes (go to question 1a, then 2)	
	no (go straight to question 2)	
1a If he/she was born prematurely was it by:	more than six weeks	
	between 3 and 6 weeks	
	less than three weeks	
2 What was his/her birth weight?		
3 Has he/she ever had any:	hearing difficulties (please specify):	
	sight difficulties (please specify: glasses/exercises/overlays/other)	
	speech therapy (please specify):	
3a At the moment does he/she have any:	hearing difficulties (please specify):	
	sight difficulties (please specify: glasses/exercises/overlays/other)	
	speech therapy (please specify):	
3b When were her/his eyes last tested?		
3c What was the outcome of the last eye test?		
4 How would you describe his/her progress with reading?	faster than expected	
	as expected	
	slower than expected	
	troubled	
5 How would you describe his/her reading now?	avid reader	
	reads for pleasure	
	only reads if necessary	
	avoids reading	
6 How would you describe his/her attitude to handwriting?	loves writing	
	writes when necessary	
	avoids writing	
7 How often does he/she play action computer games?	every day	
	several times per week	
	once or twice per week	
	less than once per week	

	never	
8 Has he/she ever been formally diagnosed (by a doctor, specialist teacher, educational psychologist or occupational therapist) with a specific learning difference (SpLD) such as dyslexia, dyspraxia, AD(H)D, Asperger's Syndrome, autism.	yes (go to question 8a and consider 8c)	
	no (go to question 8b)	
8a If the answer to question 8 is YES, what was the diagnosis?		
8b Do you think your child has an SpLD that has <u>not</u> been formally diagnosed?	yes (go to question 8c)	
	no (go to question 9a)	
8c If you think your child has an SpLD that has <u>not</u> been formally diagnosed what do you think it is?		
9a Are there any SpLDs among his/her blood relatives?	yes (go to question 9b)	
	no (go to question 10a)	
9b If the answer to question 9a is YES, what are the SpLDs.		
10a Is English your child's first language?	yes	
	no	
11 Has a member of your child's family been diagnosed with schizophrenia?*	no	
	yes	
	I'd rather not say	
*People with schizophrenia and sometimes their relatives can have abnormal performance to tests such as the inspection time test.		

Inspection time. Participants sat about 60 cm from the monitor, with images at eye level. Within sight was a diagram that supplemented verbal explanations and showed which button press was required. Four inspection time tests, *IT Tests 1–4,* had one pair of stimulus images each (Figures F1–F4). IT Tests 1–4 measured IT1–4.

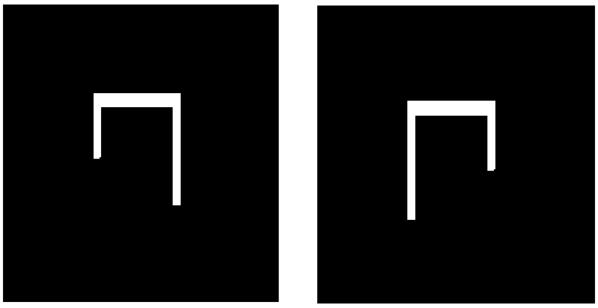


Figure F1. Test 1. White standard mirrored pi-figure with short left or right feature (black background).

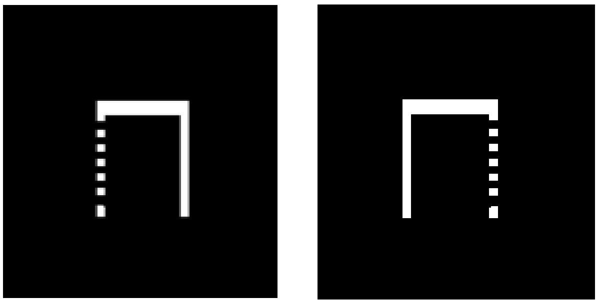


Figure F2. Test 2. White novel pi-figure with dotted and plain left or right feature (black background).

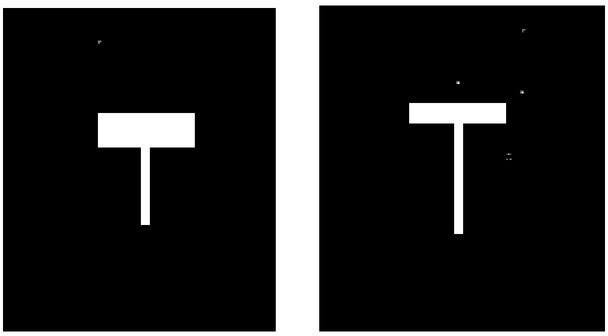


Figure F3. Test 3. White novel short or long T−shaped figure (black background).

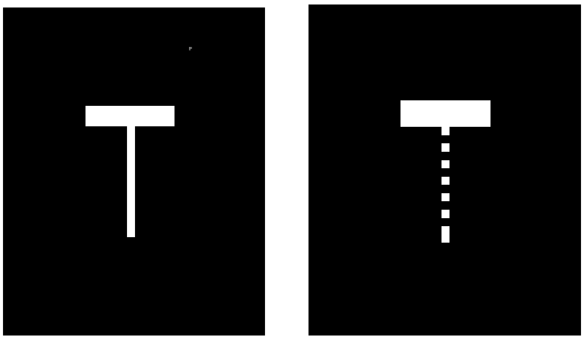


Figure F4. Test 4. White novel dotted or plain T-shaped figure (black background).

Each stimulus pair required a different set of visuospatial discriminations (Table F1). Distinctions between stimuli that relied on line-length judgement were in IT Tests 1 and 3; left or right discrimination in IT Tests 1 and 2; dotted pattern in IT Tests 2 and 4. Target stimuli with different spatial demands were as similar in white pixel number to each other as possible.

Table F1

Study 1: Discriminations for Four Inspection Time Tests (Tests IT1–4)

	Discriminations				
Test	Left/ right	Long/ short	Dotted/ plain	Number	Spatial compatibility with response
1	yes	yes	no	2	yes
2	yes	no	yes	2	yes
3	no	yes	no	1	no
4	no	no	yes	1	no

Viewing angles and dimensions are in Table F2.

During task development, the usual lightning flash mask (Figure 1) was noticeably ineffective for the dotted stimuli, so there was employed a different mask of white

Table F2

Study 1: On-screen Dimensions and Viewing Angles, Inspection Time Tests 1–4

Images	On-screen dimension	Value (mm)	Pixels	Viewing angle º
Locating cross	Height	9.53	24	0.90
	Width	9.51	24	1.06
	Line thickness	0.06	2	0.08
Stimulus figures	Height of long limb	30.58	77	2.92
	Height of short limb	< 15.89	40	1.59
	Width	< 17.87	45	1.70
	Difference between two limbs	14.69	37	1.40
	Line thickness	1.98–6.34	5–16	0.19–0.61

Note. Stimulus line thickness varied to keep the same area for various shapes. Viewing distance = 60 cm.

dots with diameters from two to 10 pixels, randomly drawn on a black background, every trial (Figure F5). Black to white ratio of pixels in the mask varied.

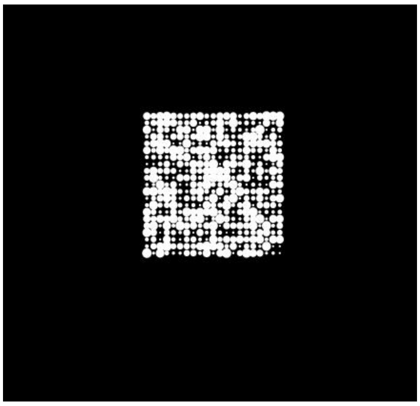


Figure F5. Random dot mask (black background).

In IT Tests 1 and 2, the stimulus had spatial compatibility with the response. For the short line or dots on the left, participants pressed the left button and for the right, the right button. In IT Tests 3 and 4, for a single line-length, discrimination was not to left or right, although the response was to either the left or right. Participants pressed the left button for the short vertical or dotted line of the T-shaped figure.

Middle Years Information System (MidYIS). MidYIS nonverbal tests contain cross-sections, block counting, picture addition, subtractions and sequences to test ability in spatial and 3-D awareness. MidYIS vocabulary tests ability, fluency and speed in vocabulary but the test requires identification of a word of a similar meaning by reading four words. This test purports to measure vocabulary but relies on reading. MidYIS skills were *proofreading:* children identify spelling errors by a comparison against a correct version and *perceptual speed and accuracy:* children quickly recognise and match symbols. MidYIS maths tested computation fluency and speed.

Elision. Elision is a subtest of the Comprehensive Test of Phonological Processing (CTOPP -2; Wagner, Torgeson, Rashotte & Pearson, 2013). By removing syllables and phonemes from words to make a new word, elision assesses ability to distinguish between adjacent units of sound that occur across a brief time interval. The test starts with removal of syllables, “Say ‘toothbrush’ without saying tooth”. Elisions become more complex: “Say ‘split’ without saying /p/”. Reading skills closely reflect development of phonological awareness (e.g., Bradley & Bryant, 1983).

Spelling. Spelling (blue form) was from the Wide Range Assessment Test (WRAT-4; Wilkinson & Robertson, 2006). Scores were of number correct.

Design. The design was of repeated-measures, to show any differences for the group between inspection times, the dependent variable, from four different stimulus types, the independent variables. For each individual the difference between pairs of tests that used different spatial demands were calculated. Correlations were made between the four types of inspection time and tests of cognition and attainment and their differences explored.

Procedure. School staff administered MidYIS tests to children in the summer term of Year 6 and the researcher administered handwriting and spelling tests at the same time. Parents completed the questionnaire about second language, literacy and SpLDs and gave permission for the researcher to view MidYIS test results and children to participate. Individual tests took place in a school classroom with plain walls and light from one window. The researcher sat to the child’s right. Psychometric tests administered in fixed order (Table F3) for about 25 minutes preceded the computer tests.

Table F3

Study 1: Order of Tests and Metrics

Tests	Units
Group tests	
MidYIS: nonverbal test, vocabulary, proofreading, perceptual speed & accuracy, maths	standard scores
WRAT-4 spelling	number correct
DASH handwriting: copy best	words/minute
alphabet writing	letters/minute
copy fast	words/minute
graphic speed	circles crossed/minute
Individual tests (raw scores)	
WRIT verbal analogies	number correct
CTOPP-2 elision	number correct
TOWRE-2 sight words and phonemic decoding	number correct/ minute
TOMAL-2 digits forward and backward	number correct
TOMAL-2 abstract visual memory	number correct
Four inspection time tests, IT Tests 1–4	inspection times (ITs 1–4) in milliseconds
	total number of false starts

Note. CTOPP-2 = Comprehensive Test of Phonological Processing (Wagner, Torgeson, Rashotte & Pearson, 2013); DASH = Detailed Assessment of Speed of Handwriting (Barnett, Henderson, Scheib & Schulz, 2010); MidYIS = Middle Years Information System *(*Durham University, Centre for Evaluation and Monitoring); TOMAL-2 = Test of Memory and Learning (Reynolds & Voress, 2007); TOWRE-2 = Test of Word Reading Efficiency (Torgeson, Wagner & Rashotte, 2012); WRAT-4 = Wide Range Achievement Test (Wilkinson & Robertson, 2006); WRIT = Wide Range Intelligence Tests (Glutting, Adams & Sheslow, 2000).

All participants took IT Tests 1–4 administered in orders dictated by a 4-way Latin Square (E.J. Williams, 1949). The researcher thanked the participants with a certificate.

Question 11 was because schizophrenia affects masking (Green, Lee, Wynn, & Mathis, 2011). Likert scales graded some answers.

Statistical analyses. Analyses were with raw scores, unless stated otherwise, in IBM SPSS Statistics for Windows, Version 20 (IBM Corp., Armonk, NY, USA) and MATLAB R14a (The Mathworks Inc. Natick MA, USA). A nonparametric one-way repeated-measures ANOVA evaluated differences between ITs 1–4. Correlation analyses were between ITs1–4, and between summed z-scores of IT1–4, cognitive and attainment tests. Statistical analyses used .05 as the decisive significance value of alpha. Cohen's standard (Cohen, 1988) evaluated effect sizes with value 0.10 to 0.29, a small association; 0.30 to 0.49, medium; 0.50 or over, large. Statistically significant differences between correlations were compared by Cocor (Diedenhofen & Musch, 2015), an on-line statistical tool. No adjustments for multiple correlations were used, to make sure that significant results were not overlooked. At an exploratory stage, to include all possible covariates, it is expedient to tolerate possible Type I errors (e.g., Streiner & Norman, 2011).

Results. After most of the participants had been tested it became apparent, from conversations with the participants about their performance and from the researcher's observations of image sequences, that occasionally, solid elements of stimulus figures seemed superimposed upon the mask because of a *shine-through* effect (e.g., R. Miller, Rammsayer, Schweizer & Troche, 2010). These solid elements, although physically replaced by the random dot mask, visibly persisted during the time that the mask was also on the screen. Consequent to variable shine-through effects, the original intention to compare stimulus images was unfair. Nevertheless, the tests were completed and results reported to show the consequences of shine-through.

Descriptive statistics. Table F4 shows descriptive statistics for ITs 1–4. Three out of four distributions for these inspection time results failed Shapiro-Wilk tests of normality, indicating the necessity to use nonparametric statistical methods. Table

F5 displays descriptive statistics for the results of the questionnaire, MidYIS, cognitive and attainment tests.

Table F4

Study 1: Descriptive Statistics for Inspection Times

N = 26	Inspection time (IT)						
Test	Skewness SE = 0.46	Kurtosis SE = 0.89	Shapiro Wilk Test	Median (ms)	Interquartile range (ms)	Mean (ms)	Standard Deviation (ms)
1. Standard mirrored pi-figure	0.71	– 0.32	.92	27	13	27	9
2. Dotted/plain pi-figure	0.69	– 0.73	.91*	37	24	41	16
3. Short/long T-shape	3.42	14.22	.64***	32	18	38	25
4. Dotted/plain T-shape	1.10	0.01	.84**	38	32	48	27
	Total false starts = 0–4						

Note. ms rounded to whole numbers. *$p < .05$, ** $p < .01$; *** $p < .001$, two-tailed.

Table F5

Study 1: Descriptive Statistics for MidYIS, Cognitive and Attainment Tests

N = 26	Skewness (*SE* = .46)	Kurtosis (*SE* = .90)	Minimum	Maximum	Shapiro-Wilk Test statistic	Mean	Standard deviation	Median	Interquartile range
				MidYIS tests (standard score)					
Nonverbal	– 1.51	2.96	61	135	.88**	115	17.09	118	20
PSA	– 0.56	– .09	67	128	.96	104	15.26	107	21
Proofreading	0.74	0.98	83	137	.94	102	13.10	102	15
Vocabulary	– 0.33	– 0.78	91	138	.96	116	12.52	118	20
Maths	0.52	0.08	76	152	.96	111	19.37	108	19
				Cognitive tests (raw score)					
Analogies (WRIT)	– 0.44	0.38	16	28	.98	23	2.77	23	4
Elision	– 1.84	5.19	18	33	.85*	29	3.04	29	3
Digit forward	– 0.05	– 1.42	18	65	.92	43	15.88	43	31
Digit backward	1.08	0.33	12	54	.89**	25	11.71	21	16
AVM	– 0.13	– 1.06	11	38	.97	25	7.58	26	12
				Attainment tests (raw score)					
Sight word	0.45	– 0.12	70	107	.97	85	9.42	85	13
Phonemes	– 1.31	2.57	23	61	.90*	48	8.58	50	9
Spelling	– 0.35	1.44	22	54	.97	39	6.47	39	8
Copy best	0.62	0.82	17	54	.96	34	8.26	32	9
Alphabet	0.31	– .43	25	107	.97	60	20.36	58	33
Copy fast	– 0.41	– .19	32	63	.96	48	7.96	49	10
Graphic speed	– 0.07	1.85	4	59	.95	31	10.97	31	11
				Questionnaire (raw score)					
Prematurity	3.97	16.03	0	2	.30***	0.12	0.43	0	0
Sight difficulties	0.96	– 0.26	0	2	.72***	0.54	0.71	0	1
Action computer gaming habits	.638	– 1.00	0	4	.83***	1.38	1.44	1	3

Note. AVM = abstract visual memory, Test of Memory and Learning-2 (TOMAL-2; Reynolds & Voress, 2007)*;* copy best, alphabet, copy fast and graphic speed, Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); digit span tests, TOMAL-2; PSA = Perceptual Speed and Accuracy, Middle Years Information System*,* Durham University, Centre for Evaluation and Monitoring (MidYIS); rapid automatic naming and elision, Comprehensive Tests of Phonological Processing (Wagner, Torgeson, Rashotte & Pearson, 2013); sight word reading and phonemic decoding efficiency, Test of Word Reading Efficiency

(Torgeson, Wagner & Rashotte, 2012); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).

Inferential statistics.

Analysis of variance. The null hypothesis, that there were no mean differences between ITs 1–4, was tested with Friedman's nonparametric ANOVA. This test revealed a probability that that there was a significant difference between the mean ranks of ITs 1–4 (χ^2 (103) = 27.70, p <.001). Post hoc multi-comparison analysis, using Tukey-Kramer correction, indicated that the mean rank of standard IT1 was significantly less, and therefore easier, than for IT2 and IT4 from the dotted tests (mean ranks for ITs 1–4: 1.50, 3.04; 2.40; 3.06, respectively; Figure F6). There were no significant group differences, at the .05 level, between means of IT2–IT4.

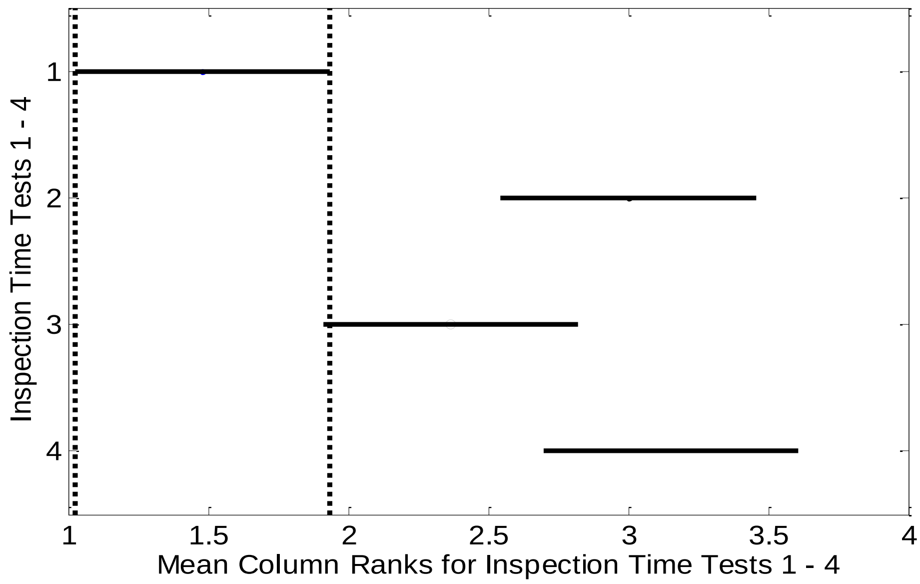


Figure F6. Comparison of mean column ranks for inspection times 1–4 by Friedman's test.

Correlation analyses. Spearman correlation analyses described the strengths of associations between results of ITs 1–4. There were medium or large positive correlations except between IT1 and IT3 (Table E11). None of these correlations significantly differed to any others (Diedenhofen & Musch, 2015).

Table F6

Study 1: Spearman Correlation Analyses for Inspection Time Tests 1–4

N = 26	1	2	3	4
1. IT1	1.00			
2. IT2	**.48****	1.00		
3. IT3	.28	**.48****	1.00	
4. IT4	**51****	**.50****	**.42****	1.00

Note. Significant correlations are in bold. IT = inspection time. * $p < .05$, ** $p < .01$ level, two-tailed.

Inspection time and memory. Spearman correlation analyses were between results of IT1–4 and three tests of memory. Results omitted those of the child whose first language was not English. There were significant correlations between digit backward and IT2 and IT3 only (r_s (24) = − .54, p = .006; r_s (24) = − .61, p = .001, respectively).

Inspection time, other cognitive and attainment tests. Z-scores for ITs1–4 were amalgamated for correlation analyses of inspection time with cognitive and attainment test results, bar those of the child whose first language was not English. Significant correlations with inspection time were: MidYIS nonverbal test (r_s (24) = − .59, p = .002); WRIT analogies (r_s (24) = − .45, p = .023); CTOPP-2 elision (r_s (24) = − .57, p = .003); TOMAL-2 digit span backward (r_s (24) = − .59, p = .002); TOWRE-2 sight word efficiency (r_s (24) = − .50, p = .011); TOWRE-2 phonemic decoding efficiency (r_s (24) = − .42, p = .035). Participants diagnosed with SpLDs had no exceptional inspection times. Gender, action video gaming habits, history of perinatal and sight difficulties were not significantly related to *z*-scores for ITs 1–4.

Discussion Study 1. Explorations of the effects on inspection time of spatial awareness skills in schoolchildren were unsuccessful, because there was a shine-through effect. The inadequate mask led to inspection time results that were shorter than anticipated from published inspection times for this age group, which although not directly comparable, have a median value of around 50 ms (Preiss & Burns, 2012). A difference between inspection times for the different tests was probably because the mask obscured the after-image of stimulus figures to different degrees, not from spatial demands of the stimuli. Analysis of variance showed that there were significant differences in median inspection times between an inspection time choice that used the standard pi-figure and the other three novel stimuli. Solid elements in the images appeared more susceptible to shine-through. Stimuli with a dotted pattern had longer inspection times probably because random dots better masked the dotted pattern. Yet another unwanted variable would be if individual differences existed between perceived shine-through, which may rely on visible persistence. Because there is a delay of several milliseconds between frames for a small image on the screen followed by a small mask (Appendix E), there was potential for individual differences in persistence to affect inspection time, even had the mask been effective. Apart from one exception, results of the four inspection time tasks significantly correlated to a medium level or more, which indicates that most participants made similar responses to the four separate tests. The stimulus images, drawn from many pixels, may also have resulted in shorter than usual inspection times. Finally, the low number of recorded false starts in the whole group indicates that either none of the participants was impulsive or false starts did not reflect degree of impulsivity.

Judgments about effective masking are subject to human error, as happened in Study 1. The shine-through effect, not noticed initially, limited the intended comparisons between inspection times from different images. This mishap demonstrated the importance of effective masking, especially for a comparison of different pairs of stimulus images. Random dots do not effectively mask figures with solid elements and therefore are likely to be inappropriate to act as masks for alphanumeric or other figural stimuli.

An amalgamation, formed from the four inspection times, had large and significant correlations with MidYIS nonverbal, analogies, elision, backward digit span, phonemic decoding and sight word reading efficiency. The large, significant negative correlation noted with the nonverbal test supports a hypothesis that spatial skills drive, in part, individual differences in inspection time. The MidYIS nonverbal test is similar in design to Raven's Progressive Matrices, commonly used to assess nonverbal intelligence. It demands evaluations of size, position and orientation. The correlation was higher than expected from small values published from a meta-analysis for the relationship between inspection time and crystallised intelligence (Sheppard & Vernon, 2008). Large significant relationships between these tests may indicate that the common content of the tests, that require spatial skills, is important to both tests, as implied by Mackenzie, Molloy, Martin, Lovegrove and McNicol (1991, as cited in Stokes & Bores, 2001). However, there was not a significant difference between the correlations with inspection time of the nonverbal test on the one hand and with verbal analogies on the other. That there is little difference between these correlations does not reinforce an idea that shared spatial awareness differences are fundamental to either MidYIS nonverbal or inspection time. Furthermore, R. Miller et al. (2010) noted that iconic memory positively correlates with intelligence so there could have been additional affinity with intelligence above that from standard well-masked inspection time, because of shine-through. This possibility offers a further explanation for the higher than usual correlation between the tests. The inadequate mask could also explain the large negative significant correlation with working memory tested with digit span backward. Digit span backward utilises visual working memory in some cases (Hoshi et al., 2000). Working memory may relate to visible persistence. This could also be an explanation for the large relationship observed between inspection time and elision, as both may depend on working memory. Mockler (2003) did not find that elision correlated with inspection time in the children that she tested. Correlations with sight word reading and phonemic decoding efficiency were also higher than expected from reports of reading speed by Mockler (2003).

Another technical problem in this experiment was that the shortest inspection times were too close to the duration of one frame; there was a possibility that participants with short inspection times would be indistinguishable from those with even shorter inspection times. In subsequent experiments, the line width of the stimulus figures was reduced, which made the stimulus figure more difficult to evaluate and thus increased the time needed for evaluation. This then pulled inspection times up away from 11.76 ms — the minimum possible stimulus duration. Furthermore, a response to the stimulus figure composed of one descender was not compatible with the decision that distinguished the figure, as is the case for a left/right decision, which is compatible with a left/right response. This may have added another variable from uneven demands on memory in the different inspection time tests. Finally, all the participants selected themselves by volunteering and therefore could have characteristics, such as motivation, in common.

APPENDIX G: Inspection Time Task Development: Study 2

Study 2 used new stimuli designed to avoid technical problems encountered in Study 1. Again, a hypothesis tested was that some participants would have better inspection times if there were no left/right directional judgements, if they were not required to make length discriminations or both. New stimulus figures were composed of circles of one pixel width and had no solid linear elements. Random dots effectively masked these fine lines and curves. Fine lines in the stimulus figures might also increase the inspection times, and thus pull the lower limit of inspection time up away from the shortest stimulus duration of 11.76 ms; this would increase accuracy. Pairs of stimuli reappeared on the screen after the mask. The participant made a response via a mouse click once they had placed the cursor over their chosen stimulus figure.

Method.

Participants. As in Study 1, the Faculty of Science and Technology, Anglia Ruskin University Ethics Panel approved the study designs. Participants were the same participants as in the previous investigation who all kindly volunteered to repeat the computer tests. Parents gave further written consent and all children again gave verbal consent. Test conditions were as in Study 1.

Materials.

Inspection time stimuli and responses. The various target stimuli were as similar to each other as possible. Each of four different pairs of target stimuli was an arrangement of eight circles (Figures G1-4). These were *circles IT Tests 1, 2, 3 and 4* and the respective inspection times were *circles IT1–4.* Each pair of stimuli required a different set of visuospatial discriminations to make a decision about the image shown (Table E12). In circles IT Test 1 (Figure E23), the stimuli were obviously different: a cross and a circle. Stimuli for circles IT Tests 2 and 3 were mirror images of each other with a gap feature either left or right (Figure 9); or top and bottom (Figure E25). Circles IT Test 4 had an uneven cross with the long axis presented vertically or horizontally (Figure E27), which required a discrimination of relative length to identify the stimulus.

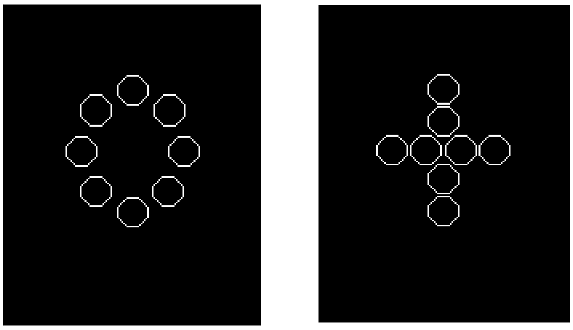


Figure G1. White stimulus images for circles inspection time Test 1 (black background).

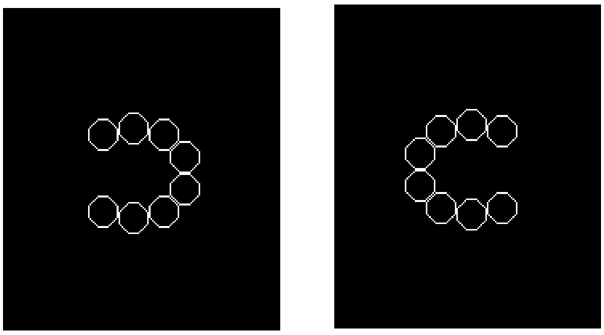


Figure G2. White stimulus images for circles inspection time Test 2 (black background).

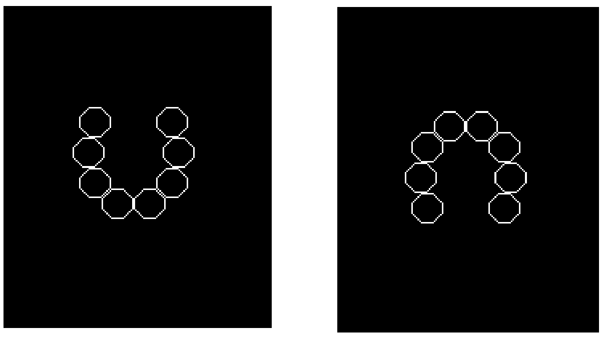


Figure G3. White stimulus images for circles inspection time Test 3 (black background).

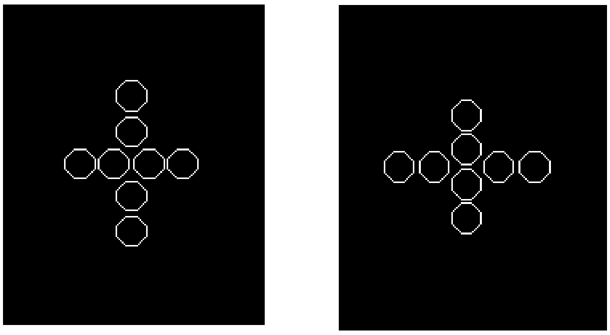


Figure G4. White stimulus images for circles inspection time Test 4 (black background).

Table G1

Study 2: Discriminations for Circles Inspection Time Tests 1–4

Circles inspection time test	Discrimination demands		Number of discriminations	Spatial compatibility with response
	Left/ right	Long/ short		
1	no	no	multiple	no
2	yes	no	2	yes
3	no	no	2	yes
4	no	yes	2	no

Table G2 displays on-screen dimensions and viewing angles.

Table G2

Study 2: On-screen Dimensions and Viewing Angles for Circles Inspection Time Tests 1–4

Image	On-screen dimension	Value (mm)	Pixels	Viewing angle (º)
Individual small circles	Diameter	7.53	19	0.72
	Line width	0.40	1	0.04
Cross	Height	37.67	95	3.60

Note. Viewing distance = 60 cm.

Both images reappeared on the screen, randomly above or below each other after random dots masked them for 353 ms (Figure E). There was no shine-through so the random dot mask apparently masked the circles stimuli effectively. Participants pointed the cursor with the mouse to identify with a mouse click the image that they had recognised. Participants initiated the next trial after a displayed message: '**`Press the middle button to start.`**' As in Study 1, responses were un-speeded.

Design and procedure. Design and procedure were the same as in Study 1 except participants pressed and kept pressing the mouse wheel to initiate and maintain the sequence of images before lifting a finger from the wheel to make each response. The intention of this change in procedure was to avoid making demands on working memory, which may have influenced the results. Tests lasted about 25 minutes. For differences in participants' evaluation of directionality and/or figure length, Friedman's nonparametric analysis was made of the four circles IT responses. Differences between pairs of circles IT tests that used skills of directionality (circles IT2 – IT3) or length/orientation (circles IT4 – IT1) were calculated. Correlation analyses were between circles IT1–4, and between circles IT1–4 and cognitive and attainment tests.

Results.

Descriptive statistics. Table E14 displays descriptive statistics for circles IT 1–4. Distributions for these inspection time results again failed Shapiro-Wilk tests of normality, which warranted the use of nonparametric statistical methods.

Table G3

Study 2: Descriptive Statistics for Circles Inspection Times

N = 26	Test	Skewness SE = 0.46	Kurtosis SE = 0.89	Shapiro Wilk Test	Median (ms)	Interquartile range (ms)	Mean (ms)	Standard Deviation (ms)
Circles inspection	1	1.68	4.16	.86**	28	16	30	12
time (IT)	2	0.35	– 0.81	.90*	32	24	36	15
	3	1.57	2.21	.83***	27	17	33	15
	4	1.47	2.31	.86**	61	54	75	45
Circles IT2 – IT3		– 0.80	1.57	.95	4	22	3	16
Circles IT4 – IT1		1.14	1.13	.91*	36	47	44	38

Note. Circles IT1–4 ms rounded to whole numbers. Circles IT2–IT3 shows differences in individual scores between IT2 and IT3. Circles IT4–IT1 shows differences in individual scores between IT4 and IT1. *$p < .05$, ** $p < .01$, *** $p < .001$, two-tailed.

Inferential statistics.

Analysis of variance. Friedman's analysis tested the null hypothesis that there were no mean differences between circles IT1–4. This test revealed a probability that there is a significant difference between the mean ranked circles IT1–4 (χ^2 = 43 (103), p <.001). Post hoc Tukey-Kramer multi-comparison analysis indicated that the mean rank of circles IT4 was significantly different to that for circles IT1–IT3 (mean ranks for circles IT1–4: 1.71, 2.50, 1.94, 3.85, respectively; Figure 12). There were no significant differences between conditions, at the .05 level, between means of circles IT1–3.

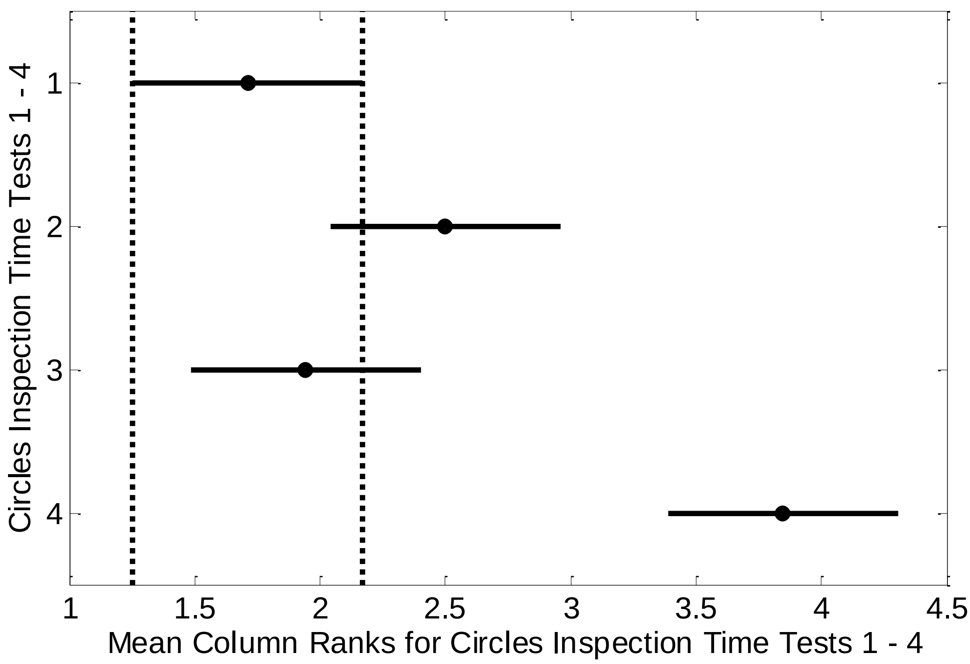


Figure G5. Comparison of mean column ranks for circles inspection times 1–4 by Friedman's test.

Individual differences in tests for left/right and up/down discriminations. A calculation, circles (IT2 – IT3), showed the differences between performance for left/right and up/down discriminations in each individual. Circles IT Test 2 trended towards more difficult than circles IT Test 3 (Figure G5). Only eight participants found circles IT Test 3 more difficult than circles IT Test 2, 18 participants found circles IT Test 2 more difficult. Participant 2, who has dyslexia, found the up/down decision of circles IT Test 3 considerably more difficult, that is had longer inspection times, than the left/right decision of Test 2 on this occasion, in contrast to most of the other participants.

Individual differences between tests for length/orientation discriminations. Participants 7 and 10 were outliers with longer circles inspection times for length discrimination, IT4, in comparison to other participants (Figure G2). As circles IT4 was significantly longer than in IT1, IT2 and IT3, calculations of the differences between raw scores, dominated by the result for circles IT4, were not meaningful.

Correlational analyses. Table G4 shows Spearman correlations between circles IT1–4. These show that there were significant correlations between all of circles IT1–4 (r_s (24) > .49, p < .011).

Table G4

Study 2: Spearman Correlation Analyses for Circles Inspection Time Tests 1–4

N = 26	1	2	3	4
1. Circles IT1	1.00			
2. Circles IT2	**.49***	1.00		
3. Circles IT3	**.61*****	**.55****	1.00	
4. Circles IT4	**.53****	**.68*****	**.69*****	1.00

Note. Significant correlations are in bold. IT = inspection time. * p < .05, ** p < .01 level, two-tailed.

Correlational analyses between circle ITs and results of tests of cognition and attainment. Table G5 shows correlations between circle ITs and results of tests of cognition and attainment. Correlations with circles ITs are described in more detail below. There were no significant correlations with circles (IT2–IT3) or, after conversion to z-scores, circles (IT4–IT1).

Table G5

Study 2: Spearman Correlations Between Circles Inspection Time Tests 1–4 and Results From Tests of Cognition and Attainment

N = 25		Inspection Time		
	Circles IT1	Circles IT2	Circles IT3	Circles IT4
MidYIS nonverbal	– .34	**– .61*** **	**– .56** **	**– .74*** **
WRIT Verbal analogies	– .19	**– .48***	– .32	**– .49***
Abstract visual memory	**– .45***	**– .40***	– .33	**– .45***
Digit forward	– .26	**– .47***	**– .41***	**– .53** **
Digit backward	– .03	– .32	– .20	– .36
Elision	– .13	– .19	**– .44***	**– .42***
Sight words	– .33	**– .47***	– .33	**– .43***
Phonemic decoding	– .08	– .29	– .35	– .38
Copy best	– .12	– .11	– .07	– .04
Copy fast	– .02	– .35	– .14	– .38
Alphabet	– .05	– .15	– .29	**– .47***
Graphic speed	– .06	– .10	.00	– .13
Spelling	**– .42***	– .23	**– .57** **	**– .54** **
Maths	– .26	– .15	– .36	**– .40***

Note. Statistically significant values are in bold. Copy best, alphabet, copy fast and graphic speed, Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); digit span tests and abstract visual memory, Test of Memory and Learning-2 (Reynolds & Voress, 2007); MidYIS = Middle Years Information System, Durham University, Centre for Evaluation and Monitoring; rapid automatic naming and elision, Comprehensive Tests of Phonological Processing (Wagner, Torgeson, Rashotte & Pearson, 2013); sight word reading and phonemic decoding efficiency, Test of Word Reading Efficiency (Torgeson, Wagner & Rashotte, 2012); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * $p < .05$, ** $p < .01$ level, two-tailed.

MidYIS nonverbal test. There were negative relationships between MidYIS nonverbal test results and circles IT1–4. The largest relationship was with circles IT4 (Figure G4; $r_s(25) = – .74$, $p < .001$). Other significant correlations of MidYIS nonverbal test were with circles IT2 ($r_s(24) = – .61$, $p < .001$); circles IT3 ($r_s(24)$ =

– .56, *p* =.004). There was a significant difference between the correlations with nonverbal analogies for circles IT1 and circles IT4 (Diedenhofen & Musch, 2015; Fisher's *z* = – 2.57, *p* = .005).

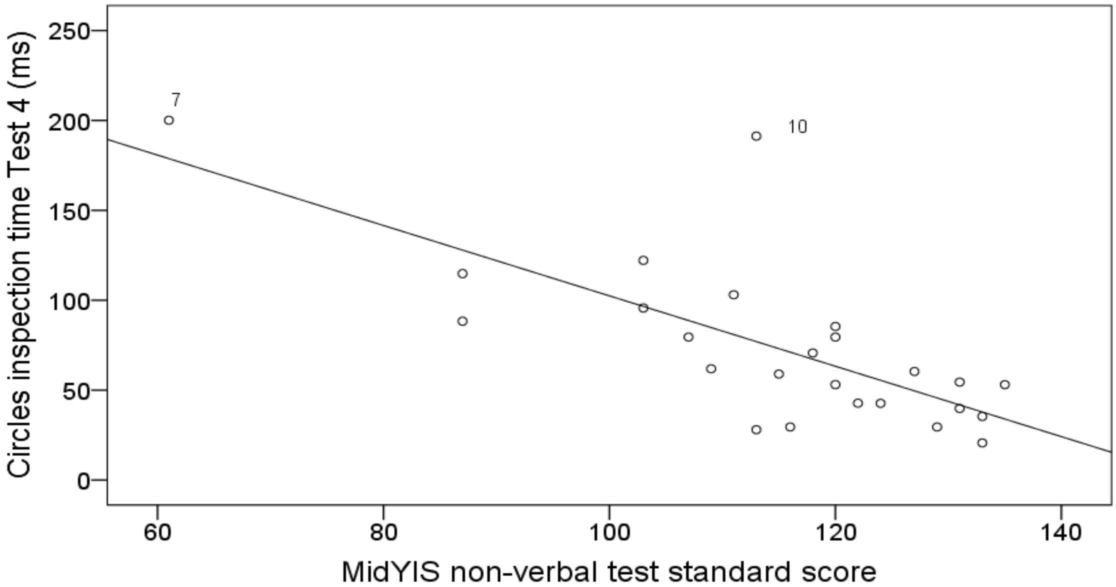


Figure G6. Scatter graph showing the relationship between results for MidYIS nonverbal test and circles inspection time Test 4. MidYIS = Middle Years Information System, Durham University, Centre for Evaluation and Monitoring. Outliers are Participants 7 and 10.

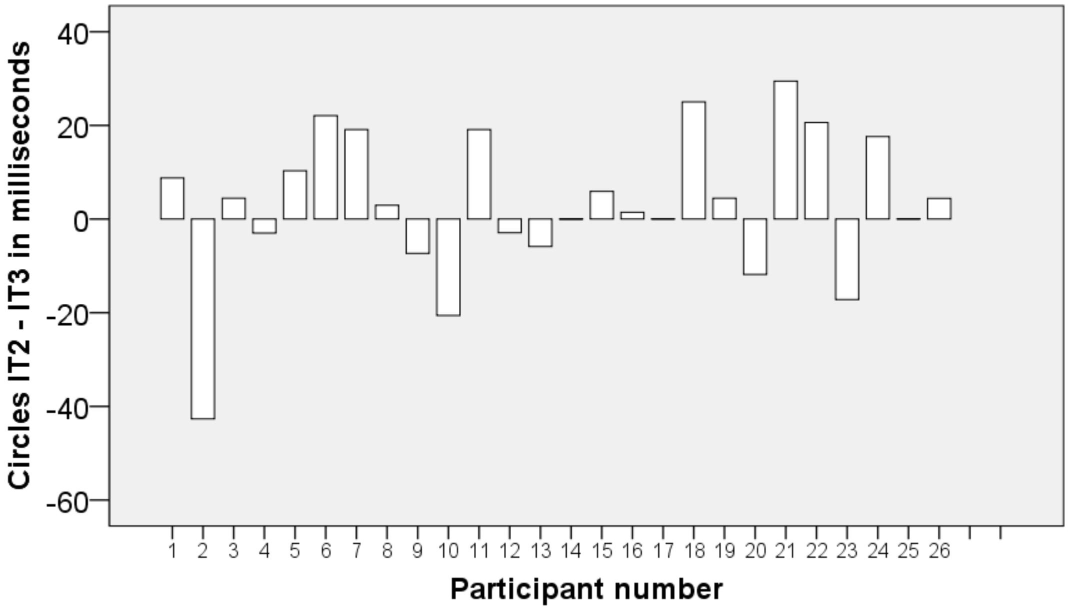


Figure G7. Bar chart showing circles (IT2 – IT3) in individual Year 7 children. *Note.* Participant 2 has dyslexia; Participants 5 and 22 have Asperger's Syndrome.

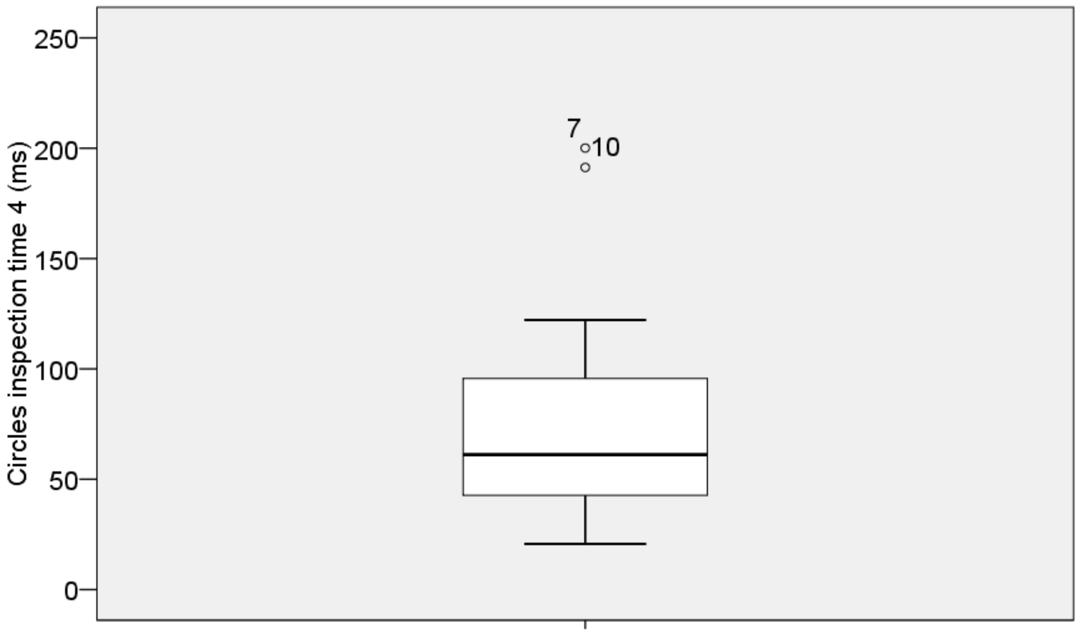


Figure G8. Box plot showing outliers in circles inspection time Test 4 (Participants 7 & 10).

Verbal analogies. WRIT verbal analogies correlated to a medium level with circles IT2 and IT4 (r_s (24) = – .48, p =.016; r_s (24) = – .49, p = .013, respectively).

Tests of memory. There were medium significant negative correlations between results for abstract visual memory and circles IT1, IT2 and IT4. Spearman correlations between results for tests of memory and circles IT 1–4 showed that the largest correlation was between circles IT4 and digit forward (r_s (24) = – .53, p = .006). There were no significant correlations between circles IT test results and digit backward.

Elision. Elision results correlated significantly with both circles IT3 and IT4 (r_s (24) = – .44, p = .028; r_s (24) = – .42, p = .036, respectively).

Reading speed. Phonemic decoding results did not correlate significantly with any circles IT. Sight word reading efficiency results correlated significantly with circles IT2 and IT4 (r_s (24) = – .47, p =.017; r_s (24) = – .43, p = .032, respectively).

Writing speed. Only alphabet correlated with circles IT4 (r_s (24) = – .47, p =.015).

Spelling. Spelling correlated significantly with circles IT1, 3 and 4 (r_s (24) = – .42, p = .037; r_s (24) = – .57, p =.003; r_s (24) = – .54, p = .006, respectively).

Maths. MidYIS maths correlated significantly with circles IT4 only (r_s (24) = – .40, p =.048).

Correlational analyses between inspection times from Studies 1 and 2. The correlation between the two summed *z*-scores of the four inspection time tests in each of Studies 1 and 2 was (r_s (24) = .44, p = .025).

Discussion Study 2. In Study 2, in which random dots appeared to mask stimuli effectively, the first aim was to determine if spatial aspects of stimuli relate to inspection time. The cross-circle decision, that generated circles IT1, was easier than the other tests. It is possible that the familiarity of the stimulus shape could affect the time required to assess and remember the stimuli and there are several points of difference between a cross and a circle. There was a significant difference between medians for circles IT1, IT2 and IT3 on the one hand and circles IT4, which required length/orientation discrimination. Circles IT4 was longer and therefore must have been more difficult for most of the group. Participants 7 and 10 both found the length/orientation discrimination of circles Test IT4 extremely difficult. For Participant 7, the result for inspection time was in line with that for MidYIS nonverbal but for Participant 10 the long inspection time was unexpected. This suggested another issue, for example of eyesight. There were significant relationships between all pairs of circles test results, which indicates that most participants reacted consistently across the four circles tests.

The second aim of Study 2 was to investigate the relationships between inspection time and results of tests of cognition and attainment. Large significant negative correlations noted between the MidYIS nonverbal test and circles IT2–4 supports the hypothesis that spatial aspects of the stimuli are important to inspection time evaluation. The very large correlations between circles inspection time tests and MidYIS nonverbal reinforce those found in Study 1. Once more, a property shared by IT tests, this time of circles design, and MidYIS nonverbal tests is a dependence on spatial awareness and discrimination. Tests of verbal analogies, abstract visual memory, digit span forward, single word reading speed, spelling, alphabet writing and maths correlated significantly with some of the circles inspection times and at least one reason for this could be that underlying ability, memory, spatial skills or all these can limit inspection time. There were not significant correlations between inspection time and phonemic decoding, copy best, copy fast and graphic speed, the last three that require motor skills. Previous research (Section 2.3.1) indicated that inspection time and motor skills would not correlate.

A criticism of the stimulus figure in circles IT Test 4 was that not only did the participant have to make the discrimination between long and short, intended to test length discrimination, but they also had to discriminate between vertical and horizontal. Moreover, the need for the participant to remember and recognise two differences to identify the stimulus complicated the distinction between the shapes. Another difference of the figures composed of circles in Study 2 compared to a standard pi-figure was that the circles design requires an evaluation of the gestalt of overall shape rather than identification of a more focussed (spatially localised) aspect of the stimulus. This may have required different processes and skills. However, the medium significant positive correlation between amalgamated inspection times from Study 1 and 2 suggested that the test designs measured similar processes. This has to be a cautious interpretation because the distribution of the inspection time tasks were not normal and therefore a reliance on *z*-scores to sum results was not entirely satisfactory. Another difference in the procedure in Study 2 was that to report it relied on recognition memory, which introduced a new variable. The original rationale for including a different response in Study 2 was to reduce the demand on memory because of the unexpectedly large correlation between memory and inspection time noted in Study 1. That iconic memory might have contributed to inspection time results was another likely reason for that large correlation. Although the response method relied on recognition memory in Study 2, there were only mild correlations between abstract visual memory, which test relies on recognition memory, and circles inspection time. There may be other, overriding, cognitive processes involved in inspection time when it is properly masked. These could be, for example, neural speed, sensitivity or spatial awareness.

To summarise, evidence from Study 2 suggests that stimulus design affected inspection time consistently across most participants but that there were outliers in which some participants had more difficulty with certain designs than did others. With circles stimuli, most participants found a discrimination of length/orientation to be more difficult than a decision that involves directionality: a left/right or up/down feature; or a distinction between two quite different shapes: a cross and circle. A clear correlation existed between MidYIS nonverbal and circles inspection time so spatial awareness may be a common factor. Other tests, of verbal analogies, single word reading speed, spelling, alphabet writing and maths, correlated with some of the circles inspection times and at least one reason for this could be that underlying ability, memory, spatial skills or all acted as limiting factors.

APPENDIX H: Study 3

Questionnaire for Inspection Time Study 3 in Adults

Participant number:	
Question	**Answer**
What is your age and date of birth?	Age: Date of birth:
What is your gender?	
Are you right or left handed?	Right Left Ambidextrous
Do you have a diagnosed specific learning difference (AD(H)D, Asperger's, autism, dyslexia, dyspraxia, other)?	Yes No I'd rather not say
If the answer to Question 2 is 'Yes', it would be helpful to know your diagnosis?	My diagnosis was: _______________ I'd rather not say
Have you been diagnosed with schizophrenia? *	No Yes I'd rather not say
Has a member of your family been diagnosed with schizophrenia? *	No Yes I'd rather not say
How often do you play action computer games?	every day several times/week once or twice/week less than once/week never
Is there anything you know of that might affect your performance on this test?	
Have you normal or corrected to normal eyesight?	
Have you smoked a cigarette in the last 12 hours? **	Yes No

	I'd rather not say
Were you born prematurely?	
Is there a history of specific learning differences in your family?	
* People who have diagnosed schizophrenia or who have a relation with diagnosed schizophrenia may have a different response to the inspection time task (Green, M. F., Lee, J., Wynn, J. K., & Mathis, K. I. (2011). Visual masking in schizophrenia: overview and theoretical implications. *Schizophrenia Bulletin*, *37*(4), 700–8). ** Nicotine is known to improve a subject's inspection time performance (Stough, C., Mangan, G., Bates, T., & Kerkin, B. (1995). Effects of nicotine on perceptual speed. *Psychopharmacology*, *119*(3), 305–310.	

Psychometric Profiles of Adult Participant Groups

Table H1 shows profiles of three adult SpLD groups from Study 3 as *z*-scores calculated against the group of participants with typical development. Table H2 shows summaries of a) *ß*s from regression analyses described in more detail in Appendices L–R, in which Step 1 had age, gender and WRIT matrices and Step 2 had SpLD groups as dummy variables, b) *ß*s with visual discomfort evaluated by The Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999) added to Step 1 of the regression.

Table H1

Mean Psychometric Profiles of Groups of Adults With Specific Learning Differences Compared to Participants With Typical Development

Dyslexia group (*n* = 40)		*Z*-score		
Test	– 3.0 +	– 2.0 +	– 1.0 +	0 +
Visual matrices (WRIT)			– 0.32	
Verbal analogies (WRIT)			– 0.25	
Elision (CTOPP-2)		– 1.10		
RAN digits + letters (CTOPP-2)	– 2.25			
RAN colours + objects (CTOPP-2)			– 1.05	
Digit memory forward (TOMAL-2)			– 0.24	
Digit backward (TOMAL-2)			– 0.31	
Abstract visual memory (TOMAL-2)			– 0.10	
Corsi block test forward			– 0.44	
Corsi blocks backward			– 0.41	
SDMT			– 1.00	
Sight Words (TOWRE-2)		– 1.78		
Phonemic Efficiency (TOWRE-2)		– 1.60		
Copy best (DASH 17+)			– 0.85	
Copy fast (DASH 17+)			– 0.75	
Alphabet writing (DASH 17+)			– 0.86	
Graphic speed (DASH 17+)			– 0.09	
Inspection time 1 (IT1)*			– 0.25	
Simple decision time*			– 0.70	
Choice decision time – 1T1*		– 1.025		
Simple motor time*			– 0.61	
Visual Discomfort Scale*	– 3.06		– 0.64	
AD(H)D 1*		– 1.44		
AD(H)D 2*		– 1.87		
DCD1*	– 2.15			
DCD2*	– 2.11			

Developmental coordination disorder group (n = 33)			*Z*-score	
Test	– 3.0 +	– 2.0 +	– 1.0 +	0 +
Visual matrices (WRIT)			– 0.29	
Verbal analogies (WRIT)			– 0.03	
Elision (CTOPP-2)			– 0.31	
RAN digits + letters (CTOPP-2)	– 2.17			
RAN colours + objects (CTOPP-2)			– 0.75	
Digit memory forward (TOMAL-2)				0.02
Digit backward (TOMAL-2)			– 0.05	
Abstract visual memory (TOMAL-2)				0.22
Corsi block test forward			– 0.48	
Corsi blocks backward			– 0.89	
SDMT		– 1.03		
Sight Words (TOWRE-2)		– 1.18		
Phonemic Efficiency (TOWRE-2)			– 0.40	
Copy best (DASH 17+)		– 1.18		
Copy fast (DASH 17+)		– 1.02		
Alphabet writing (DASH 17+)			– 0.75	
Graphic speed (DASH 17+)			– 0.54	
Inspection time 1 (IT1)*			– 0.47	
Simple decision time*		– 1.48		
Choice decision time – 1T1*		– 1.92		
Simple motor time*			– 0.75	
Visual Discomfort Scale*	– 2.98			
AD(H)D 1*	– 2.04			
AD(H)D 2*	> – 3.00			
DCD1*	> – 3.00			
DCD2*	> – 3.00			

Dyslexia/developmental coordination disorder group (n = 18)			*Z*-score	
Test	– 3.0 +	– 2.0 +	– 1.0 +	0 +
Visual matrices (WRIT)			– 0.88	
Verbal analogies (WRIT)			– 0.61	

Elision (CTOPP-2)		– 1.36	
RAN digits + letters (CTOPP-2)	– 2.42		
RAN colours + objects (CTOPP-2)		– 1.29	
Digit memory forward (TOMAL-2)			– 0.93
Digit backward (TOMAL-2)			– 0.44
Abstract visual memory (TOMAL-2)			– 0.09
Corsi block test forward			– 0.61
Corsi blocks backward			– 0.77
SDMT		– 1.28	
Sight Words (TOWRE-2)	– 2.40		
Phonemic Efficiency (TOWRE-2)		– 1.97	
Copy best (DASH 17+)		– 1.28	
Copy fast (DASH 17+)			– 0.86
Alphabet writing (DASH 17+)		– 1.11	
Graphic speed (DASH 17+)		– 1.06	
Inspection time 1 (IT1)*		– 1.15	
Simple decision time*		– 1.73	
Choice decision time – 1T1*		– 1.43	
Simple motor time*		– 1.56	
Visual Discomfort Scale*	> – 3.00		
AD(H)D 1*	– 2.26		
AD(H)D 2*	> – 3.00		
DCD1*	> – 3.00		
DCD2*	> – 3.00		

Note. Z-scores taking typically developed participant group as standard. * denotes transposed from positive to negative. ADHD 1 & 2 = Sections 1 & 2, Adult ADHD Self-Adult Self-Report Scale (ASRS—v.1.1) Symptom Checklist (Adler, Kessler & Spencer, 2005); Corsi = Corsi Block Task *(*Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000; The Psychological Investigation Building Language, PEBL; Mueller, 2010); CTOPP-2 (Wagner, Torgeson, Rashotte & Pearson, 2013); DASH 17+ = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); DCD1 & 2 = Sections 1 & 2, Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC) for Further and Higher Education (Kirby & Rosenblum, 2008); RAN = rapid automatic naming; RAN, digit spans and abstract visual memory from TOMAL-2 = Test of Memory and Learning-2 (Reynolds & Voress, 2007); SDMT = Symbol Digit Modalities Test (Smith, 1982); Test of Word

Reading Efficiency (TOWRE-2; Torgeson, Wagner & Rashotte, 2012); Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).

Table H2

Summary of ßs from Hierarchical Regression Analyses for Cognitive Tests in Groups of Participants With Specific Learning Differences Compared to Participants With Typical Development

	ß Without control for Visual Discomfort Scale			*ß* With control for Visual Discomfort Scale		
	Dyslexia	DCD	Dyslexia/ DCD	Dyslexia	DCD	Dyslexia/ DCD
Visual Discomfort Scale	-	-	-	**.54*** **	**.53*** **	**.53*** **
Corsi Block f	**– .20***	**– .26***	– .17	– .18	– .20	– .14
Corsi Block b	– .15	**– .35***	– .19*	– .04	**– .24***	– .19
AVM	.01	.13	.07	.07	.18	.13
Digit span f	– .09	.03	**– .28****	– .02	.10	– .21
Digit span b	– .10	.00	– .06	.02	.08	.01
SDMT	**– .33*****	**– .33*****	**– .28*****	**– .21***	**– .21***	– .17
SDT	.17	**– .34*****	**.31*****	.12	**– .30****	**.26***
CDT	**.20***	**.35*****	**.23***	.06	**.22***	.10
SMT	.14	.18	**.23***	.02	.07	.12
RAN letters	**.47****	**.44****	**.34*****	**.31****	**.32****	**.21***
Sight words	**– .49*****	**– .31*****	**– .47*****	**– .33****	– .19*	**– .34*****
Phonemic decoding	**– .50*****	– .11	**– .44*****	**– .43****	– .11	**– .43*****
Copy fast	**– .29*****	**– .35*****	**– .25****	– .16	– .23*	– .13
Graphic spd	– .02	–.21*	**– .31*****	.08	– .12	– .21*
IT1	.07	.15	**.26***	.00	.13	**.22***
IT2	.00	.06	**.27***	– .07	.04	**.23***
IT3	.17	**.23***	.17	.01	.12	.04
IT4	.19*	.11	**.27***	.16	.15	**.32****

Note . All analyses controlled for age, gender and WRIT matrices. Significant results in bold after correction for multiple correlations. Symptom Checklist (Adler, Kessler & Spencer, 2005); AVM = abstract visual memory; Corsi = Corsi Block Task *(*Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000; The Psychological Investigation Building Language, PEBL; Mueller, 2010); CTOPP-2 (Wagner, Torgeson, Rashotte & Pearson, 2013); DASH 17+ = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); DCD1 & 2 = Sections 1 & 2, Adult Developmental Coordination Disorder/Dyspraxia Checklist (ADC) for Further and Higher Education (Kirby & Rosenblum, 2008) SDMT = Symbol Digit Modalities Test (Smith, 1982); RAN = rapid automatic naming; digit span tests and

AVM from TOMAL-2 = Test of Memory and Learning-2 (Reynolds & Voress, 2007); Test of Word Reading Efficiency (TOWRE-2; Torgeson, Wagner & Rashotte, 2012); Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000)..* $p < .05$, ** $p < .01$, *** $p < .001$.

APPENDIX I: Additional Participants with Dyslexia/DCD?

Participant 70, who had a diagnosis of dyslexia, was an outlier with long inspection time for standard inspection time (IT1), shown in Figure 2. This participant was at risk of DCD from the ADC Checklist. Participant 79, also an outlier shown in Figure 2, had a diagnosis of DCD, but had short digit span backwards, exceptionally slow sight word reading, phonemic decoding speed, RAN and alphabet writing, all consistent with a diagnosis of dyslexia. Thus, the number of participants with dyslexia/DCD in the long standard inspection time (IT1) group could have been six, not four. In McLean et al.'s (2011) study, there were four children who had exceptionally long inspection times in the same number of participants with dyslexia as the present study. Small non-significant inspection times differences between typically developed and dyslexia groups, represented as *b* (Table 6) could be due to participants with unidentified co-occurring conditions that are prevalent in SpLDs. A further analysis run without Participant 70 reduced *b* for dyslexia from 2.92 [95% confidence interval (CI) = – 4.40–10.25] to 0.86 [CI = – 5.7–7.42]. It is possible that the groups of participants with dyslexia and with DCD in the previous studies of inspection time in children contained some participants with dyslexia/DCD. In DCD, differences for inspection times represented as *b* could be partly due to other co-occurring unidentified SpLDs. A further analysis run without Participant 79 reduced *b* for DCD from 6.42 [– 1.32–14.16] to 4.49 [– 2.45–11.44].

APPENDIX J: Individual Difference Scores Inspection Time Tests 1 and 2

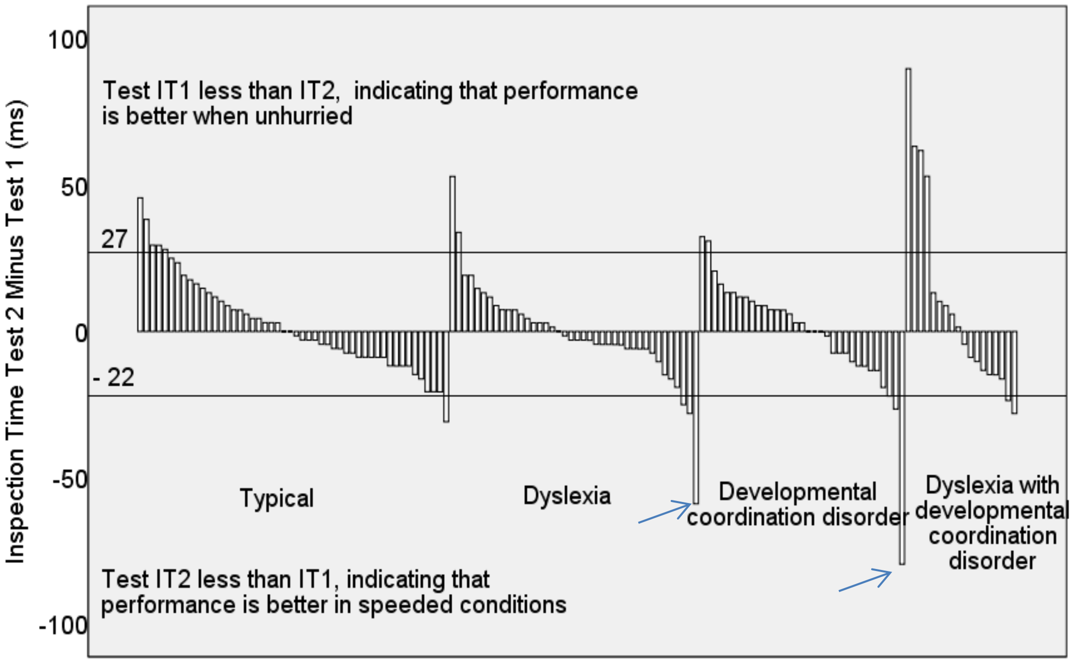


Figure J1. Differences between inspection time Tests IT2 and IT1. *Note.* A cut-off of 27 ms, 1.5 *SD* above the average (IT2 − IT1) *z*-score of typical participants, marked the maximum value for the average typical positive (IT2 – IT1). Similarly, beyond a cut-off of – 22 ms showed the participants who were responding unusually better under speeded conditions. Arrows indicate Participants 70 and 79.

Figure J1 shows the (IT2 − IT1) difference scores plotted for every participant. Although (IT2 − IT1) difference scores are calculated from single inspection times, each inspection time evaluation is the result of several trials. For visual inspection of Figure J1, one has to bear in mind that groups were not directly comparable, particularly for number of participants and intelligence. Intelligence scores were less in the dyslexia and DCD groups and much less than the typical group in the dyslexia/DCD group. However, IT1, IT2 and (IT2 – IT1) were not significantly correlated with WRIT matrices, so the reason for the greater variability in dyslexia/DCD may not be attributable to weaker intelligence. In Figure J1, values above the *x*-axis were from participants who had IT2 longer than IT1 and therefore performed less well under speeded conditions on that occasion. A cut-off of 27 ms, 1.5 *SD* above the average (IT2 − IT1) *z*-score of typical participants, was taken to mark the maximum value for the average typical positive (IT2 − IT1) difference score. Participants for whom IT2 was over 27 ms more than IT1 could be those with below average response under pressure. Vice versa, for values below the *x*-axis, a shorter IT2 than IT1 resulted in a negative value and implied that the performance under the speeded condition was better than for the un-speeded condition on that occasion. The cut-off was – 22 ms beyond which participants responded unusually better under speeded conditions. Participants with better inspection time responses when speeded had an even distribution across groups except for one participant in each of the dyslexia (Participant 70) and DCD (Participant 79) groups who had markedly better speeded performance, on this occasion. It may be that these participants had dyslexia/DCD (Section 6.3). If Participants 70 and 79 have dyslexia/DCD then the trend, observed from Figure J1, towards an advantage for standard inspection time in dyslexia/DCD, is mostly counteracted.

Individual Difference Scores Inspection Time Tests 3 and 4

In Figure J2, the difference in score between IT3 and IT4 (IT3 − IT4) was plotted for every participant. The maximum value before a typical difference became atypical was 33 ms. This score was derived in the same way as before for (IT2 − IT1). Participants with IT3 over 33 ms more than their IT4 could be those who responded better with an up/down decision to make. Figure J2 shows that all groups had a few participants who responded much better with an up/down decision. In particular, six participants in the DCD group had positive difference scores outside the average range indicating that the left/right decision in IT3 was a relative challenge for them on that occasion, as opposed to one participant with DCD who found the reverse. On the other hand, there were participants with dyslexia, and dyslexia/DCD who found the up/down IT4 more of a challenge than the left/right IT3, on that occasion.

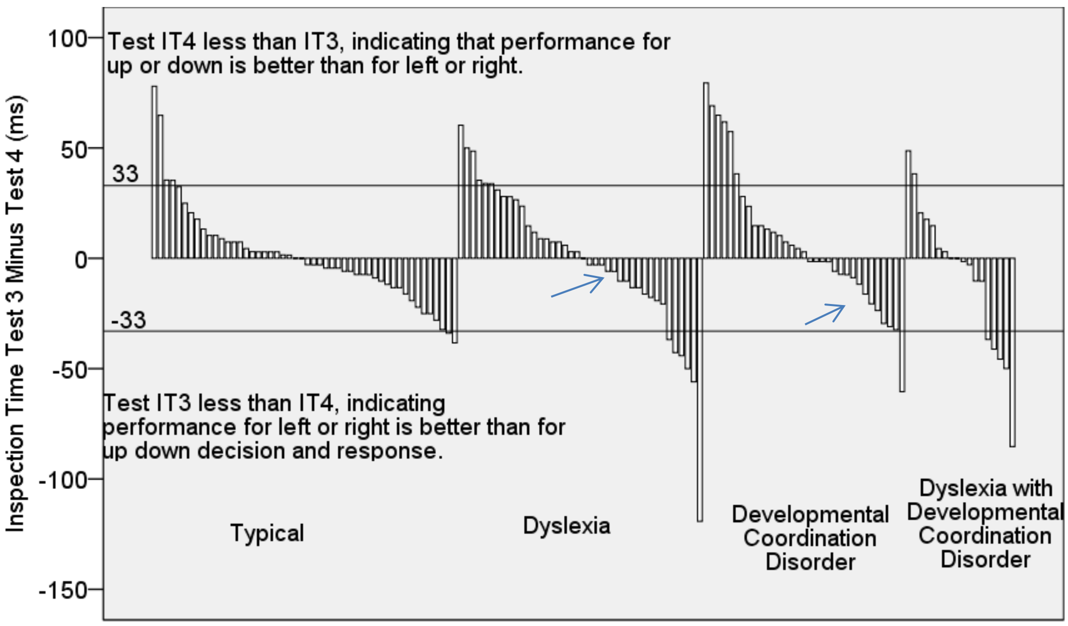


Figure J2. Difference score between inspection time Tests IT3 and IT4 for adult participants. *Note.* A cut-off of 33 ms, 1.5 SD above and below the average *z*-score of typical participants marked the maximum value for average typical positive or negative (IT3 – IT4), respectively. Arrows indicate Participants 70 and 79.

Table J1

Study 3: Hierarchical Regression to Predict Inspection Time Difference (IT3 – IT4)

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*β*	*b*	*SE b*	*β*	*LL*	*UL*
Step 1 Constant	− 2.73	18.57		− 1.67	19.67			
Age	− 0.02	0.02	− .10	− 0.02	0.02	− .09	– 0.06	0.02
Gender	4.33	5.40	.07	5.05	5.42	.08	– 5.67	15.77
WRIT	0.23	0.40	.05	0.16	0.41	.11	– 0.64	0.97
Step 2 Dyslexia				− 0.71	6.31	− .01	– 13.18	11.76
DCD				7.23	6.67	.10	– 5.95	20.41
Dyslexia/DCD				− 7.79	8.35	− .09	– 24.31	8.74

R^2 = .04; *Step 1: Δ* R^2 = .02; Step 2: *Δ* R^2 = .02.

Note. Codes: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** CI = confidence interval for *b* in Model 2, LL & UL = lower & upper limits; DCD = developmental coordination disorder; IT = inspection time (ms); WRIT m = matrices, Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).

Summed Scores for Inspection Times 3 and 4

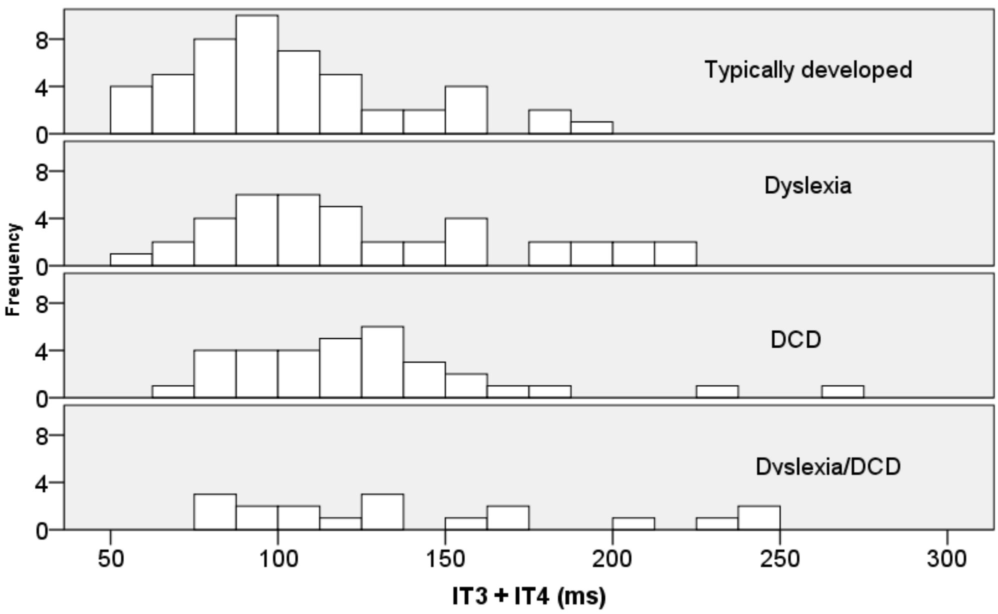


Figure J3. Histograms of distributions of (IT3 + IT4) in four groups. *Note.* DCD = developmental coordination disorder.

APPENDIX K: Change Scores

Change scores: Test 2/Test 1. Table 20 displays results of a regression analysis with the change scores between IT1 and IT2 as the dependent variable. Participants 53, 70 and 79 were retained outliers. Age in months, gender and WRIT matrices were variables in Step 1. SpLD groups were in Step 2. Results for IT2/ IT1 change score show that the full model of age, biological sex, WRIT Matrices, and SpLD to predict IT2/IT1 change was not significant, R^2 = .08, F (6, 134) = 2.00, p = .07). Age and biological sex influenced the outcome but WRIT matrices did not. The addition of SpLD to the regression in Model 2 gave a significant change in R^2 (ΔR^2 = .07, F (3, 134) = 3.29, p = .023). The dyslexia/DCD group significantly predicted IT2/ IT1 change (p = .007).

Change score IT3/IT4. Table 24 displays the results of a hierarchical regression analysis with the IT3/ IT4 change score as the dependent variable. Assumptions, tested as in previous regression analyses, were not violated after the removal of two outliers: Participants 7 (dyslexic) and 11 (typically developed). Results for IT3/ IT4 change score showed that the full model of age, gender, WRIT matrices, and SpLD to predict IT3/IT4 change was not significant, R^2 = .08, F (6, 132) = 1.82, p = .099). Age, gender and WRIT matrices did not significantly influence the outcome. The addition of SpLD in Step 2 significantly increased R^2 = .06, F change (3, 132) = 2.73, p = .047). All SpLD groups significantly predicted the IT3/ IT4 change score.

APPENDIX L: Visual Discomfort

Regression analyses: Control of Visual Discomfort Scale for inspection time from Tests 1, 2, 3 and 4

The results of the Visual Discomfort Scale were controlled in Step 1 of hierarchical regression analyses in which IT1–IT4 were the dependent variables (Tables L1–L4). Regression analyses for IT1–4 without control for Visual Discomfort Scale are in Tables 17, 18, 21 & 22, respectively. As before, the dyslexia/DCD group still significantly predicted standard (IT1) and speeded (IT2) inspection times after statistically controlling for Visual Discomfort Scale. DCD significantly predicted left/right inspection time (IT3) before control for Visual Discomfort Scale, but after statistical control, no group predicted left/right inspection time (IT3). Dyslexia and dyslexia/DCD significantly predicted up/down inspection time (IT4) before control for Visual Discomfort Scale but after statistical control there was little change in the results for dyslexia/DCD, although dyslexia no longer significantly predicted up/down inspection time (IT4).

Table L1

Study 3: Hierarchical Regression Analysis to Predict Inspection Time IT1 With Visual Discomfort Scale

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	59.56	11.29		54.72	11.61			
Age in months	0.01	0.01	.16	0.01	0.01	.07	− 0.01	0.03
Gender	6.15	3.30	.17	**6.70**	**3.32**	**.18***	**0.14**	**13.27**
WRIT matrices	− 0.35	0.24	− .13	−0.26	0.24	− .09	− 0.74	0.22
Visual Discomfort	**0.18**	**0.09**	**.17***	0.08	0.11	0.08	– 0.15	0.31
Step 2 Dyslexia				0.10	4.52	.00	− 8.84	9.03
DCD				5.38	4.65	.13	− 3.82	14.58
Dyslexia/DCD				**11.49**	**5.81**	**.22***	**– 0.02**	**22.99**
R^2 = .15***; Step 1 Δ* R^2 = .11*; *Step 2 Δ* R^2 = .04*								

Note. In Step 2, statistically significant values are in bold.* Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** The full model was significant (R^2 = .15, *F* (7, 128) = 3.10*, p* = .005)*.* CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; dyslexia = developmental dyslexia; DCD = developmental coordination disorder; IT = inspection time in milliseconds; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). *p* < .05, ** *p* < .01, *** *p* < .001, two-tailed.

Table L2

Study 3: Hierarchical Regression Analysis to Predict Inspection Time IT2 With Visual Discomfort Scale

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	64.18	15.56		58.86	15.80			
Age in months	0.01	0.02	.06	0.01	0.01	.07	− 0.02	0.04
Gender	**9.53**	**4.54**	**.18***	**9.52**	**4.52**	**.18***	**0.59**	**18.46**
WRIT matrices	− 0.53	0.33	− .14	− 0.40	0.33	− .10	− 1.05	0.26
Visual Discomfort	0.19	0.12	.13	0.10	0.16	.72	– 0.21	0.41
Step 2 Dyslexia				– 3.93	3.15	– .07	− 16.09	8.23
DCD				2.09	6.33	.04	− 10.44	14.61
Dyslexia/DCD				**17.23**	**4.91**	**.23***	**1.57**	**32.88**
R^2 = .16***; *Step 1* ΔR^2 = .10**; *Step 2* ΔR^2 = .06*								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** The full model was significant (R^2 = .16, F (7, 128) = 3.59, p = .001). CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; dyslexia = developmental dyslexia; DCD = developmental coordination disorder; IT = inspection time in milliseconds; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * p < .05, ** p < .01, *** p < .001, two-tailed.

Table L3

Study 3: Hierarchical Regression Analysis to Predict Inspection Time IT3 With Visual Discomfort Scale

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	54.38	16.6		51.80	17.36			
Age in months	0.01	0.02	.06	0.01	0.01	.09	− 0.02	0.05
Gender	**3.21**	**4.85**	**.06***	**4.02**	**4.97**	**.07***	**– 5.80**	**13.85**
WRIT matrices	− 0.27	0.35	− .07	− 0.24	0.36	− .06	− 0.97	0.46
Visual Discomfort	0.42	0.13	.27	**0.35**	**0.17**	**.23***	**0.02**	**0.69**
Step 2 Dyslexia				0.88	6.76	.07	− 12.40	10.25
DCD				7.20	6.96	.15	− 1.56	20.96
Dyslexia/DCD				3.29	8.70	.04	– 13.92	20.50
R^2 = .12*; *Step 1 Δ* R^2 = .11*; *Step 2 Δ* R^2 = .01								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** The full model was significant (R^2 = .12, *F* (7, 128) = 2.37, *p* = .026). CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; dyslexia = developmental dyslexia; DCD = developmental coordination disorder; IT = inspection time in milliseconds; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * *p* < .05, ** *p* < .01, *** *p* < .001, two-tailed.

Table L4

Study 3: Hierarchical Regression Analysis to Predict Inspection Time IT4 With Visual Discomfort Scale

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	65.05	15.69		53.89	16.00			
Age	0.02	0.17	.12	0.02	0.02	.13	− 0.02	0.05
Gender	2.29	4.58	.04	**3.55**	**4.58**	**.07***	**0.13**	**13.85**
WRIT matrices	− 0.52	0.33	− .14	− 0.32	0.33	− .08	− 0.71	0.24
Visual Discomfort	**0.42**	**0.13**	**.12**	**– 0.07**	**0.16**	**– .05**	**0.02**	**0.69**
Step 2 Dyslexia				8.72	6.22	.16	− 3.60	21.03
DCD				8.95	6.41	.15	− 3.73	21.63
Dyslexia/DCD				**22.96**	**8.01**	**.32****	**7.10**	**38.82**

R^2 = .12*; *Step 1* Δ R^2 = .07; *Step 2* Δ R^2 = .06*

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** The full model was significant (R^2 = .12, *F* (7, 128) = 2.55, *p* = .017). CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; dyslexia = developmental dyslexia; DCD = developmental coordination disorder; IT = inspection time in milliseconds; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * *p* < .05, ** *p* < .01, *** *p* < .001, two-tailed.

Scattergraphs of Visual Discomfort Scale Against Standard Inspection Time

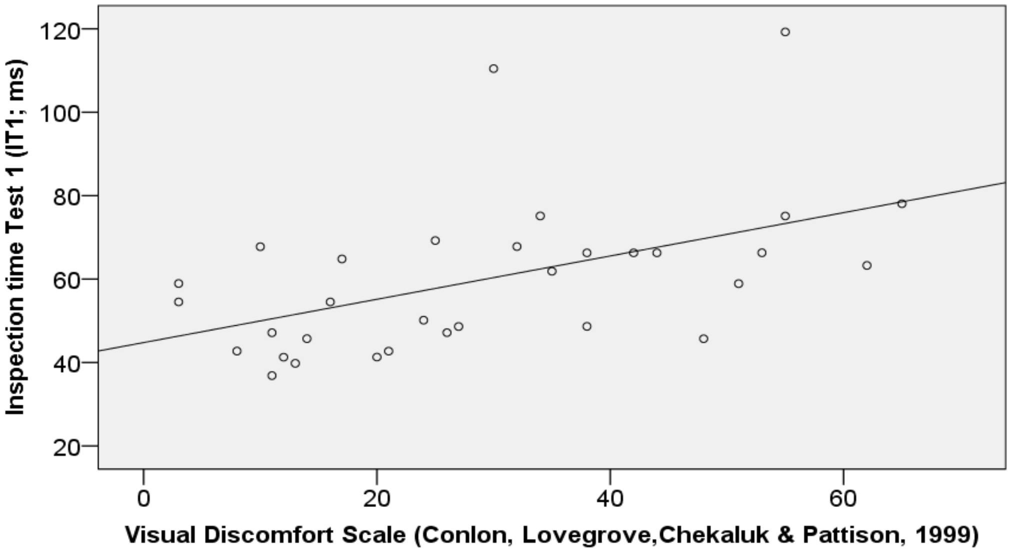


Figure L1. Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999) versus Inspection Time Test 1 in 33 participants with developmental coordination disorder. R^2 = 0.25. Note two outliers left from right, Participants 131 and 79.

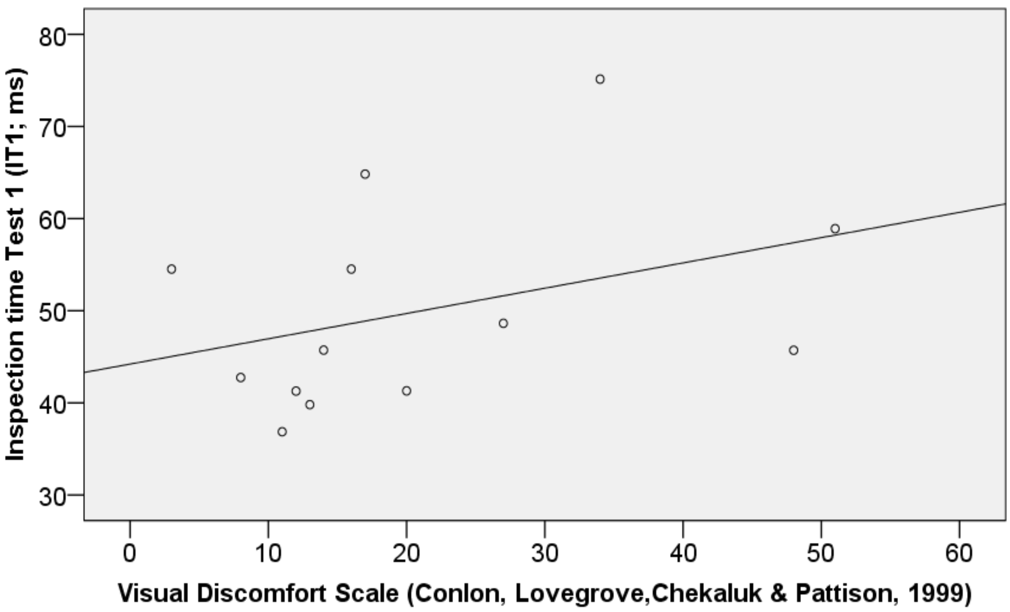


Figure L2. Total score from Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999) versus Inspection Time Test 1 in 13 men with developmental coordination disorder. R^2 = 0.14

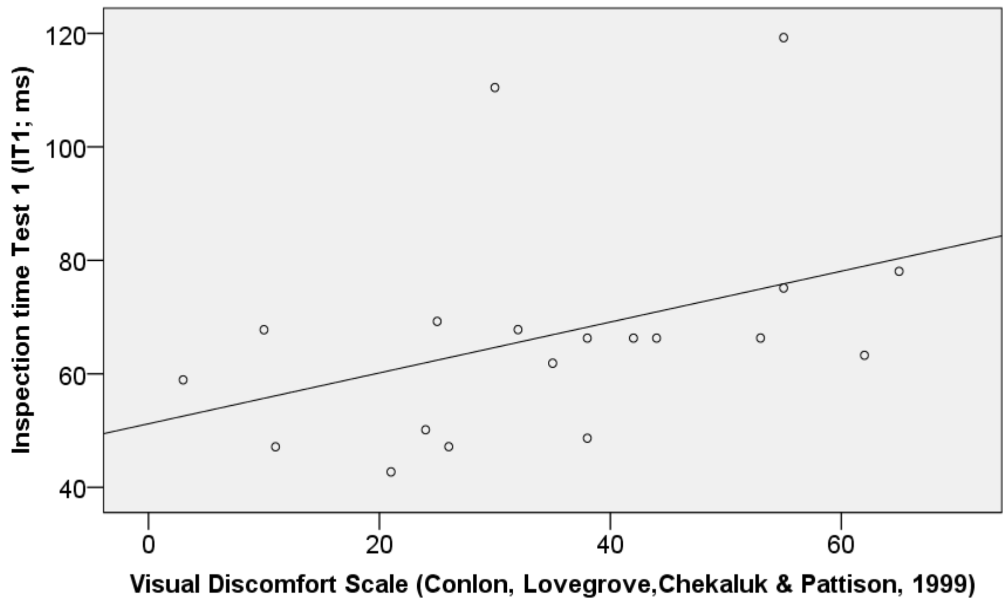


Figure L3. Total score from Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999) versus Inspection Time Test 1 in 20 women with developmental coordination disorder. $R^2 = 0.16$

Amalgamated inspection time results for novel stimulus (IT3 + IT4). A further hierarchical regression analysis was run for results for the (IT3 + IT4) inspection times, which were from the amalgamated z-scores for the novel stimulus figure from both orientations (Table L7), with and without Visual Discomfort Scale controlled in Step 1. The variables in Steps 1 and 2 were the same as in the regression analysis in Table 23 except in Step 1 was the addition of Visual Discomfort Scale. Assumptions, tested as in previous regression analyses, were not violated.

Table L5

Study 3: Hierarchical Regression Analysis to Predict Inspection Time (IT3 + IT4) Without and With Visual Discomfort Scale Controlled

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	.46	1.03		– 0.71	1.06		– 2.80	1.39
Age (months)	0.00	0.00	.14	0.00	0.00	.14	0.00	0.00
Gender	0.29	0.30	.08	0.31	0.29	.09	– 0.27	0.88
WRIT matrices	− 0.04	0.02	− .14	− 0.02	0.02	− .07	– 0.06	0.03
Step 2 Dyslexia				**0.79**	**0.34**	**.22***	**0.12**	**1.46**
DCD				**0.80**	**0.36**	**.21***	**0.10**	**1.51**
Dyslexia/DCD				**1.30**	**0.45**	**.26****	**0.42**	**2.19**
R^2 = .13**; *Step 1* ΔR^2 = .06*; *Step 2* ΔR^2 = .07*								
with visual discomfort controlled								
Step 1 Constant	– 0.41	1.01		– 0.56	1.05		– 2.64	1.51
Age (months)	0.00	0.00	.11	0.00	0.00	.12	0.00	0.00
Gender	0.21	0.30	.06	0.29	0.30	.09	– 0.31	0.88
WRIT matrices	− 0.03	0.02	− .12	− 0.02	0.02	− .09	– 0.07	0.02
Visual Discomfort	**0.02**	**.01**	**.24****	0.01	0.01	.11	– 0.01	0.03
Step 2 Dyslexia				0.37	0.41	.10	– 0.44	1.17
DCD				0.61	0.42	.16	– 0.22	1.44
Dyslexia/DCD				1.00	0.52	.21	– 0.04	2.04
R^2 = .14*; *Step 1* ΔR^2 = .11**; *Step 2* ΔR^2 = .03								

Note. In Step 2, statistically significant values are in bold.* Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; DCD = developmental coordination disorder; IT = inspection time in milliseconds; WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). $p < .05$, ** $p < .01$, *** $p < .001$, two-tailed.

Table L6

Study 3: Hierarchical Regression Analysis to Predict Inspection Time (IT3 + IT4) With Pattern Glare Test Controlled

	Model 1			Model 2			95% CIs	
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Step 1 Constant	0.26	1.06		– 0.55	1.07		– 2.66	1.56
Age (months)	0.00	0.00	.11	0.00	0.00	.12	0.00	0.00
Gender	0.33	0.30	.06	0.36	0.29	.11	– 0.22	0.94
WRIT matrices	− 0.03	0.02	− .12	− 0.02	0.02	− .08	– 0.06	0.02
Pattern Glare Test	0.24	.29	.07	– 0.8	0.30	– .02	– 0.68	0.53
*Step 2 D*yslexia				0.62	0.36	.17	– 0.10	1.33
DCD				**0.87**	**0.37**	**.23***	**0.13**	**1.61**
Dyslexia/DCD				**1.32**	**0.46**	**.28****	**0.41**	**2.23**
R^2 = .13*; *Step 1 Δ* R^2 = .06**; *Step 2 Δ* R^2 = .07*								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000**.** CI = confidence interval for *b* in Model 2, LL = lower limit, UL = upper limit; DCD = developmental coordination disorder; IT = inspection time in milliseconds; WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * *p* < .05, ** *p* < .01, *** *p* < .001, two-tailed.

Before control for Visual Discomfort Scale, all SpLD groups predicted (IT3 + IT4). The full model of age, gender, WRIT matrices, Visual Discomfort Scale and SpLD to predict (IT3 + IT4) was significant (R^2 = .14, *F* (7, 135) = 2.96*, p* = .007). Age, gender and WRIT matrices did not significantly influence the outcome. After control for Visual Discomfort Scale in Step 1, which was significant, no group significantly predicted (IT3 + IT4) in Step 2. Addition of SpLD in Step 2 did not significantly increase R^2 ; no group significantly predicted (IT3 + IT4). These results suggest that Visual Discomfort was an important factor in all groups for identification of the novel stimulus. Moreover, in the regression for (IT3 + IT4), when Visual Discomfort Scale was replaced by the Pattern Glare Test (Table L8), DCD and dyslexia/DCD still predicted (IT3 + IT4) but dyslexia no longer predicted (IT3 + IT4). The full model was significant, $R^2 = .13$, $F\ (7, 135) = 2.79$, $p = .01$). This suggests that in the group of participants with dyslexia, pattern glare was an important factor for the novel stimulus figure used in Tests 3 and 4, the left/right and up/down tests, but that it was not the only visual problem for DCD and dyslexia/DCD.

To summarise, an amalgamation of (IT3 + IT4) showed that the group of participants with dyslexia had longer inspection times from the novel stimulus figure. In the analyses above, the statistical removal of effects of pattern glare reduced to nonsignificant the prediction of inspection time from the novel figure by the dyslexia group. Alternatively, control for Visual Discomfort Scale reduced the prediction by all SpLD groups. This suggests that the novel stimulus figure in left/right and up/down (IT3 + IT4) provoked pattern glare in the dyslexia group and that this was a reason why inspection time had been longer in this group. This was not so for the DCD and dyslexia/DCD groups, which appeared to experience an additional source of visual discomfort.

Is visual discomfort, as assessed by the VDS, different in DCD?

The patterns of results in the different groups for the relationships between VDS and IT1, speeded inspection time (IT2) and left/right inspection time (IT3), prompted the question: Is visual discomfort, as assessed by the VDS, different in DCD? To explore this idea, a tally was made of the score for each question answered in the VDS, to investigate the possibility that visual discomfort experienced by participants with DCD is different to that in other participants, reflected by the questions answered.

Participants with DCD answered no questions more often than did the other groups. The only noticeable difference was that participants with DCD did not answer Questions 10–18, 21–23 (Figure L4) as often as did participants in other SpLD groups. There was no obvious common factor among these questions.

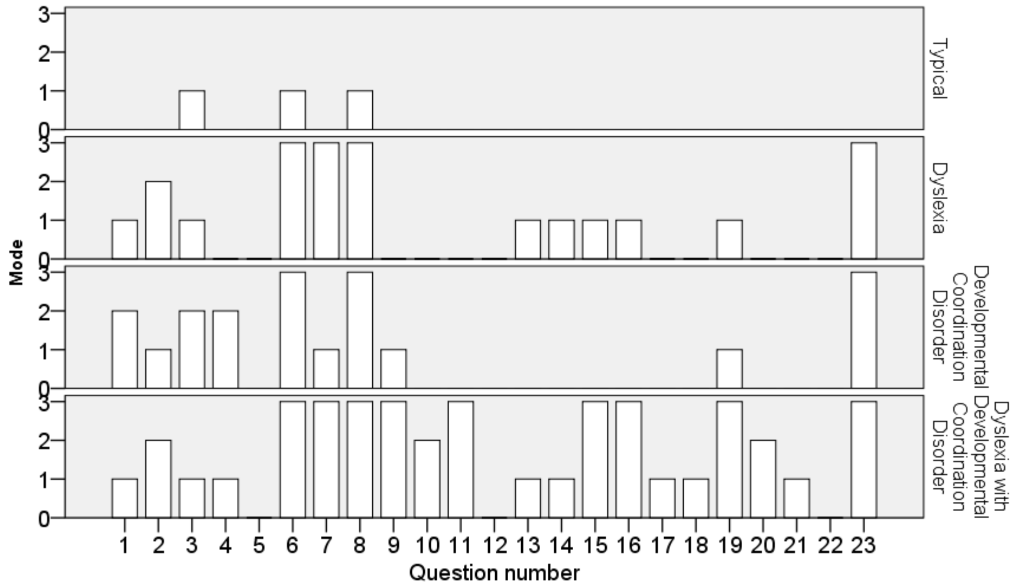


Figure L4. Mode of each question answered on a scale of 0–3 for Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999).

APPENDIX O: TESTS OF MEMORY

APPENDIX O: Memory

Covariates

The following are instances when there were significant correlations between tests of memory and age in months, gender, WRIT matrices and results of Visual Discomfort Scale.

Typical development.

- WRIT matrices and digit forward (r_s (48) = .34, p = .014)
- WRIT matrices and digit backward (r_s (48) = .47, p = .001)
- Gender and digit backward (τ_b = –.24, p = .048)

Dyslexia.

- Age and digit forward (r_s (38) = .36, p = .023)
- WRIT matrices and abstract visual memory (r_s (38) = .53, p = .001)
- Gender and Corsi forward (τ_b = –.37 p = .018).

Developmental coordination disorder.

- Age and Corsi forward (r_s (31) = – .50, p = .003)
- Age and Corsi backward (r_s (31) = – .38., p = .028)
- Visual Discomfort Scale and Corsi forward (r_s (31) = –.40, p = .020).

Dyslexia/developmental coordination disorder.

- Age and abstract visual memory (r_s (16) = – .50, p = .035)
- WRIT matrices and abstract visual memory (r_s (16) = .54, p = .022)
- WRIT matrices and digit backward (r_s (16) = .48, p = .046).

Group differences

Hierarchical regression analyses tested group differences in memory separately without and with the results of the Visual Discomfort Scale in Step 1 (Tables O1–O5). First, in Step 1 were age in months, gender, WRIT matrices. Second, Step 1 included Visual Discomfort Scale. In all analyses, Step 2 contained just the three SpLD groups; four categorical, nominal variables for the groups were recoded to three dummy variables as in Section 6.1. Assumptions assessed prior to analysis, as described in Section 6.1, were not violated.

Corsi Block Task forward. Without Visual Discomfort Scale as a regressor in Step 1, gender significantly predicted the results of the Corsi Block Task forward but age and WRIT matrices did not. Men had better scores than women. There was a significant 5% increase in R^2 in Step 2. Corsi Block Task forward significantly predicted both DCD (p = .013) and dyslexia (p = .025) groups versus the group of participants with typical development. The full model was ($R^2 = .17$, F (6, 134) = 4.68, $p < .001$).

With Visual Discomfort Scale as a regressor in Step 1, no SpLD group significantly predicted Corsi Block Task forward compared to the group of participants with typical development. In Step 1, gender and Visual Discomfort Scale significantly predicted the results of the Corsi Block Task forward but age and WRIT matrices did not. Men had better scores than women. Step 2 led to a nonsignificant 3% increase in R^2 and the influence of Visual Discomfort became insignificant. The full model was significant (R^2 = .18, F (7, 133) = 4.02, p = .001).

Corsi Block Task backward. Table O2 shows results of a regression analysis with the Corsi Block Task backwards as the dependent variable. Without Visual Discomfort Scale as a regressor in Step 1 there was a significant 10% increase in R^2 in Step 2 and the test for Corsi Block Task backward significantly predicted both groups of participants with DCD ($p < .001$) and dyslexia/DCD (p = .034) versus the group of participants with typical development.

Table O1

Hierarchical Regression Analysis With Corsi Block Task Forward as the Dependent Variable Without and With Visual Discomfort Controlled

N = 141		Model 1			Model 2		95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	49.05	14.11		62.80	14.65		33.82	91.77
Age	− 0.02	0.01	− .14	− 0.02	0.01	− .13	– .05	0.010
Gender	**− 11.74**	**4.11**	**− .24****	**− 12.29**	**4.04**	**− .25****	**– 20.27**	**– 4.30**
WRIT M	0.56	0.30	.16	0.40	0.30	.11	– 0 .20	1.00
Step 2 Dyslexia				**− 10.65**	**4.70**	**−.20***	**– 19.94**	**– 1.36**
DCD				**− 12.51**	**4.96**	**− .26***	**– 22.33**	**– 2.70**
Dyslexia/DCD				− 11.85	6.22	− .17	– 24.16	0.46
*R^2 = 17***; Step 1 Δ R^2 =.12***; Step 2 Δ R^2 =.05**								
Visual Discomfort Included in Step 1.								
N = 141		Model 1			Model 2		95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	55.18	14.19		62.59	14.70		33.51	91.67
Age	− 0.02	0.01	− .1 2	− 0.02	0.01	− .13	– .05	.01
Gender	**− 10.33**	**4.10**	**− .21****	**− 11.87**	**4.16**	**− .24****	**– 20.09**	**– 3.64**
WRIT m	0.50	0.30	.14	0.40	0.31	.11	– .20	1.01
Visual discomfort	**− 0.25**	**0.11**	**− .18***	− 0.06	0.15	− .05	– .35	–.22
Step 2 Dyslexia				− 9.24	5.69	−.18	– 20.49	2.01
DCD				− 11.12	5.90	− .20	– 22.77	0.56
Dyslexia/DCD				− 10.08	7.40	− .14	– 24.73	4.56
*R^2 = 18***; Step 1 Δ R^2 =.15***; Step 2 Δ R^2 =.03*								

Note. Statistically significant values are in bold.* Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2, LL & UL = lower limit & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT m = Wide Range Intelligence Test, matrices (Glutting, Adams & Sheslow, 2000**)**. *p* < .05, ** *p* < .01, *** *p* < .001.

Table O2

Hierarchical Regression Analysis With the Corsi Block Task Backward as the Dependent Variable Without and With Control for Visual Discomfort

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	31.73	13.45		46.82	13.61		19.90	73.74
Age	− 0.02	0.01	− .09	− 0.02	0.01	− .09	– 0.04	0.01
Gender	− 4.25	3.92	− .09	− 5.08	3.75	− .11	–12.49	2.34
Matrices	**0.79**	**0.29**	**.23***	**0.62**	**0.28**	**.18***	**.06**	**1.17**
Step 2 Dyslexia				− 7.37	4.36	− .15	– 16.00	1.26
DCD				**− 18.19**	**4.61**	**− .35***	**– 27.31**	**– 9.07**
Dyslexia/DCD				**− 12.39**	**5.78**	**− .19***	**– 23.82**	**- 0.95**

*R^2 = .19***; Step 1 Δ R^2 =.08***; Step 2 Δ R^2 =.10****

Visual Discomfort Included in Step 1

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	40.82	13.39		45.80	13.74		18.61	73.00
Age	− 0.01	0.01	− .06	− 0.01	0.01	− .08	– 0.04	0.01
Gender	− 1.98	3.88	− .04	− 3.32	3.90	− .08	–11.03	4.39
Matrices	**0.67**	**0.28**	**.20***	**0.64**	**0.29**	**.19***	**.08**	**1.20**
Visual discomfort	**− 0.37**	**0.10**	**− .29*****	− 0.26	0.14	− .20	– 0.52	0.01
Step 2 Dyslexia				− 1.88	5.27	−.04	– 12.31	87.55
DCD				**− 12.52**	**5.54**	**− .24***	**– 23.47**	**– 1.56**
Dyslexia/DCD				− 5.16	6.97	− .08	– 18.95	8.63

*R^2 = .21***; Step 1 Δ R^2 =.17***; Step 2 Δ R^2 =.04*

Note. Statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2, LL & UL = lower limit & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); Matrices from WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000). * p < .05, ** p < .01, *** p < .001.

With Visual Discomfort Scale as a regressor in Step 1, WRIT matrices and Visual Discomfort Scale significantly predicted the results of the Corsi Block Task backwards but age and gender did not. Higher WRIT matrices scores significantly predicted longer, better scores for Corsi Block Task backwards. Step 2 led to a 4% increase in R^2 and the influence of Visual Discomfort became insignificant. When the results of the Visual Discomfort Scale were controlled, only the group of participants with DCD significantly predicted a reduction in performance from the test of Corsi Block Task backwards (p = .025) compared to the group of typically developed participants. The full model was significant (R^2 = .21, F (7, 133) = 4.80, p < .001).

Abstract Visual Memory. Table O3 shows results of a regression analysis with abstract visual memory as the dependent variable. In Step 1, higher visual intelligence assessed by WRIT matrices significantly predicted better scores for the test of abstract visual memory. Step 2 led to a nonsignificant increase in R^2, less than 2%. None of the SpLD groups significantly predicted scores for abstract visual memory compared to the group without SpLDs but the full model was significant (R^2 = .17, F (6, 131) = 4.37, p < .001). When the results of the Visual Discomfort Scale were added to the regression results did not change significantly.

Table O3

Hierarchical Regression Analyses With Abstract Visual Memory as the Dependent Variable Without and With Control for Visual Discomfort Scale

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	17.42	5.04		15.58	5.36		7.44	27.39
Age in months	− 0.01	0.01	− .15	− 0.01	0.01	− .15	– 0.02	0.00
Gender	− 2.39	1.48	− .13	− 2.91	1.53	− .10	– 5.31	0.53
WRIT matrices	**0.38**	**0.11**	**.29*** **	**0.40**	**0.11**	**.30*** **	**0.16**	**0.59**
Step 2 Dyslexia				0.25	1.76	.01	– 3.2	3.73
DCD				2.57	1.81	.13	– 1.01	6.15
Dyslexia/DCD				1.67	2.27	.07	– 2.83	6.16
*R^2 = .17***; Step 1 Δ R^2 =.15***; Step 2 Δ R^2 =.02*								

Visual Discomfort Included in Step 1.

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	15.16	5.36		15.16	5.36		4.82	26.05
Age in months	− 0.01	0.01	− .15	− 0.01	0.01	− .15	– 0.02	0.00
Gender	− 1.76	1.53	− .10	− 1.76	1.53	− .10	– 4.95	1.09
WRIT matrices	**0.42**	**0.11**	**.32*** **	**0.42**	**0.11**	**.32*** **	**0.18**	**0.63**
Visual discomfort	− 0.06	0.05	− .12	− 0.06	0.05	− .12	– 0.16	0.05
Step 2 Dyslexia				1.30	2.08	.07	– 2.7	5.54
DCD				3.62	2.15	.18	– 0.50	7.99
Dyslexia/DCD				3.39	2.68	.13	– 2.18	8.47
*R^2 = .17***; Step 1 Δ R^2 =.15***; Step 2 Δ R^2 =.02*								

Note. Coding: 0 = men, 1 = women; specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2, LL & UL = lower & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000**)**. *p* < .05, ** *p* < .01, *** *p* < .001.

Digit Span Forward. Table O4 shows results of a regression analysis with digit span forward as the dependent variable. None of groups of participants with SpLDs significantly predicted the results of the test of digit span forward compared to the group of typically developed participant. In Step 1, higher WRIT matrices scores predicted a longer digit span. The addition of SpLDs in Step 2 led to a significant 6% increase in R^2 but no group significantly predicted a reduction in digit span forward over the typically developed group. The full model was significant (R^2 = .14, *F (7, 134)* = 3.72, *p* = .002.

With Visual Discomfort Scale as a regressor in Step 1, WRIT matrices and Visual Discomfort Scale significantly predicted the results of digit forward but age and gender did not. Higher WRIT matrices scores significantly predicted longer, better scores for digit forward. Step 2 led to a 6% increase in R^2 and the influence of Visual Discomfort became insignificant. When the results of the Visual Discomfort Scale were controlled, no group of participants with SpLD significantly predicted a reduction in performance from the test of digit forward compared to the group of typically developed participants. The full model was significant (R^2 = .15, *F* (7, 133) = 3.42, *p* = .002). As digit backward is not a visual task a reduction in the prediction by the dyslexia/DCD group that had been evident before it was controlled cannot be entirely attributed to visual confounds. This suggests that the Visual Discomfort Scale is tapping something that is effective beyond visual processes and adds a cautionary note to conclusions that imply visual discomfort is responsible for significant results in some tests.

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Table O4

Hierarchical Regression Analysis With the Digit Span Forward as the Dependent Variable Without and With Visual Discomfort Controlled

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	23.02	9.26		29.31	9.50		10.50	48.12
Age in months	0.01	0.01	.08	0.01	0.01	.08	– 0.01	0.03
Gender	0.15	2.70	.03	0.62	2.62	.04	– 4.56	5.81
WRIT matrices	**0.60**	**0.20**	**.26****	**0.48**	**0.20**	**.21***	**0.09**	**0.87**
Step 2 Dyslexia				− 3.03	3.05	– .09	– 9.06	3.00
DCD				1.16	3.22	.03	– 5.21	7.54
Dyslexia/DCD				**− 12.43**	**4.04**	**–.28****	**– 20.42**	**0.18**
*R^2 = .14**; Step 1 Δ R^2 =.07*; Step 2 Δ R^2 =.08**								

Visual Discomfort Included in Step 1.

N = 141	Model 1			Model 2			95% CIs	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	26.66	9.34		28.94	9.50		10.15	47.74
Age in months	0.01	0.01	.08	0.01	0.01	.08	– 0.01	0.03
Gender	0.99	2.70	.03	1.37	2.69	.04	– 3.94	6.69
WRIT matrices	**0.57**	**0.20**	**.25****	**0.49**	**0.20**	**.21***	**0.10**	**0.88**
Visual discomfort	**– 0.15**	**0.07**	**– .17***	**– 0.12**	**0.09**	**– .13**	**– 0.30**	**0.07**
Step 2 Dyslexia				− 0.51	3.68	– .02	– 7.78	6.76
DCD				3.67	3.81	.10	– 3.87	11.21
Dyslexia/DCD				− 9.28	4.78	– .21	– 18.74	0.18
*R^2 = .15**; Step 1 Δ R^2 =.09**; Step 2 Δ R^2 =.06**								
R^2 = .14; Step 1 Δ R^2 =.08*; Step 2 Δ R^2 =.07**								

Note. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2, LL & UL = lower & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000**)**. In Step 2, statistically significant values are in bold.* $p < .05$, ** $p < .01$, *** $p < .001$.

Table O5

Hierarchical Regression Analyses With Digit Span Backward as the Dependent Variable Without and With Visual Discomfort Controlled

	Model 1			Model 2			95%CIs	
N = *141*	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant *Step 1*	6.74	7.92		8.74	8.43		*– 7.94*	*25.42*
Age (months)	0.00	0.01	.04	0.01	0.01	.05	– 0.01	0.02
Gender	− 1.74	2.32	− .06	− 1.69	2.32	− .05	– 0.57	3.71
WRIT matrices	**0.53**	**0.17**	**.27****	**0.50**	**0.18**	**.25****	**0.15**	**0.84**
Step 2 Dyslexia				– 2.82	2.70	– .10	– 8.17	2.53
DCD				0.12	2.86	.00	– 5.53	5.77
Dyslexia/DCD				– 2.43	3.58	– .06	– 9.51	4.66
R^2 = .09; Step 1 Δ R^2 =.08*; Step 2 Δ R^2 =.01*								
N = 141	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant Step 1	9.07	8.04		8.41	8.42		– 8.24	25.06
Age (months)	0.01	0.01	.06	0.01	0.01	.06	– 0.01	0.02
Gender	− 1.20	2.32	− .04	− 1.00	2.38	− .04	– 0.571	3.71
WRIT matrices	**0.50**	**0.17**	**.25****	**0.51**	**0.18**	**.26****	**0.16**	**0.85**
Visual discomfort	– 0.09	0.06	– .12	– 0.11	0.08	– .14	– 0.27	0.06
Step 2 Dyslexia				– 0.50	3.26	–.02	– 6.94	5.94
DCD				2.43	3.38	.08	– 4.25	9.11
Dyslexia/DCD				0.48	4.24	.01	– 7.91	8.86
R^2 = .10; Step 1 Δ R^2 =.10**; Step 2 Δ R^2 =.01*								

Note. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2, LL & UL = lower & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000**)**. *p* < .05, ** *p* < .01, *** *p* < .001.

Digit Span Backward. Table O5 shows results of a regression analysis with digit span backward as the dependent variable. In Step 1, higher WRIT matrices scores significantly predicted larger scores for the tests of Digit Span backward. Step 2 led to a nonsignificant 1% increase in R^2. The full model was significant (R^2 = .09, F (6, 134) = 2.25, p = .042). None of groups of participants with SpLDs significantly predicted results of the test for Digit Span backward compared to the group of typically developed participants.

With Visual Discomfort Scale as a regressor in Step 1, WRIT matrices significantly predicted the results of digits backwards but age, gender and Visual Discomfort Scale did not. Higher WRIT matrices scores significantly predicted longer, better scores for digit backward. Step 2 led to negligible increase in R^2 and the influence of Visual Discomfort remained insignificant. When the results of the Visual Discomfort Scale were controlled, no group of participants with SpLD significantly predicted a reduction in performance from the test of digit backward compared to the group of typically developed participants. The full model was significant (R^2 = .10, F (7, 133) = 2.17, p =.041).

For each dependent variable, in Step 1 of the regression analyses, age, gender and WRIT matrices were controlled. A subsequent set of regressions, for each dependent variable of memory, included results of the Visual Discomfort Scale in Step 1. Results of these analyses showed that, without Visual Discomfort Scale controlled, the group of participants with dyslexia predicted Corsi Block Task forward; the group of participants with DCD predicted Corsi Block Task forward and backward; and the group of participants with dyslexia/DCD predicted digit span forward. No SpLD group predicted abstract visual memory. After the results of the Visual Discomfort Scale were controlled, the group of participants with dyslexia did not significantly predict Corsi Block Task forward, the group of participants with DCD still predicted Corsi Block Task backward; and the group with dyslexia/DCD no longer significantly predicted digit span forward, by a small margin

Discussion for group differences in memory. Hierarchical regression analyses showed that

- both dyslexia and DCD groups predicted Corsi Block Task forward. After control for Visual Discomfort Scale the predictions were reduced to nonsignificant.
- DCD predicted Corsi Block Task backward and remained a significant predictor after control for Visual Discomfort Scale.
- No group of SpLDs significantly predicted abstract visual memory, before or after Visual Discomfort Scale was controlled.
- Dyslexia/DCD predicted digit span forward but this predictor lost its significance with control for Visual Discomfort Scale.
- No group significantly predicted digit span backward.

That the group of participants with dyslexia did not predict digit span forward or backward, is a different result to that obtained by Fostick and Revah (2018) from a group of 78 adults with dyslexia. These authors found significant differences in forwards and backward digit span in adults with dyslexia compared to a group of 23 “normal-reading” (p. 21) adults. Backward digit span tests different aspects of memory to forward digit span. Both forward and backward digit span tasks test sequential processes but tests for backward digit span may tap an aspect of the Baddeley and Hitch’s (1974) visuospatial sketchpad in a model of working memory. These concerns that digit span backward may not be an auditory working memory task limits interpretation of this test and may explain why results for the digit span backward test were not different for participants with dyslexia. In future investigations a record of participants’ strategies to help repeat numbers backwards would be useful. Strategies could be sub-vocal rehearsal or visual strategies (e.g., St Clair Thompson & Allen, 2013), as was the case for one participant in the study who confessed to using a keyboard in the testing room to visually support his auditory working memory.

The group of participants with dyslexia predicted Corsi Block Task forwards which was unexpected, as visual memory weakness is not usually a feature of dyslexia. The group of participants with DCD predicted Corsi Block Task forward and backward, which was expected from previous research into visual memory in DCD (Section 3.2). That there were no significant weaknesses in abstract visual memory for participants with DCD was unexpected. Previous studies have shown that there are deficits in visuospatial memory in children with DCD (e.g., Alloway, Rajendran & Archibald, 2009; Wang, Tseng, Liu & Tsai, 2017). To date, no studies have been found that report visuospatial memory and working memory in adults with DCD, although there are self-reports of manifestations of weak working memory from a behavioural scale in young adults (Tal Saban, Ornoy & Parush, 2014) and from a questionnaire upon referral (Purcell, Scott-Robert & Kirby, 2015). That visual spatial memory, evaluated by the Corsi Block Task forwards and backwards, was deficient in the group of participants in the current study is the first report in the scientific literature, as far as is known, of weaker visuospatial memory in adults with DCD.

The group of participants with dyslexia/DCD predicted digit span forward but not backwards. Forwards digit span relates to intelligence (e.g., Gignac & Weiss, 2015) and is independent of domain (Owen et al., 2000). Intelligence was controlled with WRIT matrices in this instance. Digit span backward employs the visual spatial sketchpad and this may have helped participants with dyslexia/DCD. This difference between the dyslexia/DCD group and dyslexia and DCD groups is a reason to suppose that dyslexia/DCD is not merely a result of comorbid dyslexia and DCD.

APPENDIX P: Symbol Digit Modalities and Chronometric Tests

Covariates

The following are instances when there were significant correlations between age in months, gender, WRIT matrices and results of Visual Discomfort Scale and tests of speed.

Typical development.

- WRIT matrices with SMT (r_s (48) = – .29, p = 038).

Dyslexia.

- Visual Discomfort Scale with SDT (r_s (38) = .32, p = 048)
- Gender with SMT (τ_b = .45, p = .001).

Developmental coordination disorder.

- WRIT matrices with Symbol Digit Modalities Test (r_s (31) = .36, p = 041)
- Age with CDT (r_s (48) = .35, p = 049)
- Age with SMT (r_s (31) = .41, p = 021).

Dyslexia/developmental coordination disorder.

- Age with SDT (r_s (16) = .53, p = 025).

Group differences

Hierarchical regression analyses, in which the results of speed tests: SDMT, SDT, CDT and SMT (Tables P1–P8) were the dependent variables, established differences between participant groups for each of these variables, with age in months, gender, and WRIT matrices in Step 1, with and without the results of the Visual Discomfort Scale. Procedures for Step 2 were as in Section 6. 1. Assumptions, assessed prior to analysis, were not violated.

Table P1

Hierarchical Regression Analysis With Symbol Digit Modalities Test Results as the Dependent Variable Without and With Control for Visual Discomfort

N = 141	Model 1			Model 2			95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	40.27	6.29		49.85	6.24		37.52	52.18
Age	– 0.01	0.01	– .15	– 0.01	0.01	– .14	–0.02	00
Gender	0.53	1.83	– .02	– 0.85	1.72	.04	– 4.24	2.55
Matrices	**0.43**	**0.14**	**.27****	**0.31**	**0.13**	**.19***	**0.06**	**0.57**
Step 2 Dyslexia				**– 7.58**	**2.00**	**– .33*****	**– 11.53**	**– 3.62**
DCD				**– 8.03**	**2.11**	**– .33*****	**– 12.21**	**– 3.86**
Dyslexia/DCD				**– 8.72**	**2.65**	**– .28*****	**– 13.96**	**3.49**
R^2 = .24***; *Step 1* ΔR^2 = .11 ***; *Step 2* ΔR^2 = .13***								
Visual Discomfort Scale as a Predictor in Step 1								
N = *141*	Model 1			Model 2			95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	45.74	5.98		49.44	6.16		37.26	61.63
Age	– 0.01	0.01	.12	– 0.01	0.01	– .13	– 0.02	00
Gender	0.74	1.73	.03	– 0.01	1.74	.00	– 3.45	3.44
Matrices	**0.37**	**0.13**	**.23****	**0.33**	**0.13**	**.20***	**0.07**	**0.58**
Visual Discomfort	**– 0.22**	**0.05**	**– .36*****	**– 0.13**	**0.06**	**– .21***	**– 0.25**	**– 0.01**
Step 2 Dyslexia				**– 4.76**	**2.38**	**– .21***	**– 9.47**	**– 0.04**
DCD				**– 5.23**	**2.47**	**– .21***	**– 10.12**	**– 0.35**
Dyslexia/DCD				– 5.20	3.10	– .17	– 11.33	0.94
R^2 = .26***; *Step 1* ΔR^2 = .23 ***; *Step 2* ΔR^2 = .03***								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval of *b* in Model 2, LL, lower & UL, upper limit; dummy coding; SpLD v. typical, code 0000; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT matrices (Wide Range Intelligence Test, Glutting, Adams & Sheslow, 2000). * *p* < .05, ** *p* < .01, *** *p* < .001.

Symbol Digit Modalities Test. The hierarchical regression analysis in Table P1 showed that age and gender did not significantly influence SDMT. This is in contrast to the results of digit symbol in which females perform better (N.R. Burns & Nettelbeck, 2003). WRIT matrices scores significantly predicted SDMT scores. Groups of participants with dyslexia, DCD and dyslexia/DCD all predicted SDMT ($p < .001$). A full model of age, gender and results of WRIT matrices in Step 1 and SpLDs in Step 2 significantly predicted SDMT ($R^2 = .24$, F (6, 134) = 6.95, $p <.001$).

When Visual Discomfort Scale was included in Step 1, only the group of participants with DCD significantly predicted SDMT results ($p = .048$). A full model of age, gender, WRIT matrices, Visual Discomfort Scale, in Step 1 and SpLDs in Step 2, significantly predicted SDMT ($R^2 = .26$, F (7, 133) = 6.75, $p <.001$).

Simple Decision Time. The hierarchical regression analysis in Table P2 showed that age, gender and WRIT matrices scores did not significantly influence SDT but Visual Discomfort Scale did. The full model including SpLDs was significant ($R^2 = .14$, F (6, 134) = 3.51, $p = .003$). SDT was significantly predicted by the participants with DCD ($p < .001$) and the participants with dyslexia/DCD ($p = .001$) compared to the group of typically developed participants.

When Visual Discomfort Scale was included in Step 1, groups of participants with DCD and dyslexia/DCD significantly predicted SDT ($p = .007$, $p = .015$, respectively). The full model was significant ($R^2 = .14$, F (7, 133) = 3.10, $p = .005$).

Choice Decision Time. The hierarchical regression analysis in Table P3 with CDT as the dependent variable showed that dyslexia, DCD and dyslexia/DCD significantly predicted CDT ($p =.036$, $p <.001$, $p = .013$, respectively). The full model was significant ($R^2 = .12$, F (6, 134) = 2.94, $p = .010$).

With Visual Discomfort Scale added to age, gender and WRIT matrices in Step 1 (Table P3) only participants with DCD predicted CDT ($p = .04$). The whole model was significant ($R^2 = .16$, F (7, 133) = 3.42, $p = .002$).

Table P2

Hierarchical Regression Analyses With Simple Decision Time as the Dependent Variable Without and With Control for Visual Discomfort

N = 141	Model 1			Model 2			95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	292	48		227	48		132	322
Age	0.02	0.05	.04	0.02	0.05	.04	– 0.07	0.11
Gender	12.99	13.99	.08	14.81	13.26	.08	– 11.42	41.03
Matrices	– 0.23	1.03	– .02	0.64	0.98	.06	– 1.33	2.61
Step 2 Dyslexia				29.12	15.43	.17	–1.40	59.63
DCD				**61.30**	**16.30**	**.34*****	**29.06**	**93.60**
Dyslexia/DCD				**70.45**	**20.44**	**.31*****	**30.02**	**110.87**
R^2 = .14***; *Step 1* Δ R^2 = .01; *Step 2* Δ R^2 = .13***								

With Visual Discomfort Scale as a Predictor in Step 1

N = *141*	Model 1			Model 2			95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	264	48		227	48		133	322
Age	0.01	0.05	.02	0.02	0.05	.04	– 0.07	0.11
Gender	6.39	13.74	.01	12.26	13.63	.08	– 14.71	39.22
Matrices	– 0.06	1.03	– .02	0.64	1.00	.05	– 1.37	2.58
Visual Discomfort	**1.14**	**0.47**	**.26****	0.39	0.47	– .09	– 0.55	1.33
Step 2 Dyslexia				20.55	18.64	.12	–16.33	57.42
DCD				**52.80**	**19.34**	**.30****	**14.55**	**91.04**
Dyslexia/DCD				**59.73**	**24.27**	**.26***	**11.73**	**107.74**
R^2 = .14***; *Step 1* Δ R^2 = .07*; *Step 2* Δ R^2 = .07*								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval of *b* in Model 2, LL& UL= lower & upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT matrices (Wide Range Intelligence Test, Glutting, Adams & Sheslow, 2000); *p* < .05, ** *p* < .01, *** *p* < .001.

Table P3

Hierarchical Regression Analyses With Choice Decision Time as the Dependent Variable Without and With Control for Visual Discomfort

N = *141*		Model 1			Model 2		95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	442.92	75.37		350	76		207	504
Age	0. 03	0.08	.03	0.03	0.07	.03	– 0.13	0.16
Gender	– 3.81	22	.02	– 7.96	21	.03	– 39.56	47.17
Matrices	– 1.38	1.61	– .08	- 0.28	1.58	– 0.02	– 4.56	1.81
Step 2 Dyslexia				**51.82**	**24.44**	**.20***	**3.48**	**100.15**
DCD				**98.75**	**25.83**	**.35*****	**47.67**	**149.84**
Dyslexia/DCD				**81.76**	**32.38**	**.23***	**17.73**	**145.80**
R^2 = .12*; *Step 1* Δ R^2 = .01; *Step 2* Δ R^2 = .11***								

With Visual Discomfort Scale								
N = 141		Model 1			Model 2		95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	382	73		356	76.51		204	507
Age	00	00	00	0.01	0.08	.01	– 0.14	0.16
Gender	–12	21	.04	– 4.37	21.88	– .02	– 47.67	38.92
Matrices	–1	2	.00	– 0.38	1.60	– 0.02	– 3.54	2.77
Visual Discomfort	**2.47**	**0.58**	**.36*****	**1.79**	**0.75**	**0.26***	0.30	3.28
Step 2 Dyslexia				19.59	29.77	.07	– 39.34	78.46
DCD				**62.00**	**30.65**	**.22***	**2.07**	**123.37**
Dyslexia/DCD				33.00	38.32	.09	– 42.70	108.97
R^2 = .16**; *Step 1* Δ R^2 = .13**; *Step 2* Δ R^2 = .03								

Note. In Step 2, statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences against typically developed group, code 0000. CI = confidence interval of *b* in Model 2 LL, lower & UL, upper limit; DCD = developmental coordination disorder; Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT (Wide Range Intelligence Test, Glutting, Adams & Sheslow, 2000); *p* < .05, ** *p* < .01, *** *p* < .001.

Table P4

Hierarchical Regression Analyses With Simple Motor Time as the Dependent Variable Without and With Control for Visual Discomfort

N = *141*	Model 1			Model 2			95% CI	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	129	34		98	36		30	170
Age	00	00	.01	00	00	.01	- .07	.00
Gender	**24**	**10**	**.21***	**25**	**10**	**.21***	**.95**	**.03**
WRIT Matrices	– 1	1	− .10	0	0	− .05	– 2	.00
Step 2 Dyslexia				17	11	.14	- 6	39
DCD				23	12	.18	– 1	47
Dyslexia/DCD				**38**	**15**	**.23***	**8**	**68**

R^2 = .12*; *Step 1* ΔR^2 = .06*; *Step 2* ΔR^2 = .05

With Visual Discomfort Scale as a Predictor in Step 1

N = *141*	Model 1			Model 2			95% CI	
	b	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Step 1 Constant	109	34		100	35		30	170
Age	00	00	.07	00	00	.00	- .07	.00
Gender	**20**	**10**	**.17***	**21**	**10**	**.18***	**.95**	**.03**
WRIT Matrices	– 1	1	− .08	0.00	1	− .06	– 2	.00
Visual Discomfort	**1**	**0**	**.25****	1	00	.20	- .05	1.32
Step 2 Dyslexia				3	14	.02	– 24	30
DCD				9	14	.07	- 19	37
Dyslexia/DCD				20	18	.12	- 15	55

R^2 = .14; *Step 1* ΔR^2 = .13***; *Step 2* ΔR^2 = .01

Note. Statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. CI = confidence interval for *b* in Model 2; discomfort scale = Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); LL = lower limit, UL = upper limit; DCD = developmental coordination disorder; WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000); * p < .05, ** p < .01, *** p < .001.

Simple Motor Time. In a hierarchical regression with SMT as the dependent variable (Table P4), dyslexia/DCD significantly predicted SMT compared to the group of participants who were typically developed (p = .014). The full model to predict SMT was significant (R^2 = .12, F (6, 133) = 2.87, p =.012).

With the addition of Visual Discomfort Scale in Step 1, age or WRIT matrices did not significantly predict SMT but gender influenced the outcome; men had faster SMTs than women. When Visual Discomfort Scale was included, the full model was significant (R^2 = .14, F (7, 133) = 2.98, p = .006) but no SpLD group significantly predicted SMT.

Summary.

Without Visual Discomfort Scale included in the model:

Dyslexia predicted performance for SDMT and CDT

DCD predicted performance for SDMT, SDT and CDT

Dyslexia/DCD predicted SDMT, SDT, CDT and SMT.

With Visual Discomfort Scale included (controlled) in the model:

Dyslexia predicted performance for SDMT

DCD predicted performance for CDT and SDMT

DCD and dyslexia/DCD predicted performance for SDT

No group predicted performance for SMT.

Principal Component Analysis

In the neatest solution, there were coefficients above .3; Bartlett's test of sphericity was significant; and the Kaiser-Meyer-Olkin measure of sampling adequacy, .774, was sufficient as it was above .6. There was a clear two-factor solution with eigenvalues above one, which explained 52.40% of the variance. A Varimax rotation confirmed two factors, labelled: *Speed* and *Memory* (Table P5). Varimax rotation was preferred as it produced a clear solution and the correlation matrix value was .28, which suggests that the two factors were sufficiently unrelated to justify its use (Pallant, 2002). The Speed factor explained 28.68% of the variance and the Memory factor explained 23.73% of variance. Inspection time loaded .53 on the Speed factor. Of note, loadings of the SDMT occurred for both Speed and Memory. When Visual Discomfort Scale was included as a component in the analysis, (Table P5 in brackets), it loaded on the Speed factor.

In view of the longer inspection times seen in dyslexia/DCD and to a limited, insignificant extent in DCD, another principal component analysis (PCA) was conducted with Varimax rotation as above but with only these two groups of participants (Table P5). As before, correlation coefficients were above .3. Bartlett's test of sphericity was significant and the Kaiser-Meyer-Olkin measure of sampling adequacy was .78. A clear two-factor solution explained 57.4% of the variance. The correlation matrix value was – .28, which justified the use of Varimax rotation, as before. The rotation confirmed two factors, again labelled: *Speed* and *Memory*. The Speed factor explained 32.05% of the variance and the Memory factor 25.35% of variance. Inspection time loaded .41 on the Speed factor and – .58 on the Memory factor. Again, loadings of the SDMT occurred for both Speed and Memory but more on the Memory factor in this group of participants.

Table P5

Principal Component Analysis With Varimax Rotation of Tests of Standard Inspection Time, Visual Memory, Speed and Control Measures

Participants	All participants (typically developed, with dyslexia, DCD and dyslexia/DCD *N* = 141		DCD and dyslexia /DCD groups *n* = 33 + 18 = 51	
Factors	*Speed*	*Visual Memory*	*Speed*	*Visual Memory*
Simple reaction time	.89 (.86)	-	.88	-
Choice reaction time	.88 (.87)	-	.893	-
Symbol Digit Modalities Test	.69 (.70)	.41 (.38)	– .58	.56
Standard inspection time	– .53 (.52)	-	.41	– .58
Abstract visual memory		.68 (.68)		.67
WRIT matrices		.67 (.67)		.68
Corsi backward	– .35 (– .38)	.63 (.61)		.66
Corsi forward	– .35 (– .36)	.61 (.60)		.63
Age		– .46 (– .46)		– .69
(Visual Discomfort Scale)	(.52)	-	-	-
Percentage of variance explained	28.68 (28.43)	23.73 (21.25)	32.05	25.35

Note. When Visual Discomfort Scale was added as a component this is in brackets. Age in months; abstract visual memory from TOMAL-2 = Test of Memory and Learning-2 (Reynolds & Voress, 2007); Corsi = Corsi Block Task *(*Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000; The Psychological Investigation Building Language, PEBL; Mueller, 2010); Symbol Digit Modalities Test (Smith, 1982); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).

APPENDIX Q: Rapid Automatic Naming

Correlates of Four Tests of Rapid Automatic Naming.

Typical development.

- WRIT matrices correlated significantly with all four RAN tests (r_s (48) > – .45, p = .001).

Dyslexia and dyslexia/DCD. Age, gender, results of Visual Discomfort Scale (VDS) and WRIT matrices did not correlate significantly with any RAN test.

DCD.

- colours RAN and VDS (r_s (31) = – .45, p = .012)
- objects RAN and VDS (r_s (31) = – .49, p = .004).

Group differences for rapid automatic naming of letters.

Results. Table Q1 displays results of a hierarchical regression analysis for the test result for RAN letters, the dependent variable. Design of the analyses was as for previous analyses (e.g., Section 6.1). Assumptions assessed prior to analysis were not violated. Results show that gender was a significant covariate and in Model 2, after age, gender and WRIT matrices had been accounted for, all SpLD groups had significantly slower RAN letters' performance than the typically developed group (p <.001); the addition of SpLD groups in Step 2 significantly increased R^2. The full model of age, gender, WRIT matrices, and SpLD to predict RAN letters was significant (R^2 = .28, F (6, 140) = 8.72, p < .001).

Furthermore, visual discomfort was a significant covariate and in Model 2, as before but results of Visual Discomfort Scale included, all SpLD groups had significantly slower RAN letters' performance than the typically developed group. Addition of SpLD groups in Step 2 significantly increased R^2 and all groups predicted RAN letters. Results show that the full model of age, gender, WRIT matrices, VDS and SpLD to predict RAN letters was significant (R^2 = .31, F (7, 135) = 8.36, p < .001).

Table Q1

Hierarchical Regression Analyses, Rapid Automatic Naming of Letters as Dependent Variable Without and With Control for Visual Discomfort

N = 141	Model 1			Model 2			Confidence intervals	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	14.40	2.92		8.77	2.71		3.40	14.13
Age (months)	0.00	0.00	− .01	0.00	0.01	− .02	− 0.01	0.00
Gender	1.95	0.85	.20	**2.17**	**0.75**	**.22****	**0.00**	**0.70**
WRIT Matrices	− 0.02	0.06	− .03	0.04	0.06	.06	– 0.07	0.15
Step 2 Dyslexia				**4.88**	**0.87**	**.47****	**3.17**	**6.60**
DCD				**4.86**	**0.92**	**.44****	**3.05**	**6.68**
Dyslexia/DCD				**4.70**	**1.15**	**.34*****	**2.43**	**6.98**

R^2 = .28***; *Step 1 Δ* R^2 *= .04; Step 2 Δ* R^2 = .24***.

With Visual Discomfort in Step 1

N = 137	Model 1			Model 2			Confidence intervals	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	*LL*	*UL*
Constant	11.24	2.68		8.96	2.69		3.64	14.27
Age (months)	0.00	0.00	– .05	0.00	0.00	– .04	– 0.01	0.00
Gender	1.23	0.78	**.12**	**1.74**	**0.77***	**.18**	**0.22**	**3.26**
WRIT Matrices	0.01	0.06	.01	0.36	0.06	.05	– 0.07	0.15
Visual Discomfort	**0.12**	**0.02**	**.46*****	**0.07**	**0.03***	.25	0.02	0.12
Step 2 Dyslexia				**3.27**	**1.05**	**.31****	**1.20**	**5.33**
DCD				**3.50**	**1.08**	**.32****	**1.37**	**5.63**
Dyslexia/DCD				**2.86**	**1.35**	**.21***	**0.20**	**5.52**

R^2 = .31**; *Step 1 Δ* R^2 *= .25***; Step 2 Δ* R^2 = .07**.

Note. For dyslexia, DCD and dyslexia/DCD, bold = significant Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. Dyslexia = developmental dyslexia; DCD = developmental coordination disorder; typical coded as 0 0 0, CIs are for Model 2; WRIT = Wide Range Intelligence Test. * *p* < .05, ** *p* < .01, *** *p* <= .001.

Discussion. Letters were taken as an example of RAN. The hierarchical regression analyses show that, compared to typically developed participants, all groups of participants with SpLDs have slower RAN of letters, whether visual discomfort, assessed by the VDS, was controlled or not. Moreover, profiles of participants in the group (Table H1) show that the other RAN tests, grouped as digits and letters; colours and objects, are also deficient in all groups. Davies (2013) found that both RAN letters and RAN objects were significantly slower in adults with dyslexia compared to adults with typical development. In another study, Hebrew-speaking adults with dyslexia had deficient RAN letters and objects (Beidas, Khateb & Breznitz, 2013). Vukovic, Wilson and Nash (2004) showed that digits, letters, objects and colours were all deficient in adults with reading disabilities. The study reported here supports these findings. However, the work reported here extends these findings for adults because it shows that slow RAN is not confined to participants with dyslexia but is a feature of DCD and dyslexia/DCD.

Correlations with inspection time: all participants together. Table I2 (Appendix I) shows that, in the whole 141-participant set, there were weak positive relationships between standard inspection time (IT1) and RAN digits, letters, colours and objects, once age and WRIT matrices had been controlled. Further Spearman's partial correlation analyses were made for the whole set with VDS controlled in addition. Results were as follows: digits, (r_s (140) = .12, p = .170); letters, (r_s (140) = .16, p = .068); colours, (r_s (140) = .13, p = .127); objects, (r_s (140) = .20, p = .020). Thus, after these controls only RAN objects correlated with inspection time across the whole participant set.

APPENDIX R: Reading and Writing

Reading

Correlates of sight word reading and phonemic decoding efficiency. Significant correlations between reading and age, gender, WRIT matrices and Visual Discomfort Scale (VDS) were:

Typical development.

- WRIT matrices and sight word reading (r_s (49) = .46, p = .001)
- WRIT matrices and phonemic decoding (r_s (49) = .41, p = .003).

Dyslexia.

- age and sight words (r_s (39) = .59, p < .001)
- age and phonemic decoding (r_s (39) = .30, p = .022)
- gender and sight words (τ_b (39) = – .45, p = .003)
- Visual Discomfort Scale and sight word reading (r_s (39) = – .38, p = .020).

DCD.

- VDS and sight word reading (r_s (32) = – .43, p = .013).

***Dyslexia/Developmental Coordination Disorder*.** There were no significant correlations with either sight word or phonemic decoding efficiency.

Group differences for word reading efficiency. Tables R1 and R2 display results of two hierarchical regression analyses for each of sight word reading and phonemic decoding efficiency as dependent variables. Age, gender and WRIT matrices were in Step 1. For each dependent variable, one analysis also had VDS in Step 1 and one analysis did not.

Table R1

Hierarchical Regression Analyses with TOWRE-2 Sight Word Reading as the Dependent Variable Without and With Visual Discomfort Scale in Step1

Step 1	Model 1			Model 2			C Is at 95%	
	b	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	75.76	8.88		94.65	7.98		78.86	110.44
Age (months)	0.02	.01	.13	**.0.02**	**0.01**	**.15***	0.00	0.03
Gender	**– 6.96**	**2.59**	**– .23****	**– 7.18**	**2.20**	**– .23*****	**– 11.53**	**– 2.83**
Matrices	0.32	0.19	.14	0.06	0.17	.03	– 0 .26	.39
Dyslexia				**– 16.08**	**2.56**	**– .49*****	**– 21.14**	**– 11.02**
DCD				**– 10.83**	**2.70**	**– .31*****	**– 16.18**	**– 5.48**
Dyslexia/DCD				**– 20.56**	**3.39**	**– 47*****	**– 27.26**	**– 13.85**

*R^2 = .37***; Step 1 ΔR^2 = .10**; Step2 ΔR^2 =.27****

With Visual Discomfort Scale in Step 1.

Step 1	Model 1			Model 2			CIs at 95%	
	b	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	84.46	8.06		92.96	7.95		77.23	108.68
Age	**0.02**	**.01**	**.17***	**.0.02**	**0.01**	**.17***	0.00	0.03
Gender	**– 4.80**	**2.35**	**– .15***	**– 5.94**	**2.20**	**– .19***	**– 10.44**	**– 1.44**
Matrices	0.25	0.17	.11	0.12	0.17	.05	– .22	0.44
Visual discomfort	**– 0 .39**	**0.06**	**– .47*****	**– 0.21**	**0.08**	**– .24***	**– 0.36**	**– 0.05**
Dyslexia				**– 10.98**	**3.09**	**– .33****	**– 17.10**	**– 4.87**
DCD				**– 6.70**	**3.18**	**– .19***	**– 13.00**	**– 0.40**
Dyslexia/DCD				**– 14.78**	**3.98**	**– .34*****	**– 22.26**	**– 6.90**

*R^2 = .39***; Step 1 ΔR^2 = .31***; Step2 ΔR^2 =.08****

Note. Statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. DASH = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); TOWRE-2 = Test of Word Reading Efficiency (Torgeson, Wagner & Rashotte, 2012); DCD = developmental coordination disorder; WRIT = Wide Range Intelligence Test. * *p* < .05, ** *p* < .01, *** *p* < .001.

Table R2

Hierarchical Regression Analyses with TOWRE-2 Phonemic Decoding Efficiency as the Dependent Variable Without and With Visual Discomfort Scale in Step1

	Model 1			Model 2			CIs at 95%	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	36.00	7.00		48.15	6.30		36.70	60.60
Age months	0.01	.01	.09	**.0.01**	**0.01**	**.11***	0.00	0.02
Gender	– 1.46	2.04	– .06	– 1.3	1.74	– .06	– 4.76	2.10
Matrices	**0.31**	**0.19**	**.18***	0.14	0.13	.08	– 0 .12	0.39
Dyslexia				**– 12.55**	**2.02**	**– .50*****	**– 16.55**	**– 8.56**
DCD				– 3.03	2.13	– .11	– 7.25	1.19
Dyslexia/DCD				**– 14.90**	**2.67**	**– 44*****	**– 20.19**	**– 9.61**

*R^2 = .32***; Step 1 ΔR^2 = .05; Step2 ΔR^2 =.28****

With Visual Discomfort Scale in Step 1.

Step 1	Model 1			Model 2			CIs at 95%	
	b	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	39.06	6.68		46.48	6.28		34.06	58.91
Age	0.01	.01	.11	.0.01	0.01	.11	0.00	0.02
Gender	– 0.84	1.95	– .04	**– 1.15**	**1.80**	**– .07***	**– 5.09**	**2.02**
Matrices	0.33	0.14	.20	0.19	0.13	.11	– 0.07	0.45
Visual discomfort	**– 0 .18**	**0.05**	**– .29*****	– 0.25	0.06	– .04	– 0.15	0.01
Dyslexia				**– 10.73**	**2.44**	**– .43*****	**– 15.57**	**– 5.90**
DCD				– 2.72	2.52	– .11	– 7.70	– 2.26
Dyslexia/DCD				**– 13.87**	**3.15**	**– .43*****	**– 20.10**	**– 7.65**

*R^2 = .32***; Step 1 ΔR^2 = .15***; Step2 ΔR^2 =.17****

Note. Statistically significant in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. DASH = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); TOWRE- 2 = Test of Word Reading Efficiency (Torgeson, Wagner & Rashotte, 2012); DCD = developmental coordination disorder; WRIT = Wide Range Intelligence Test. * $p < .05$, ** $p < .01$, *** $p < .001$.

Sight word reading efficiency.

Sight word reading without Visual Discomfort Scale in Step 1. Table R1 shows that gender was a significant covariate and that in Model 2 after age, gender and WRIT matrices had been accounted for, all SpLD groups had significantly slower sight word reading performance than the typically developed group; the addition of SpLD groups in Step 2 significantly increased $R^{2.}$ Results show that the full model of age, gender, WRIT matrices, and SpLD to predict sight word reading efficiency was significant (R^2 = .38, F (6, 140) = 12.93, p < .001).

Sight word reading with Visual Discomfort Scale in Step 1. With visual discomfort in Step 1, age, gender and visual discomfort significantly predicted sight word reading and in Model 2 after age, gender, WRIT matrices and visual discomfort had been controlled, all SpLD groups had significantly slower sight word reading performance than the group with typical development. The addition of SpLD groups in Step 2 significantly increased $R^{2.}$ Results show that the full model of age, gender, WRIT matrices, VDS and SpLD to predict sight word reading efficiency was significant (R^2 = .39, F (7, 135) = 11.90, p < .001). All ßs were less after VDS had been controlled and in DCD the significance of the difference between sight word reading to that of participants with typical development was reduced.

Phonemic decoding efficiency*.* Phonemic decoding efficiency in dyslexia and dyslexia/DCD groups both before and after controlling for VDS was less than in the typically developed group. The DCD group did not have significant differences from the typically developed group.

Phonemic decoding efficiency without Visual Discomfort Scale. In Table R2 it can be seen that gender significantly predicted phonemic decoding and that in Model 2 after age, gender and WRIT matrices had been accounted for, all SpLD groups had significantly slower phonemic decoding performance than the group with typical development; the addition of SpLD groups in Step 2 significantly increased $R^{2.}$ Results show that the full model of age, gender, WRIT matrices, and SpLD to predict sight word reading efficiency was significant (R^2 = .32, F (6, 140) = 10.91, p < .001).

Looking at group differences, phonemic decoding efficiency did not appear to be improved significantly by control of results of VDS in any SpLD group. Any influence from visual discomfort may be outweighed by the effort required by all participants to decode phonemically.

Phonemic decoding efficiency with Visual Discomfort Scale. In Table R2, with visual discomfort in Step 1, it can be seen that WRIT matrices and visual discomfort significantly predicted phonemic decoding. In Model 2 after age, gender, WRIT matrices and visual discomfort had been accounted for, the group of participants with dyslexia and dyslexia/DCD had significantly slower phonemic decoding performance than the group of participants with typical development, but the group with DCD did not. Results show that the full model of age, gender, WRIT matrices, VDS and SpLD to predict phonemic decoding efficiency was significant (R^2 = .32, F (7, 135) = 8.58, p < .001).

Summary group differences for reading. **H**ierarchical regression analyses showed differences in literacy test performances between SpLD groups and the group of typically developed participants. Two analyses were made for each of sight word reading efficiency and phonemic decoding efficiency as dependent variables. For each dependent variable, one analysis used VDS to control for visual discomfort in Step 1 and one analysis did not. Age, gender and WRIT matrices were always controlled in Step 1. Results are summarised as follows:

Dyslexia. For the group with dyslexia, sight word reading and phonemic decoding efficiency were significantly less than in the typically developed group both with and without visual discomfort controlled.

Developmental coordination disorder. The DCD group had significantly weaker sight word reading without visual discomfort controlled. Once VDSwas controlled sight word reading was no longer significantly weaker than typical.

Dyslexia/developmental coordination disorder. The dyslexia/DCD group had significantly less sight word reading and phonemic decoding efficiency both with and without VDS controlled.

Correlations between novel inspection time, sight word reading and phonemic decoding efficiency. Table R3 shows the correlation matrix for reading and inspection times from the novel stimulus (IT3 + IT4), in the four groups. There were no significant correlations between reading and inspection time from the novel stimulus in any group.

Table R3

Study 3: Spearman Correlation for (IT3 + IT4), Sight Word Reading Efficiency and Phonemic Decoding Efficiency in Four Groups

Typically developed *n* = 50	1	2	3
1 (IT3 + IT4)	1.00	-	-
2 sight words	.04	1.00	-
3 phonemic decoding	.05	**.68***	1.00
Dyslexia *n* = 40			
1 (IT3 + IT4)	1.00	-	-
2 sight words	– .02	1.00	-
3 phonemic decoding	– .01	**.37***	1.00
DCD *n* = 33			
1 (IT3 + IT4)	1.00	-	-
2 sight words	– .28	1.00	-
3 phonemic decoding	– .19	**.74***	1.00
Dyslexia/DCD *n* = 18			
1 (IT3 + IT4)	1.00	-	-
3 phonemic decoding	– .38	1.00	-
2 sight words	– .09	**.65****	1.00

Note. Significant correlations are in bold. DCD = developmental coordination disorder; dyslexia = developmental dyslexia; (IT3 + IT4) = Inspection Time Test 3 + Test 4; sight words and phonemic decoding from Test of Word Reading Efficiency (Torgeson, Wagner & Rashotte, 2012). * *p* < .05, ** *p* < .01, *** *p* <= .001, two-tailed.

Writing

Correlates of copy fast and graphic speed.

Typically developed.

- age and copy fast (r_s (49) = .40 p = .004)

Dyslexia.

- age and copy fast (r_s (39) = .33 p = .036)

DCD. No significant correlations.

Dyslexia/Developmental Coordination Disorder.

- WRIT matrices and graphic speed (r_s (17) = .54, p = .020).

Group differences. The weakest correlation between copy best and copy fast was in the DCD group (r (32) = .49, p = .004). For simplicity and because it was done under pressure of time, only copy fast was used for analyses. Hierarchical regression analyses were made with dependent variables as copy fast and graphic speed.

***Copy fast without Visual Discomfort Scale in Step 1*.** In Table R4, it can be seen that age significantly predicted copy fast and that in Model 2 after age, gender and WRIT matrices had been accounted for, all SpLD groups had significantly slower copy fast performance than the group with typical development; the addition of SpLD groups in Step 2 significantly increased $R^{2.}$ The full model of age, gender, WRIT matrices, and SpLD to predict copy fast was significant (R^2 = 20, F (6, 140) = 5.41, p < .001).

Copy fast with Visual Discomfort Scale in Step 1. In Table R4 with visual discomfort in Step 1, age, gender and visual discomfort were significant. In Model 2, only the DCD group had weaker performance than the group with typical development. The addition of SpLD groups in Step 2 significantly increased $R^{2.}$ The full model of age, gender, WRIT matrices, VDS and SpLD to predict sight word reading efficiency was significant (R^2 = .22, F (7, 135) = 5.22, p < .001). Copy fast was slower than typical in all SpLD groups and graphic speed slower in dyslexia/DCD. When VDS was controlled, copy fast in DCD was deficient.

Table R4

Hierarchical Regression Analyses with Copy Fast as the Dependent Variable Without and With Visual Discomfort Scale in Step1

	Model 1			Model 2			CIs 95%	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	25.29	4.32		31.46	4.31		22.94	39.98
Age months	**0.01**	**0.00**	**.25****	**.0.01**	**0.00**	**.25****	**0.01**	**0.02**
Gender	1.68	1.26	.11	1.43	1.19	.09	– 0.92	3.78
Matrices	0.0	0.09	.10	0.03	0.09	.03	– 0 .15	0.21
Dyslexia				**– 4.52**	**1.38**	**– .29*****	**– 7.26**	**– 1.79**
DCD				**– 5.84**	**1.46**	**– .35*****	**– 8.23**	**– 2.95**
Dyslexia/DCD				**– 5.32**	**1.83**	**– .25****	**– 8.94**	**– 1.70**
*R^2 = .20***; Step 1 ΔR^2 = .07*; Step2 ΔR^2 =.12****								

With Visual Discomfort Scale in Step 1.

	Model 1			Model 2			CIs 95%	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	30.03	4.01		32.11	4.14		23.92	40.30
Age	**0.01**	**0.00**	**.25****	**0.01**	**0.01**	**.24****	**0.00**	**0.02**
Gender	**2.53**	**1.17**	**.18***	**2.04**	**1.18**	**.14***	**– 0.31**	**4.38**
Matrices	0.06	0.09	.05	0.03	0.07	.03	– 0.14	0.20
Visual discomfort	**– 0 .15**	**0.03**	**– .38*****	**– 0.10**	**0.04**	**– .25***	**– 0.18**	**– 0.02**
Dyslexia				– 2.49	1.61	– .16	– 5.68	0.69
DCD				**– 3.63**	**1.66**	**– .23***	**– 6.91**	**– 0.35**
Dyslexia/DCD				– 2.68	2.07	– .13	– 6.79	1.42
*R^2 = .22***; Step 1 ΔR^2 = .19***; Step2 ΔR^2 =.03*								

Note. Statistically significant values are in bold. Coding: 0 = men, 1 = women, specific learning differences group against typically developed group, code 0000. Copy fast from DASH = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); DCD = developmental coordination disorder; WRIT = Wide Range Intelligence Test. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table R5

Hierarchical Regression Analyses with Graphic Speed as the Dependent Variable Without and With Visual Discomfort Scale in Step1

	Model 1			Model 2			CIs 95%	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	29.04	7.95		36.84	8.02		20.99	52.70
Age months	**– 0.02**	**0.01**	**.18***	**– 0.02**	**0.01**	**.18***	– 0.03	– 0.00
Gender	– 1.46	2.04	– .06	– 1.3	1.74	– .06	– 3.86	4.86
Matrices	**0.35**	**0.17**	**.18***	0.23	0.17	.11	– 0 .10	0.56
Dyslexia				– 0.45	2.57	– .02	– 5.53	4.62
DCD				**– 6.22**	**2.71**	**– .21***	**– 11.58**	**– 0.86**
Dyslexia/DCD				**– 11.66**	**3.39**	**– .31*****	**– 18.36**	**– 4.96**
*R^2 = .17***; Step 1 ΔR^2 = .07*; Step2 ΔR^2 =.10***								

With Visual Discomfort Scale in Step 1.

	Model 1			Model 2			Confidence intervals	
Step 1	*b*	*SE b*	*ß*	*b*	*SE b*	*ß*	LL	UL
Constant	32.78	8.05		35.66	8.14		19.56	51.78
Age	– 0.01	.01	– .15	– 0.02	0.01	– .16	– 0.03	0.00
Gender	1.62	2.34	.06	1.37	2.32	.05	– 3.22	5.97
Matrices	0.32	0.17	.16	0.25	0.17	.13	– .08	0.59
Visual discomfort	**– 0 .18**	**0.06**	**– .24****	– 0.13	0.08	– .17	– 0.28	0.03
Dyslexia				2.33	3.15	.08	– 3.91	8.57
DCD				– 3.50	3.25	– .12	– 9.93	2.93
Dyslexia/DCD				– 8.11	4.05	– .21*	– 16.13	– 0.09
*R^2 = .19***; Step 1 ΔR^2 = .12**; Step2 ΔR^2 =.06**								

Note. Statistically significant values are in bold.* Coding: 0 = men, 1 = women; dummy coding for specific learning differences group against typically developed group, code 0000. Graphic speed from DASH = Detailed Assessment of Handwriting (Barnett, Henderson, Scheib & Schulz, 2007); DCD = developmental coordination disorder; WRIT = Wide Range Intelligence Test. $p < .05$, ** $p < .01$, *** $p < .001$.

Graphic speed without Visual Discomfort Scale. In Table R5 it can be seen that age significantly predicted graphic speed and that in Model 2 after age, gender and WRIT matrices had been accounted for, DCD and dyslexia/DCD groups had significantly slower graphic performance than the typically developed group; the addition of SpLD groups in Step 2 significantly increased R^2. Results show that the full model of age, gender, WRIT matrices, and SpLD to predict graphic speed was significant (R^2 = .17, F (6, 139) = 4.59, p < .001).

Graphic speed with Visual Discomfort Scale. In Table R5 with VDS in Step 1 it can be seen that visual discomfort significantly predicted graphic speed and that in Model 2, after age, gender, WRIT matrices and visual discomfort had been accounted for, only the dyslexia/DCD group had significantly slower graphic performance than the typically developed group. Results show that the full model of age, gender, WRIT matrices, VDS and SpLD to predict phonemic decoding efficiency was significant (R^2 = .19, F (7, 135) = 4.16, p < .001).

Summary.

Handwriting speed. Copy fast was significantly slower in all groups. After controlling for VDS in Step 1, a significant difference from typical was found only in the DCD group.

Graphic speed. Graphic speed was significantly slower in the DCD and dyslexia/DCD groups. After controlling for VDS in Step 1, there were no significant differences between SpLD groups and the typical group.

Writing. As with reading, two hierarchical regression analyses were made for each of copy fast and graphic speed as dependent variables, and as before, one analysis controlled for VDS in Step 1 and one analysis did not. Results, detailed in Appendix R (Table R3 & R4) are as summarised as follows:

Dyslexia. In the group with dyslexia, copy fast was significantly less than was typical without, but not with, VDS controlled. Graphic speed was not significantly different to the typically developed group.

Developmental coordination disorder. Copy fast was slower than typical in the DCD group both with and without VDS controlled. Graphic speed was not significantly different to the typically developed group.

Dyslexia/developmental coordination disorder. Copy fast and graphic speeds were significantly slower in the dyslexia/DCD group without VDS controlled. When VDS was controlled, copy fast and graphic speed were not significantly different to the typically developed group.

APPENDIX S: Long Inspection Time Group Profiles

Results: Inspection Time Group Profiles

For all 141 participants, standard inspection time (IT1) was not normally distributed and failed the Shapiro Wilk Test (test statistic = .89, $p < .001$) so the median value of 54.52 ms was used as a measure of central tendency. The median value plus the value of the interquartile range, 21.31 ms, formed a cut-off for long standard inspection time (54.52 + 21.31 = 75.83 ms). There were 16 participants with standard inspection times (IT1s) greater than 75.83 ms and these formed a group of participants with long, long standard inspection time (IT1). In the same way, the 16 participants with the shortest standard inspection time (IT1) also formed a group of participants who achieved highly for inspection time. A final group, the majority, of participants fell between the long and short groups. Mean values or equivalent in the three new groups: long, medium and short, were calculated for standard inspection time (IT1), age, gender, original participant group, WRIT matrices and WRIT analogies (Table I1). Participants with long inspection time were on average older than those with short inspection times; results for mean WRIT matrices were better in the medium and high inspection time groups than in the low inspection time group; mean WRIT analogies was consistent across groups; 22% of participants with dyslexia/DCD were in the long inspection time group compared to 10% in each of the other groups.

On examination of outliers for standard inspection time (IT1), shown in Figure 4, Participant 70, who had a diagnosis of dyslexia, was at risk of DCD from the ADC

Checklist. Participant 79, who had a diagnosis of DCD, had short digit span backwards, exceptionally slow sight word reading, phonemic decoding speed, RAN and alphabet writing, all consistent with a diagnosis of dyslexia. Thus, the number of participants with dyslexia/DCD in the long standard inspection time (IT1) group was probably six, not four.

Table S1

Values of Variables for Long, Medium and Short Standard Inspection Times

Variable	Measure	Inspection time group (ms)		
		Long > 75.83	Medium	Short < 39.81
n		16	109	16
IT1, standard inspection time (ms)	Mean	94	55	36
Age (months)	Mean	406	359	354
Gender: men (women)		2 (14)	40 (69)	6 (10)
Typical	Percent in	31.30	33	56.30
Dyslexia	each long,	25	27.50	37.50
DCD	medium or	18	26.60	6.30
Dyslexia/DCD	short group	25	12.80	0
WRIT matrices	Mean raw	34.06	37.49	38.75
WRIT analogies	score	24.31	24.75	24.50

Note. WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).

It could be argued that these groups: long, medium and short, were simply related to underlying ability, as measured by WRIT matrices, age or both. Consequently, hierarchical regression analyses were made that controlled for intelligence, gender and age. Analyses with a range of measured variables as the dependent variables, are summarised in Table S2. The regression analyses were as analyses described in Section 6.1.1, except for Step 2, in which the three categorical, nominal variables for the participant groups were long, medium and short inspection time. These recoded to two dummy variables: long (10), and short (01), each compared against the group of medium inspection time participants (00).

Analyses showed that after age, gender and WRIT matrices were controlled, the longk inspection time groups predicted several measures. These were simple decision time (SDT), SDT standard deviation (SDTSD), simple motor time (SMT), choice decision time (CDT), CTOPP-2 rapid automatic naming (RAN) of digits, letter, colours and objects, TOWRE-2 sight words efficiency and symbol digit modalities test (SDMT). The long inspection time group did not predict abstract visual memory, Corsi Block Task forward or backward, TOMAL-2 digit span forward or backward, CTOPP-2 elision, visually guided pointing task— real or imagined totals, TOWRE-2 phonemic decoding efficiency, DASH handwriting tests, DCD checklists Section 1 or 2, ASRS checklist Sections 1 and 2, Visual Discomfort Scale results, video or smoking habits.

Table S2

Status of a Range of Dependent Variables in Hierarchical Regression Analyses Predicted by Long (Weak) Inspection Times; and Whole Group (N = 141) Spearman Partial Correlations

Dependent Variable	Hierarchical regression analyses						Spearman's whole set partial correlations	
	b	*SE b*	*ß*	*p for ß*	CIs (95%) for *b*			
					LL	*UL*	r_s	*p*
SDT	0.07	0.02	**.30**	**.000**	0.03	0.11	**.25**	**.003**
SDTSD	0.04	0.02	**.19**	**.029**	0.00	0.07	.14	.091
SMT	0.04	0.02	**.21**	**.016**	0.01	0.07	**.18**	**.035**
CDT	0.08	0.03	**.23**	**.010**	0.02	0.15	**.20**	**.017**
RAN digits	4.68	1.12	**.34**	**<.001**	2.47	6.89	**.23**	**.007**
RAN letters	4.25	1.22	**.29**	**.001**	1.84	6.67	**.27**	**.002**
RAN colours	3.85	1.43	**.23**	**.008**	1.03	6.68	**.21**	**.012**
RAN objects	6.09	1.56	**.32**	**< .001**	3.01	9.18	**.27**	**.002**

Sight words	– 10.12	3.80	**– .22**	**.009**	– 17.63	– 2.60	**– .24**	**.005**
SDMT	– 6.56	2.68	**– .20**	**.016**	– 11.87	– 1.26	**– .31**	**001**
Corsi Block forward	Significantly predicted by short IT1 group						**– .22**	**.010**
Corsi Block backward	No significant group prediction						**– .19**	**.026**

Note. Statistically significant values are in bold. Long inspection time group (n = 16) > 75.83 ms; Step 1 = age in months, gender & WRIT matrices; Step 2 = long and short inspection time groups compared to medium inspection time group; Spearman partial correlations control for age and WRIT matrices; CDT = choice decision time; CI = confidence interval for b in Model 2, LL = lower limit, UL = upper limit; RAN = rapid automatic naming from Comprehensive Test of Phonological Processing-2 (Wagner, Torgeson, Rashotte & Pearson, 2013); Corsi = Corsi Block Task (Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000; The Psychological Investigation Building Language, PEBL; Mueller, 2010); Detailed Assessment of Handwriting 17+ (DASH; Barnett, Henderson, Scheib & Schulz, 2010); SDT = simple decision time; Symbol Digit Modalities Test (Smith, 1982); SMT = simple motor time; Test of Memory & Learning-2 (Reynolds & Voress, 2007); Test of Word Reading Efficiency-2 (Torgeson, Wagner & Rashotte, 2012); Symbol Digit Modalities Test (SDMT; Smith, 1982); Visual Discomfort Scale (Conlon, Lovegrove, Chekaluk & Pattison, 1999); WRIT = Wide Range Intelligence Test (Glutting, Adams & Sheslow, 2000).* p = two-tailed.

Spearman's partial correlation analyses between standard inspection time (IT1) and a range of variables controlled for age and WRIT matrices were made for the whole 141-participant set (Table I2). It can be seen that again standard inspection time (IT1) predicted the same variables as did the long standard inspection time (IT1) group, except for SDT standard deviation.

Discussion: Inspection Time Group Profiles

An examination was made of cognitive and attainment profiles of a group comprised of 16 participants who had the longest inspection times out of 141 participants, irrespective of SpLD. Participants with dyslexia/DCD formed 22% of the long inspection time group, whereas none of the short, strong inspection time group had dyslexia/DCD. Analyses showed that after control for age, gender and intelligence, participants' very long inspection times were reflected by performances for a number of variables. The predicted variables were all from speeded tests and the effect sizes were small, except for RAN digits and objects in which the effect sizes were medium. Memory tasks did not predict exceptionally long inspection time.