An Accessible and Multi-Sensory Web-Based Approach to Dyslexia Screening

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Abstract

Encouraging the use of multiple senses to teach dyslexic children has become common practice in schools and computer-based tests that follow a multi-sensory approach to dyslexia screening have emerged over the past decade.

At the present time, there are no statistically valid computer-based tests designed to provide a tentative conclusion on whether a participant may have dyslexia or not without the participant undertaking a full battery of tests. In addition, no computer-based tests have yet been designed specifically for deployment on the World Wide Web. Therefore, this excludes a large base of people who believe that they might have dyslexia but do not know where to turn, or those who would wish for an indication of whether they may have dyslexia or not before undergoing timely and costly professional assessment procedures.

A multi-sensory web-based test was designed with permission from the British Dyslexia Association, based on their paper-based 'Adult Dyslexia Checklist' designed by Dr. Michael Vinegrad in 1994. This was achieved with ongoing user involvement from both dyslexic and non-dyslexic groups. Emphasis was not only placed on statistical validity, but also ensuring that the test is usable, practical to access, even by those with slower Internet connections and accessible to those with multiple disabilities.

The web-based and paper-based tests were administered to both dyslexic and non-dyslexic individuals. Sufficient statistical evidence was found to suggest that the web-based test is as effective as the paper-based test at discriminating between dyslexic and non-dyslexic groups. The web-based test provided a significant improvement in ease-of understanding over the paper-based test and the multi-sensory approach provided by pictures and sound was found to be 'very useful' in helping participants to understand the meanings of the test questions presented to them. The web-based test was found to be easy-to-use and accessible to all, in line with the W3 consortium's accessibility guidelines.

Acknowledgements

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1. Introduction

1.1 Definition of Dyslexia

There are a large number of definitions of dyslexia, hence information regarding the constituents of dyslexia varies greatly. [b4] The terminological confusions remain attributable to the complexities of the issues, the involvement of different professions and *"some have the clarity of oxtail soup."* [b5]

Singleton [b6] asserts that the neurological bases of dyslexia are well established and reflected in current definitions of the condition, such as from the Orton Dyslexia Society (1994) and the British Dyslexia Association (1995): *"Dyslexia is a complex neurological condition which is constitutional in origin. The symptoms may affect many areas of learning and function, and may be described as a specific difficulty in reading, spelling and written language."*

Keates found a consensus that the reading and spelling ability of the Dyslexic student is not commensurate with his or her intelligence. [b4] Heaton & Winterton investigated further and found that *"the Dyslexic child often shows a 'spiky' profile on general intelligence tests. Poor performances in mental arithmetic, visual/motor coding, general knowledge and short-term auditory memory tasks contrast with high scores in other areas."* [b3] Furthermore, Singleton states that dyslexia neither implies poor educational potential, nor is dependent on social background. [b6]

Often people with dyslexia do not have the same cluster of symptoms and this can make diagnosis difficult. [b5] Ott supports this argument by quoting Naidoo's (1979) findings, which showed he *"did not find a single, common pattern which typifies all these children."* This had led to the classification of dyslexia as a syndrome: associated characteristics that vary in degree from person to person. These characteristics encompass not only distinctive clusters of problems but also distinctive talents. [b6] For example, some Dyslexics are considered to be 'spatially talented' [a2]. However, Georgiou has not found a satisfactory explanation as to why what is principally regarded as a 'deficit' in the brain should give rise to positive effects.

Whilst some educationalists take issue with the use of medical terminology to describe dyslexia symptoms, Ott describes the following terms as useful characteristics of dyslexia: [b5]

- Congenial – People are born with it.
- Genetic – Inherited and runs in families. Affects more males than females. Singleton (2000) quotes a male: female ratio of between 3:1 and 5:1 cites evidence that *"in at least two-thirds of cases, dyslexia has a genetic cause."*
- Constitutional – There is a neurological basis.
- Problems with phonological awareness – difficulties with letter sounds when reading and writing.
- Problems with language – such as verbal naming or word retrieval or pronunciation.
- Problems with short-term memory – which particularly affect auditory sequential memory (such as the repetition of digits) or visual sequential memory (such as used in coding skills).

Figure 1.11: Characteristics of dysleixa. *Adapted from How To Detect and Manage Dyslexia: A Reference and Resource Manual, Ott, P. 1997, pp. 14-17.*

Georgiou attributes a 'disorientated subject' as the cause of many of the above problems: *"When that disorientation manifests in the conceptual (topological) landscape, in terms of problems in finding one's way around symbols, we call it dyslexia."* [a2]

This conceptual disorientation appears on the surface as a *"difficulty in the use of words, how they are identified, what they signify, how they are handled in combination, how they are pronounced and how they are spelt."* [a5]

The problems of 'spatial and directional confusion' which have traditionally been thought of to be root causes of dyslexic difficulties should be concluded *"merely as one facet of an underlying disorder of language*." [b3] Vellutino also concluded that *"spatial and directional confusion is not a significant cause of reading disability"* and went on to question *"the very essence of this disorder as has been discussed in the literature."* [b7]

This diagram claims that the factors in column II, which have all at one time or another been thought of as causal, are not causes but 'side-effects' or 'consequences' of the primary cause. [b3]

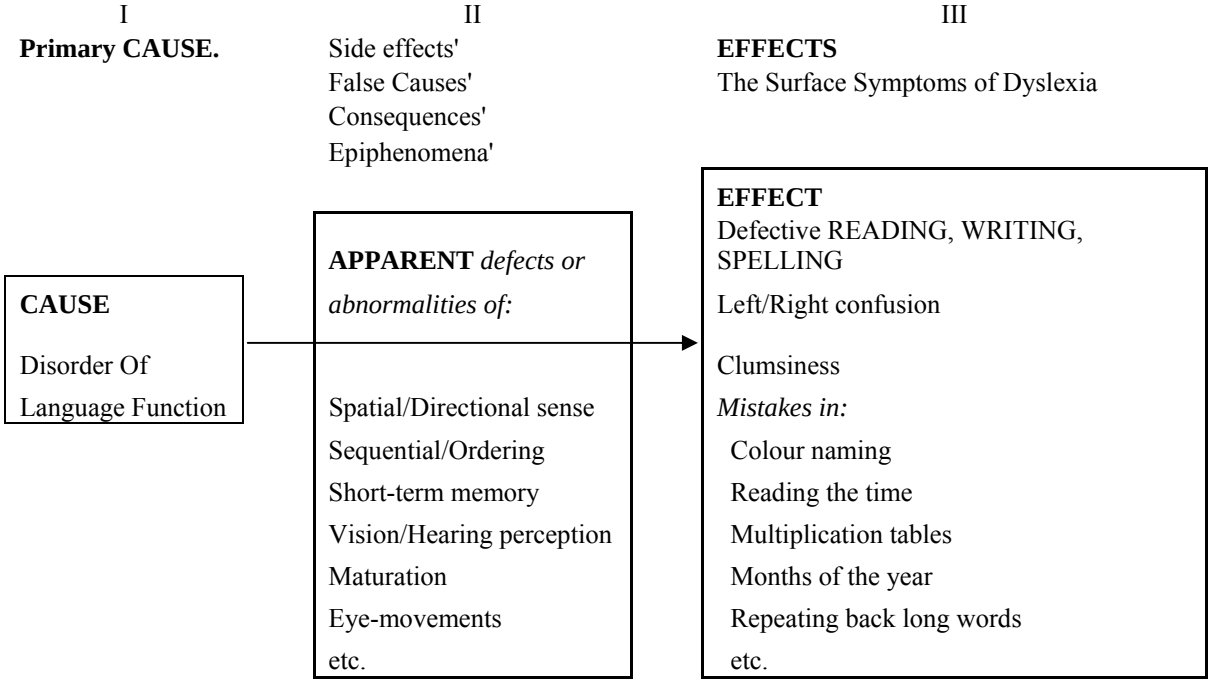

Figure 1.11: Showing that an underlying disorder of *language function* accounts for all the signs and symptoms of dysleixa. The operation of this cause sets up a number of consequential effects which may be mistakenly thought of as causal. *Adapted from Heaton, P. & Winterton, P., Dealing With Dyslexia 2nd Ed., 1996 pp.33.*

Heaton & Winterton further note that the 'false causes' are various different ways of misinterpreting the primary linguistic cause. [b3] However statistical evidence supporting this is difficult to find, since although some recognise the neurological basis of dyslexia [b6], others feel that it is *"not conclusive that the function or structure of the dyslexic's brain is different from the brain of the normal reader."* [w5]

Despite the existence or non-existence of a primary cause, dyslexia is legally recognised as a 'disability.' It is not a 'disease' nor can it be 'cured' [b6] *"but there is evidence that early recognition and intervention can help solve many of the Dyslexic's practical, emotional and intellectual problems."* [b3]

1.2 Dyslexia in Adult Learners

The International Dyslexia Association Website lists the following characteristics of Adult Dyslexics [w2]:

- May hide their reading problems; many subterfuges
- May spell poorly; relies on others
- Avoids writing; may not be able to write
- Often very competent in oral language
- Relies on memory; may have excellent memories
- Often has good 'people' skills
- Often is spatially talented; engineers, architects, designers, artists and craftspeople, mathematicians, physicists, physicians (esp. orthopaeds, surgeons), dentists
- May be very good at 'reading' people (intuitive)
- In jobs is often working well below their intellectual capacity
- May have difficulty with planning and organisation
- May have difficulty with time; often too early, late or forgets appointments. Relies on digital watches; cannot tell time
- Often entrepreneurs; may have lost one or more businesses they started

Figure 1.21: Characteristics of adult dyslexics. *Adapted from International Dyslexia Association:* http://www.interdys.org/servlet/compose?section_id=5&page_id=44 [Accessed 09/12/02]

Georgiou [a2] has witnessed first-hand many of the above characteristics in Dyslexic students and notes that often students are ashamed of 'awful concentration' or 'non-existent motivation.' However, she notes that strong motivation and sharp concentration are the outcomes of effective process not the starting point.

Ott [b5] also identifies this 'ashamedness' and asserts that many adults expend enormous energies hiding their disabilities, either for fear of ridicule or discrimination. She quotes West (1991) who opined that *"there are no rewards for revelation, and the penalties can take the most humiliating forms."* This has led to an educational need for an 'inclusive' policy for Dyslexic students, instead of labelling them as 'less able.' Tomlinson's influential Inclusive Learning Report (1996) was a fundamental driver for such an inclusive policy. Tomlinson does not distinguish between disabled and non-disabled students in the process of matching the lecturer's needs and aspirations to the learning environment. [a1] *"By the time they reach adulthood, most Dyslexics have learned to avoid situations which might expose their difficulties to others. They devise means of compensating for their difficulties."* [b6]

Compensation strategies vary by individual but factors such as persistence, self-confidence, the will to conquer adversity, and strong character have been cited as contributing to the success of individuals with disabilities (Maker, 1978). This has been synthesised by authors into one overriding factor – the desire and effort to gain control of one's life. [w4]

In a comprehensive study of learning specialists' logs that recorded the activities of sessions with university students with learning disabilities, McGuire, Hall and Litt (1991) found specific areas that were commonly addressed, included specific types of note-taking strategies, time management, test-taking preparation, and library skills. [w4] Interviews with some of the students that helped participate in the research for this dissertation uncovered varied and innovative compensation strategies. Examples included concentrating fully on lecturers and photocopying others' notes (also noted in [w4],) comparing and discussing notes with peers to fill in any omissions and even predominantly using diagrams/brainstorming instead of continuous prose when note-taking. One student even simplified essay planning by identifying a key theme for each paragraph, writing it on a post-it-note and re-arranging the notes on her bedroom wall to form an essay structure.

A series of focus groups found that most Dyslexic students had a history of educational failure, which they instinctively interpreted as a personal failure. Recognition of dyslexia offered them

personal legitimation through conversation about shared experiences. [a1] However a recurring pattern was a belief in their own ability, which had developed during their adult life and which, in turn, led to the discovery of their dyslexia.

Once diagnosed, adult Dyslexics still face an uphill battle to maintain pace in an academic environment, as supported by Keates. [b4] She has found that the processing of sound in lessons and note-taking to be huge problems for most Dyslexic students, causing problems for speed of writing which results in the student omitting words or writing in a way that is not very legible. [b4] This can leave the student unable to follow lessons or read what they have been writing. This leaves many Dyslexic students unable to read tasks or dates for handing in work and unable to use notes for revision purposes. Technology can help students to create practical strategies for overcoming problems such as these.

1.3 Benefits of Assistive Technologies to Adult Learners

Different profiles of dyslexia may be benefited by different types of assistive technology. Therefore it is wrong to generalise as to which equipment is most beneficial for Dyslexic students. However, Mind-mapping software helps many Dyslexic students understand the concept and structure of organising principles and therefore to structure written work. Voice-activated software provides an alternative input method than the keyboard for students with exceptional spelling problems. Also, screen-readers and advanced spellcheckers enable students to hear what they have written. This multi-modal combination of speech and highlighted words encourages affirmation of a particular sound, spelling or pronunciation and helps poor readers in general by reading aloud.

Fidler, R. [w1] noticed that *"most of the literature tends to be based on general support strategies for Dyslexics"* and *"does not look in detail at how Dyslexic students use particular equipment, or how important they consider particular equipment to be."* However, Hargreaves & Annan highlight some of the benefits of screen-readers in a case study based on a Thames Valley University student, who found her post-graduate research easier than her degree by scanning in textbook chapters and listening to them read aloud. [b2]

In a quantitative study of the benefits of assistive technology at Roehampton University, Fidler found that 35.8% of Dyslexic students consider TextHelp screen-reader software to be 'essential.' The breakdown of the differing usage of the software is shown below. The most used function was for proof-reading purposes, which was chosen by 60.4% of respondents. A minority of students (13.2%) did not make much use of it at all. [w1]

Stated use of software (Some students indicated that they used the software for more than one purpose)	Number of students indicating using the software for a particular use	Percentage of use based on type of use as a % of the total number of students with access to the software
Proof-reading	32	60.4
Spelling	16	30.2
Punctuation	1	1.9
Reading texts	8	15.1
Grammar checker	4	7.5
Thesaurus	1	1.9
Sentence structure	3	5.7
Dictionary	1	1.9
General positive comment	1	1.9
Other usage	3	5.7
Don't use much	7	13.2

Figure 1.31: Breakdown Of The Differing Use Of The TextHelp Screen-reader Software By Surveyed Students. *Adapted from Fidler, R., An Evaluation Of The Use Of Specialist Support Services By Dyslexic Students At a Higher Education Institution.*

Fidler also highlights the fact that there is significant debate as to the merits of voice-activated software. Only 20 out of 81 respondents were recommended voice activated software in their Needs Assessment and only 20% found the software essential, 25% good, 30% adequate, 10% not very good and 15% did not use the software at all. [w1]

Whilst there is little research on the benefits of other types of assistive technology, Hargreaves & Annan argue that assistive technology is only beneficial if targeting the Dyslexic student's tailored needs. Therefore *"it is fundamental to the effective use of IT in this role that a Needs Assessment takes place, performed by a trained and experienced practitioner so that a close match is obtained between the needs of the student and the technology."* [b2]

1.4 Chapter References

Chapter 1: Books Cited

Book Nº	Author	Title	Publisher	Date	Page
[b1]	Chivers, M.	Practical Strategies For Living With Dyslexia	Jessica Kingsley	2001	pp. 26-29
[b2]	Hargreaves, S. & Annan, A.	Disconnected for Connected Learning: The Fate Of The Dyslexic Student	UCISA Conference Paper	2002	pp. 4, 12
[b3]	Heaton, P. & Winterton, P.	Dealing With Dyslexia 2nd Ed	Bath : Better Books	1996	pp. 32-33
[b4]	Keates, A.	Dyslexia and ICT: A Guide For Teachers and Parents	David Fulton	2000	pp. 1, 3
[b5]	Ott, P.	How To Detect and Manage Dyslexia: A Reference and Resource Manual	Heinemann Educational	1997	pp. 14-17
[b6]	Singleton, C	'Computer Support For Adult Dyslexics' published in Crisfield, J. The Dyslexia Handbook	British Dyslexia Association	1992	pp. 56-
[b7]	Vellutino, F.R.	Dyslexia: Theory and Research	MIT Press	1979	pp. 40-41

Chapter 1: Articles Cited

Article Nº	Author	Title	Publication	Date	Page
[a1]	Dale, M. & Taylor, B.	How Adult Learners Make Sense Of Their Dyslexia	Disability & Society, Vol. 16, No. 7	2001	pp. 997-1008
[a2]	Georgiou, P	Learning Difficulties – An Introduction (Unpublished research paper)	Unpublished	2002	pp. 1-2

Chapter 1: Websites Cited

Site Nº	Site URL	Date Visited	Comment
[w1]	http://www.roehampton.ac.uk/dyslexia/skilljournalarticle.doc	17/11/02	Fidler, R., An Evaluation Of The Use Of Specialist Support Services By Dyslexic Students At a Higher Education Institution., 2002
[w2]	http://www.interdys.org/servlet/compose?section_id=5&page_id=44	20/10/02	International Dyslexia Association Website, Common Signs Of Dyslexia: Adults.
[w3]	http://www.devdis.com/guestart-jun.html	17/10/02	Singleton, C, IPS Guest Article: Understanding Dyslexia, June 2000.
[w4]	http://www.ditd.org/floater.php?location=265	19/01/03	Compensation Strategies Used by High-Ability Students With Learning Disabilities
[w5]	http://www.audiblox2000.com/dyslexia_dyslexic/dyslexia013.htm	27/04/03	Is Dyslexia a Brain Dysfunction? An Alternative Interpretation of the Facts

2. Dyslexia Screening Methods

2.1 Dyslexia Screening Methods in Higher Education

Whilst the benefits of assistive technology are clear for developing compensatory strategies for dyslexia, the benefits of computer-based screening are only recently being realised and use of traditional paper-based screening test is still common.

In a national survey of Higher Education Institutions, 70% of the 93 respondents reported some form of screening or preliminary assessment before referral for a full psychological/diagnostic assessment. Traditional, non-specialist screening methods such as interviews are used by 94% of the HEIs. [b1] Standardised and informal assessment of literacy skills is used by 40% and 58% of responding HEIs respectively. Cognitive and intellectual measures were used less frequently (by 24% of respondents), *"perhaps because such tests are restricted to use by psychologists."* [b1]

The Bangor Dyslexia test [b2] is a screening test designed for use with individuals 7-18 years old and is administered by 56% of HEIs. It comprises of 10 subtests, including repeating polysyllabic words, saying the months of the year forwards and backwards and reciting multiplication tables. However, it is not fully standardised and not particularly discriminating when used with adults. [b1]

The British Dyslexia Association's 'Adult Dyslexia Checklist' (also known as the 1994 Vinegrad Checklist), is the most common screening method in Higher Education, administered by 72% of HEIs. It asks 20 simple 'yes' or 'no' questions such as "Do you find it difficult to say the months of the year backwards?" and "Was it difficult to learn your multiplication tables when you were at school?" *(See appendix 1 for a copy).*

Vinegrad tested the validity of his checklist and found that dyslexic group of adults had a mean number of 'yes' responses of 12.7 compared to a general group average of 4.4. He concluded that 8 or more 'yes' responses is an 'extreme' score and a statistically valid potential indicator of dyslexia. Vinegrad also noted that 12 questions *"are especially good indicators of dyslexia*" and that *"a high*

score on these items may be of greater significance than a high score on the questionnaire as a whole." [a1]

Other dyslexia checklists *"all have similar questions which relate to the individual's self perceptions of difficulties in activities such as reading, spelling, writing and remembering."* [b1] However although many may improve on the ambiguity of some of Vinegrad's questions (for example Ian Smythe's 'Checklist for the Identification of Dyslexia in Adults.' [w2]), none are backed by statistics to support their validity.

2.2 Developments in Computer-Based Screening

Several self-administered computer programs have emerged from newly-established software-houses. McLean's 'The Dyslexia Test,' 'Instines' and 'LADS' are all examples of a battery of tests designed to test for similar traits as measured by the paper-based methods above.

All of the computer-based tests above test word recognition, word construction and working memory. For example LADS employs lexical decoding, involving the speeded recognition of real words from non-words to test word recognition, speeded encoding of non-words from syllables to test word construction and a backwards digit span to test working memory. LADS goes further than the other tests by using non-verbal matrix reasoning to detect those profiles of highly-intelligent individuals who have used compensatory strategies to mask their dyslexia. [b3] LADS is the only computer-based test supported by a detailed validation study *(see appendix 3).*

'QuickScan' is a questionnaire-based system that identifies students' preferred learning modalities and recommends how to optimise study skills and whether they may have dyslexia. Those in a dyslexia 'at risk' category are invited to complete 'StudyScan,' a comprehensive battery of cognitive and educational tests designed for students in Higher Education.

Developers of QuickScan claim that *"results have been compared to the findings of Educational Psychologists using traditional methods and the match has been found to be around 95%,"* [w1] However there is no explanation of the methodology used nor any firm statistical evidence to support this claim. For example, a correlation co-efficient of 0.9 is claimed to be an indicator that the results of QuickScan are *"reliable,"* even though there is no mention in the research paper of the data series being correlated. This suggests only face validity.

2.3 Chapter References

Chapter 2: Books Cited

Book Nº	Author	Title	Publisher	Date	Page
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[b2]	Miles, T.R.	Bangor Dyslexia Test	Bangor University Press	1993	N/A
[b3]	Singleton, C.	LADS Abridged Manual	Lucid	2000	pp.1

Chapter 2: Articles Cited

Article Nº	Author	Title	Publication	Date	Page
[a1]	Vinegrad, M.	A revised Dyslexia Checklist	Educare No. 48	March 1994	pp. 21-23

Chapter 2: Websites Cited

Site Nº	Site URL	Date Visited	Comment
[w1]	http://www.zyworld.com/studyscan/Page1.htm	31/02/03	QuickScan and StudyScan: Research Background
[w2]	http://web.ukonline.co.uk/wdnf/adultcheck.pdf	31/02/03	Ian Smythe's 'Checklist for the Identification of Dyslexia in Adults'

3. Legal Implications for Web Accessibility

3.1 Accessibility and Dyslexia

Providing accessibility means *"removing barriers that prevent people with disabilities from participating in substantial life activities, including the use of services, products and information."* [b2] Although in the UK there is no specific legal requirement for computer-based screening software to be accessible, the developer of QuickScan in interview asserted that *"we want users to be able to use our software even when blindfolded and with mittens on."* Whilst the UK undergraduate population with multiple disabilities is only around 500 compared to a dyslexic population of around 5500, [w1] this does not mean that interfaces designed to test for signs of dyslexia should ignore non-dyslexia-specific accessibility issues.

For example, Irlen Syndrome is also often diagnosed in many Dyslexics. Overlapping images being sent to the brain makes the brain expend more energy in interpreting the images than normal, causing headaches, eyestrain and/or fatigue. Bright lights, fluorescent lights, or glossy paper will often make the problems worse, as the increased contrast will increase the problem of persistent images. [a1] However, just as custom coloured overlays seem to work by filtering out light that causes distortions to print, tailored adjustment of computer display settings (especially colours) improves readability by changing application text and background to colours that will not aggravate the Irlen Syndrome sufferer. [b1]

3.2 UK Legislation

The Disability Discrimination Act 1995 outlawed discrimination against disabled people in employment, the provision of goods and services, and the selling and letting of property. [w2] However education (and therefore dyslexia screening within education) was originally exempted.

The Special Needs and Disability Act 2001 placed new duties on educational establishments, including HEIs. The most prominent are *"a duty not to treat disabled students less favourably, without justification, for a reason which relates to their disability; and a duty to make reasonable adjustments to ensure that people who are disabled are not put at a substantial disadvantage compared to people who are not disabled in accessing further, higher and LEA secured education."* [w3]

One such 'adjustment' might include the mandatory screening of students for common disabilities, including dyslexia, to ensure no disadvantage occurs. This suggests the need for a screening test that is quick to administer, inexpensive to the institution and easy to administer. However argument exists as to whether failure to diagnose dyslexia is treating an individual 'less favourably...for a reason which relates to their disability.' The issue of treatment 'without justification' with regards to screening has never been tried in the courts.

Further confusion lies when the education provider's responsibilities; Whilst screening software is likely to fall under the category of institutional and educational services, and therefore is encompassed by the act, institutions *"will not be expected to duplicate services that are funded or provided from another source."* [w2] Therefore, there is the potential for outsourced screening software (such as packages mentioned in 2.2) to be considered exempt from the act, whilst any screening designed internally might be covered by the act. This supports a common sense approach when designing computer-based screening: ensuring that interfaces that will be used by the disabled are inclusive to those with all types and profiles of disability. Whilst the 2001 act does not

enforce any specific guidelines, the World Wide Web Consortium's (W3C) guidelines [w4] are *"generally recognised as a good reference point."* [w5]

3.3 Worldwide Legislation

The Americans with Disability Act is similar to UK legislation. In addition Section 508 of the Rehabilitation Act (1998) goes further than UK law by specifying requirements that should be adhered to when designing online education-based sites. An interpretation of these requirements is found at [w6]. These requirements map to corresponding W3C guidelines. For example Section 508 Standard §1194.22 requires *"a text equivalent for every non-text element"* to be provided. [w6] This is identical in wording and in essence to W3C guideline 1.1. [w5]

The need to adhere to such requirements amongst HEIs in the US has been addressed. MIT, for example, requires that *"all web pages associated with the administration and services, courses of instruction, departmental programs and institute sponsored activities must conform to the web accessibility principles."* [a2]

Different developed countries have different laws governing the accessibility of electronic and information technology. Canada, for example, currently has no such laws. Section 5 of the Canadian Human Rights Act 1985 does protect citizens against *"any discriminatory practice in the provision of goods, service, facilities..."* However, similarly to the US, guidelines have been established by the Treasury Board Secretariat and the Public Service Commission of Canada (two federal government departments). These guidelines based on the W3C guidelines were approved in May 2000. [a3]

Similarly to Canada, the European Commission's 2001 document recommends (but does not demand) *"adoption of the Web Accessibility Initiative guidelines"* [w9] to ensure that *"public sector websites and their content in the Member States and in the European institutions must be designed to be accessible to ensure that citizens with disabilities can access information."* [w9]

3.4 Tools for Ensuring Web Accessibility

Bobby is a free application developed by the Centre for Applied Special Technology (CAST) [w7] that analyses web pages based on the W3C guidelines in [w5]. Problems are characterised into priorities. Priority 1 accessibility problems *"seriously affect a page's usability by people with disabilities,"* for example those using customised display settings or screen-reader software to read-out content that is present on-screen. Priority 2 problems *"are not as vital as Priority 1"* but *"are those you should try to fix."* Priority 3 problems *"are third-tier access problems which you should also consider."* [w7] Bobby also checks separately for Section 508 accessibility problems, noting that a few guidelines are unique to Section 508 and although most relate to the W3C guidelines, guidelines with different levels of priority as judged by the W3C receive equal priority in Section 508. [w7]

Other software packages also exist to evaluate conformance to the W3C guidelines and fix any usability problems found. A-Prompt [w8] for example, displays the accessibility objectives that need addressing and asks a series of questions to ensure a quality 'fix' to the HTML code of the website. Similar functionality is offered by Watchfire, Bobby's sister product.

In Canada, only 14.9% of post-secondary institutions in met priority 1 checks as established by the W3C guidelines. Only 1.7% were free of both priority 1 and 2 errors. [a3] Similar results were found in US studies, as cited in [a2]: A study within the University of Wisconsin-Madison revealed

that only 38% of the 101 departmental homepages evaluated were free of accessibility problems. They also discovered that 83% of the errors were easy to correct. Even a study by the National Center for Disability Research on the websites of 213 programs it funded found that only 43% of the homepages were accessible. [a2]

Given that web-accessibility guidelines are similar in nature, nigh often identical in wording, it is of greater importance to adopt a set of recognised professional guidelines than to mull over which to adopt. Although a toolbox approach may be tempting, where guidelines are chosen from different sources, W3 or Section 508 approval can only be achieved if one set of guidelines is used. In addition, further manual checks should be performed regardless of the software tool chosen. For example Bobby suggests several manual checks that should be performed regardless to ensure Bobby approval.

3.5 Chapter References

Chapter 3: Books Cited

Book Nº	Author	Title	Publisher	Date	Page
[b1]	Chivers, M.	Practical Strategies For Living With Dyslexia	Jessica Kingsley	2001	pp. 26-29
[b2]	Bergman, E, & Johnson, E.	Towards Accessible Human-Computer Interaction	Ablex	1995	pp. 87-89

Chapter 3: Articles Cited

Article Nº	Author	Title	Publication	Date	Page
[a1]	Georgiou, P	Learning Difficulties – An Introduction (Unpublished research paper)	Unpublished	2002	pp. 13-14
[a2]	Schmetzke, A.	Online Distance Education - "Anytime, Anywhere" But Not For Everyone	*Information Technology and Disabilities* Vol. VII No. 2	April 2001	pp. 1-8
[a3]	Zaparyniuk, N., Montgomerie, C.T.	The Status of Web Accessibility of Canadian Universities and Colleges	*World Conference on Educational Multimedia, Hypermedia and Telecommunications* Vol. 2002, Issue. 1, 2002.	2002	pp. 2139-2143

Chapter 3: Websites Cited

Site Nº	Site URL	Date Visited	Comment
[w1]	http://www.ukc.ac.uk/cdo/web/presentations/access-01-03/accessibility.ppt	13/03/03	University of Kent and Canterbury IT Training Programme 2002/3: Making your Web Material Accessible to all
[w2]	http://www.jisc.ac.uk/pub/index.html#briefing	30/12/02	JISC Senior Management Briefing Paper 15, Disability, Technology and Legislation, September 2001
[w3]	http://www.legislation.hmso.gov.uk/acts/en/2001en10.htm	12/03/03	The Special Educational Needs and Disability Act 2001
[w4]	http://www.w3.org/TR/WCAG10/	03/10/02	World Wide Web Consortium (W3C) Web Content Accessibility Guidelines 1.0
[w5]	http://www.ex.ac.uk/its/access/webaccess/	30/03/03	University of Exeter: Accessible I.T. (Computing for Special Needs)
[w6]	http://www.webaim.org/standards/508/508checklist.pdf	23/03/03	Section 508 Web Accessibility Checklist
[w7]	http://bobby.watchfire.com/	23/03/03	CAST: Bobby Website
[w8]	http://aprompt.snow.utoronto.ca/	23/03/03	A-Prompt Web Accessibility Verified Website
[w9]	http://europa.eu.int/information_society/topics/citizens/accessibility/web/wai_2002/ces_opinion_web_wai_2002/index_en.htm	27/04/03	European Commission: Web Accessibility Guidelines

4. Designing an Accessible and Multi-Sensory Web-Based Dyslexia Screening Site

4.1 Need for a Multi-Sensory Approach

Multi-sensory and multimedia are complimentary terms, although not synonymous. Multi-sensory websites *"involve several bodily senses,"* [w2] often through the use of multimedia: the *"combined use of several media...such as text, graphics, full-motion video and sound."* [w3] Whilst it is possible to present information in a multimedia fashion without being multi-sensory (e.g. a presentation of text, graphics and video, but no sound) the reverse is not possible, since multimedia technology is required to facilitate multi-sensory computer-based presentation of information.

Although there is no research on the benefits of a multi-sensory approach for computer-based dyslexia screening, authors have found an educational foundation to suggest it improves learning amongst individuals with dyslexia. Cooke found that *"it is difficult to separate the interaction of sight and hearing: what may seem to be a simple visual task may have underlying resonances of sound, while an auditory task may be helped by pictorial images. For instance, a child who cannot recall the sound for the letter p may get to it by remembering the picture of a pipe."* [b2]

The notion of multi-sensory teaching was explored long before the advent of 'multimedia' enablers. Ott quotes Hickley (1977) that *"the value of multi-sensory learning is that it enables the individuals to use their own approach to the tasks through utilising their strong areas and at the same time exercising their faulty ones."* [b3] This has also been noted by other authors including Cooke [b2] who asserts that *"each channel supports the others."* These views are supported by the principles underlying the multi-sensory method, which shows *"the memory may be over-impressed with*

information that is stored." [b4] In Figure 4.1, the auditory channel fails to connect, suggesting that the "*chills may read and be able to form his letters, but find it hard to repeat accurately and/or spell."* [b4] In fact "*significantly different situations arise when any one of the four sensory channels fails to connect with the others."* [b4]

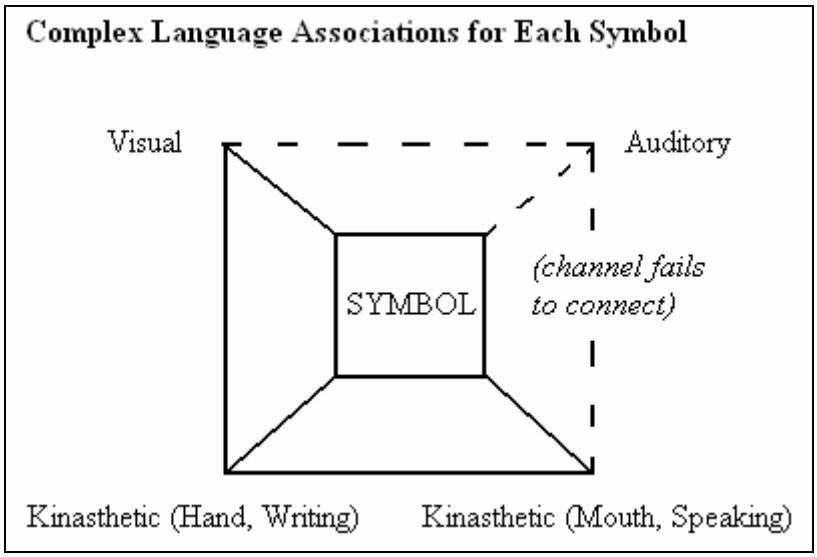


Figure 4.1: The principles underlying the multi-sensory method of teaching and learning. *Adapted from Heaton, P. & Winterton, P.: Dealing With Dyslexia 2nd Ed [b4]. This diagram was originally printed in Wolf, A.G., 'Assessment and Teaching of Dyslexic Children, London: ICAA (1973).*

This gives rise to the possibility that a multi-sensory approach to a web-based screening test might provide clarity for some of the ambiguity of paper-based screening checklists explored in section 2.1. Although not directly related to learning, an assumption can be made that the better an individual with dyslexia understands the written questions asked in a screening checklist, the more truthful his or her answers will be and therefore the more accurate any tentative conclusions can be from such a test. It might be argued that an individual with dyslexia that does not take on board the meanings of paper-based questions is likely to be highlighted by the screening process. For example, Vinegrad claims that *"watching individuals fill out [his] questionnaire is in itself a powerful indicator of dyslexia."* [a1] However, watching individuals may not be practical in mass-screenings and as more UK HEIs employ an anticipatory approach to comply with the Special Needs In Education Act 2001, more mass-screenings are likely to ensure that the HEI is not treating students "*less favourably, without justification."* [w4]

4.2 Choice of Screening Methodology

4.21 Ensuring Ethical Screening

The University of Hertfordshire 'Application for Ethics Approval for Research' [w12] states the possibility of "*emotional harm"* caused to human research subjects. In order to minimise this possibility, the British Psychological Society's 'Guidelines for the Development and use of Computer-Based assessments,' [b7] were followed when designing and administering the web-based screening test, alongside the university's ethics guidelines.

4.22 Selecting a Valid Screening Method to Adapt

Selecting an existing valid screening method to adapt to a multi-sensory web-platform proved to be more cut-and-dry than expected. The board of Lucid software, developers of LADS, gave permission for the development of a prototype development of their computer-based screening test. However this was deemed beyond the scope of this degree, since it would require specialist programming knowledge.

Additionally, Ian Smythe's 'Checklist for the Identification of Dyslexia in Adults' *(see appendix 2)* appeared to remove some of the ambiguity found in the Vinegrad checklist. It avoids a dichotomous approach by allowing participants to respond by selecting the degree in which they agree to a particular question. However the deletion and adaptation of questions, along with altered weighting, is likely to affect the way that the possibility of dyslexia is calculated. Therefore this test could not be adapted, since research has not yet been published to suggest its statistical validity. Proving the statistical validity of an entire screening test is beyond the scope of this dissertation.

It was therefore decided to adapt the Vinegrad Checklist in appendix 1. Full permission was gained from the British Dyslexia Association. In order to ensure a multi-sensory approach, pictures accompanied each of the 20 questions and a 'read out' facility was provided, where the on-screen test was spoken aloud through the computer's speakers.

4.23 Selecting the Picture Elements of the Web-Based Test

A small group of 3 students that had been professionally assessed and found to have dyslexia were selected to choose the pictures that they felt would best facilitate better understanding of the wording of the proposed test questions. The group was restricted to choosing clipart pictures to maintain simplicity and aesthetic consistency. Keywords related to the required image types were suggested by the students and typed into the image search of Google, a popular web search engine that indexes thousands of clipart images. For example for a question addressing reading aloud, the first word suggested was 'reading' and produced several clipart images to choose from (see [w16] for an example). Upon discussion and consensus, available non-copyrighted images were saved for use in the computer-based test.

4.24 Adapting Questions from the Vinegrad Checklist

When adapting questions from the Vinegrad checklist, it was also important to ensure that they still functioned as potential indicators (or high-indicators) of dyslexia. Therefore a larger pilot group was formed of 12 university students that has been professionally assessed and diagnosed to have dyslexia and a further 12 students that did not have dyslexia (as far as could be determined by the Vinegrad checklist). The individuals were closely matched for age and gender and asked to complete selected questions from the Vinegrad checklist and selected questions that were proposed to be included in the web-based test. Although it may have also been possible to include non-students, it was decided that a stratified student sample would contain enough natural diversity to ensure reliable results when comparing dyslexic with non-dyslexic individuals.

The pilot groups were shown the proposed questions (see appendix 4) and the corresponding questions from the Vinegrad checklist (appendix 1) that they were adapted from. They were asked, without conferring, to compare the questionnaires and select the questions that they consider the text had been adapted in a way that is likely to change the meaning of the question or the outcome of the response (i.e. yes or no). Two questions differed slightly from those in appendix 4; the penultimate option for question 5 read 'the chosen plan would not help the weaker mice' and the

boundaries of question 7 were narrower (<4 mistakes, 4-6, 6-8, 9-11, >11 mistakes). Given the high level of agreement between the dyslexic and non-dyslexic groups, the results were combined in Figure 4.21.

Question Number (See Appendices 1 & 4)	Nº of Students believing that the meaning/ outcome would be affected	Cumulative % of total statements that the meaning/ outcome would be affected
1	24	19.5%
2	24	39.0%
5	24	58.5%
7	24	78.0%
4	20	94.3%
14	3	96.7%
12	2	98.4%
11	1	99.2%
3	1	100%
6	0	100%
8	0	100%
9	0	100%
10	0	100%
13	0	100%
15	0	100%
16	0	100%
17	0	100%
18	0	100%
19	0	100%
20	0	100%

Figure 4.21: Potential questions that are likely to change the meaning of the existing Vinegrad questions or change the outcome or response of the participant. ***See appendix 10 for workings out.***

Figure 4.21 shows almost unanimous agreement that questions 1, 2, 5 and 7 are most likely to change the meaning of the existing Vinegrad questions or change the outcome or response of the participants. These responses fell into the top 10% of the sample. The pilot group did not consider slightly altered wording to affect outcome or response.

For example, consider selecting one of the options of Question 3: 'Feel embarrassed, scared or unconfident because you dislike reading aloud, especially in front of others.' This was not deemed to be different to answering 'Yes' to the original Vinegrad question 'Do you dislike reading aloud?' Similarly questions 12 and 14 were only thought by 2 and 3 of the 24 students to potentially change the outcome or response of the participants, even though both questions now imply a calculation/recital to test the Vinegrad statements 'Do you find it more difficult to do sums in your head without using fingers or paper?' and 'Do you find it difficult to say the months of the year forwards in a fluent manner?'

Questions 1, 2, 4, 5 and 7 from both questionnaires were therefore administered to both pilot groups *(see figure 4.22).*

Question Number	Nº of students **both** tests suggest **have** the related dyslexic trait		Nº of students the Vinegrad test suggests **have** the related dyslexic trait but the responses to the adapted questions suggest they **do not**.		Nº of students the Vinegrad test suggests **do not** have the related dyslexic trait but the responses to the adapted questions suggest they **do**.	
	Dyslexic	Non-Dyslexic	Dyslexic	Non-Dyslexic	Dyslexic	Non-Dyslexic
1	9	2	0	4	3	0
2	4	0	1	1	3	0
4	9	0	0	0	0	0
5	5	3	0	0	7	9
7	6	1	0	0	6	11

Figure 4.22: Discrepancies in the results of the two tests for questions 1, 2, 5 and 7.

For questions 1, 2 and 4 the discrepancies do not highlight evidence that the meaning of the question or outcome may be altered. For question 4, the findings suggest that the cut-off-point of 50 seconds to read the story is effective in discriminating between dyslexic and non-dyslexic individuals. This confirms an initial study, where the non-dyslexic pilot group were timed to see how long it would take them to read the story. A mean time of 41.6 seconds was recorded. To ensure that only extreme responses were counted as dyslexia-type-responses, a 99.9% confidence interval was constructed, yielding a cut-off point of 51.0 seconds (i.e. >50 seconds).

However for questions 5 and 7, even the remaining non-dyslexic individuals who did not have these particular traits highlighted by the Vinegrad checklist, tested positive for the dyslexic trait when answering the adapted questions. This suggested that questions 5 and 7 were too harsh, catching both individuals with and without dyslexia.

The story in question 5 was chosen from a top-level primary school reading book, to ensure that intelligence did not play a significant part in the participant 'understanding the meaning' of what is read. It soon became apparent that the wording of the options confused all participants, leading to wrong answers being given. Research by the University of Ulster [w13] revealed that the eleven simple spelling mistakes in Question 7 were only spotted by 1 in 500 people. Even so, many of the mistakes can be identified as those common to dyslexia, as defined by Professor T. Miles and quoted by Ott. [b3] The problem was identified with the boundaries were included to make this a discriminatory test between individuals with and without dyslexia. It became clear that they were too narrow, resulting in many non-dyslexic individuals selecting an incorrect option.

To reverse this situation, the wording of the penultimate option in question 5 was altered to 'tying a bell to the cat's tail would not help the weaker mice to escape' (i.e. making the potential answer more explicit rather than the difference between answers more obvious) and the boundaries of question 7 were more broadened as shown in the final question in appendix 4. Upon re-testing the pilot group, responses to these questions fell within the boundaries of questions 1 and 2. Overall, the pilot test suggested that the web-based test upholds the statistical validity of the paper-based test, although any multi-sensory benefits are unclear at this stage.

4.25 Methodology for Administering the Final Web-Based Test

Following the pilot, it was possible to proceed with the chosen 20 questions. Both the Vinegrad checklist and adapted questions were administered to a group of 15 individuals who had been professionally assessed to have dyslexia and 15 individuals who had not been assessed. The sample size was selected under the advice of Dr. Chris Singleton, who carried out the LADS validation study in appendix 3. In interview, he noted that validity results were equally sound with a sample

of 15 dyslexic and 15 non-dyslexic individuals compared with larger sample sizes. These control groups were necessary to test for false negative and false positive results when comparing the tests. Only by knowing that the participant was professionally diagnosed with dyslexia can the outcomes of the test be benchmarked. Test-subjects were given a choice of whether they completed the paper or web-based test first, to reduce any potential bias imposed by completing one test before the other.

The sample was selected with a similar student:non-student ratio as used by Vinegrad in 1994 (80% students, 20% non-students). However, practicalities such as the need to ensure all participants were over the age of eighteen meant that all students assessed were in Higher Education. The selection of non-dyslexia-assessed individuals was not unfairly biased by selecting a disproportion of those who believed they may have dyslexia, or of people certain that they do not have dyslexia.

Participants were asked to complete both the Vinegrad and web-based test. They were asked to provide their age, whether they are a student and whether they have been professionally diagnosed to have dyslexia. They were also asked to comment on the site's ease of use and navigation, the ease of understanding of both tests and the use of pictures and sound in helping them better understand the meanings of the questions. Questions about the web-based test were administered electronically at the end of the test and could be used to gain further feedback if the site is deployed in future. The questions concerning the 'ease of understanding' of both tests were administered verbally. To ensure usability issues did not hamper feedback, help in filling out the feedback section of the site was offered to all participants.

Similarly to the paper-based test, *"a score of eight or more [dyslexia-type responses]"* was judged as "*an 'extreme' score and a potential indicator of dyslexia."* [a1] Therefore those individuals with a score of eight or more on the web-based test are told that they *might* have dyslexia. In addition Vinegrad claims that *"twelve items on [Vinegrad's original test] are especially good indicators of dyslexia"* and that *"a high score on these items may be of greater significance than a high score on the questionnaire as a whole."* [a1] Since the essence of the questions remains unaltered in the web-based test, the notion of 'high indicators of dyslexia' were also included in the web-based test by ensuring that the participant is also told that they *might* have dyslexia if six of the twelve high dyslexia indicators are present. In hindsight it may have been more suitable to weight each question in accordance with the 'Discriminant Function Analysis' performed by Vinegrad [a1], since this would reflect that even 'high indicators' have different levels of weighting when deciding whether the participant makes dyslexia-type responses.

In line with the British Psychological Society's (BPC) [b7] and university ethics guidelines [w12] individuals were told that they would be part of research into the validity and usability of a web-based dyslexia screening product. They were shown the equivalence between the Vinegrad and web-based assessments, although no discussion was entered into that may bias their opinion of either method. Although any comments made on the ambiguity or suitability of either questions was noted, this was not invited, nor were discussions made on such comments until after the test had been completed. As suggested by the BPC, reference is made to the *"research evidence supporting the validity of scores and interpretations"* [b7] and advice is given at the end of the testing process on how to obtain further information about dyslexia, regardless of the outcome of the web-based test. Test-subjects were ensured that their replies would be treated confidentially and that they were free to end participation at any time and were given the option to 'send results' or 'do not send results' at the end of the web-based test.

Finally, to facilitate comparison of the paper and web-based tests, hypotheses were formed to examine the match between the two tests, user perceptions of the ease of understanding both tests and the successfulness of the web-based test in discriminating between dyslexic and non-dyslexic individuals. Formally stated hypotheses are embedded with the relevant findings in section 5.

4.3 Choice of Development Methodology

It is inadvisable to *"blindly follow a rigid methodology...given the diversity of systems tackled today."* [b1] However, it is possible to adapt a traditional rigid systems development model such as the Systems Development Life Cycle for web development purposes. Figure 4.31 illustrates a possible adaptation of the traditional SDLC for a web-based screening site:

Applying the Traditional Systems Development Life Cycle to Web Development:

Determine information requirements

- Identify objective of site
- Plan the project, what is the goal to be accomplished?
- What information should be delivered? To whom?
- What information should be collected? From whom?

Analyse system needs

Logical Design: Plan the content and any external links

Design system: ***Physical Design:*** Plan the physical structure and navigation

Visual Design: Graphics, layout, sound, possible style sheets

Test the system: Verify with usability heuristics and check site accessibility

Implement and Evaluate the System: Evaluate site in light of defined goals once implemented

Figure 4.31: How the traditional SDLC can be adapted for use with web development. Similarly to the Waterfall model, the designer can step back one or several stages (i.e. the headings in bold) should any improvements or changes be required. *Adapted from University of Southampton: HCI Design Process [w1]: http://www.ecs.soton.ac.uk/~nmg/hci/design/ Accessed on [02/03/03].*

An adapted waterfall approach is a viable approach for designing, implementing and testing the system, especially since the approach is linear and all design and testing stages occur in sequence. It also facilitates better project management as the stages are clear-cut and is suited since the requirements of the system are known before actual design commences. [b5]

However, this semi-structured approach may not be best suited for a multi-sensory system that uses multimedia technology, since special attention needs to be paid to the usability and accessibility of the site for users with dyslexia. It is possible to incorporate usability and accessibility requirements into the 'requirements analysis' stage of the waterfall and not only in the 'testing' stage after hours have been spent on the design. However it is important for usability, accessibility and potential psychological issues to be addressed as they arise. This is because without designing the site from a dyslexic user's perspective from the outset and continually assessing how aptly the system allows the user to complete the screening process, there is the risk of designing a system that requires a complete overhaul or re-design once testing is complete.

This suggests the need to put formal methodologies aside, even if semi-structured, and adopt an iterative prototyping method for developing the site. *"Prototypes are models of the system that implement a limited range of the system's features and functions."* [b5] Central to prototyping is the concept that *"the only way we can be really certain about an interface is to build it and test it on some typical users,"* [b5] in this case dyslexic and non-dyslexic users that might wish to be screened. In the multimedia industry, prototyping has become more popular than even semi-structured methodologies such as the SDLC (waterfall model), as shown by Figure 4.32:

Table 1. General Approaches Used in Multimedia Systems Development

Approach	*General Industry (n = 8)*		*Multimedia Industry (n = 15)*		*Aggregate Response (n = 23)*	
	Incidence		Incidence		Incidence	
Semi-structured SDLC	8	100%	6	40%	14	61%
Prototyping	2	25%	9	60%	11	48%
Production-oriented Approach	1	13%	8	53%	9	39%
Structured SDLC	3	38%	4	27%	7	30%
Advertising / Graphic Design	2	25%	5	33%	7	30%
Object-oriented Approach	3	38%	3	20%	6	26%
Other	1	13%	4	27%	5	22%
Artistic Approach	0	0%	4	27%	4	17%
Media Design Approach	0	0%	4	27%	4	17%

Figure 4.32: The trend to favour towards prototyping for multimedia systems development. *Re-printed from Techniques And Methodologies for Multimedia Systems Development: A Survey Of Industrial Practice [w6]: http://www.is.nuigalway.ie/mlang/research/IFIP_WG82_2001.pdf Accessed on [12/03/03].*

In practice, prototyping allowed benefits stated by Miller-Jacobs in [b6] to be realised. It enabled early visualisation of the requirements of the site, allowing iterative manual improvements to the coding, usability and accessibility of the site to made as needed and with user input. For example, a pilot group of users (see section 4.2) unanimously agreed that the button to access the site's help facility should be moved from the top-right-hand-corner of the screen to top-left so that it is not missed.

Prototyping also facilitates early testing and enabled the screening functionality of the site to be tested and improved separately to the usability and aesthetic features of the site. For example, early prototyping focused on coding a test-answering procedure that passed answers from previous questions onto the next screen, enabling a tailored report at the end of the process that would determine whether the test-subject may or may not have dyslexia. An iterative approach was used, first ensuring that one page was able to pass its answer over to the next. Once this was accomplished, the prototype evolved to making sure that the answer (parameter) passed over to the next page could be accessed and understood by the page that had received it. Only once this had been accomplished with a limited functionality prototype could the pages be strung together in a chain, resulting in a test with several questions, a report at the end and the facility of sending research results by e-mail to avoid any need for paperwork.

However, some of the potential problems identified by Miller-Jacobs in [b6] were also experienced; it was tempting to underestimate the amount of hours left to complete the site, since even an aesthetically sound, usable and accessible site might still not perform the screening function to the required standard. In addition, the visual simplicity of the site enticed some over-ambitious potential requirements, such as allowing full customisation of the interface, so that individuals with dyslexia could change the background, foreground and font colours and styles of all pages. Although not essential to the site's function, it was not possible to implement this feature due to technical obstacles *(see section 4.4).*

4.4 Choice of Development Environment and Multimedia Standards

It was decided to use JavaScript, a stripped-down version of Sun's 'Java' programming language that is read and processed by the web-browser (known as client-side processing). In order for JavaScript to function correctly, *"it must be part of a webpage that is being displayed in a browser that understands the language."* [w6] This was necessary because HTML, the standard language for creating web documents cannot *"perform mathematics, store variables or dynamically display content,"* [w6] all of which are required by a web-screening system.

The feasibility of an online-testing site was clear from the start, as illustrated by [w7], a 'Question Generator' created by Hudson and Benett of the University of Hertfordshire's Learning Technology Development Unit. It facilitates the creation of multiple-choice tests that can be marked and scores given. It generates the result in JavaScript to allow the test to be published on the Internet. Although permission was gained to use the Question Generator and adapt the resulting JavaScript, it soon became clear that the complexity of the JavaScript code was beyond the scope of this degree and beyond my programming capabilities.

Other programming languages were considered, although JavaScript is most relevant since the foundations learned earlier in this degree could be built upon. Perhaps the use of software such as Macromedia Flash may have provided a more multi-media site, however there is a grey-area between the type of quick screening that a site such as this provides and a more, in-depth screening (such as offered by LADS, Instines and StudyScan) which focuses highly on a battery of tests.

However several issues, in hindsight, question the use of JavaScript to develop the site. Firstly, the use of a client-side script does not facilitate saving the results on a database on the Internet server. This means that although results are automatically sent by e-mail when a user agrees to submit them, they have to be re-entered into a statistical package for analysis to take place. This would not have been the case if an alternate server-side language such as CGI or ASP had been used, where data is calculated on the server and not on the individual client computer. In addition, the client-side facility to send e-mail is highly dependant on the e-mail software installed on the user's machine, if any. This means that a computer without default e-mail software installed would not be able to send the results automatically by e-mail, making the task of data analysis difficult. In addition, different e-mail software packages handle the JavaScript e-mail commands in a different way, sometimes causing unexpected results.

This highlights the common assertion that whilst it may be possible to design a functional, usable and accessible website, there can be no guarantee that it will work on every possible system configuration, even if the site is tested to ensure that it works as intended with the majority of browsers and with the majority of e-mail software. In addition, whilst it is good practice to *"try to ensure that even if the script can't run the user has an alternative way of getting access to the functionality of the script,"* [w11] this is not practical and often not possible when designing a site where the test functionality provided by JavaScript is integral and critical to the functionality of the site.

As mentioned in section 4.3, it was also hoped to extend the usability of the site by offering customised background, foreground and font colours/styles of all test pages. An example of this, achieved in CGI, can be found at the British Dyslexia Associaton's Website. [w8]
A feasible method was discovered by combining style sheets and cookies. Style sheets *"benefit accessibility by separating document structure from presentation"* and *"allow the precise control of font characteristics, backgrounds, alignment and positioning."* [w9] A cookie is *"one or more pieces of information stored as text strings on your machine. A Web server sends you a cookie and the browser stores it. The browser then returns the cookie to the server"* [w10] the next time the

information from the cookie is required. When combined, it is possible for a JavaScript-based site's look and feel to be customised and the settings stored in a cookie so that every time the user visits the site, it will reflect their tailored settings.

However although this implementation was successful, it removed the data that was appended to the test page's web address (URL) i.e. the participant's answers to the questions that should be passed from one page to the next. Whilst it was possible to implement customisation features in JavaScript without the use of cookies, this would only allow one page's colours and fonts to be customised at a time and would require the process to be repeated when each of the several test pages was loaded. This was an unacceptable solution and therefore dismissed, hence any extra customisation features were not implemented in the final site, since they hampered the functionality of the test itself. Perhaps re-writing the test in an alternate language might solve this 'incompatibility' problem.

A final reason for re-writing the site in another language, that can only be appreciated in hindsight is the politics surrounding publishing an open-source Internet site, where any user is able to view and copy the source of the site. Upon conversing with developers of the screening software in section 2.1, it became clear that the niche of the site might attract copycat versions for profit, should the screening test prove to be statistically sound. Other languages would protect the code used, therefore could be published on the Internet on a not-for-profit basis without fear.

For the multi-media features of the site, care was taken to promote inclusion for all, not just users with a fast Internet connection. Graphics were compressed in GIF format to facilitate speedy loading and most are less than 15k each in size. An uncommon AU format was chosen for the sound features, since testing revealed that many browsers cannot play highly compressed WAV format files. The AU format was developed by Sun, the creators of Java and allows a whole minute of audio to be compressed into 492.5k – roughly the size of a high-resolution image. [w14] These features combined allowed the full multimedia features of the site to be implemented, yet only take up the space of two floppy disks (2.7Mb). This is more than suitable for all types of Internet connection, even narrowband.

Due to the nature of JavaScript, where code is not pre-compiled, it is possible for the website to run but errors only to be unearthed when a feature exposing them is invoked. Therefore, all features were unit tested to ensure that the program ran as intended. Each question was tested to ensure that only by selecting a dyslexia-type response would an 'indicator' or 'highindicator' score increment. All pages were found to produce the correct output in the web-address of the browser (i.e. 0 for a non-dyslexia-type response and 1 for a dyslexia-type response). *See annotated code in appendix 5.* To test the IF statements that determine whether a user might or might not have dyslexia, the test data in Figure 4.33 was used. Testing showed that the program performed as intended, as discussed in section 4.2.

Test data entered to test the statement: if(highindicator>5 || indicator>7 {document.write('The answers that you have given are consistent with someone that has Dyslexia'}	**Expected recommendation of dyslexia report in rec.htm**	**Algorithm performs as intended?**
Answering non-dyslexia-type responses to all questions (should result in a highindicator of 0 and indicator of 0)	'might not have dyslexia'	☑
Data that should result in a highindicator of 0 and an indicator of 7- i.e. answers of 0, 0, 1, 0, 1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0)	'might not have dyslexia'	☑
Data that should result in a highindicator of 0 but an indicator of 8 (achieved by only providing dyslexia-type responses to all the non-high-indicator questions - e.g. answers of 0, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0)	'might have dyslexia'	☑
Data that should result in a highindicator of 6 and an indicator of 6 - e.g. answers of 1, 0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0)	'might have dyslexia'	☑
Answering dyslexia-type responses to all questions (should result in a highindicator of 12 and indicator of 20)	'might have dyslexia'	☑

Figure 4.33: Testing to ensure that the algorithms within the JavaScript of the Web-Based screening test function as intended. Note that 0 stands for a dyslexia-type response, 1 for a non-dyslexia-type response. Previous responses are visible in the web-address of the web-based test.

4.5 Choice of Usability Methodology

A Heuristic approach is preferable to an informal, unstructured evaluation method and was achieved by inviting the initial pilot group to comment on the interface. It is also suitable in situations where the *"resources for empirical usability testing"* are lacking [b5]. Heuristic evaluation is performed by *"having each individual evaluator inspect the interface alone. Only after all evaluations have been completed are the evaluators allowed to communicate and have their findings aggregated."* [b8] This is based on design principles.

The pilot group gave feedback at an early stage, as soon as the first interface prototype had been constructed. They also provided feedback towards the end of the prototyping stage. Although numerous usability heuristics are available, they are similar in essence. Nielsen's 10 usability heuristics [w15] are recommended by both Hill and Dix, and have become a de facto standard for heuristic evaluation. They were considered throughout the prototyping stage and discussed at each meeting with the group. Figure 4.5 shows, beside each heuristic, the decisions reached as a consensus by the pilot group of dyslexic and non-dyslexic individuals:

Usability Heuristic	**Consensus at 1st meeting with pilot group in the early stages of prototyping**	**Consensus at 2nd meeting with pilot group in the late stages of prototyping**
1) Visibility of system status	There is no need to provide on-screen confirmation that an answer has been selected. However, users should be informed if they try to progress through the test without selecting an answer.	A timer should be displayed in the status bar for timed questions such as Question 5. An alert box should tell users how long it took them to read the story in Question 5.
2) Match between system and the real world	Both the wording of the questions and the speech used must be easy-to follow and understand.	The final recommendation report and Frequently Asked Questions about Dyslexia should be adapted to be simple and easily understood, so as not to intimidate a user that may have been told they might have dyslexia.

3) User control and freedom	Users should be able to go back to correct their previous answer if they decide to progress to the next question in error.	Users should be given the option to exit the test without submitting their results for inclusion in research.
4) Consistency and standards	All 'read out' and 'help' icons should appear in the same size, in the same place. Question pages should have the same size and placed headings, fonts and pictures to ensure consistency.	'Help' and 'Read Out' buttons should be placed in the top-left rather than top-right hand corner of the screen.
5) Error prevention	A help facility should always be available. Context sensitive help should be offered if general help does not fit on a single screen.	Context sensitive help is not required, since the help section fits comfortably on a single screen. Users that finish reading the short story in Question 5 under 10 seconds should be warned of the consequences of their actions and invited to step back.
6) Recognition rather than recall	A help facility should be visible from each page. The same form of inter-action (i.e. multiple choice radio boxes) should be used for all user input.	N/A
7) Flexibility and efficiency of use	System should allow general browser shortcut keys (such as ALT-B for back)	The page should load before the 'read out' sound file has been downloaded, so as not to hold up users taking the test on slower Internet connections.
8) Aesthetic and minimalist design	No irrelevant information should be included.	N/A
9) Help users recognise, diagnose, and recover from errors	Explain any error messages in plain English (such as trying to progress to the next question without selecting an answer in the current question.)	N/A
10) Help and documentation	It is essential that the help section should not be too large.	The 'read out' facility must also work within the help section.

Figure 4.5: Application of Nielsen's 10 usability heuristics. *Adapted from [w15]:* http://www.useit.com/papers/heuristic/heuristic_list.html *Accessed on [13/03/03].*

In addition to judging the usability of the site by the heuristics above, Hill [b5] quotes Eaton, suggesting that *"the major indicator of usability is whether a system or a feature is in fact used."* It was therefore also decided to ask participants if the help or 'read out' facility were used after the completion of the web-based test.

4.6 Choice of Accessibility Testing Methodology

In light of the possible choices in section 3.4 and the need to avoid a toolbox approach, A-Prompt was used to check and repair accessibility problems throughout the web-based test. In line with and surpassing the W3C recommendations in section 3.4, all priority 1, 2 and 3 errors were eliminated. Code that was suggested to be added in order to improve the usability of the site is highlighted in appendix 5.

It would be unwise, however, to trust one tool alone to pinpoint any of the numerous W3C accessibility guidelines that had not been properly implemented. Although there is no research on A-Prompt's effectiveness, *"Bobby's creators freely admit that their product is not a perfect tool."*

[a2] Research has shown of an *"inability to distinguish between degrees of impact between different manifestations of the same error"* as well as reports of falsely positive and negative results. Most importantly, in contrast to A-Prompt, Bobby cannot *"check for the accessibility of script, such as JavaScript...or script-generated content."* [a2] This suggested the need to use A-Prompt as a primary accessibility check and repair tool. A-Prompt's accessibility findings were confirmed by using Bobby and by conducting a manual check before concluding that the site was AAA compliant (i.e. free of all accessibility errors). *(See appendices 5, 6 and 7).*

A final accessibility check involved testing the finished site in different browser and e-mail client environments. Although some isolated problems surfaced, the site was fully functional in Netscape, Internet Explorer and Opera versions 3.0 upwards and IBM Webexplorer 1.1. Note that the functionality of client-side result sending by e-mail is dependent on the e-mail software and not the browser. Problems therefore occurred sporadically as predicted in section 4.4, although this did not restrict the functionality of the test itself.

4.7 Chapter References

Chapter 4: Books Cited

Book Nº	Author	Title	Publisher	Date	Page
[b1]	Britton, C. & Doake, J.	Software System Development: A Gentle Introduction 2nd Ed	McGraw Hill	1996	20
[b2]	Cooke, A.	Tackling Dyslexia: The Bangor Way	Whurr Publishers	1993	pp. 99-100
[b3]	Ott, P.	How To Detect and Manage Dyslexia: A Reference and Resource Manual	Heinemann Educational	1997	pp. 64-65
[b4]	Heaton, P. & Winterton, P.	Dealing With Dyslexia 2nd Ed	Bath : Better Books	1996	pp. 77
[b5]	Hill, S.	A Practical Introduction to the Human Computer Interface	D.P. Publications	1995	pp. 64-71
[b6]	Miller-Jacobs, H. Edited by Karat, J.	Taking Software Design Seriously	Academic Press	1990	pp. 274-280
[b7]	The British Psychological Society	Guidelines for the Development and Use of Computer-Based Assessments	Psychological Testing Centre	April 2002	pp. 6-9
[b8]	Dix, A.J et al	Human Computer Interaction 2nd Ed.	Prentice Hall	1998	pp. 412-415

Chapter 4: Articles Cited

Article Nº	Author	Title	Publication	Date	Page
[a1]	Vinegrad, M.	A revised Dyslexia Checklist	Educare No. 48	March 1994	pp. 21-23
[a2]	Schmetzke, A.	Online Distance Education - "Anytime, Anywhere" But Not For Everyone	*Information Technology and Disabilities* Vol. VII No. 2	April 2001	pp. 1-8

Chapter 4: Websites Cited

Site Nº	Site URL	Date Visited	Comment
[w1]	http://www.ecs.soton.ac.uk/~nmg/hci/design/	02/03/03	University of Southampton: HCI Design Process
[w2]	http://dictionary.reference.com/search?q=multi-sensory	02/03/03	Dictionary.com Definitions
[w3]	http://dictionary.reference.com/search?q=multimedia	02/03/03	Dictionary.com Definitions
[w4]	http://www.legislation.hmso.gov.uk/acts/en/2001en10.htm	12/03/03	The Special Educational Needs and Disability Act 2001
[w5]	http://www.is.nuigalway.ie/mlang/research/IFIP_WG82_2001.pdf	12/03/03	Techniques And Methodologies For Multimedia Systems Development: A Survey Of Industrial Practice
[w6]	http://www.webaim.org/howto/javascript	12/03/03	Webaim: What is JavaScript?
[w7]	http://www.herts.ac.uk/lis/ltdu/tutorials/question_generator/	12/03/03	LTDU Question Generator
[w8]	http://81.89.134.99/main/view/index.asp	12/03/03	British Dyslexia Association: Accessibility Page
[w9]	http://www.ldu.leeds.ac.uk/ldu/resources/access/Using%20Style%20Sheets%20to%20Improve%20Accessibility.doc	12/03/03	Leeds University: Using Style Sheets to Improve Accessibility
[w10]	http://www.howstuffworks.com/question82.htm	12/03/03	Howstuffworks: "What is an Internet Cookie?"
[w11]	http://www.raingod.com/raingod/resources/Programming/JavaScript/Notes/Compatibility.html	12/03/03	Rain God: Coping With Browser Differences
[w12]	http://www.herts.ac.uk/business/ethicsapp%20form%2021.doc	12/03/03	University of Hertfordshire Business School: Application for Ethics Approval for Research
[w13]	http://www.radiouniversity.co.uk/spell.htm	13/03/03	University of Ulster: Spelling Mistake Research
[w14]	http://www.phon.ucl.ac.uk/home/mark/audio/play.htm	13/03/03	University College London: Demonstration of How to Play a Sound From a Web Page
[w15]	http://www.useit.com/papers/heuristic/heuristic_list.html	13/03/03	Jakob Nielsen's Ten Usability Heuristics
[w16]	http://images.google.co.uk/images?hl=en&lr=&ie=UTF-8&oe=UTF-8&q=reading+clipart	13/03/03	Google Image Search for Clipart Images of 'reading'

5. Findings

5.1 Match between Vinegrad Paper-Based Test and Web-Based Test

Ho: There is no difference at the 5% level between the mean score of the paper-based test and the mean score of the web-based test amongst both groups.
Ha: There is a difference at the 5% level between the mean score of the paper-based test and the mean score of the web-based test amongst both groups.

Although individual discrepancies between tests occurred, there was sufficient statistical evidence to conclude that the results from both tests do not differ significantly. This is suspected at first glance due to the closely-matched mean indicator scores between the paper-based and web-based tests for both groups; 12.27 and 11.47 respectively for the dyslexic group and 5.20 and 4.87 respectively for the non-dyslexic group.

A two-sample difference-between-means test (T-Test), assuming unequal variances, was carried out examining both pairs of means above *(see appendix 10, figures 17 and 18 respectively).* The tests obtained P-Values of 0.418 amongst the dyslexic group and 0.630 amongst the non-dyslexic group. Since both exceed 0.05, we do not reject the null-hypothesis, therefore we conclude that there is no difference at the 5% level between the mean score of the paper-based test and the mean score of the web-based test amongst both groups.

Note that the t-distribution *"has a property called robustness, which means that even if the assumption of normality is moderately violated, the p-values returned by the t-statistic will still be pretty accurate."* [b2] However, it would be inadvisable to rely on the results of such t-tests if the frequencies of indicator results being compared do not follow a bell-shaped normal distribution.

Figures 9-12 in appendix 10 show that the do not appear to closely follow the super-imposed normal distribution curves. Therefore, normal P-Plots were generated to ensure that the data is, in fact, normal. Figures 13-16 confirm this, with P-Values closely following the linear trend (the lowest correlation is a modest 0.9701). This suggests that whilst not all of the histograms show a normal distribution, the data is in fact normally distributed. Coupled with the robustness of the t-test, this allows such t-tests as carried out above to be used with confidence in analysing the data.

Ho: There is no correlation at the 5% level between indicator results obtained in the paper-based test and indicator results obtained in the web-based test, in both groups.
Ha: There is a correlation at the 5% level between indicator results obtained in the paper-based test and indicator results obtained in the web-based test, in both groups.

Figure 5.11 shows positive correlations between total indicator values for each test amongst both groups. The match between results in the paper and web-based tests does not appear to be as close amongst the non-dyslexic group as the dyslexic group. The dyslexic group has a correlation co-efficient (R^2) value of 0.7464 compared with 0.5921 for the non-dyslexic group.

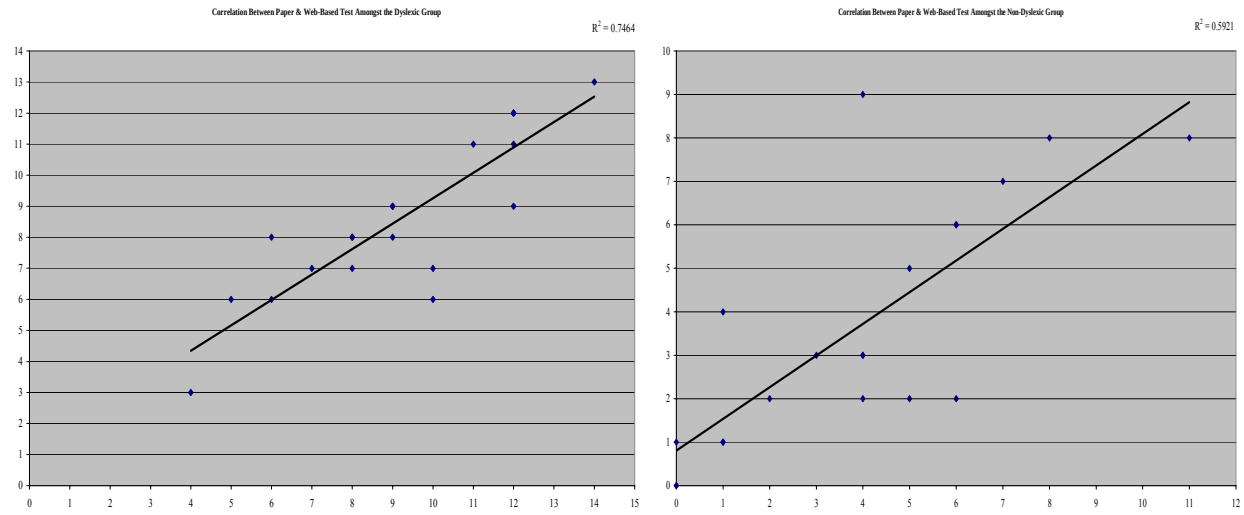


Figure 5.11: The positive correlation between the total indicators scored in the paper-based test and the total indicators scored in the web-based test, amongst both dyslexic and non-dyslexic groups,

A one-tailed test at the 5% level with a sample size of 15 indicates an R^2 critical value of 0.4409 [b1]. Since 0.7464 and 0.5921 both exceed this value, we reject the null-hypothesis and conclude that there is a correlation at the 5% level between indicator results obtained in the paper-based test and indicator results obtained in the web-based test, in both groups.

Ho: There is no connection at the 5% level between how easy to understand the paper-based test is perceived to be and how easy to understand the web-based test is perceived to be, in both groups.
Ha: There is a connection at the 5% level between how easy to understand the paper-based test is perceived to be and how easy to understand the web-based test is perceived to be, in both groups.

Figure 5.12 highlights differences between how easy each test is to understand. Whilst the majority of the non-dyslexic group found the paper-based test 'Quite easy' or 'Very easy' to understand, the majority of the dyslexic group fount it to be 'Not very easy' or 'Not easy' to understand. The web test was found to be 'Very easy' or 'Quite easy' to understand by almost all respondents, with the majority of dyslexic and non-dyslexic individuals choosing 'Very easy.'

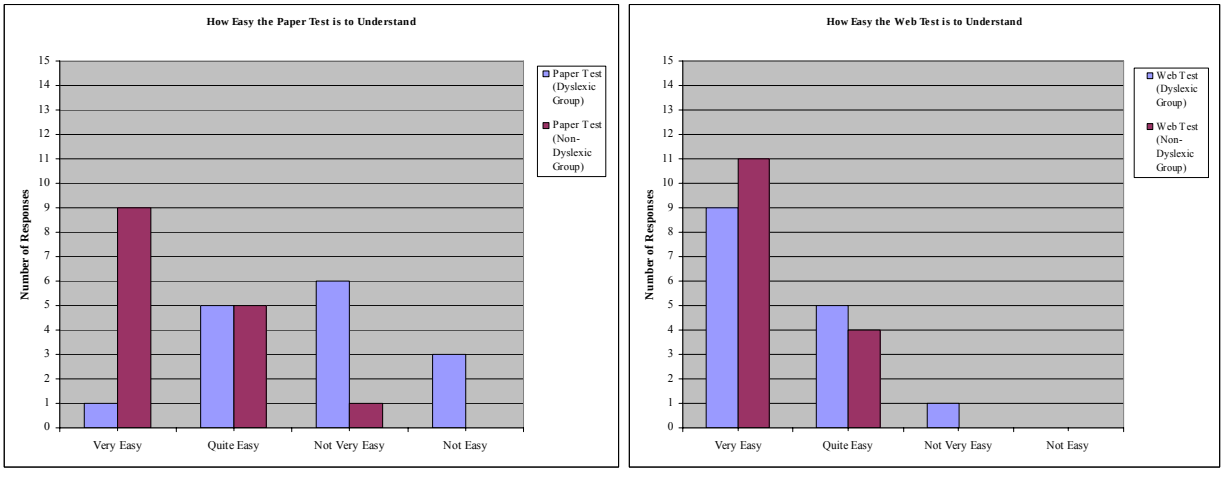


Figure 5.12: Comparison of participants' perception as to how easy to understand both the paper and web-based tests are.

Chi-Squared tests (χ^2) were used to examine the difference in perceived ease of understanding amongst both groups (*see appendix 10, figures 7 and 8).* Amongst the dyslexic group, a chi-squared statistic of 0.9 was found not to exceed the critical value of 5.991 and amongst the non-dyslexic group, 0.15 did not exceed 3.841. Therefore, for both groups, the null-hypothesis was not rejected and it can be concluded that there is no connection at the 5% level between how easy to understand the paper-based test is perceived to be and how easy to understand the web-based test is perceived to be in both groups, indicating that the web-based test is perceived as significantly easier to understand than the paper-based test.

5.2 Inter-Test Comparisons and Discrepancies between Dyslexic and Non-Dyslexic Groups

Although individual discrepancies occurred, where a dyslexia-type response was given in one test but not the other, overall discrepancies based on final scores were rare. None of the dyslexic individuals were given the false tentative conclusion that they 'might not' have dyslexia, however participant number 14 in the non-dyslexic group was told he/she 'might' have dyslexia by the web-based test and told the opposite by the paper-based test, due to two discrepancies that 'tipped the scale' *(see appendix 10, figure 6).*

Singleton comments that screening procedures which generate more than 25% of false negatives or false positives (expressed as percentages of those predicted to be 'dyslexic' or 'non dyslexic' in each case) are not likely to prove very useful. [b4] A single false-positive, however, does not in itself cause the validity of the web-based test to be questioned.

Importantly, it can be noted that many borderline cases existed amongst both groups. However, borderline results appear consistent throughout both tests, perhaps indicating that a dichotomous algorithm may not be wholly appropriate for either test, as asserted by Ian Smithe of the International Dyslexia Association in conversation.

There is enough statistical evidence to deem the tests closely matched overall, and most discrepancies between results are not biased in one direction (i.e. on a particular question, one participant might give a dyslexia-type response in the paper-based test but not the web test, whilst on the same question another participant might give a dyslexia-type response in the web-based test but not the paper one).

However, figure 5.21 shows a difference between total dyslexia-responses for some questions answered by the dyslexic group. The highest differences are for questions 4, 9 and 18. Figure 5.22 also suggests these questions demonstrate a higher discrepancy level than with other questions and suggests that the discrepancies are biased, indicating that a dyslexia-type response was given in the paper-based-test but not the web-based test.

This suggests that some dyslexic participants believed it takes them a 'long time to read a page of a book,' (question 4) when in fact, their time fell within the acceptable region defined by the confidence interval. This was also noted within the non-dyslexic group *(see figures 5.23 and 5.24).* It can also be argued that the picture of a smiling man making a presentation in question 9 convinced some respondents in both groups to alter their opinions and decide that speaking in front of a group was not 'confusing.' Similarly, it is likely that the picture of a blank checklist form on question 18 reassured some dyslexic individuals that they did not always find forms difficult to fill in.

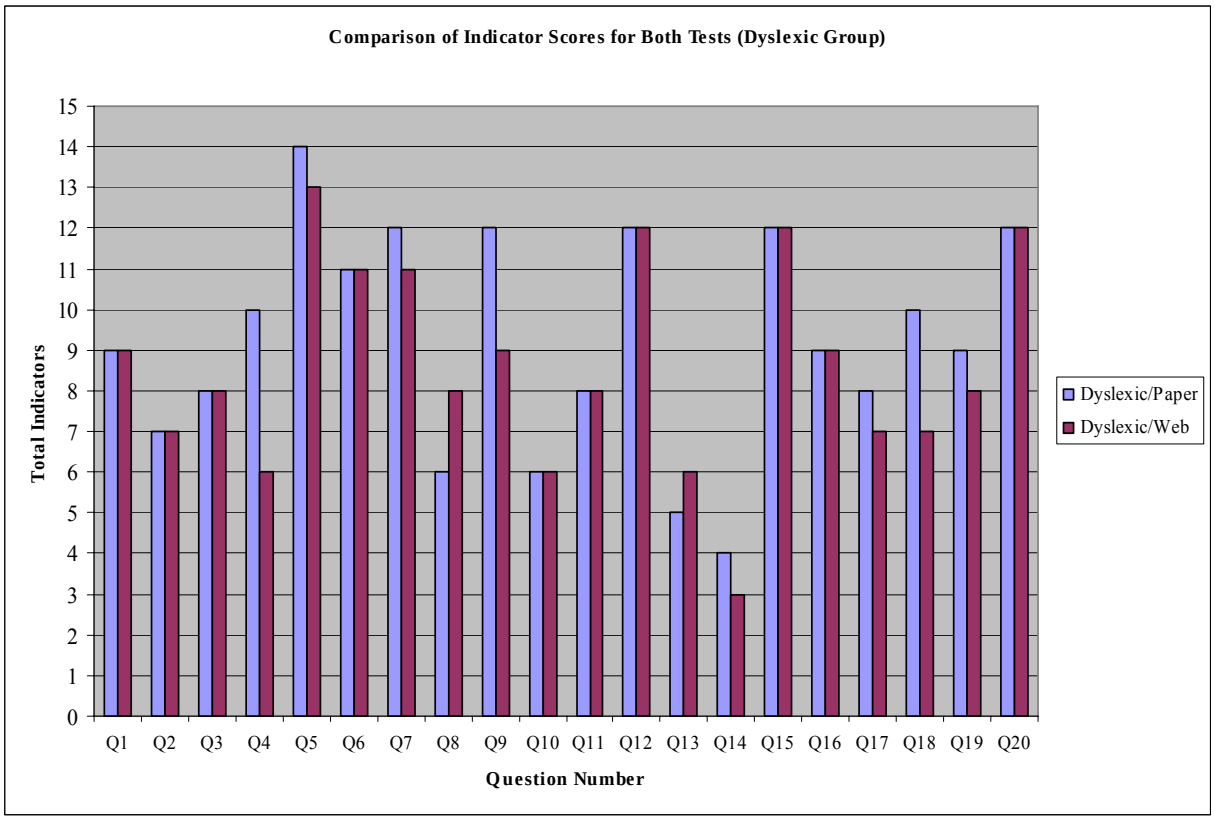


Figure 5.21: Comparison of indicator scores for both tests amongst the dyslexic group.

Figure 5.22: Comparison of individual response discrepancies for both tests amongst the dyslexic group.

Most noticeable discrepancies for the non-dyslexic group that have not already been highlighted by the dyslexic group involved questions 1, 5, 9 and 12, as illustrated in Figures 5.23 and 5.24. *See appendix 4 for screen-shots of the web-based questions.*

It is likely that non-dyslexic individuals who thought that they knew their left from right in the paper-based test did not always know someone else's left from right (i.e. the cartoon bear). Similarly some non-dyslexic individuals thought they do not 'understand the meaning of what they have read' even when they managed to correctly answer question 5. Interestingly though, 10 of the non-dyslexic participants did not manage to understand the sense of the story given, even though only 4 indicated in the paper-based test that they found this difficult. Vinegrad ranked the question as 13th most important of his 20 in indicating dyslexia. [a1] This suggests the need to see if question 5 is a fair discriminator between groups or if there is a general trend amongst both groups to find it difficult to understand the meaning of what they have read.

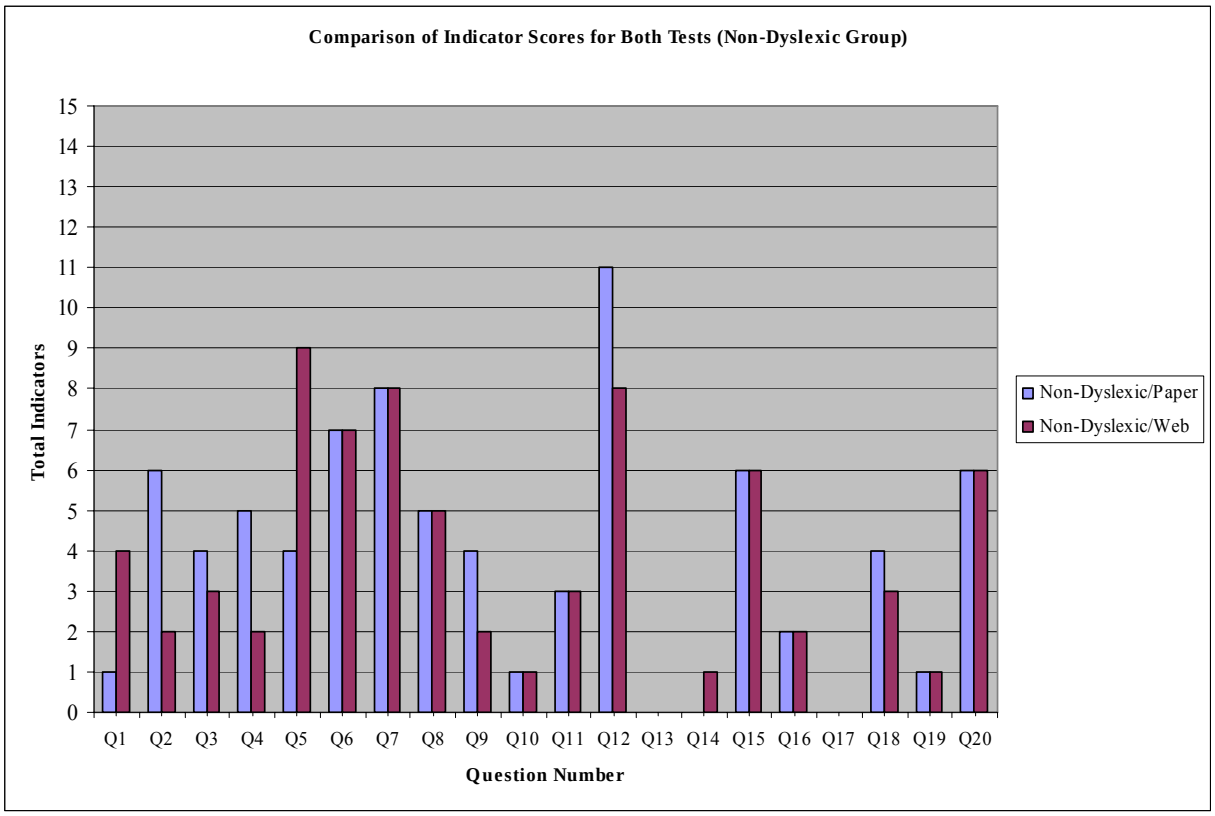


Figure 5.23: Comparison of indicator scores for both tests amongst the non-dyslexic group.

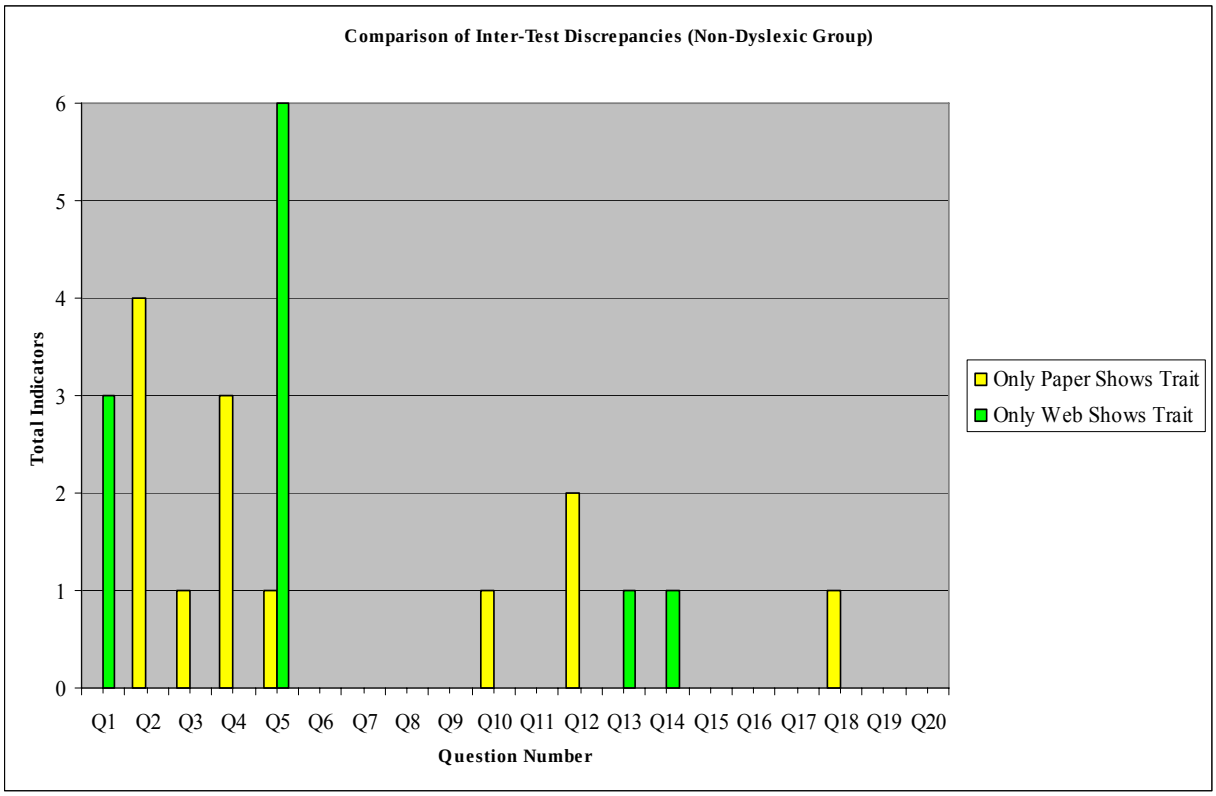


Figure 5.24: Comparison of individual response discrepancies for both tests amongst the non-dyslexic group.

Although participants were at no stage asked to comment on the ambiguity or non-ambiguity of questions, or the reasons for many recorded discrepancies, most dyslexic individuals felt the need to do so. Reasons varied from confusion with the wording of the question to, as Vinegrad found when administering his paper-based test, a *"psychological impossibility"* for *"some people to respond 'yes' to a question where a strategy for dealing with the difficulty has been painfully worked out."* [a1] For example, one participant commented on a compensation strategy for telling left from right (question 1) and confessed that only by mimicking the bear's actions could she tell what he was holding in his left hand. Another dyslexic individual's reading speed was extremely fast, perhaps facilitated by highlighting the active sentence with the mouse as he read the story in question 4 on the computer. Similarly another participant found that by setting reminders on her telephone, she would no longer 'mix up dates and times and miss appointments' (question 16).

Other reasons for discrepancies were varied. Two participants said they never used cheques, yet one admitted it was because they look daunting. Another participant worked in a bank, therefore quickly developed a compensation strategy for understanding cheques.

Several comments were made on the possible bias to the meaning of the questions caused by the pictures. One participant mentioned that the picture of reading aloud (question 3) showed a classroom environment which seemed informal, therefore would not dissuade him from reading aloud. In addition, 'confused' was not an accurate word to describe his fear of speaking in front of a group as in question 9, since it depended on the level of planning undertaken before the speech. *(See appendix 11 for other comments).*

A particularly pertinent comment came from a participant, who only felt she needed to look at the pictures if she was unsure which option to choose. This might highlight the potential for the pictures to act as the cause of potential discrepancies, as more attention may only be paid to them when answering 'ambiguous' questions. For example, she noted that the form in the picture in question 18 looked 'similar in outline' to the paper-based form issued to participants. Since she

found the Vinegrad-test daunting, the picture swayed her opinion. Another found the form simplistic and therefore un-daunting, resulting in the opposite change of opinion.

Ho: There is no difference at the 5% level between the mean score of dyslexic participants and the mean score of non-dyslexic participants amongst both tests.
Ha: There is a difference at the 5% level between the mean score of dyslexic participants and the mean score of non-dyslexic participants amongst both tests.

In spite of the individual discrepancies mentioned above, both tests performed well in distinguishing between dyslexic and non-dyslexic groups. The paper test found means of 12.27 for the dyslexic group compared with 5.20 for the non-dyslexic group. This closely matches Vinegrad's own obtained values of 12.7 and 4.4 [a1]. The web-based test found means of 11.47 compared with 4.87.

Similarly to section 5.1, a two-sample difference-between-means test (T-Test), assuming unequal variances, was carried out examining both pairs of means above *(see appendix 10, figures 19 and 20 respectively).* Both tests obtained P-Values of 0.000 (3s.f.) indicating extremely small values indeed. Since both do not exceed 0.05, we reject the null-hypothesis and conclude that there is a difference at the 5% level between the mean score of dyslexic participants and the mean score of non-dyslexic participants amongst both tests.

5.3 Usability Results amongst Dyslexic and Non-Dyslexic Groups

Figure 5.3 shows similar usability feedback for both dyslexic and non-dyslexic participants, with the vast majority finding the site 'very easy' to use and the pictures and 'read out' facility 'very easy' to understand. Some non-dyslexic individuals found these features less useful for understanding the meanings of the questions. Whilst a multi-sensory approach has been shown to be beneficial to dyslexic individuals *(see section 4.1)*, it is likely that non-dyslexic individuals would not struggle with reading or understanding the questions as much as the dyslexic individuals. This is supported by the fact that more non-dyslexics found the paper-based test 'quite easy' or 'very easy' to understand in the first place, as noted in figure 5.3.

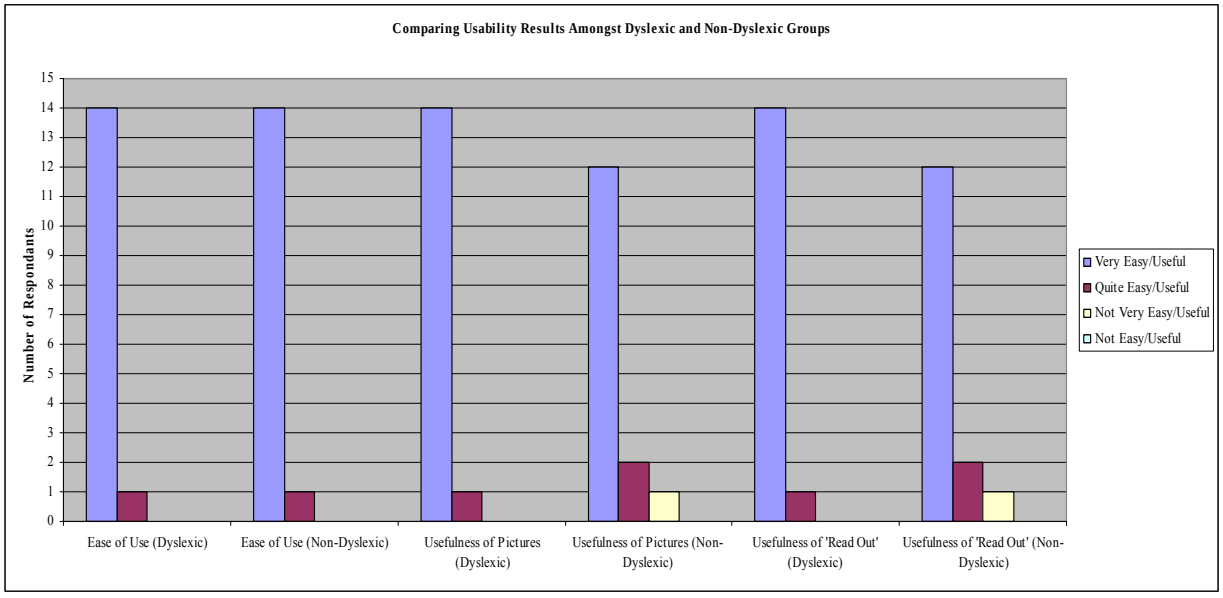


Figure 5.3: Comparison of usability results for the web-based test amongst both dyslexic and non-dyslexic groups.

5.4 Implications of Findings

There is enough statistical evidence to suggest that the web-based test is as effective as the Vinegrad test, upon which it was based, at discriminating between dyslexic and non-dyslexic groups. In addition, there is a significant positive correlation between the answers given in both tests amongst the dyslexic and non-dyslexic groups. This is supported by the fact that the paper and web-based mean indicator results were closely matched.

Even though the tests do not yield statistically different results overall, individual response discrepancies did exist between tests. These were often biased in a particular direction and suggest the need for further scientific study in order to ascertain whether certain individual questions (especially questions 1, 2, 4, 5, 9 and 18) are fair discriminators of dyslexia *(see appendix 4).*

Although difficult to quantify, the multi-sensory approach is likely to have contributed to some of the discrepancies above. Although it is not certain that the inclusion of pictures and sound provided an overall net benefit, this is suggested by the significant improvement in understanding, amongst both groups, that the web-based test provided over the paper-based test. This notion is also supported by the fact that both groups found the pictures and 'read out' facility to be 'very useful' in helping them to understand the meanings of the questions presented to them.

Although no mention was made of the 'read out' facility causing any question bias through the tone or speed of voice, the pictures may have contributed to some of the bias, especially amongst the dyslexic group and in regards to questions deemed 'ambiguous' by the participants. Further study is warranted in this area, especially to test the hypothesis that all pictures used in the test are equally subjective, therefore are unlikely to cause respondents to sway in a particular direction.

Aside from being easier to understand, the web-based test was judged by users to be 'very easy to use,' supported by the fact that no participants felt that it was 'easy to get lost' in the site, nor did any participant feel the need to use the help facility, despite no other help being offered for the completion of the test. Although some of the ease-of-use can be attributed to the semantic links between considering usability and accessibility, further study is also warranted in order to examine the relevance and usefulness of the web-based test amongst groups with multiple disabilities.

Overall the web-based test can be considered an easy-to-use and valid discriminator between dyslexic and non-dyslexic groups. It is accessible to those with multiple disabilities by conforming to the W3C AAA standard and its multimedia features can be accessed even by those with slower internet connections. Therefore the test can be considered suitable for deployment on the web in terms of statistical validity, usability, accessibility and practicality.

5.5 Chapter References

Chapter 5: Books Cited

Book Nº	Author	Title	Publisher	Date	Page
[b1]	Attwood, G. & Dyer, G.	Heinemann Modular Mathematics for London AS and A-Level: T2	Heinemann	1995	209
[b2]	Berk, K. & Carey, P.	Data Analysis With Microsoft Excel	Duxbury	2000	pp. 211-250
[b3]	Barlow, J.F.	Excel Models for Business and Operations Management	Wiley	1999	pp. 217-227
[b4]	Singleton, C. et.al	Working Party Report on Dyslexia in Higher Education	University of Hull Press	1999	87

Chapter 5: Articles Cited

Article Nº	Author	Title	Publication	Date	Page
[a1]	Vinegrad, M.	A revised Dyslexia Checklist	Educare No. 48	March 1994	pp. 21-23

6. Potential for Future Study within the Field of Dyslexia and IT

The following potential options for future study within the field of dyslexia and IT are discussed in appendix 8:

6.1 Impact study on the usefulness of assistive technology and study on the relationship between the usefulness of assistive technology, personality and the individual's profile of dyslexia

6.2 Comparison between dyslexia screening software and examination of inconsistencies within a single screening method

6.3 Study into effective multi-sensory screening for monolingual, bilingual and multilingual individuals

6.4 Further proposals considered by the Centre for Applied Research in Educational Technologies, University of Cambridge

Appendix 1: Vinegrad/British Dyslexia Association Checklist

Adapted from http://www.dyslexia-inst.org.uk/pdffiles/checklist.pdf [accessed 23/01/03]

Instructions to administrator:

1. Ask the students to fill out the questionnaire as honestly as possible, without any limit of time, but preferably while gathered together in a single session. Ten minutes ought to suffice.
2. Collect the questionnaires, checking that names (and any other information requested, such as year or residence) are given.
3. In the last column, record in the un-shaded boxes a tick if the respondent has answered that question with a Yes.
4. Record the total number of Yes answers in the box provided at the foot of the page.
5. In the second line of the box record the total number of ticks in the last column.
6. Select all questionnaires with eight or more Yes responses. This is likely to identify 11% of the student population. Though this will include all the more dyslexic students, this is still too large a fraction to allow a reasonable chance of intervention.
7. From those identified, further select respondents with the most Yes answers in the last column. Positive responses to six or more of these most dyslexia-sensitive questions "…may be of greater significance than a high score on the questionnaire as a whole." (Vinegrad, 1994, p. 22)

Instructions to test subject:

Answer Yes or No to the numbered questions. If you are unsure of which answer to choose, tick the one that you feel is true most often.

(please tick)	**Yes**	**No**
1. Do you find difficulty in telling left from right?		
2. Is map reading, or finding your way to a strange place confusing?		
3. Do you dislike reading aloud?		
4. Do you take longer than you should to read a page of a book?		
5. Do you find it difficult to remember the sense of what you have read?		
6. Do you dislike reading long books?		
7. Is your spelling poor?		
8. Is your writing difficult to read?		
9. Do you get confused if you have to speak in public?		
10. Do you find it difficult to take messages on the telephone and pass them on correctly?		
11. When you have to say a very long word do you find it difficult to get all the sounds into the right order?		
12. Do you find it more difficult to do sums in your head without using your fingers or paper?		
13. When using the telephone, do you get the numbers mixed up when you dial?		
14. Do you find it difficult to say in order the months of the year forwards in a fluent manner?		
15. Do you find it difficult to say in order the months of the year backwards?		
16. Do you mix up dates and times and miss appointments?		
17. When writing cheques, do you frequently find yourself making mistakes?		
18. Do you find forms difficult and confusing?		
19. Do you mix up bus numbers like 95 and 59?		
20. When you were at school, did you find it hard to learn your multiplication tables?		

Appendix 2: Checklist for the Identification of Dyslexia in Adults

Re-printed with permission from Ian Smythe.

Checklist for the identification of dyslexia in adults

Thank you for helping with our research and completing our questionnaire. We hope that as a result of your efforts we shall be able to provide a good checklist for the identification of dyslexia in adults as well as an indication of preferred learning styles. Please note that in order to make this research of good quality, we need respondents that are dyslexic and non-dyslexic. Completed questionnaires should be send to the correspondence address given at the end of the last page.

Please answer every question. If in doubt put the answer that you feel is true most often.

1. When writing, do you avoid using some words because you cannot spell them?
   ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

2. Is filling in forms a problem for you?
   ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

3. Do you read books for pleasure?
   ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

4. How easy for you is it to speak a foreign language?
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

5. How easy is it for you to learn to write a foreign language?
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

6. How easy do you find it to recite the alphabet?
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

7. How easy do you find it to sound out words? (E.g. el-e-phant)
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

8. How easy do you find it to make/understand plays on words?
   Type 1: Hush my brat instead of Brush my hat.
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

   Type 2: I am not under the affluence of alcohol (should be influence)
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

   Type 3: Dog and bone for phone
   ❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

9. Do you get confused when given several instructions at once?
   ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

10. Do you make mistakes when taking down telephone messages?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

11. If asked to repeat a phone number you have just heard, do you mix up or miss out numbers?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

12. Do you mispronounce long words?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

13. Do you mix up numbers, like 95 and 59?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

14. Do you forget people's names even though you have just been told them?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

15. Do you lose your place or miss out lines when reading?
    ❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

16. Do you make mistakes copying things down?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

17. If you had a choice would you prefer instructions to be given verbally, written down or in diagrams?
❑ Verbally ❑ Written down ❑ Diagrams

---

18. Do you find words jump around on the page?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

19. Do you find your vision blurred when trying to look at fine details such as on a map?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

20. How easy do you find visualising an object or pattern that you have just seen?
❑ Very easy ❑ Easy ❑ Difficult ❑ Very difficult

---

21. What do you consider your reading speed to be?
❑ Fast ❑ Average ❑ Slow ❑ Very slow

---

22. Do you make lots of mistakes when required to think fast?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

23. Would you say you speak slowly and carefully?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

24. Do you enjoy pastimes that require manual dexterity (e.g. basketball, netball, jigsaws)?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

25. Would you say you are clumsy?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

26. Do you confuse words when saying them, such as "lampshade" for "lamppost"
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

27. Do you confuse visually similar words when reading (e.g. tan,ton)?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

28. Do you find it difficult to find the right word to say in everyday conversation?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

29. Do you confuse the names of things, such as objects (for example table for chair)?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

30. When reading, do you mistake a word for one which means something similar, such as doctor for nurse?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

31. When writing do you find it difficult to organise your thoughts on paper?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

32. How often do you obtain a wrong number when using the telephone?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

33. Are you told your handwriting is difficult to read?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

34. Did you find yourself being one of the last to be chosen for a side in a team sport?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

35. Do you have difficulty telling left from right?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

36. Is map reading or finding your way to a strange place confusing?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

37. Do you find it difficult to organise yourself?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

38. Do you misplace personal items such as keys?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

39. Do you mix up dates and times, and miss appointments?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

40. Do you find it difficult to do sums in your head without using your fingers or paper?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

41. Do you re-read pages or paragraphs you have just read to understand them?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

---

42. Do you think of unusual (creative) solutions to problems?
❑ Rarely ❑ Occasionally ❑ Often ❑ Most of the time

When you were at school did you ....

---

43. ... write shorter essays than others? ❑ Yes ❑ No

---

44. ... learn your multiplication tables easily? ❑ Yes ❑ No

---

45. ... have difficulty when asked to read aloud? ❑ Yes ❑ No

---

46. ... take longer than others to read a page of a book? ❑ Yes ❑ No

---

47. ... receive extra help? ❑ Yes ❑ No

---

48. How would you categorise yourself?
❑ Not dyslexic
❑ Mildly dyslexic
❑ Fairly dyslexic
❑ Very dyslexic
❑ Unknown

---

49. Age now (approx if over 21)? _____

---

50. What age were you when you were diagnosed? _____

In order to process this information we would appreciate you filling in your name below and sending it to the correspondence address. (At least initials must be entered for the data to be usable.) All information is treated in the strictest confidence. Research results, along with other relevant information will be published on our we site (web.ukonline.co.uk/wdnf/) as soon as it is available.

Name ..... E-mail .....

Suggested additional question:

All correspondence should be addressed to Ian Smythe, 34 Collingwood Road, Sutton, Surrey SM1 2RZ

Email: ian.smythe@ukonline.co.uk
Tel: +44 (0) 208 770 0888 Fax: +44 (0) 208 770 0936

Appendix 3: Validation of the Non-Adaptive Elements of LADS

Re-printed with permission from LADS Administrator Manual, Abridged Version.

This study (Singleton and Horne, 2001) involved 8 centres catering for adults with dyslexia; 2 were in universities, 3 were in colleges of further education, and 3 were in basic skills centres. A total of 140 adults participated in initial trials of the system; 71 of these were known to be dyslexic on the basis of conventional psychological assessments, and the remaining 69 were not dyslexic (as far as could be determined).

The participants were administered the three dyslexia-sensitive tests in LADS, with the full (not adaptive) forms of Word Recognition (120 items) and Word Construction (50 items) being used. Scores are number of items correct in all cases. Descriptive statistics of the sample are shown in Table 2.

Table 2. LADS results from three different types of institution.[9]

		Word Recognition		**Word Construction**		**Working Memory**	
	N	Mean	SD	Mean	SD	Mean	SD
University	47	99.95	12.30	38.70	9.78	5.56	2.70
FE College	47	91.38	23.90	33.27	12.33	4.28	2.54
Basic Skills	46	85.55	25.04	27.91	14.93	3.50	2.47
Total	140	90.60	23.12	32.47	13.10	4.21	2.63

As a check on the validity of the separation into 'Dyslexic' and 'Non Dyslexic' groups, all participants in Study A were administered the Adult Dyslexia Checklist (Vinegrad, 1994), which is a list of 20 yes/no questions relating to difficulties commonly experienced by adults with dyslexia, e.g. 'Do you have difficulties when writing cheques?' The dyslexic group obtained a mean (average) of 12.03 positive dyslexia indicators on the checklist (SD 3.87) while the non-dyslexic group obtained a mean of 4.47 positive dyslexia indicators (SD 3.32). Scores of 8 or higher are usually regarded indicating a strong likelihood of dyslexia. Statistical analysis (ANOVA) revealed that all three tests in LADS distinguished significantly between the dyslexic and non-dyslexic groups (see Table 3).[10]

Table 3. Comparison of dyslexic and non-dyslexic adults on the LADS tests used in Validation Study A.

		Word Recognition		**Word Construction**		**Working Memory**	
	N	Mean	SD	Mean	SD	Mean	SD
Dyslexic	71	74.10	19.83	23.68	11.00	3.20	2.22
Not Dyslexic	69	107.49	11.01	41.12	8.47	5.16	2.68
Significance level		$p < 0.001$		$p < 0.001$		$p < 0.001$	

Internal consistency statistics were also computed and this enabled unreliable items to be eliminated. The overall internal reliability (alpha) scores for the final version of LADS were: Word Recognition: $\alpha = 0.95$; Word Construction: $\alpha = 0.96$, which are very high.

The results of comparing dyslexics with non-dyslexics within the three types of institutions were broadly similar, although results for Working Memory were of a lower significance level, especially in the university group. For this reason, further research was carried out to see if a more sensitive measure for the backwards digit span test could be found. Statistical analysis showed that the most sensitive measure was a combined score created by adding the total

number of items correct to the total number of digits in their correct positions. Using this combined score showed a highly significant difference was found between the dyslexic and non-dyslexic groups (see Table 4) and the statistical significance for the three types of institution were greatly improved. It was therefore decided to use this combined score in the developmental version of LADS.

Table 4. Comparison of dyslexic and non-dyslexic adults on the combined score obtained from the LADS Working Memory test.

	N	Mean	SD
Dyslexic	71	14.67	10.65
Not Dyslexic	69	25.97	15.00
Significance level		$p < 0.001$	

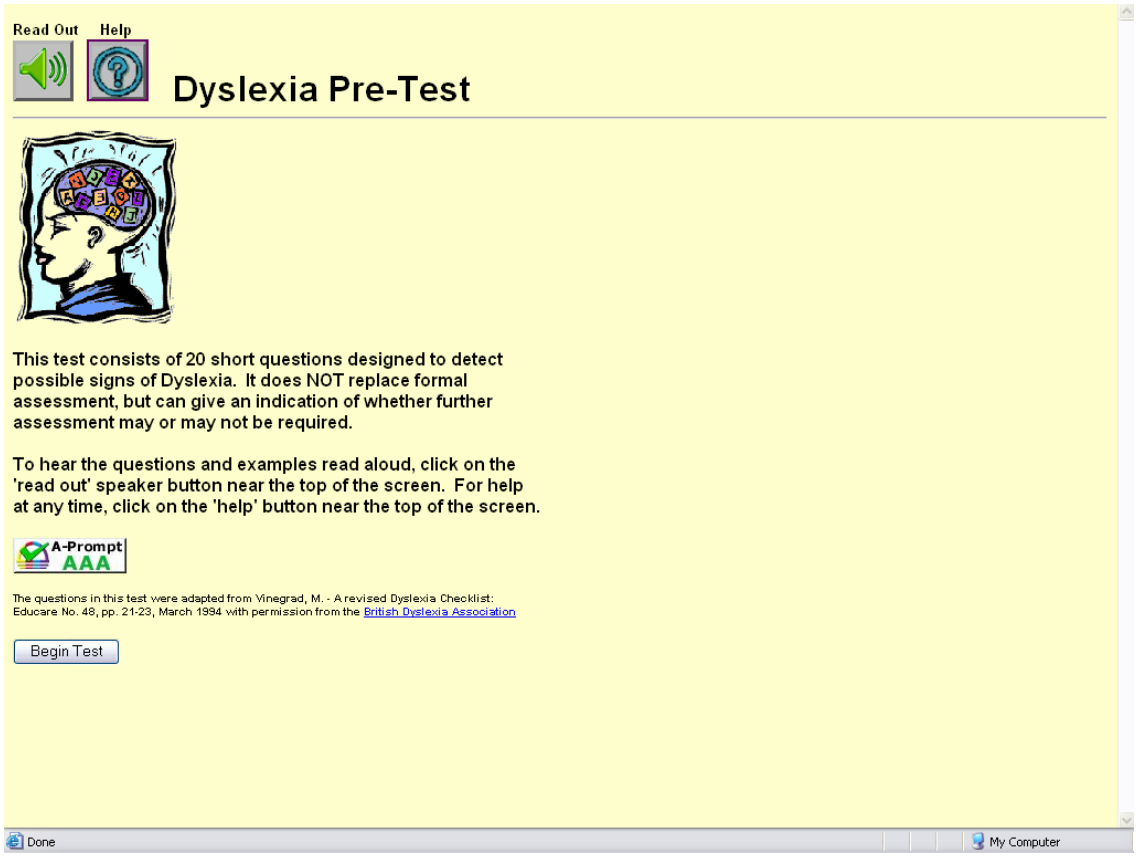
9 SD stands for 'standard deviation', a statistical term that represents the amount of variability of the scores obtained by the members of the group; the higher the SD, the greater the variance amongst the scores in the group. It is not necessary to understand this concept in order to follow the statistical results in this section.

10 The level of statistical significant is shown as a probability value (p); e.g. $p < 0.01$ means that the result obtained would be expected to occur by chance less than once in every hundred times that these data were collected. In other words, it is highly unlikely that this result is simply a chance event and therefore highly likely that the outcome represents a real difference. Similarly, $p < 0.001$ means that the result obtained would be expected to occur by chance less than once in every thousand times. Hence the smaller the p value the greater degree of confidence one can have in the finding.

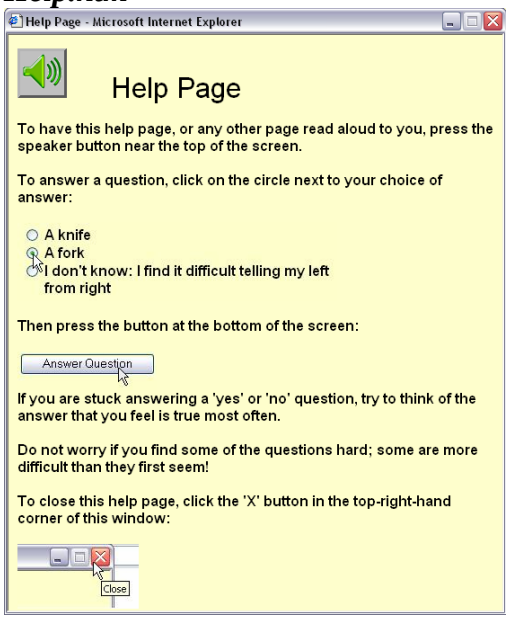
11 Correlation is a statistical measure of relatedness between scores obtained on two different measures by the same individuals. The correlation coefficient (r) varies between 1.0 (absolute correlation) and 0 (zero correlation. A positive r indicates that the scores on the two measures are both in the same form, while for the Word Construction test, the correlation was –0.96. Both these correlations are exceptionally high and are statistically significant ($p < 0.001$). These results indicate that a high degree of confidence can be placed in the fractionation algorithm as the mathematical basis for the adaptive forms of these tests. A similar calibration exercise was carried out on data from the Working Memory test to create outputs that were on the same scale as that of the Word Recognition and Word Construction tests (i.e. ranging from 1 to 9). To check this, data for Working Memory test from Study B were analysed and the correlation between the recalibrated scores and the original raw scores was found to be –0.85, which is also statistically significant ($p < 0.001$).

Appendix 4: Actual Screenshots of the Web-Based Dyslexia Screening Test

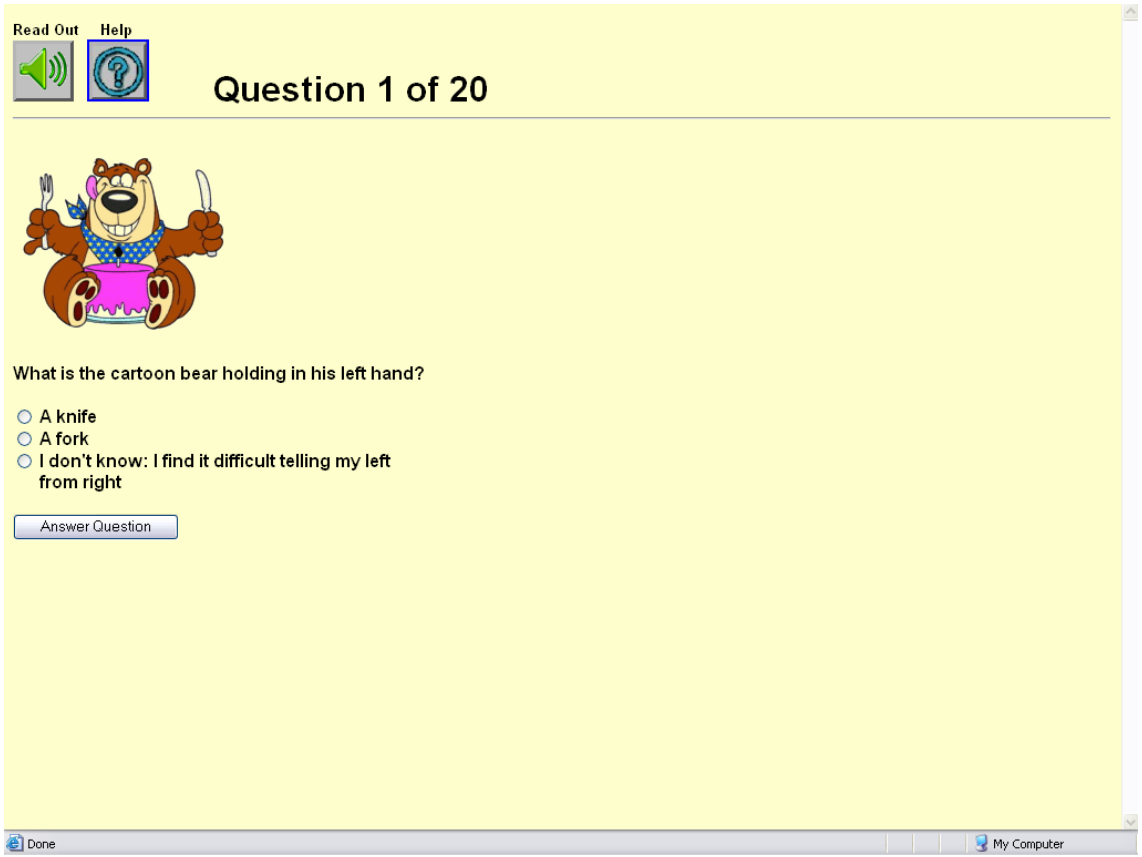
Index.htm



Help.htm



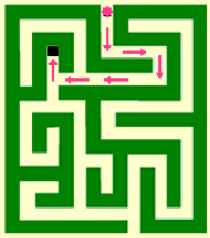
01.htm



02.htm

Read Out Help

Question 2 of 20



You are the person going into the maze (the pink dot).
Following the arrows, how would you get to the black square?

- ○ Walk into the maze, turn right, then left, then left again and finally take the second (2nd) turning on the left
- ○ Walk into the maze, turn left, then right, then right again and finally take the second (2nd) turning on the right
- ○ I don't know: I find map reading and finding my way to a strange place confusing

Answer Question

Done My Computer

03.htm

Read Out Help

Question 3 of 20

You have been asked to read aloud in front of a small group. Are you likely to:

- ○ Feel embarrassed, scared or unconfident because you dislike reading aloud, especially in front of others?
- ○ Feel fine and start reading?

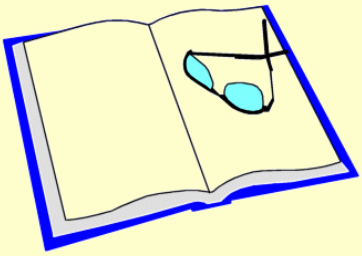
Answer Question

Applet started My Computer

04A.htm

Read Out Help

Question 4 of 20



On the next screen, you will be shown a small story.
You will be timed to see how long it takes you to read it.

However, try not to rush as it is important that you understand the story to answer later questions.

Once you have finished reading, click on the button at the bottom of the page.

I am ready to start reading

Done My Computer

04B.htm

Read Out Help

The Conference Of The Mice

There was a large cat which spread terror among the mice that lived in the cellar. Nobody dared go outside for fear of being caught by the awful cat. The mice decided to hold a conference to find a way of stopping the cat. One day, when the cat was away, mice of all ages streamed into the conference room. And certain that they could solve the matter, each one put forward a suggestion.

“Let’s build a big trap,” one mouse suggested. When this idea was turned down, another said “What about poisoning her?” But nobody knew of a poison that would kill cats. “Let’s cut her claws and teeth, so she can do no more harm” proposed another. But the conference did not approve of this idea.

At last, one of the mice, wiser than the rest, scrambled to the top of the lantern that shone over the meeting. Waving a bell, he called for silence: “We’ll tie this bell to the cat’s tail, so we’ll always know where she is!” We’ll have time to escape, and the slow and weaker mice will hear her coming and be able to hide!”

A round of hearty applause met the wise mouse’s words. “We must decide who is going to tie the bell on the cat’s tail,” he said. There was not a sound in the room except from a faint murmur: “I can’t, because…” Nobody was brave enough to put the plan into action and the conference ended without any decision being made.

I have finished reading

Timer: 2 second(s) My Computer

05.htm

Read Out Help

Question 5 of 20

Which of the following statements about the story you have just read is false?

- All of the mice suggested a way of stopping the cat.
- The group of mice did not approve of cutting the cat's claws and teeth.
- The moral of this story is "It's very easy to have bright ideas, but putting them into practice is more difficult."
- Tying a bell to the cat's tail would not help the weaker mice to escape.
- The cat was away during the convention of the mice.

Answer Question

Done My Computer

06.htm

Read Out Help

Question 6 of 20

Do you dislike reading long books?

- Yes, I hate reading long books
- No, I quite enjoy reading long books

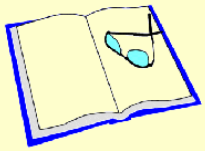
Answer Question

Applet started My Computer

07.htm

Read Out Help

Question 7 of 20



There are some mis-spelt words in the following passage. How many can you spot?
Make sure you read each word very carefully:

I was borne in Yorkshire but we moved home when I was eight. I used to quarrell with my twin brother although I wasn't suppose to. Our parents were realy worried so they seperated us and sent us to diffrent schools. We were quite happy about that because we enjoyed being apart and we had plenty to tell each other during the hollidays. My brother wanted to study medecine but I prefered to study litterature. It meant I could spend my time reading books and thinking about all the wonderful caracters in them.

- ○ 1 or 2 mistakes
- ○ 3, 4 or 5 mistakes
- ○ 6, 7 or 8 mistakes
- ○ 9, 10 or 11 mistakes
- ○ More than 11 mistakes
- ○ I don't know: I often find it difficult to spell words correctly

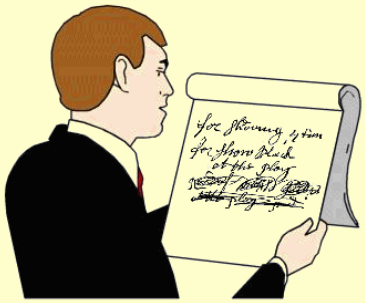
Answer Question

Done My Computer

08.htm

Read Out Help

Question 8 of 20



Is your handwriting difficult for you or others to read?

- ○ Yes, my handwriting is often bad
- ○ No, my handwriting is neat and easily readable

Answer Question

Done My Computer

09.htm

Read Out Help

Question 9 of 20

You have been asked to speak in public, in front of a group.
Are you likely to get confused?

- ○ Yes
- ○ No, I do not get confused speaking to groups of people

Answer Question

Done My Computer

10.htm

Read Out Help

Question 10 of 20

Click on the speaker at the top of the screen to hear a short telephone message.

Do you find it difficult to take messages on the telephone and pass them on correctly?

- ○ Yes, I find it difficult
- ○ No, I do not find it difficult

Answer Question

Done My Computer

11.htm

Read Out Help

Question 11 of 20

When you have to say a long word such as 'conforming,' 'phonetic' or 'photosynthesis,' do you sometimes find it hard to get the sounds in the right order?

- ○ Yes, I often get the sounds in words in the wrong order
- ○ No, I rarely mix up the sounds in words

Answer Question

Done My Computer

12.htm

Read Out Help

Question 12 of 20

Calculate the answer to 14 x 12 in your head.

Was it difficult to do the sum in your head without using your fingers or paper?

- ○ Yes, I need to use my fingers or paper
- ○ No, I worked out the answer fine
- ○ No, I did not use fingers or paper, but I usually do

Answer Question

Done My Computer

13.htm

Read Out Help

Question 13 of 20

When using the telephone, do you get numbers mixed up when you dial?

- ○ Yes, I get telephone numbers mixed up when I dial them
- ○ No, I do not get phone numbers mixed up

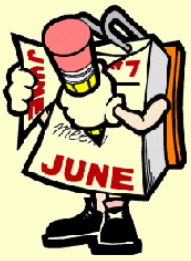
Answer Question

Done My Computer

14.htm

Read Out Help

Question 14 of 20



How many months are there between April and October? (not including April and October themselves)

- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ I don't know: I find it difficult saying the months of the year forwards fluently

Answer Question

Done My Computer

15.htm

Read Out Help

Question 15 of 20

Click on the speaker near the top of the screen to hear the months of the year backwards.

Do you find it difficult to say the months of the year backwards?

- Yes
- No

Answer Question

Applet started My Computer

16.htm

Read Out Help

Question 16 of 20

You have an appointment on 9th February at 10am and another on 10th Februrary at 9am.

Are you likely to mix up the dates and times and perhaps miss the appointments?

- Yes
- No

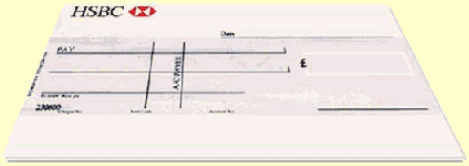
Answer Question

Applet started My Computer

17.htm

Read Out Help

Question 17 of 20



You have been asked to fill out a cheque like the one shown in the picture. Are you likely to:

- ○ Fill it in without any problems
- ○ Make some mistakes or get confused with how to fill it in

Answer Question

Applet started My Computer

18.htm

Read Out Help

Question 18 of 20

You have been asked to fill out a form like the one shown in the picture. Are you likely to:

- ○ Start to fill it in without any problems
- ○ Make some mistakes or get confused with how to fill it in, especially if the form looks complicated

Answer Question

Done My Computer

19.htm

Read Out Help

Question 19 of 20

Imagine you have to catch two buses to get somewhere:
the 95 bus followed by the 59 bus.

Are you likely to mix up the bus numbers and perhaps
wait for the wrong bus?

- Yes
- No

Answer Question

Applet started | My Computer

20.htm

Read Out Help

Question 20 of 20

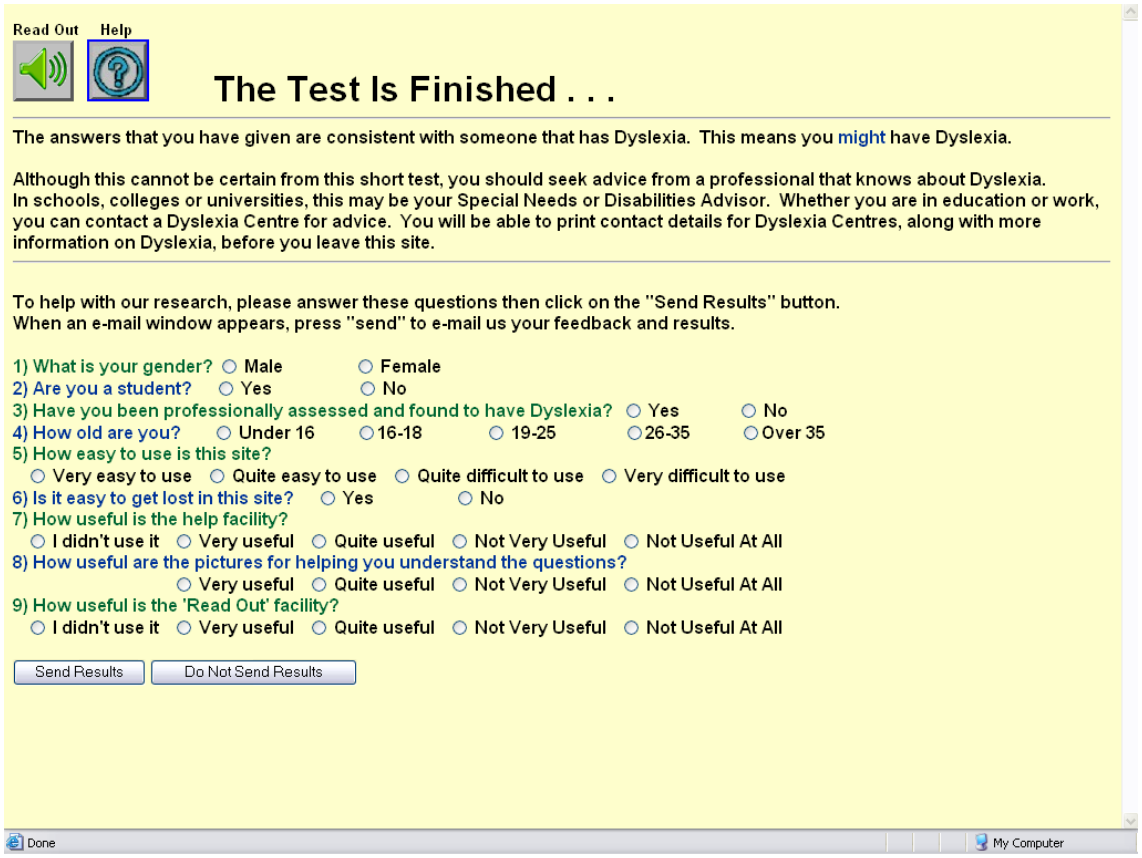
Did you find it difficult to learn your multiplication tables
at school?

- Yes
- No

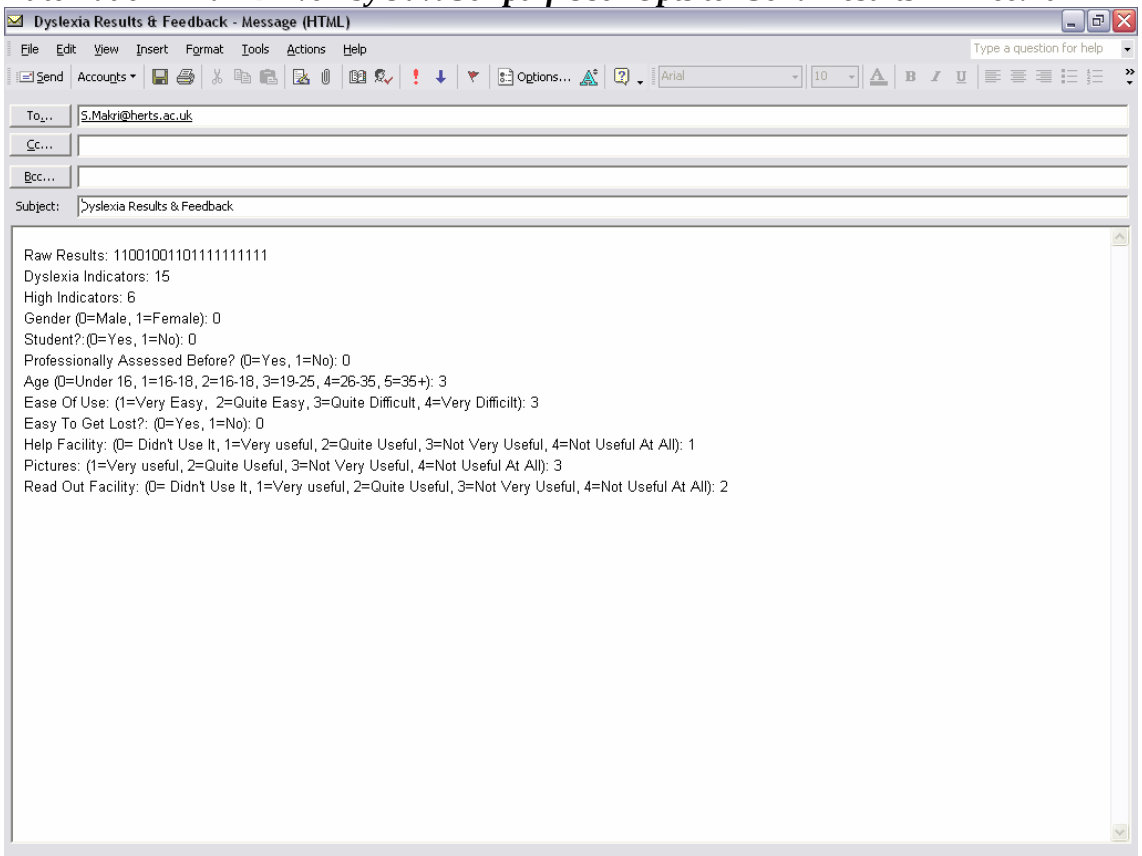
Finish Test

Done | My Computer

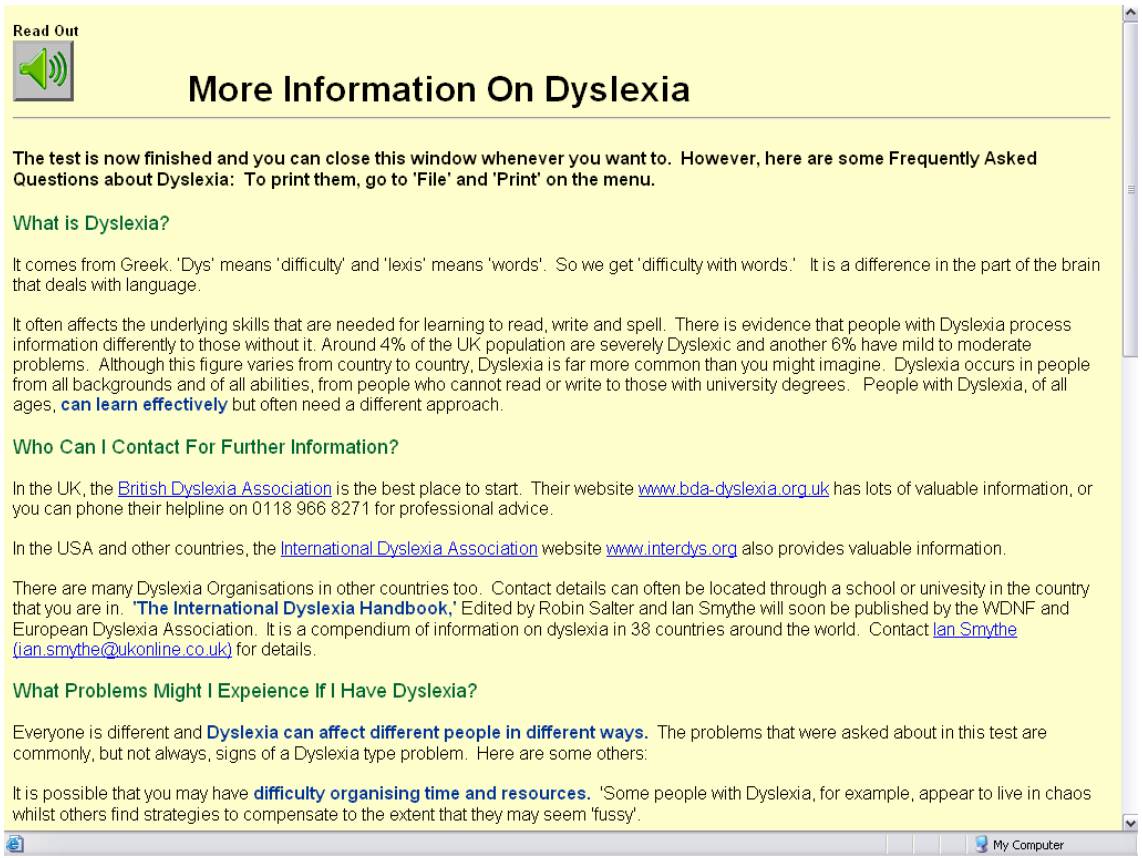
Rec.htm



Automatic E-Mail Driven by JavaScript if User Opts to 'Send Results' in Rec.htm



Faq.htm


Read Out
More Information On Dyslexia
The test is now finished and you can close this window whenever you want to. However, here are some Frequently Asked Questions about Dyslexia: To print them, go to 'File' and 'Print' on the menu.
What is Dyslexia?
It comes from Greek. 'Dys' means 'difficulty' and 'lexis' means 'words'. So we get 'difficulty with words.' It is a difference in the part of the brain that deals with language.
It often affects the underlying skills that are needed for learning to read, write and spell. There is evidence that people with Dyslexia process information differently to those without it. Around 4% of the UK population are severely Dyslexic and another 6% have mild to moderate problems. Although this figure varies from country to country, Dyslexia is far more common than you might imagine. Dyslexia occurs in people from all backgrounds and of all abilities, from people who cannot read or write to those with university degrees. People with Dyslexia, of all ages, can learn effectively but often need a different approach.
Who Can I Contact For Further Information?
In the UK, the British Dyslexia Association is the best place to start. Their website www.bda-dyslexia.org.uk has lots of valuable information, or you can phone their helpline on 0118 966 8271 for professional advice.
In the USA and other countries, the International Dyslexia Association website www.interdys.org also provides valuable information.
There are many Dyslexia Organisations in other countries too. Contact details can often be located through a school or univesity in the country that you are in. 'The International Dyslexia Handbook,' Edited by Robin Salter and Ian Smythe will soon be published by the WDNF and European Dyslexia Association. It is a compendium of information on dyslexia in 38 countries around the world. Contact Ian Smythe (ian.smythe@ukonline.co.uk) for details.
What Problems Might I Expeience If I Have Dyslexia?
Everyone is different and Dyslexia can affect different people in different ways. The problems that were asked about in this test are commonly, but not always, signs of a Dyslexia type problem. Here are some others:
It is possible that you may have difficulty organising time and resources. 'Some people with Dyslexia, for example, appear to live in chaos whilst others find strategies to compensate to the extent that they may seem 'fussy'.
My Computer

Appendix 5: Examples of the HTML Code and Underlying JavaScript Source Code Used to Implement the Web-Based Screening Test

Not all pages of the test have been listed here, since most follow exactly the same format of JavaScript code. These pages have been annotated with comments surrounded by a box, which are not part of the HTML or JavaScript code.

Note that accessibility features that were added by the A-Prompt accessibility software are highlighted. No additional accessibility problems were uncovered in a manual check. **The site can therefore be considered AAA approved.**

02.htm

This is the first page that not only sends a score to the next page (03.htm) but also reads the previous answer that has been appended to the web-address by the previous page (01.htm). The other pages calculate and pass on scores in the same way as this page, with the notable exception of 04B.htm.

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN" "http://www.w3.org/TR/html4/strict.dtd">
<html lang="eng">
```

This specifies the document language and tells the browser that the site strictly complies with the HTML 4.0 specification.

```
<head>
<meta name="keywords" content="Dyslexia, dyslexic, test, pre-test, screening, assessment" />
<meta name="description" content="Dyslexia Pre-Test" />
```

The meta descriptions allow the site to be easily indexed by search engines.

```
<title>Question 1 of 20</title>
</head>

<title>Dyslexia Pre-Screening Test</title>
<body>
<body bgcolor="#FFFFCC" text="#000000" link="#0000FF" alink="#0000FF" vlink="#660066">
```

This sets the background colour of the page to cream, text to black, regular and active links to blue and followed links to purple. This can be overwritten by users who customise their browser settings. These colours were deemed by A-Prompt to contrast well together.

```
<font face="Arial" size=2><b>Read Out     Help</font></b>
<br>

<applet code=AudioButton.class name=Audio1 width=55 height=55>
  <param name=image value="speak.gif">
  <param name=audio value="02.au">
</applet>
```

This is the code to start the 'Read Out' Java applet, which plays the sound 02.au. The applet was used with permission from www.phon.ucl.ac.uk/home/mark/audio/play.htm [accessed 31/03/03]

```
  <a href="javascript:popUp('help.htm')"><img src="question.jpg" alt="Click here for help"></a>
```

```
<script>
function popUp(URL) {
day = new Date();
id = day.getTime();
eval("page" + id + " = window.open(URL, '" + id + "',
'toolbar=0,scrollbars=0,location=0,statusbar=0,menubar=0,resizable=0,width=550,height=640,left = 5,top = 87');");
}
```

This piece of JavaScript pops up the help facility, help.htm when the user clicks on the help button.

```
</script>
<noscript><p>
<br />Sorry, but in order to take the dyslexia pre-test, you need to have JavaScript enabled in your browser.<br />
</p></noscript>
```

A-Prompt insisted on a NOSCRIPT tag being used every time a potential piece of JavaScript could fail and leave the user wondering why the page was unable to load.

```
<font face="Arial" size=6><b>      Question 2 of 20</b></font>
<br><hr><br>
<img src="02.gif" alt="For help, click on the button at the top of the screen">
<br><br>
<font face="Arial" size=3><b>
You are the person going into the maze (the pink dot).<br>
Following the arrows, how would you get to the black square?
</b><br>
</font>

<script>
var answer = 0
var checkAnswered = -1
```

This ensures that no previous answer has been made

```
var d = document.location.toString();
var e = d.split("?")[1];
var parms = new Array();
var valus = new Array();
var f = e.split("&");
for(var i=0;i<f.length;i++) {
  parms[i]=f[i].split("=")[0];
  valus[i]=f[i].split("=")[1];
}
```

Once the page has loaded, this goes through the web-address and splits everything that follows the address and is preceded by a '?'. It places each previous answer into an array, allowing the answers to be used in calculations later.

The facility to pass and receive parameters between pages was adapted from JavaScript examples: www.js-x.com/example/?ex=234&mode=2 [accessed 31/03/03]

```
</script>
<noscript><p>
<br />Sorry, but in order to take the dyslexia pre-test, you need to have JavaScript enabled in your browser.<br />
</p></noscript>


<FORM name=form> <font face="Arial" size=3><b>
<input type="radio" name="q1" value="1" onclick="answer=this.value, checkAnswered=this.value" id="radio-1062261547" onkeypress="answer=this.value, checkAnswered=this.value"><label for="radio-1062261547"> Walk into the maze, turn right, then left, then left again</label><br>     and finally take the second (2nd) turning on the left<br>
<input type="radio" name="q1" value="0" onclick="answer=this.value, checkAnswered=this.value" id="radio-1062259931" onkeypress="answer=this.value, checkAnswered=this.value"><label for="radio-1062259931"> Walk into
```

the maze, turn left, then right, then right again</label>
     and finally take the second (2nd) turning on the right
<input type="radio" name="q1" value="1" onclick="answer=this.value, checkAnswered=this.value" id="radio-1062243251" onkeypress="answer=this.value, checkAnswered=this.value"><label for="radio-1062243251"> I don't know: I find map reading and finding my way</label>
     to a strange place confusing

This creates option buttons with pre-assigned values of 0 or 1 depending on whether the option signifies a dyslexia-type response or not. Once an answer is selected, the variable 'checkAnswered' is changed from -1 to either 0 or 1. This is to ensure that the user answers the question before proceeding to the next one and is checked later. Notice that the answer variable for the question also takes the value of the selected option: 0 for a non-dyslexia-type response and 1 for a dyslexia-type response.

A-Prompt named each option box and provided functionality to allow options to be selected by the keyboard as well as the mouse.

<INPUT TYPE="BUTTON" VALUE="Answer Question" onClick="passScore()" onkeypress="passScore()">
</form>

This input button allows the user to confirm the selected answer from the option buttons and progress to the next page (i.e. the next question).

<script>
function passScore() {

if (checkAnswered==-1) alert('Please answer the question before you try to continue. For help, click on the help button (?) near the top of the screen.');

This provides a check facility so that the user cannot go onto the next question without answering the current question.

if (checkAnswered!=-1)
{
var d = document.location.toString();
var e = d.split("?")[1];
var urlString = '03.htm' + '?';
var s0='';
if(document.form.q1.value!="") s0 = 'q1='+answer+'&';
urlString += e+"&"+s0;
urlString = urlString.substr(0,urlString.length-1);
document.location = urlString;
}}

This code tells the browser to append the question number (q1=) and the answer (0 or 1) to the web address that the browser goes to next (i.e. the next question). Answers are separated by an ampersand and the string of answers is proceeded by a question mark. E.g. a typical web address by question 4 would look like this: 04A.htm?q0=0&q1=1&q2=0.

The facility to pass and receive parameters between pages was adapted from JavaScript examples: www.js-x.com/example/?ex=234&mode=2 [accessed 31/03/03]

</script>
<noscript>

Sorry, but in order to take the dyslexia pre-test, you need to have JavaScript enabled in your browser.
</noscript>

</body>
</html>

04B.htm

This page reads the previous scores in the web-address and passes them on to 05.htm, however it calculates a dyslexia-type-response depending on the time taken to read the page. A dyslexia-type response is noted as >50 seconds. Only the code that differs from the example above has been included.

```
var counter = 0;
// call Update function in 2 seconds after first load
ID=window.setTimeout("Update();",2000);
function Update() {
  counter++;
  window.status="Timer: "+counter+" second(s)";
```

This displays the timer count on the windows status bar at the bottom of the screen. This code also allows the timer to update.

The timer example was adapted from http://www.cs.nccu.edu.tw/~lien/BCC/HTML/Js4/ch05_timeout.htm [accessed 31/03/03]

```
// set another timeout for the next count
  ID=window.setTimeout("Update();",2000);
}

<INPUT TYPE="BUTTON" VALUE="I have finished reading" onClick="passScore()" onkeypress="passScore()">
</form></font></b>

<script>
function passScore() {

var finaltime = counter
alert("You read the story in " +finaltime+ " seconds.")
```

This brings up a message box informing the participant, once they have finished reading, how long it took them to read the short story. Only once the user clicks 'I have finished reading' will the timer stop.

```
var d = document.location.toString();
var e = d.split("?")[1];
var s0='';
var answer =0;
if(finaltime>50) answer=1;
```

A dyslexia-type response (i.e. an answer of 1) is recorded if the time taken to read the short story is > 50 seconds.

```
if(finaltime<10) alert("That was very quick! Please make sure that you are truthful when answering the questions to make sure that, at the end of the test, you get the correct recommendation.");
```

This brings up an error message box if the user has read the story in less than 10 seconds, which is faster than humanly possible.

Rec.htm

This is the final page that responses to questions are passed onto. From here, results are calculated and, depending on the outcome, the user is informed that from the responses given that they 'might' or 'might not' have dyslexia. This page also handles the usability questionnaire, e-mailing all results together when the user elects to 'Send Results.' Once again, some duplicated code is omitted in this listing.

```
var snd="Unanswered";
var pics="Unanswered";
var hlp="Unanswered";
var easy="Unanswered";
var age="Unanswered";
var gen="Unanswered";
var lost="Unanswered";
var assess="Unanswered";
var student="Unanswered";
```

This initialises variables to store details like the participant's age and their views on the site's usability. Because it was not decided to force users to answer some of these questions, the default value of 'Unanswered' is stored unless the user decides to answer the question.

```
var indicator = 0
for (var i=0;i<20;i++) {
indicator = indicator + parseInt(valus[i]);}

//Notice that a FOR loop would be inappropriate here, since we are adding up specific question answers
var highindicator =
parseInt(valus[0])+parseInt(valus[3])+parseInt(valus[6])+parseInt(valus[9])+parseInt(valus[10])+parseInt(valus[12])+p
arseInt(valus[13])+parseInt(valus[15)]+parseInt(valus[16])+parseInt(valus[17])+parseInt(valus[18])+parseInt(valus[19]
);
```

The FOR loop adds up all the indicator scores in an iterative fashion

This takes the 12 specific high-indicator answers that Vinegrad defined and adds them together. Notice the use of the parseInt function to change the answer values from string to integer to facilitate their addition.

```
if(highindicator>5 || indicator>7){document.write('<b><font face="Arial" size=3>The answers that you have given are
consistent with someone that has Dyslexia.  This means you <font color=#003399>might</font color>
have Dyslexia.<br><br>Although this cannot be certain from this short test, you should seek advice from a professional
that knows about Dyslexia.<br>In schools, colleges or universities, this may be your Special Needs or Disabilities
Advisor.  Whether you are in education or work, you can contact a Dyslexia Centre for
advice.  You will be able to print contact details for Dyslexia Centres, along with more information on
Dyslexia, before you leave this site.</font></b><br><hr>');}
```

This is the IF statement that determines whether the final recommendation report will suggest that the participant 'might' or 'might not' have dyslexia. Note the use of the document.write command to display different text on the screen in either case.

```
else{document.write('<font face="Arial" size=3><b>The answers that you have given are consistent with someone that
does not have Dyslexia.  This means it is <font color=#003399>unlikely</font color> that you have
Dyslexia.<br><br>However this cannot be completely certain from such a short test.  If you are still
concerned and would like to seek further advice, you will be able to print contact details for Dyslexia Centres, along
with more information on Dyslexia, before you leave this site.</font></b><br><hr>');}

document.write('<b><font face="Arial" size=3><b><br>To help with our research, please answer these questions then
click on the "Send Results" button.<br>When an e-mail window appears, press "send" to e-mail us your feedback and
results.');
</script>
<noscript><p>
<br />Sorry, but in order to take the dyslexia pre-test, you need to have JavaScript enabled in your browser.<br />
</p></noscript>

<form name=form>

<font color=#006633>1) What is your gender?</font color>
<input type="radio" name="gender" onclick="gen=0" onkeypress="gen=0">
Male               
<input type="radio" name="gender" onclick="gen=1" onkeypress="gen=1"> Female<br>

<font color=#003399>2) Are you a student?</font color>    
```

```
<input type="radio" name="studnt" onclick="student=0" onkeypress="student=0">
Yes               &nbs
p;  
<input type="radio" name="studnt" onclick="student=1" onkeypress="student=1"> No<br>

<font color=#006633>3) Have you been professionally assessed and found to have Dyslexia?</font color> 
<input type="radio" name="assessed" onclick="assess=0" onkeypress="assess=0">
Yes            
<input type="radio" name="assessed" onclick="assess=1" onkeypress="assess=1"> No<br>

<font color=#003399>4) How old are you?</font color>      
<input type="radio" name="aged" onclick="age=0" onkeypress="age=0"> Under
16        
<input type="radio" name="aged" onclick="age=1" onkeypress="age=1">16-
18             
<input type="radio" name="aged" onclick="age=2" onkeypress="age=2"> 19-
25              
<input type="radio" name="aged" onclick="age=3" onkeypress="age=3">26-
35          
<input type="radio" name="aged" onclick="age=4" onkeypress="age=4">Over 35<br>

<font color=#006633>5) How easy to use is this site?</font color><br>  
<input type="radio" name="ease" onclick="easy=1" onkeypress="easy=1"> Very easy to use  
<input type="radio" name="ease" onclick="easy=2" onkeypress="easy=2"> Quite easy to use  
<input type="radio" name="ease" onclick="easy=3" onkeypress="easy=3"> Quite difficult to use  
<input type="radio" name="ease" onclick="easy=4" onkeypress="easy=4"> Very difficult to use<br>

<font color=#003399>6) Is it easy to get lost in this site?</font color>    
<input type="radio" name="navi" onclick="lost=0" onkeypress="lost=0">
Yes               &nbs
p; 
<input type="radio" name="navi" onclick="lost=1" onkeypress="lost=1"> No<br>

<font color=#006633>7) How useful is the help facility?</font color><br>  
<input type="radio" name="help" onclick="hlp=0" onkeypress="hlp=0"> I didn't use it  
<input type="radio" name="help" onclick="hlp=1" onkeypress="hlp=1"> Very useful  
<input type="radio" name="help" onclick="hlp=2" onkeypress="hlp=2"> Quite useful  
<input type="radio" name="help" onclick="hlp=3" onkeypress="hlp=3"> Not Very Useful  
<input type="radio" name="help" onclick="hlp=4" onkeypress="hlp=4"> Not Useful At All<br>

<font color=#003399>8) How useful are the pictures for helping you understand the questions?</font
color><br>              &nbs
p;                
    
<input type="radio" name="pictures" onclick="pics=1" onkeypress="pics=1"> Very useful  
<input type="radio" name="pictures" onclick="pics=2" onkeypress="pics=2"> Quite useful  
<input type="radio" name="pictures" onclick="pics=3" onkeypress="pics=3"> Not Very Useful  
<input type="radio" name="pictures" onclick="pics=4" onkeypress="pics=4"> Not Useful At All<br>

<font color=#006633>9) How useful is the 'Read Out' facility?</font color><br>  
<input type="radio" name="sound" onclick="snd=0" onkeypress="snd=0"> I didn't use it  
<input type="radio" name="sound" onclick="snd=1" onkeypress="snd=1"> Very useful  
<input type="radio" name="sound" onclick="snd=2" onkeypress="snd=2"> Quite useful  
<input type="radio" name="sound" onclick="snd=3" onkeypress="snd=3"> Not Very Useful  
<input type="radio" name="sound" onclick="snd=4" onkeypress="snd=4"> Not Useful At All<br><br>

<input type="button" value="Send Results" onClick="sendEmail()" onkeypress="sendEmail()">
<input type="button" value="Do Not Send Results" onClick="leave()" onkeypress="leave()">
</form></font></b>

<script>
function sendEmail() {
var address = "S.Makri@herts.ac.uk";
```

```
var subject = "Dyslexia Results & Feedback";
var body = "Raw Results: "
+valus[0]+valus[1]+valus[2]+valus[3]+valus[4]+valus[5]+valus[6]+valus[7]+valus[8]+valus[9]+valus[10]+valus[11]+v
alus[12]+valus[13]+valus[14]+valus[15]+valus[16]+valus[17]+valus[18]+valus[19]+"\nDyslexia Indicators:
"+indicator+"\nHigh Indicators: "+highindicator+"\nGender (0=Male, 1=Female): "+gen+"\nStudent?:(0=Yes, 1=No):
"+student+"\nProfessionally Assessed Before? (0=Yes, 1=No): "+assess+"\nAge (0=Under 16, 1=16-18, 2=16-18,
3=19-25, 4=26-35, 5=35+): "+age+"\nEase Of Use: (1=Very Easy,  2=Quite Easy, 3=Quite Difficult, 4=Very Difficilt):
"+easy+"\nEasy To Get Lost?: (0=Yes, 1=No): "+lost+"\nHelp Facility: (0= Didn't Use It, 1=Very useful, 2=Quite
Useful, 3=Not Very Useful, 4=Not Useful At All): "+hlp+"\nPictures: (1=Very useful, 2=Quite Useful, 3=Not Very
Useful, 4=Not Useful At All): "+pics+"\nRead Out Facility: (0= Didn't Use It, 1=Very useful, 2=Quite Useful, 3=Not
Very Useful, 4=Not Useful At All): "+snd;
document.location = "mailto:"+escape(address)+"?subject="+escape(subject)+"&body="+escape(body)+" ";
location.href="faq.htm";}
```

The sendEmail() function invokes the user's default e-mail software and automatically fills out the e-mail address to send results to and the subject. Their raw results, along with calculated 'indicator' and 'high-indicator' results are displayed in the body of the e-mail. This is accompanied by any personal or usability answers given in rec.htm. To send the e-mail, the user must click the 'send' button (or equivalent) in their e-mail software.

Note that the escape function converts any non-alphanumeric character to its ASCII value (in hexadecimal notation). In this way, any ampersands and question marks in the subject or body fields do not confuse the browser when it interprets the mailto: URL.

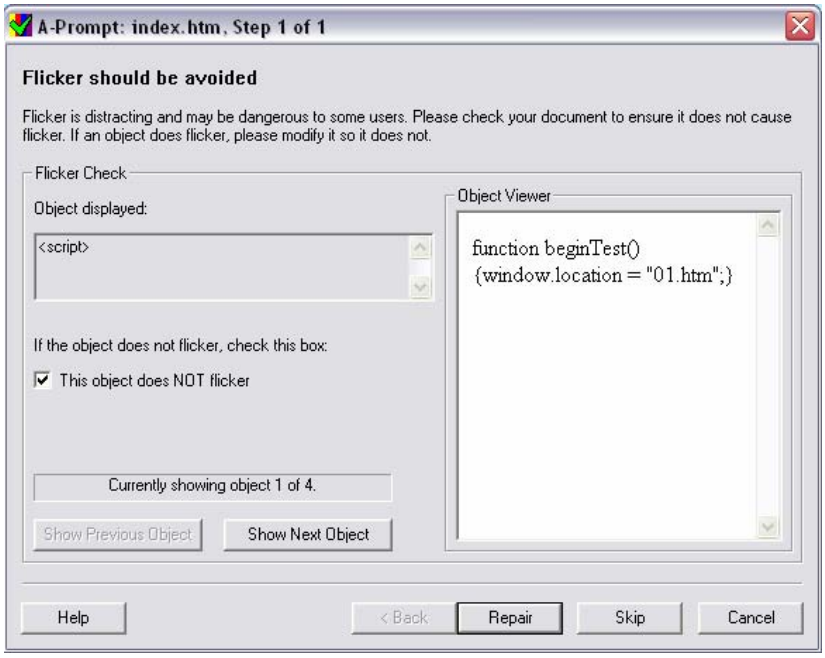
The automatic e-mail function was adapted from Webreference: http://www.webreference.com/js/column70/7.html [accessed 31/03/03]

```
function leave() {
location.href="faq.htm";}
</script>
```

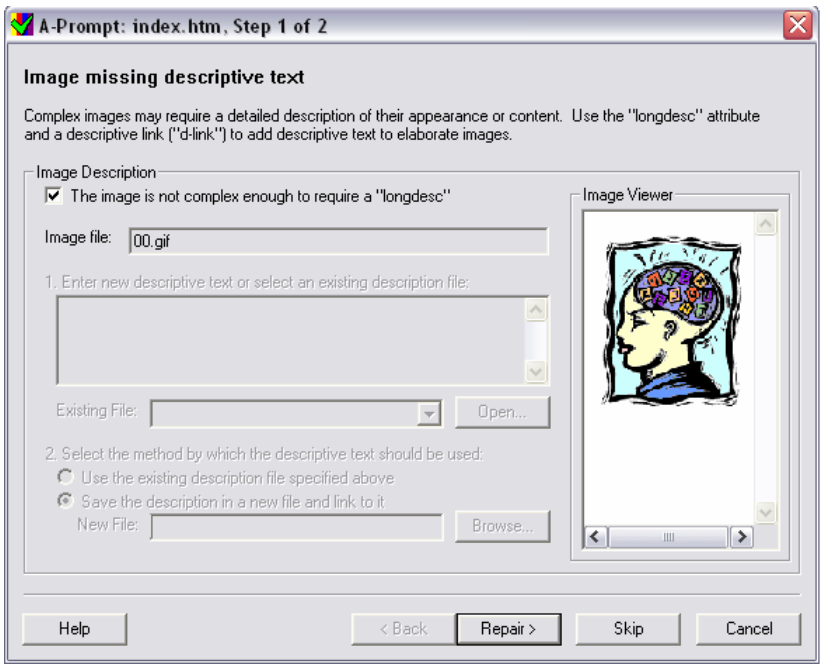
At the end, whether the user decides to send their results by e-mail or not, they are automatically taken to the faq.htm, where they are presented with Frequently Asked Questions about dyslexia.

Appendix 6: Screenshots of Selected A-Prompt Tests and Repairs

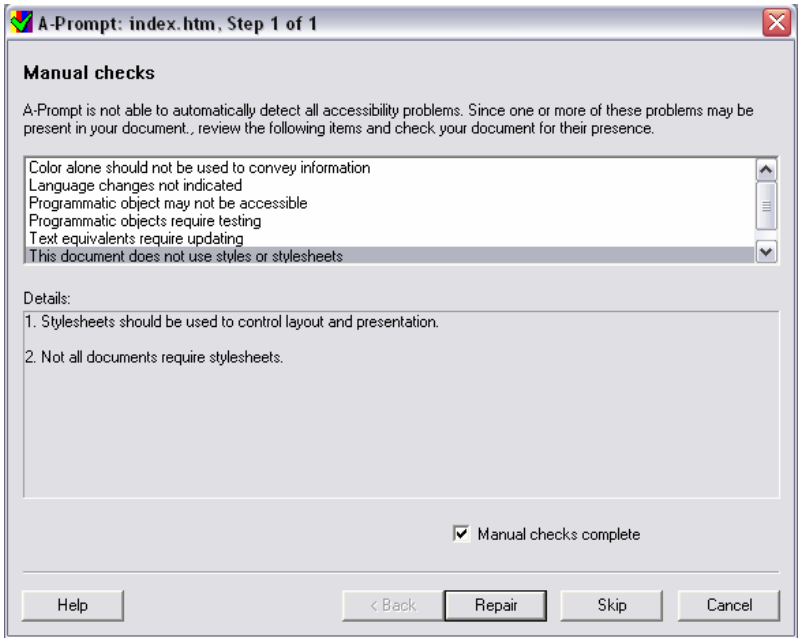
Note that, unlike Bobby, A-Prompt allows the user to disagree with a particular statement. For example, simple images with a short alternative (ALT) description may not be complex enough to require a long description too (LONGDESC).



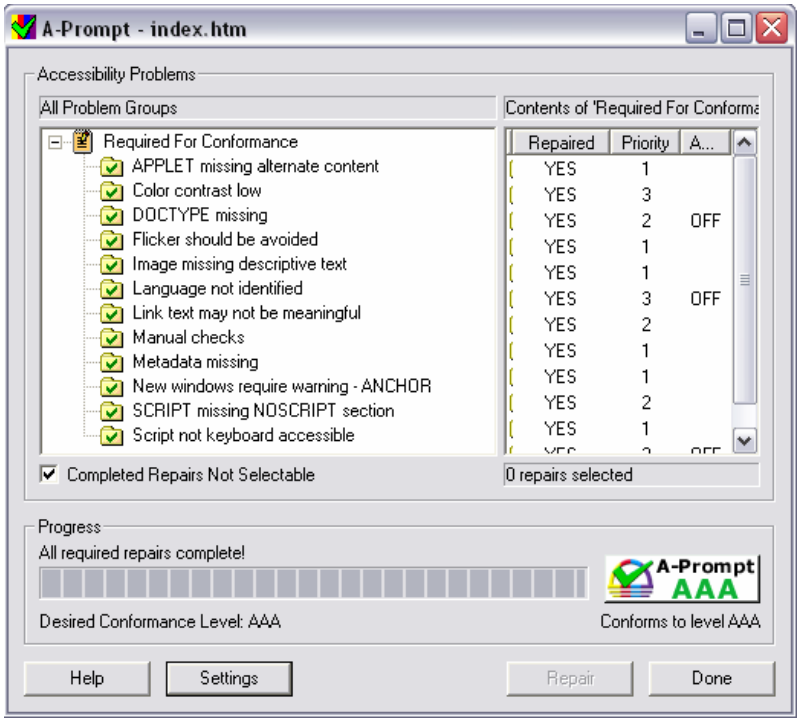
A-Prompt allows the user to verify that the movement from one web address to another (i.e. between questions) will occur without flickering.



It is possible to avoid entering a long description (LONGDESC) for an image if it does not require an additional text description than the one provided in the alternative description (ALT).



Manual checks reflect many items such as style sheets that were considered during prototyping.



After repairing all accessibility errors, a website is entitled to display the 'A-Prompt AAA Approved' image in the bottom-right-hand corner of the screen.

Appendix 7: Bobby Report on Accessibility of Web-Based Test

Note that the 'user checks' are identical to those implemented and already checked by the A-Prompt software. Highlighted comments have been added to explain where some of the results may be falsely positive. It can be concluded that although the site would be free of all priority 1, 2 and 3 errors should the falsely positive results be ignored, the site does not receive Bobby approval at the moment. It was decided to only list A-Prompt AAA approval on the homepage of the site to avoid any possible misleading statements.

Priority 1 Accessibility

This page does not meet the requirements for Bobby A Approved status. Below is a list of **1** Priority 1 accessibility error(s) found:

1. Provide alternative text for each APPLET. *(1 instance)*
   Line 24

A-Prompt was able to identify that the 'Read Out' Java Applet already had a text description, therefore it would not be necessary to name it twice.

Priority 1 User Checks

User checks are triggered by something specific on the page; however, you need to determine manually whether they apply and, if applicable, whether your page meets the requirements. Bobby A Approval requires that all user checks pass. Even if your page does conform to these guidelines they appear in the report. Please review these **7** item(s):

1. If you can't make a page accessible, construct an alternate accessible version.
2. Provide accessible alternatives to the information in scripts, applets, or objects. *(1 instance)*
   Line 24
3. If you use color to convey information, make sure the information is also represented another way. *(2 instances)*
   Lines 29, 47
4. Make sure pages are still usable if programmatic objects do not function. *(1 instance)*
   Line 24
5. Synchronize equivalent alternatives with multimedia presentations. *(1 instance)*
   Line 24
6. Make sure that the page does not cause the screen to flicker rapidly.
7. If an image conveys important information beyond what is in its alternative text, provide an extended description. *(2 instances)*
   Lines 29, 47

The following **2** item(s) are not triggered by any specific feature on your page, but are still important for accessibility and are required for Bobby A Approved status.

8. Identify any changes in the document's language.
9. Use the simplest and most straightforward language that is possible.

Priority 2 User Checks

User checks are triggered by something specific on the page; however, you need to determine manually whether they apply and, if applicable, whether your page meets the requirements. Bobby AA Approval requires that all user checks pass. Even if your page does conform to these guidelines they appear in the report. Please review these **10** item(s):

1. Check that the foreground and background colors contrast sufficiently with each other. *(3 instances)*
   Lines 19, 29, 47
2. If objects use event handlers, make sure they do not require use of a mouse.
3. Avoid use of obsolete language features if possible. *(6 instances)*
   Lines 21, 24, 43, 49, 58, 64
4. Use style sheets to control layout and presentation wherever possible.
5. Is the user made aware that there will be pop-up windows or changes in the active window? *(1 instance)*
   Line 60
6. Make sure that all elements that have their own interface are operable without a mouse. *(1 instance)*
   Line 24
7. If this gif image is animated, make sure it does not contain fast or distracting motion. *(1 instance)*
   Line 47
8. If scripts create pop-up windows or change the active window, make sure that the user is aware this is happening. *(2 instances)*
   Lines 10, 31
9. Add a descriptive title to links when needed.
10. Mark up any quotations with the Q and BLOCKQUOTE elements.

The following **7** item(s) are not triggered by any specific feature on your page, but are still important for accessibility and are required for Bobby AA Approved status.

11. Make sure that all link phrases make sense when read out of context.
12. Group related elements when possible.
13. Make sure your document validates to formal published grammars.
14. Is there a site map or table of contents, a description of the general layout of the site, the access features used, and how to use them?
15. Is there a clear, consistent navigation structure?
16. Use the latest technology specification available whenever possible.
17. Where it's possible to mark up content (for example mathematical equations) instead of using images, use a markup language (such as MathML).

Priority 3 Accessibility

Priority 3 User Checks

User checks are triggered by something specific on the page; however, you need to determine manually whether they apply and, if applicable, whether your page meets the requirements. Bobby AAA Approval requires that all user checks pass. Even if your page does conform to these guidelines they appear in the report. Please review these **4** item(s):

1. Consider furnishing keyboard shortcuts for form elements.

This seems to be a falsely positive result, since A-Prompt added keyboard shortcuts for all input elements of forms.

2. If this document is part of a collection, provide metadata that identifies this document's location in the collection.

A-Prompt added a document description for each page. For example page 03.htm was labelled 'Question 1 of 20.' Therefore this is likely to be another falsely positive error.

3. Use the ABBR and ACRONYM elements to denote and expand any abbreviations and acronyms that are present.

No acronyms or abbreviations were included, therefore this is likely to be another falsely positive error.

4. Consider adding keyboard shortcuts to frequently used links.

There are no frequently visited links that shortcuts would benefit. In addition, the buttons to answer questions, and therefore go back and forth between the questions are all keyboard-shortcut accessible.

The following **5** item(s) are not triggered by any specific feature on your page, but are still important for accessibility and are required for Bobby AAA Approved status.

5. Is there distinguishing information at the beginning of headings, paragraphs, lists, etc.?
6. If there is a search feature, are there different types of searches for different skill levels and preferences?
7. Are there navigation bars for easy access to the navigation structure?
8. Do you allow users to customize their experience of the web page?
9. Is there a consistent style of presentation between pages?

Appendix 8: Potential for Future Study within the Field of Dyslexia and IT

8.1 Impact study on the usefulness of assistive technology and study on the relationship between the usefulness of assistive technology, personality and the individual's profile of dyslexia

The usefulness of assistive technology over time to individuals with different profiles of dyslexia was examined by an MSc student of the University of Hull in 1998, although the researcher found it difficult to find participants that would aid her research on a regular basis.

Although participation is still an issue, a new research angle involves administering standard psychometric personality tests to each dyslexic individual and examining any correlation between personality types or traits and how useful the individual finds assistive technology such as screen-readers and brainstorming packages. This study would aim to explore the possibility that individuals with different profiles of dyslexia and different personality traits might benefit from a more tailored use of assistive technologies. For example a dyslexic student with fewer reading and spelling difficulties and more time-management difficulties might benefit more from time management software rather than screen-reader software.

8.2 Comparison between dyslexia screening software and examination of inconsistencies within a single screening method

No research has yet been carried out on the inter-comparison of computer-based dyslexia screening tests, making the selection of the 'best' screening method an arduous process. However this proposal may be best suited to partial fulfilment of a statistics degree, or an interdisciplinary student with knowledge of statistical techniques such as ANOVA *(see appendix 3).*

In addition, research has not been undertaken in examining inconsistencies within a single computer-based screening method such as LADS. Individuals should be tested on multiple occasions over a suitable timeframe to examine the variability of test results. Furthermore, an attempt can be made to determine whether the degree of inconsistencies vary amongst individuals of different age, gender or educational background. Dr. Chris Singleton, head of development of the software, is keen for such research to take place.

8.3 Study into effective multi-sensory screening for monolingual, bilingual and multilingual individuals

This research is based on the notion that dyslexia has different manifestations and a different level of impact on individuals depending on the individual's mother tongue. Whilst many computer-based dyslexia screening tests have been developed in English, many of which offering word construction and decomposition tests (such as LADS) it can be hypothesised that different languages require different types of tests to be conducted in order to provide the most effective dyslexia screening.

Differences may occur between monolingual dyslexics and those who speak or perhaps write a different language. Differences should be examined in those with English as their sole language, primary language or secondary language of communication and used to devise and test the validity of multi-media-based dyslexia screening tests in languages other than English.

Ian Smythe, of the International Dyslexia Association is currently developing a Macromedia Flash based multi-media screening test, also for deployment over the web, in Mandarin Chinese. This was based on his study on 'Cognitive Profiles and Literacy in a Multi-Lingual Community.' Although time constraints prevented further research in this area for the purpose of this dissertation, future study might build on Smythe's theory that profiles and severity of dyslexia varies between languages, regardless of factors such as non-verbal intelligence, age, school background, gender, language background, reading and spelling ability.
(see http://www.bdainternationalconference.org/presentations/a_thu_p1_b_20.htm [Accessed 27/04/03])

8.4 Further proposals considered by the Centre for Applied Research in Educational Technologies, University of Cambridge

The following report excerpt outlines other possible research projects identified by the University of Cambridge's research group CARET, including their preferred choice: An online screening test that, as of May 2003 has been developed in Macromedia Flash format and is undergoing beta validity testing.

Re-printed from http://www.caret.cam.ac.uk/pdfs_ppts/dyslexia_report.pdf (Page 9) [Accessed 01/04/03] with permission.

Possible development proposals
In the light of our findings, the following may be appropriate development projects for CARET:

Study aid
CARET could develop a comprehensive, flexible, intelligent study aid targeted at adults of high intellectual ability. This product should include mind mapping, text-to-speech, word and phrase prediction (including in specialist academic disciplines), and spell checking with homophone awareness. *Comments: This would be a large project and would partially replicate existing software. This proposal is not recommended.*

OKI development
The initial findings of this report, together with further research, could be used to develop the Open Knowledge Initiative (OKI) Learning Management Support system's[11] student tracking capabilities. Tracking may be able to be used to screen for possible dyslexia or to train dyslexics in effective learning strategies based on their online behaviour and success rate. *Comments: This would provide a new and integrated approach to diagnosis and training. Both the Dyslexia Support Coordinator and Warwick Bailey, leader of the CARET OKI project, consider this to be an exciting proposal, though it is likely to be very complex to implement.*

Online screening
CARET could develop an online dyslexia screening program, making use of multiple modes of information presentation, such as audio/text, colour contrasts, and linear/diagrammatic. *Comments: Taking part in beta testing of LADS CD-based screening test for Higher Education may help clarify the potential for online testing development. A copy of the beta version LADS test has been requested.*

Visual thinking
CARET could develop an online environment that facilitates visualisation of ideas and nonverbal communication. According to West[12], creative visual thinkers (many of whom have had difficulty with verbal skills), aided by computers, will be at the forefront of innovation in a dramatically changing society. *Comments: This is an ambitious project but a good match with CARET's interests in visualisation and collaborative learning.*

University dyslexic community learning environment
CARET could develop a web environment for the dyslexic community at the University of Cambridge that is available to all teachers and students in the University. The web environment should include multiple modes of access to information (e.g. choice of colour contrasts, hyperlinked mind-map, audio options), a discussion board (possibly using audio messages or spatial maps), and academic and support resources. *Comments: This project could be a variant of the OKI environment. It has great potential for supporting students directly; generating data for research on dyslexics'*

learning; and raising awareness within the University community of both dyslexic students' challenges and special skills. However, major parts of this proposal fall outside CARET's scope of work.

[11] The OKI Learning Management Support system is a modular, Internet-based environment for assembling, delivering and accessing educational resources currently being developed by CARET, in conjunction with other institutions. As part of the project, tools focussed on communication, course logistics, integration with campus support services, online testing, self-testing, and course material management are being developed.

[12] West, TG *In the Mind's Eye*, 1991 Review and summary at http://lava.ds.arch.tue.nl/books/west.html

Appendix 9: Planning Issues, Obstacles and How They Were Overcome

It was necessary to maintain a dedicated and methodical approach towards the research, given the fact that relatively little research has been conducted in the field of Dyslexia and IT. Importantly, it was important to assess the feasibility of certain research angles early on in the project. Note in Figure 9.3 that it was decided to allow almost a month to explore the feasibility and various research angles available. Figure 9.1 shows the initial disparate topics identified in October 2002:

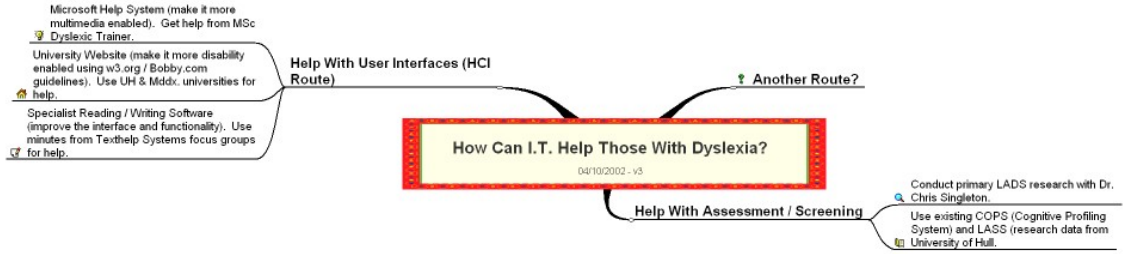


Figure 9.1: Initial Brainstorm of Unrelated Research Topics to Include in Dissertation – Created 4/10/02.

A significant obstacle involved managing the potential complexity of the project and ensuring that an undergraduate dissertation did not expand into the wider world of research. This was achieved by maintaining focus on the objectives set in the Work Breakdown Structure in Figure 9.3. Although the specifics of some of the tasks were altered during the dissertation, the essence and structure remained the same. Focus was also maintained by using Mind Manager software to show the linkage between previously unrelated research topics that would be covered, hence placing this project in proper context. This is shown below in Figure 9.2:

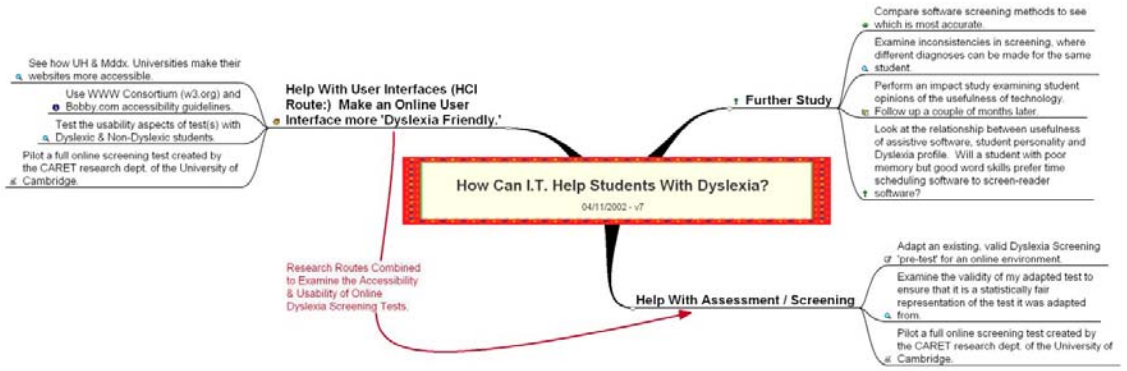


Figure 9.2: Subsequent Brainstorm of Newly-Related Research Topics to Include in Dissertation – Created 4/11/02.

Task	Sub-Task	Work Breakdown Structure (Version 1.0) *1st October 2002*	Immediate Predecessor(s)			Est. Duration (Days)
A	**INITIAL RESEARCH**					
	A1	Distribute Mail-merge E-Mail to Regional Dyslexia Associations/Software Companies. Catalogue Replies.	--			14
	A2	Produce Mind Map & Decide Research Focus. Begin Cataloguing Possible Future Research/Dissertation Topics.	A1			1
	A3	Conduct Preliminary Literature Review. Search Online Sites And Databases. Search For Hard-Copy Books/Journals.	A1	A2		14
	A4	Fill In & Hand In Ethics Form.	A1	A2	A3	2
	A5	Fill In & Hand In Research Proposal Form.	A4			1
B	**FINALISE TITLE**	Finalise Exact Title & Research Area/Objectives.	A			7
C	**RESEARCH PREPARATION**					
	C1	Draft Questionnaires (Where appropriate).	B			1
	C2	Pilot Questionnaires.	C1			7
	C3	Prepare Interview Questions (Where appropriate).	B			1
	C4	Obtain Focus Group Materials (Where appropriate).	B			7
	C5	Create Test Software (Where appropriate).	B			14
	C6	Pilot & Debug Test Software.	C5			14
	C7	Conduct Full Literature Review.	B			14
	C8	Hand In Fully Referenced Literature Review.	C7			1
D	**IN-DEPTH RESEARCH**					
	D1	Conduct Primary Research (with Questionnaires, Interview Questions and/or Test Software from C).	C7			90
	D2	Input Result Data.	D1			1
	D3	Perform Statistical Analysis On Result Data & Make Tentative Conclusions/Indications.	D2			7
E	**WRITE-UP**					
	E1	Review Two Or Three 'A' Grade Dissertations.	--			1
	E2	Write Introduction.	C8			3
	E3	Write Literature Review & Methodology Sections.	C8			7
	E4	Discuss Result Data & Relevant Literature. Make Indications Or Conclusions.	D3			7
	E5	Check Referencing Is Accurate & Complete.	E4			1
	E6	Produce Another Copy Of Dissertation To Honour Anonymity/Non-Disclosure Agreements.	E5			1
F	**DRAFT DISSERTATION**	Hand In Draft Dissertation (If Appropriate).	E			1
G	**AMEND DISSERTATION**	Amend Following Supervisor Comments On Draft.	F			14
H	**HAND IN FINAL DRAFT**					
	H1	Prepare CD-R Including Microsoft Word File, Spreadsheet Plans/Revisions, Test Software etc.	G			1
	H2	Hand In Final Dissertation (On or before 5th May 2003).	H1			1

Figure 9.3: Initial Work Breakdown Structure for Dissertation - Created 1/10/02.

In order to keep within the estimated timeframe listed in Figure 9.3 above, it was necessary to implement a strict policy, where research was not allowed to drag on to the detriment of the development of the web-based test, or the write-up of this dissertation report. Although more research was necessary at certain points, where new questions arose or the research that I had uncovered seemed lacking, sufficient slippage time was allowed for this. The estimated project time of just under170 days (see Figure 9.4) allowed for an approximate month and a half extra for any possible slippage due to unforeseen circumstances.

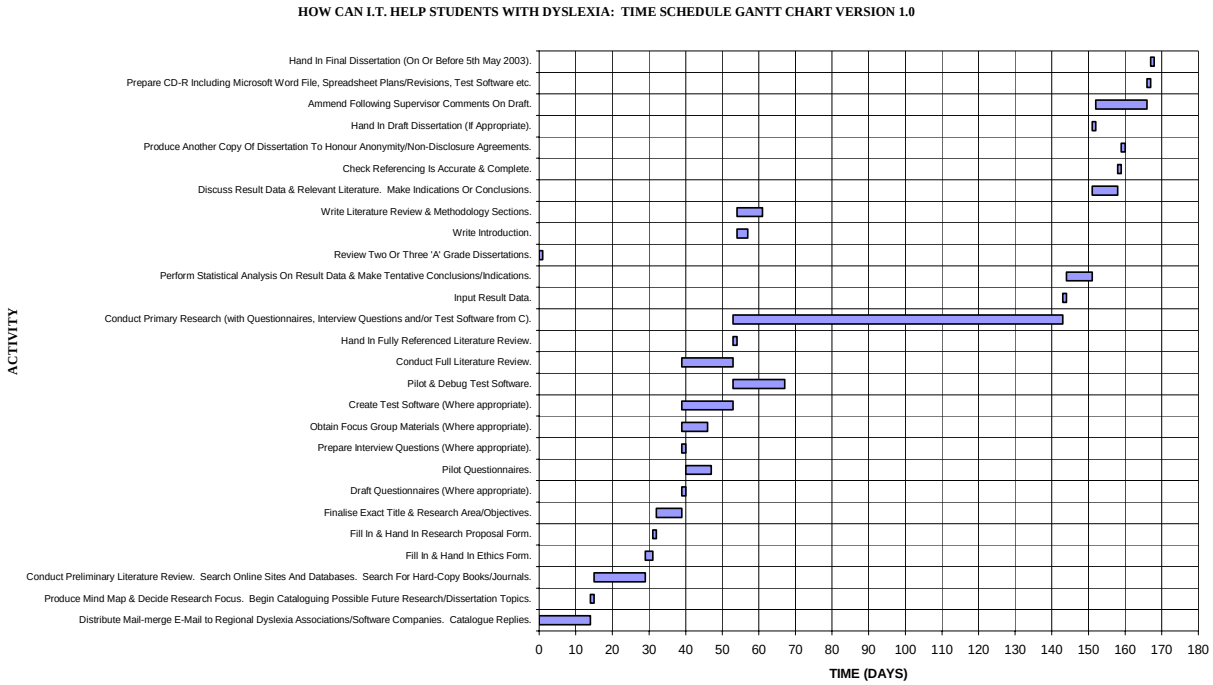


Figure 9.4: Initial Gantt Chart Based on Work Breakdown Structure in Figure 9.3 - Created 1/10/02.

Although no major differences exist between the proposed and actual Gantt Chart and underlying Work Breakdown Structures, (see Figures 9.4 and 9.5 respectively) it was wise to include 90 days for primary research to occur. Although it has initially been planned to conduct the research on dyslexic individuals within the University of Hertfordshire as one big group, administration errors, slippages and pressures rendered this impossible. In hindsight, this may have been pre-empted and a meeting of several dyslexic students within the university planned confirmed early in the year to ensure that the research could have been undertaken with the original University of Hertfordshire dyslexic students, even if problems that would take weeks to rectify emerged.

Fortunately the 90 day timescale provided sufficient leeway to proceed with alternative arrangements; conducting the research with a mixture of individual volunteers from both the University of Hertfordshire and the University of Middlesex. Since ethics approval had already been granted for research to take place at dyslexic students' place of residence, the project was able to continue unhindered and with none of the initial objectives compromised.

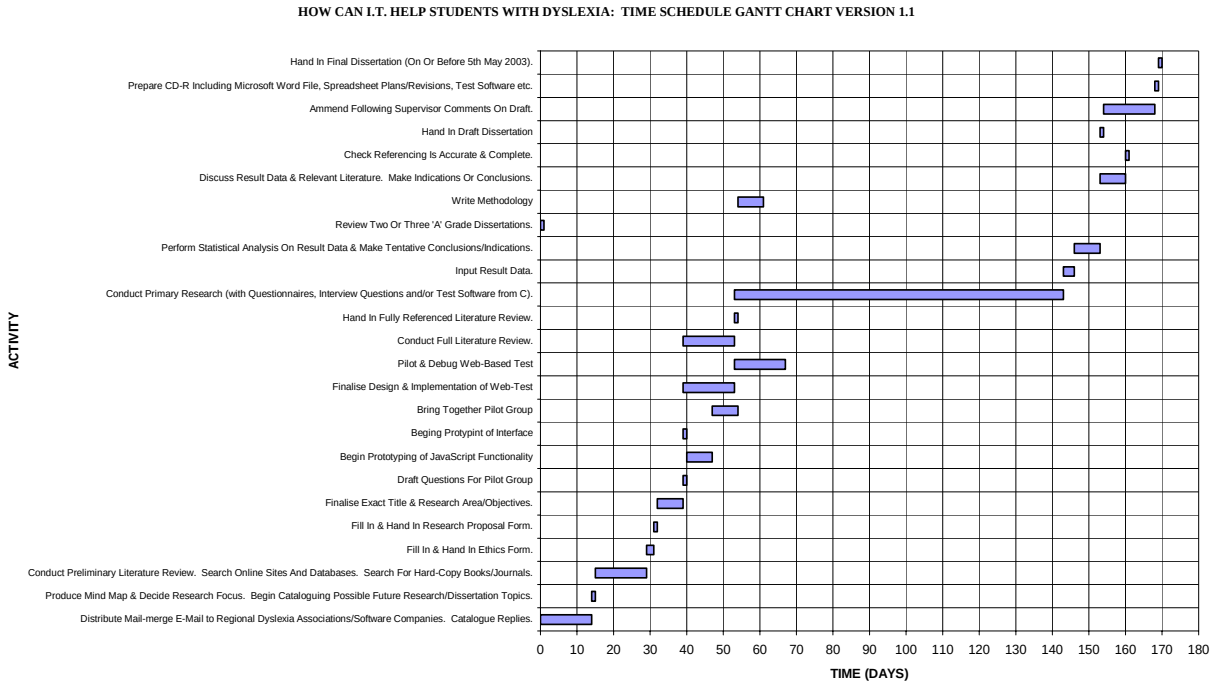


Figure 9.5: Final Gantt Chart

A final obstacle to content with, which had the potential to impact on the timeframe or objectives of the project, was the politics encountered when conversing with experts in the field of dyslexia screening. Each expert had their own distinct view on which screening method was most appropriate to adapt to a web-based platform and many offers were extended to test unpublished or so far statistically invalid screening tests and methods. Although many of the offers were enticing, many would have caused me to fall into the trap of producing research material more suited to a PhD thesis than an undergraduate dissertation project. However, such circumstances had been envisaged and therefore could be avoided.

A situation that could not have been so easily envisaged was the possible hidden motives behind many of the offers of screening test adaptation. The ease in which it was possible to meet and converse with those heading the development of computer and web-based dyslexia screening products suggested passionate and often selfish interests held by the developers. It was clear that many wanted someone to aid with existing research or help produce a product that could then be marketed for commercial gain, yet wished for any rights to ownership of the product to be waived.

Although it had been envisaged to publish the web-based test as the first web-based and multi-sensory screening test for dyslexia as soon as this dissertation was completed, it was deemed necessary to seek legal advice before doing so. This was in order to ensure that rival developers could not copy or adapt the not-for-profit model of the site and implement a similar, yet commercial service. This is one obstacle that has not yet been overcome and potentially poses an interesting dilemma of assessing the greater evil; publishing a service that may be exploited for others' commercial benefit or not publishing a service that could act as a sound and useful tool in guiding individuals that may think they have dyslexia but do not know where to turn.

Appendix 10: Figures, Tables and Charts

Tables and Charts Used for Initial Question Refinement

Question Number (See Appendices 1 & 4)	Nº of Students believing that the meaning/ outcome would be affected	Cumulative % of total statements that the meaning/ outcome would be affected
1	24	=(B2/$B$22)*100
2	24	=((B3/$B$22)*100)+C2
5	24	=((B4/$B$22)*100)+C3
7	24	=((B5/$B$22)*100)+C4
4	20	=((B6/$B$22)*100)+C5
14	3	=((B7/$B$22)*100)+C6
12	2	=((B8/$B$22)*100)+C7
11	1	=((B9/$B$22)*100)+C8
3	1	=((B10/$B$22)*100)+C9
6	0	=((B11/$B$22)*100)+C10
8	0	=((B12/$B$22)*100)+C11
9	0	=((B13/$B$22)*100)+C12
10	0	=((B14/$B$22)*100)+C13
13	0	=((B15/$B$22)*100)+C14
15	0	=((B16/$B$22)*100)+C15
16	0	=((B17/$B$22)*100)+C16
17	0	=((B18/$B$22)*100)+C17
18	0	=((B19/$B$22)*100)+C18
19	0	=((B20/$B$22)*100)+C19
20	0	=((B21/$B$22)*100)+C20
Total:	**=SUM(B2:B21)**	

Figure 1: Table and formulae illustrating cumulative frequencies used in Section 4.2, Figure 4.21

	Seconds Taken to Read Story in Q4	
Observation 1	66	
Observation 2	45	
Observation 3	59	
Observation 4	39	
Observation 5	41	
Observation 6	35	
Observation 7	31	
Observation 8	32	
Observation 9	41	
Observation 10	34	
Observation 11	29	
Observation 12	45	
Mean Time	**41.4**	**=AVERAGE(B25:B36)**
Standard Error	**2.9**	**=STDEV(B25:B36)/SQRT(15)**
99.9% Confidence Interval	**51.0**	**=B37+3.29*B38**

Figure 2: Table and formulae illustrating the cut-off Point of >50 seconds used to time users in Question 4.

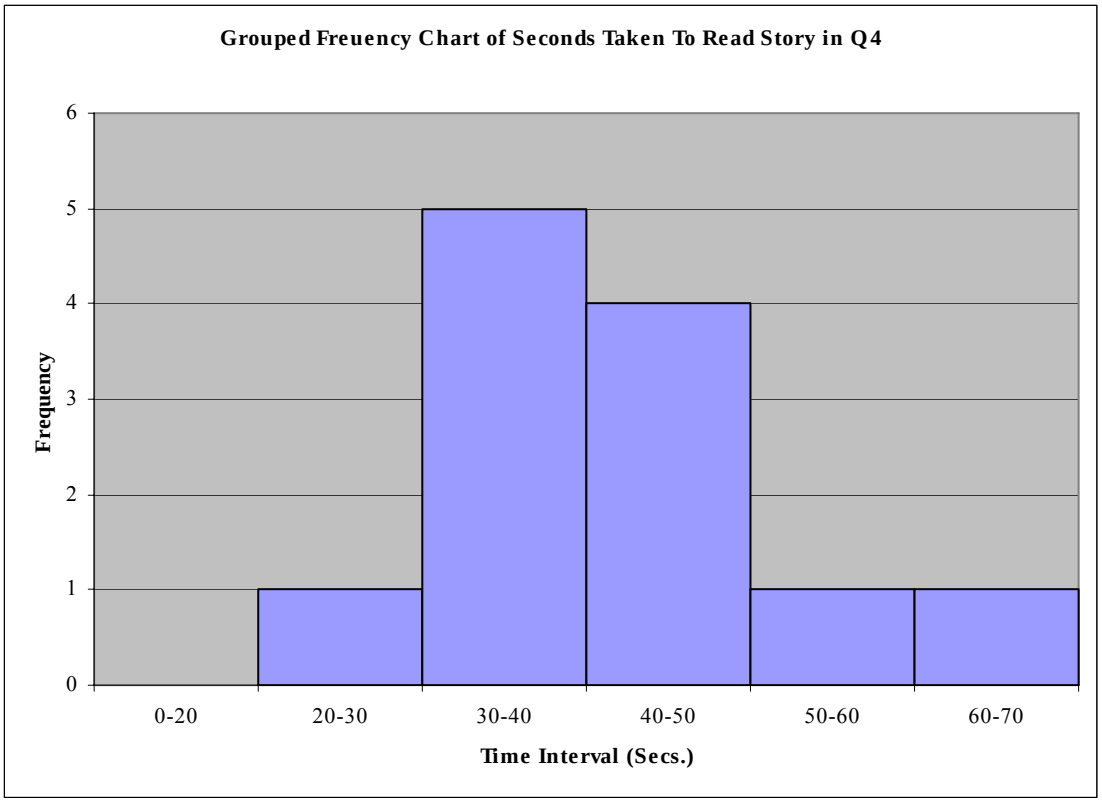


Figure 3: Grouped frequency chart showing that the mean time to read the story in Q4 is likely to be normally distributed (due to the bell-shaped nature of the graph). This supports the assumption of normality used to calculate the confidence interval in figure 10.2.

Figures and Tables Used to Examine Usability Results

	Very Easy/Useful	*Quite Easy/Useful*	*Not Very Easy/Useful*	*Not Easy/Useful*
Ease of Use (Dyslexic)	14	1	0	0
Ease of Use (Non-Dyslexic)	14	1	0	0
Usefulness of Pictures (Dyslexic)	14	1	0	0
Usefulness of Pictures (Non-Dyslexic)	12	2	1	0
Usefulness of 'Read Out' (Dyslexic)	14	1	0	0
Usefulness of 'Read Out' (Non-Dyslexic)	12	2	1	0

	Yes	*No*
Possibility of Getting Lost (Dyslexic)	0	15
Possibility of Getting Lost (Non-Dyslexic)	0	15

	Yes	*No*
Used the Help Facility? (Dyslexic)	0	15
Used the Help Facility? (Non-Dyslexic)	0	15

Figure 4: Usability results amongst dyslexic and non-dyslexic groups.

Raw Results for Comparing the Vinegrad Paper-Based Test with Web-Based Test

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	*Indicator*	*High*		
(P) 1	1	1	1	1	1	1	0	0	1	1	0	1	1	0	0	1	0	1	1	1	**14**	8	3	1
(W) 1	1	0	1	0	1	1	0	1	0	1	0	1	1	0	0	1	0	1	1	1	**12**	7		
(P) 2	1	0	0	1	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	**15**	9	2	2
(W) 2	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	**15**	9		
(P) 3	1	0	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	0	1	1	**15**	9	3	1
(W) 3	1	0	1	0	1	0	1	1	0	1	0	1	0	0	1	1	1	1	1	1	**13**	8		
(P) 4	1	0	1	1	1	1	1	0	0	1	1	1	0	0	1	0	0	1	1	1	**13**	8	2	0
(W) 4	0	0	1	1	1	1	1	0	0	1	1	1	0	0	1	0	0	0	1	1	**11**	6		
(P) 5	0	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	1	0	0	**11**	5	3	0
(W) 5	0	0	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	**8**	4		
(P) 6	0	1	0	0	1	1	0	0	1	0	1	1	0	0	1	0	0	0	0	1	**8**	2	1	1
(W) 6	1	1	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	**8**	2		
(P) 7	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	1	0	0	1	**9**	6	0	1
(W) 7	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	1	0	0	1	**10**	6		
(P) 8	0	0	1	1	0	0	1	1	1	0	1	1	1	0	1	0	1	0	0	0	**10**	5	5	3
(W) 8	0	0	0	0	1	0	1	1	0	0	0	1	1	1	1	1	0	0	0	0	**8**	4		
(P) 9	1	1	0	1	1	0	1	0	1	1	0	1	0	0	1	0	1	1	1	1	**13**	8	1	1
(W) 9	1	1	0	1	1	0	1	0	1	1	1	1	0	0	1	0	1	0	1	1	**13**	8		
(P) 10	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	**17**	10	2	1
(W) 10	1	1	1	0	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	**16**	8		
(P) 11	0	1	0	0	1	1	1	0	1	0	0	0	0	0	1	1	1	1	0	1	**10**	5	3	3
(W) 11	0	1	1	0	1	1	0	0	0	0	1	1	0	0	1	1	1	0	0	1	**10**	4		
(P) 12	1	0	0	0	1	1	1	1	1	0	1	1	0	0	1	1	0	1	1	1	**13**	7	0	1
(W) 12	1	1	0	0	1	1	1	1	1	0	1	1	0	0	1	1	0	1	1	1	**14**	7		
(P) 13	1	0	0	0	1	0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	**13**	9	2	2
(W) 13	1	1	1	0	1	0	1	0	1	0	0	1	1	1	1	0	1	0	1	1	**13**	7		
(P) 14	0	0	1	0	1	1	0	1	1	0	1	0	0	0	1	1	0	1	0	0	**9**	3	2	1
(W) 14	0	0	0	1	0	1	0	1	1	0	1	0	0	0	1	1	0	1	0	0	**8**	4		
(P) 15	1	1	0	1	1	1	1	0	1	0	0	1	1	1	1	1	0	0	1	1	**14**	8	1	0
(W) 15	1	1	0	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	1	1	**13**	8		
																						Total:	**30**	**18**

Tot.(P)	9	7	8	10	14	11	12	6	12	6	8	12	5	4	12	9	8	10	9	12	**12.27**	**6.80**	**(P)Mean**
Tot.(W)	9	7	8	6	13	11	11	8	9	6	8	12	6	3	12	9	7	7	8	12	**11.47**	**6.13**	**(W)Mean**
	1	2	2	5	2	0	1	0	4	1	2	1	0	2	0	1	1	4	1	0	**2.63**	**2.37**	**(P)S.D.**
	1	2	2	1	1	0	0	2	1	1	2	1	1	1	0	1	0	1	0	0	**2.70**	**2.07**	**(W)S.D.**

Key:

Only Paper Test Shows Trait (Web Does Not)

Only Web Test Shows Trait (Paper Does Not)

Figure 5: Results comparing the Vinegrad paper-based test with the web-based test for the *Dyslexic* Group. The highlighted sections pinpoint single discrepancies, where an individual has given a dyslexic or non-dyslexic-type-response for one particular question in the paper-based test but not in the web-based test, or vice versa. The total 'indicator' and 'high indicator' scores for each individual are also displayed.

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Indicator	High		
(P) 1	0	0	0	1	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	**7**	2	1	0
(W) 1	0	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	**5**	2		
(P) 2	0	0	1	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	**7**	2	3	1
(W) 2	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	1	**5**	2		
(P) 3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	**3**	1	3	0
(W) 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0		
(P) 4	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	**5**	3	1	1
(W) 4	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	**5**	2		
(P) 5	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	**5**	2	0	4
(W) 5	1	1	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	**7**	3		
(P) 6	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	**6**	3	0	0
(W) 6	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	**6**	3		
(P) 7	0	1	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**6**	2	1	0
(W) 7	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	**4**	1		
(P) 8	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	**6**	3	0	0
(W) 8	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	**6**	3		
(P) 9	1	1	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	1	0	0	**7**	5	1	1
(W) 9	1	0	0	0	1	0	1	0	1	0	1	0	0	0	0	1	0	1	0	0	**7**	5		
(P) 10	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	**3**	1	0	1
(W) 10	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	**4**	1		
(P) 11	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**3**	0	1	1
(W) 11	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**3**	1		
(P) 12	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**3**	0	0	0
(W) 12	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**3**	0		
(P) 13	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	**4**	0	0	0
(W) 13	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**3**	0		
(P) 14	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	**6**	4	0	2
(W) 14	1	0	0	0	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	**8**	5		
(P) 15	0	0	1	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	1	1	**7**	3	1	1
(W) 15	0	0	1	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	1	1	**7**	3		
																						Total:	**12**	**12**

Tot.(P)	1	6	4	5	4	7	8	5	4	1	3	11	0	0	6	2	0	4	1	6	**5.20**	**2.07**	**(P) Mean**
Tot.(W)	4	2	3	2	9	7	8	5	2	1	3	8	0	1	6	2	0	3	1	6	**4.87**	**2.07**	**(W) Mean**
	0	4	1	3	1	0	0	0	0	1	0	2	0	0	0	0	0	1	0	0	**1.61**	**1.49**	**(P) S.D.**
	3	0	0	0	6	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	**2.10**	**1.62**	**(W) S.D.**

Key:

Only Paper Test Shows Trait (Web Does Not)

Only Web Test Shows Trait (Paper Does Not)

Figure 6: Results comparing the Vinegrad paper-based test with the web-based test for the *Non-Dyslexic* Group.

Workings Used to Examine the Potential Connection between the Ease of Understanding of Both Tests

Chi-Squared Test: Is There a Connection Between the Ease of Understanding of Both Tests Amongst the Dyslexic Group?

Observed Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Dyslexic Group)	1	5	6	3	15
Web Test (Dyslexic Group)	9	5	1	0	15
Totals	10	10	7	3	**30**

Expected Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Dyslexic Group)	5	5	3.5	1.5	15
Web Test (Dyslexic Group)	5	5	3.5	1.5	15
Totals	10	10	7	3	**30**

Combined Expected Values (to ensure all >=5)	*Very Easy*	*Quite Easy*	*Not Very Easy or Not Easy*		*Totals*
Paper Test (Dyslexic Group)	5	5	5		15
Web Test (Dyslexic Group)	5	5	5		15
Totals	10	10	10		**30**

Degrees of Freedom (rows-1)*(columns-1)	2
Chi-Squared Statistic	0.9
Critical Value at 0.05 significance level	5.991

Chi-Squared Test: Is There a Connection Between the Ease of Understanding of Both Tests Amongst the Dyslexic Group?

Observed Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Dyslexic Group)	1	5	6	3	=SUM(B10:E10)
Web Test (Dyslexic Group)	9	5	1	0	=SUM(B11:E11)
Totals	=SUM(B10:B11)	=SUM(C10:C11)	=SUM(D10:D11)	=SUM(E10:E11)	**=SUM(F10:F11)**

Expected Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Dyslexic Group)	=(F10*B12)/$F$12	=(F10*C12)/$F$12	=(F10*D12)/$F$12	=(F10*E12)/$F$12	=SUM(B15:E15)
Web Test (Dyslexic Group)	=(F11*B12)/$F$12	=(F11*C12)/$F$12	=(F11*D12)/$F$12	=(F11*E12)/$F$12	=SUM(B16:E16)
Totals	=SUM(B15:B16)	=SUM(C15:C16)	=SUM(D15:D16)	=SUM(E15:E16)	**=SUM(F15:F16)**

Combined Expected Values (to ensure all >=5)	*Very Easy*	*Quite Easy*	*Not Very Easy or Not Easy*		*Totals*
Paper Test (Dyslexic Group)	=(F15*B17)/$F$12	=(F15*C17)/$F$12	=D15+E15		=SUM(B20:E20)
Web Test (Dyslexic Group)	=(F16*B17)/$F$12	=(F16*C17)/$F$12	=D16+E16		=SUM(B21:E21)
Totals	=SUM(B20:B21)	=SUM(C20:C21)	=SUM(D20:D21)		**=SUM(F20:F21)**

Degrees of Freedom (rows-1)*(columns-1)	2
Chi-Squared Statistic	=(((D15-D20)*(D15-D20)/D20)) + ((D16-D21)*(D16-D21)/D21)
Critical Value at 0.05 significance level	5.991

Figure 7: Chi-Squared table and formulae examining the potential connection between the ease of understanding of both tests amongst the *dyslexic* group.

Chi-Squared Test: Is There a Connection Between the Ease of Understanding of Both Tests Amongst the Non-Dyslexic Group?

Observed Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Non-Dyslexic Group)	9	5	1	0	15
Web Test (Non-Dyslexic Group)	11	4	0	0	15
Totals	20	9	1	0	**30**

Expected Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Non-Dyslexic Group)	10	4.5	0.5	0	15
Web Test (Non-Dyslexic Group)	10	4.5	0.5	0	15
Totals	20	9	1	0	**30**

Combined Expected Values (to ensure all >=5)	*Very Easy*	*Quite Easy or Worse*	*Totals*
Paper Test (Non-Dyslexic Group)	10	5	15
Web Test (Non-Dyslexic Group)	10	5	15
Totals	20	10	**30**

		Individual Yates Corrected Chi-Squared Statistics	
Degrees of Freedom (rows-1)*(columns-1)	1		
Chi-Squared Statistic	0.15	0.025	0.05
Critical Value at 0.05 significance level	3.841	0.025	0.05

Observed Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Non-Dyslexic Group)	9	5	1	0	=SUM(B3:E3)
Web Test (Non-Dyslexic Group)	11	4	0	0	=SUM(B4:E4)
Totals	=SUM(B3:B4)	=SUM(C3:C4)	=SUM(D3:D4)	=SUM(E3:E4)	**=SUM(F3:F4)**

Expected Values	*Very Easy*	*Quite Easy*	*Not Very Easy*	*Not Easy*	*Totals*
Paper Test (Non-Dyslexic Group)	=(F3*B5)/$F$5	=(F3*C5)/$F$5	=(F3*D5)/$F$5	=(F3*E5)/$F$5	=SUM(B8:E8)
Web Test (Non-Dyslexic Group)	=(F4*B5)/$F$5	=(F4*C5)/$F$5	=(F4*D5)/$F$5	=(F4*E5)/$F$5	=SUM(B9:E9)
Totals	=SUM(B8:B9)	=SUM(C8:C9)	=SUM(D8:D9)	=SUM(E8:E9)	**=SUM(F8:F9)**

Combined Expected Values (to ensure all >=5)	*Very Easy*	*Quite Easy or Worse*	*Totals*
Paper Test (Non-Dyslexic Group)	=(F8*B10)/$F$5	=C8+D8+E8	=SUM(B13:E13)
Web Test (Non-Dyslexic Group)	=(F9*B10)/$F$5	=C9+D9+E9	=SUM(B14:E14)
Totals	=SUM(B13:B14)	=SUM(C13:C14)	=SUM(D13:D14)

Degrees of Freedom (rows-1)*(columns-1)	1
Chi-Squared Statistic	=C25+D25+C26+D26
Critical Value at 0.05 significance level	3.841

Individual Yates Corrected Chi-Squared Statistics

=((ABS(B3-B13)-0.5)*(ABS(B3-B13)-0.5))/B13	=((ABS(C3-C13)-0.5)*(ABS(C3-C13)-0.5))/C13
=((ABS(B4-B14)-0.5)*(ABS(B4-B14)-0.5))/B14	=((ABS(C4-C14)-0.5)*(ABS(C4-C14)-0.5))/C14

Figure 8: Yates' Corrected Chi-Squared table and formulae examining the potential connection between the ease of understanding of both tests amongst the *non-dyslexic* group.

Charts Examining Assumptions of Normality Made When Using Difference-Between-Means Tests (T-Tests)

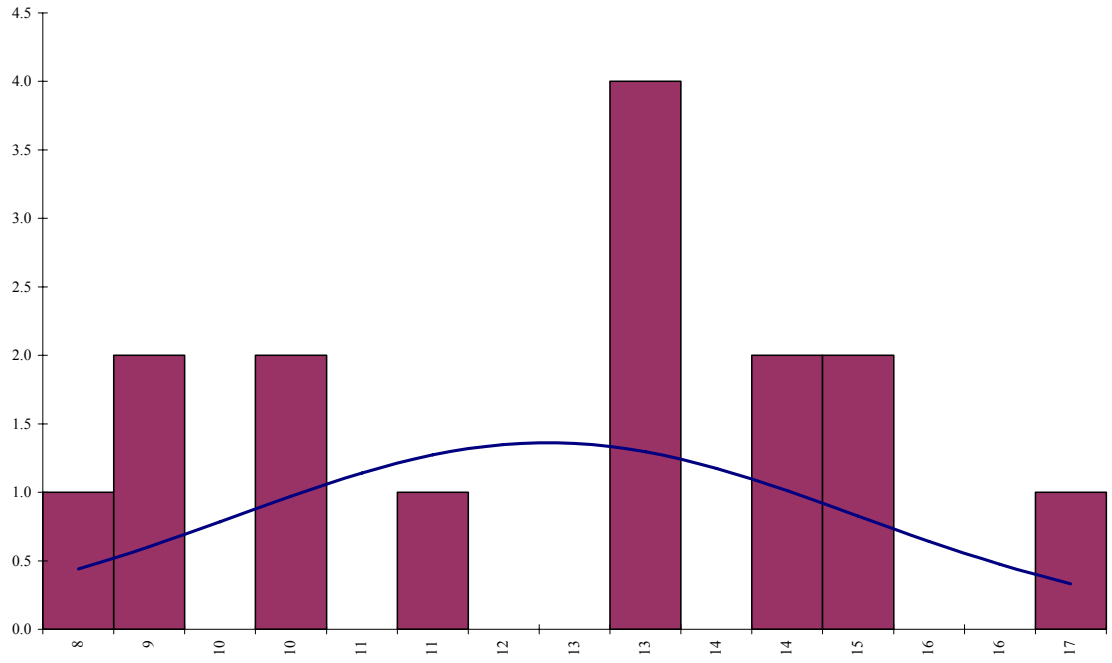


Figure 9: Histogram showing number of respondents in the *dyslexic* group scoring each 'indicator' score in the *paper-based test*. Note that the data loosely follows a normal distribution, as illustrated by the super-imposed normal curve.

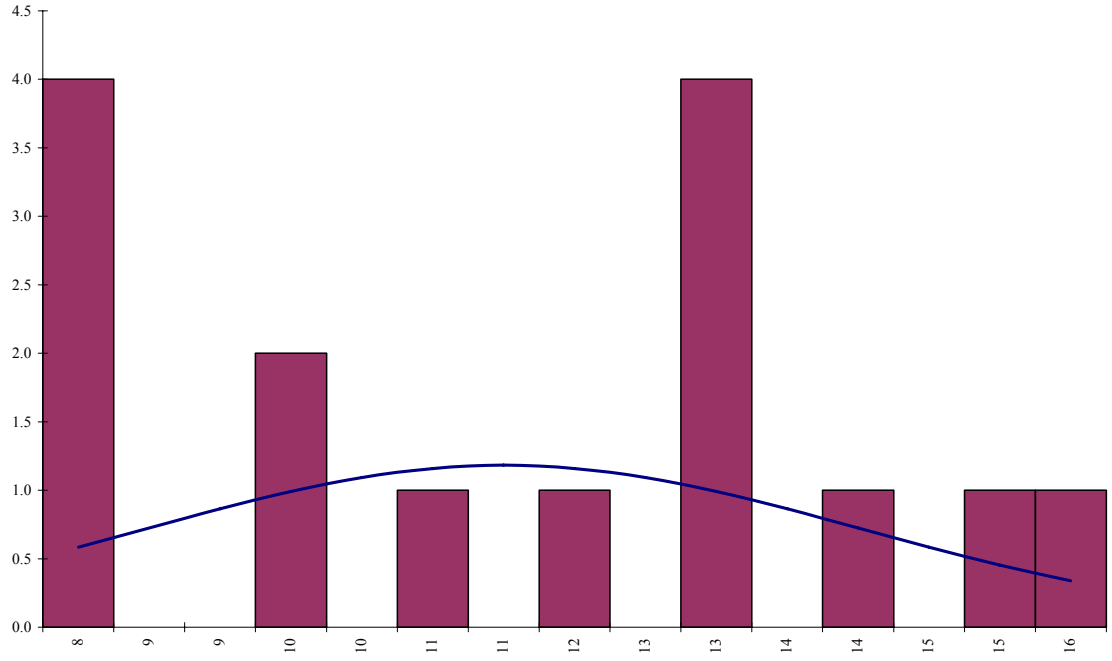


Figure 10: Histogram showing number of respondents in the *dyslexic* group scoring each 'indicator' score in the *web-based test*. Note that the data loosely follows a normal distribution, as illustrated by the super-imposed normal curve.

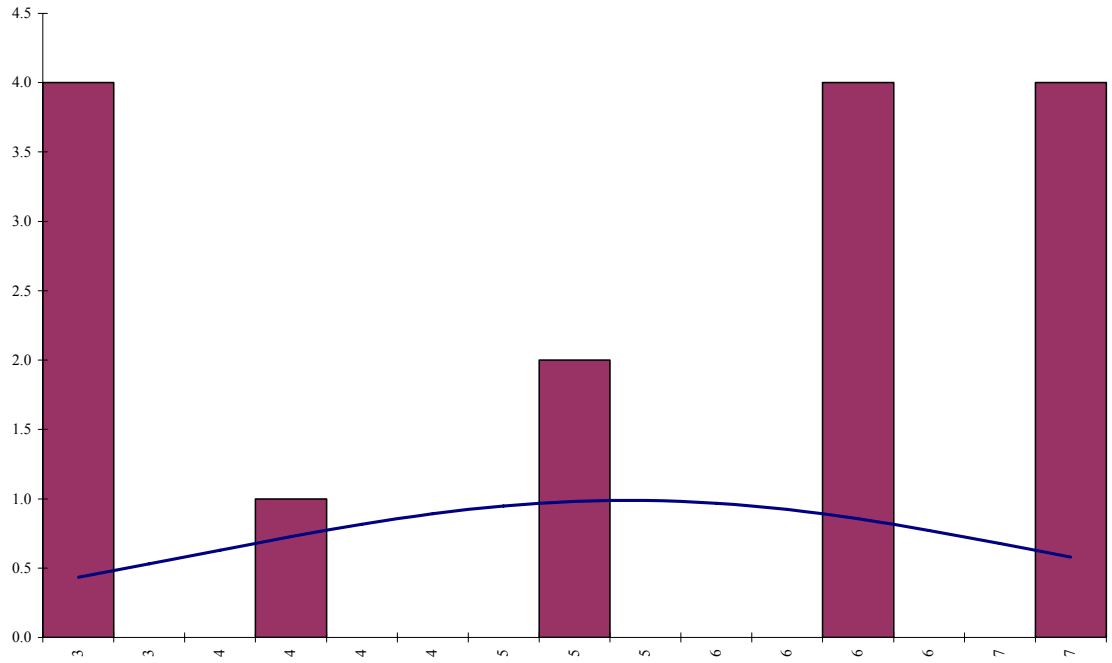


Figure 11: Histogram showing number of respondents in the *non-dyslexic* group scoring each 'indicator' score in the *paper-based test.* Note that the data loosely follows a normal distribution, as illustrated by the super-imposed normal curve.

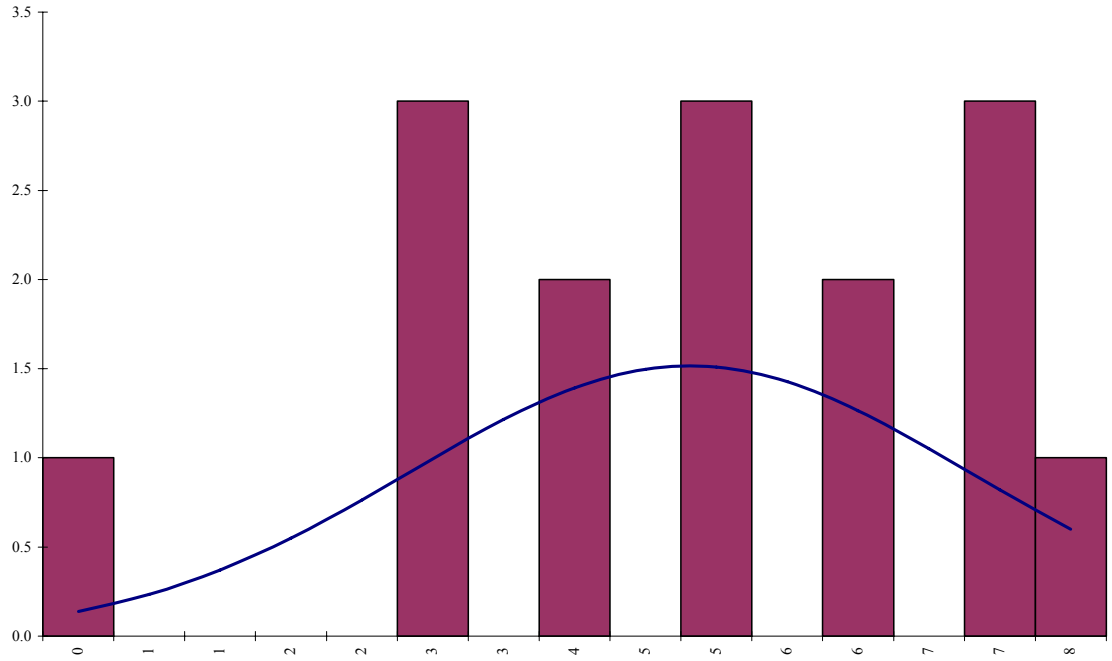


Figure 12: Histogram showing number of respondents in the *non-dyslexic* group scoring each 'indicator' score in the *web-based test.* Note that the data loosely follows a normal distribution, as illustrated by the super-imposed normal curve.

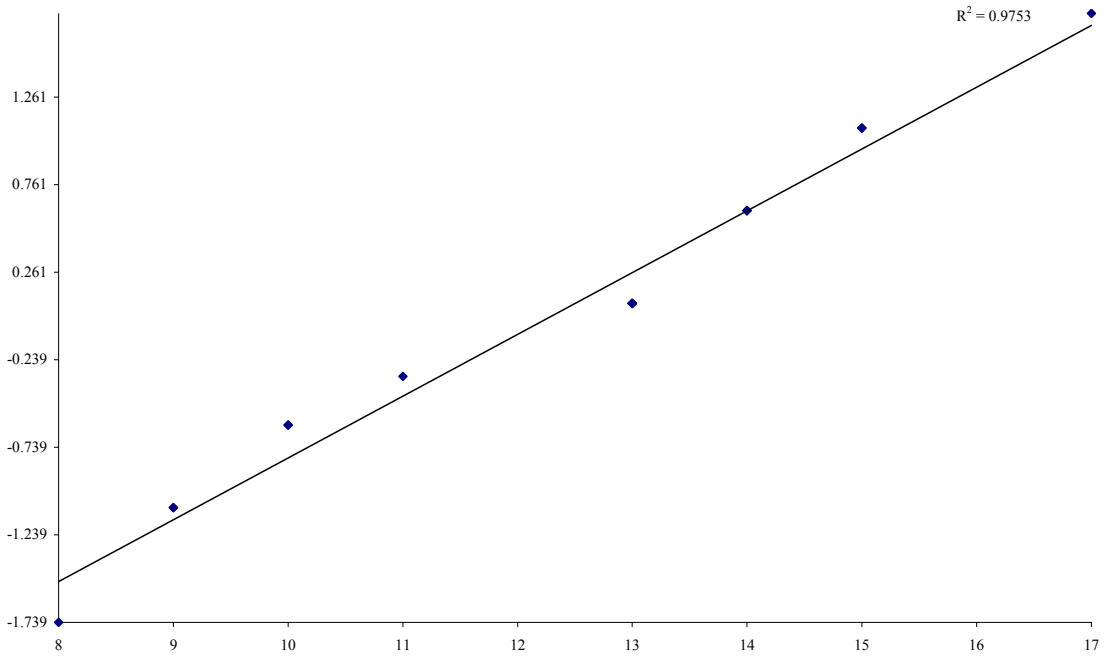


Figure 13: Normal P-Plot showing the likely conformity to the normal distribution of the *dyslexic* group 'indicator' scores in the *paper-based test.*

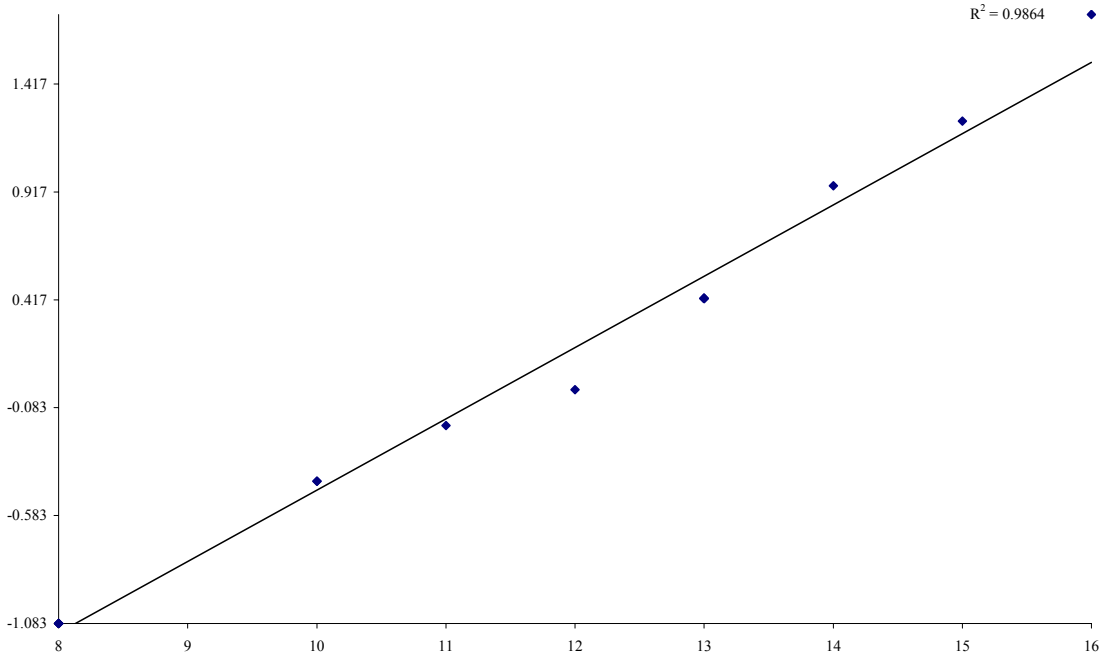


Figure 14: Normal P-Plot showing the likely conformity to the normal distribution of the *dyslexic* group 'indicator' scores in the *web-based test.*

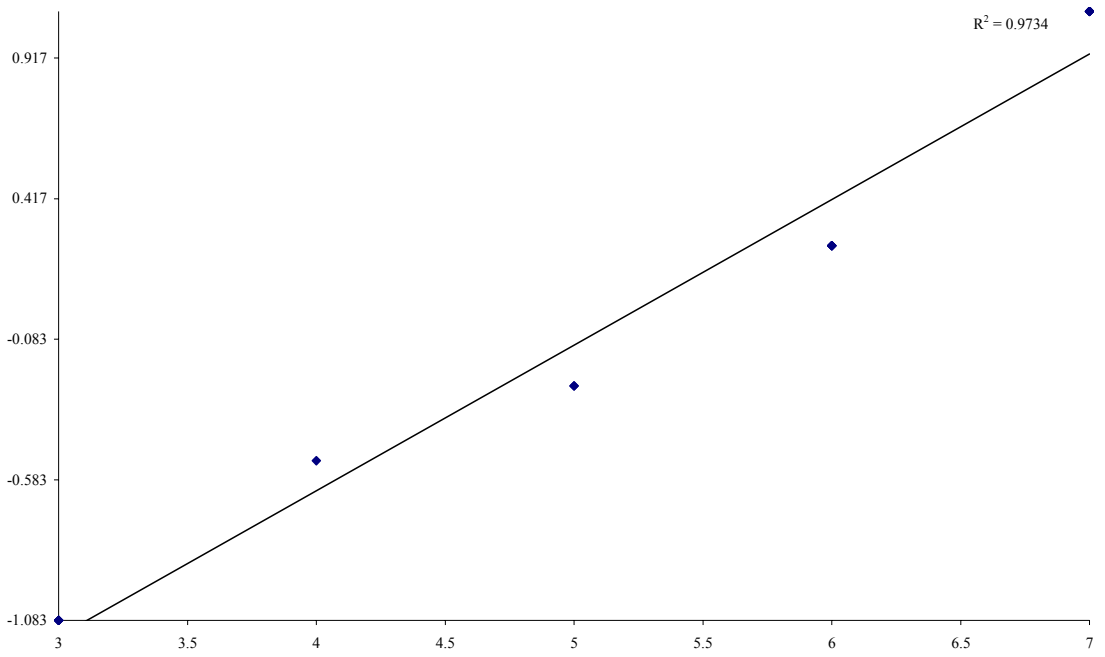


Figure 15: Normal P-Plot showing the likely conformity to the normal distribution of the *non-dyslexic* group 'indicator' scores in the *paper-based test.*

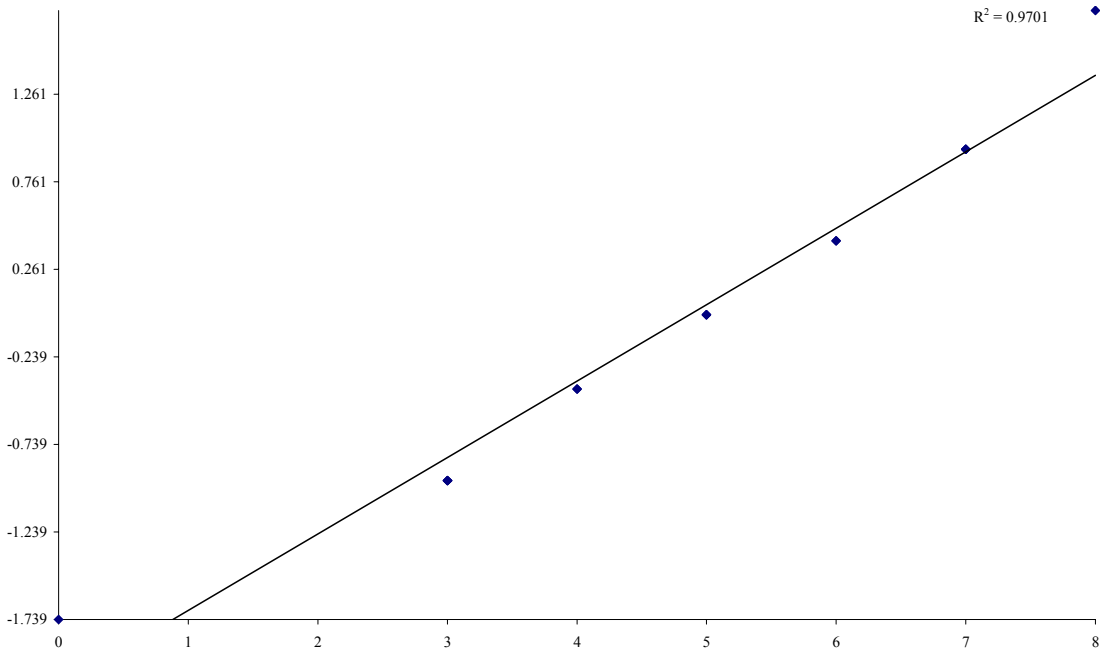


Figure 16: Normal P-Plot showing the likely conformity to the normal distribution of the *non-dyslexic* group 'indicator' scores in the *web-based test.*

Tables and Workings Used for Difference-Between-Means Tests

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Paper	Ha: Not equal to 0	0
Input Column 2	Web	Confidence	0.95
		Pooled Variance	FALSE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Paper	15	12.27	2.631	0.679
Web	15	11.47	2.696	0.696

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
0.80	0.973	0.823	27.98	0.418	-1.20	2.80

Accept Ho

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Paper	=COUNT('Dyslexic Group'!AA2:AA16)	=AVERAGE('Dyslexic Group'!AA2:AA16)	=STDEV('Dyslexic Group'!AA2:AA16)	=se('Dyslexic Group'!AA2:AA16)
Web	=COUNT('Dyslexic Group'!AB2:AB16)	=AVERAGE('Dyslexic Group'!AB2:AB16)	=STDEV('Dyslexic Group'!AB2:AB16)	=se('Dyslexic Group'!AB2:AB16)

Mean Diff.	Std. Err.	t
=AVERAGE('Dyslexic Group'!AA2:AA16)-AVERAGE('Dyslexic Group'!AB2:AB16)	=t2se('Dyslexic Group'!AA2:AA16,'Dyslexic Group'!AB2:AB16,D5)	=(A14-D2)/B14

df	p-value
=t2df('Dyslexic Group'!AA2:AA16,'Dyslexic Group'!AB2:AB16,D5)	=IF(D3=-1,TDF(C14,D14,TRUE),IF(D3=0,TDF(-ABS(C14),D14,TRUE)*2,1-TDF(C14,D14,TRUE)))

="lower "&(100*D4)&"%"	="upper "&(100*D4)&"%"
=IF(D3=-1,#N/A,A14-TINV((1-D4)*2/(2-ABS(D3)),D14)*B14)	=IF(D3=1,#N/A,A14+TINV((1-D4)*2/(2-ABS(D3)),D14)*B14)

Figure 17: Figures and working for difference between means test between the paper and web-based tests amongst the *dyslexic* group. This is based on a two-sample T-Test with un-pooled variances. Note that only workings out for this T-Test have been provided in this appendix.

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Paper	Ha: Not equal to 0	0
Input Column 2	Web	Confidence	0.95
		Pooled Variance	FALSE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Paper	15	5.20	1.612	0.416
Web	15	4.87	2.100	0.542

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
0.33	0.684	0.488	26.25	0.630	-1.07	1.74

Accept Ho

Figure 18: Figures for difference between means test between the paper and web-based tests amongst the *non-dyslexic* group. This is based on a two-sample T-Test with un-pooled variances.

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Paper	Ha: Not equal to 0	0
Input Column 2	Paper	Confidence	0.95
		Pooled Variance	FALSE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Paper	15	12.27	2.631	0.679
Paper	15	5.20	1.612	0.416

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
7.07	0.797	8.869	23.22	0.000	5.42	8.72

Reject Ho

Figure 19: Figures for difference between means test between the dyslexic and non-dyslexic groups taking the *paper-based test.* This is based on a two-sample T-Test with un-pooled variances.

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Web	Ha: Not equal to 0	0
Input Column 2	Web	Confidence	0.95
		Pooled Variance	FALSE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Web	15	11.47	2.696	0.696
Web	15	4.87	2.100	0.542

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
6.60	0.882	7.481	26.42	0.000	4.79	8.41

Reject Ho

Figure 20: Figures for difference between means test between the dyslexic and non-dyslexic groups taking the *web-based test.* This is based on a two-sample T-Test with un-pooled variances.

Appendix 11: Additional Comments Made by Dyslexic Individuals Regarding the Vinegrad and Web-Based Test Questions

- Regarding question 5: the problem was not that of analysing the information that was just read, but *remembering* what had just been read.

- Regarding question 10: making errors depended on if the message involves a written element or is purely verbal and in question 13 it is easier to mix up telephone number when dialling from memory than when simply dialling a number that is written down.

- Regarding question 7: it is not as difficult for some dyslexic individuals to spot spelling mistakes, however they may have difficulty in correcting them.

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