

Fact Sheet 4

Lucid's product research & evaluation studies

Background

In addition to having a core team of psychologists as part of the design team, Lucid retains its close research link with the Department of Psychology, The University of Hull. Lucid's Research Director, Dr Chris Singleton, holds a Senior Lectureship in the Psychology Department of the University of Hull. Dr Joanna Horne, co-author of several of Lucid's assessment and screening programs, also holds a Lectureship in the Psychology Department of the University of Hull. Dr Horne, who is an expert on statistics and test development has managed many development projects for Lucid, including national validation and standardisation studies involving many hundreds of schools.

Dr Singleton is an internationally respected expert in the field of dyslexia specialising in the computerised assessment of dyslexia. Amongst other professional responsibilities, Dr Singleton chaired the National Working Party's report on Dyslexia in Higher Education and is a member of The British Psychological Society's (BPS) Committee on Test Standards. He was one of the formal contributors to the BPS' *'Guidelines for the Development and use of Computer-Based Assessments'*. He has also been a member of the New Technologies Committee of the British Dyslexia Association for many years and has chaired four international conferences on computers and dyslexia on behalf of the British Dyslexia Association

Lucid's assessment programs are normative (statistically standardised), meet the Guidelines for the Development and Use of Computer-Based Assessments (1999) published by the Professional Affairs Board of the British Psychological Society and have been extensively researched at the University of Hull. [Being normative, teachers can easily establish where an individual falls on any of the components of the suite in relation to the population norms. It also means that direct and *meaningful* comparisons can be made *between tests* in addition to between individuals.] Lucid's programs conform to the highest professional standards for the research and development of educational and psychometric assessment software.

Lucid CoPS

In 1995 Lucid released **CoPS** (Cognitive Profiling System), which is a standardised [normative] suite of tests for ages 4 to 8 years old. The main design aim was to provide a practical tool by which teachers could reliably achieve the early identification of special educational needs (including dyslexia) and to prevent children 'slipping through the net'. CoPS can be used to identify those children who are likely to experience literacy difficulties later on even if at present they are not a particular cause of concern. CoPS can also be used to provide a useful profile of learning abilities for those children that the teacher already has concerns about. CoPS provides a cognitive profile that can show relative strengths and weaknesses of all children. CoPS is a user- and child-friendly system designed for the teacher (or assistant) to use in the classroom situation.

The original research work to develop CoPS was carried out over a seven-year period (five years for trials). The main study was a prospective longitudinal study using over 400 4-5 year old children as subjects from 24 schools. We created and programmed 27 computerised tests designed to measure the fundamental cognitive abilities that underpin learning and predict subsequent attainment. Some of these computer tasks included tests for assessing visual information processing and visual pathway functioning such as transient and sustained channel functioning in addition to the more mainstream theories advocating the measurement of phonology – phonological deficit theory – and memory. Only the tests that proved reliably predictive were kept in the final

program. In parallel to our computerised tests, we obtained concurrent assessment of literacy, numeracy and intellectual abilities using respected normative/standardised tests.

We followed up these children over a 4 year period assessing their performance using various normative/standardised conventional tests. From our statistical analyses we created the CoPS suite of programs based on the most predictive and most efficacious combination of tests that we created and evaluated. Our main analyses included correlation, factor, regression and discriminant function. Using discriminant function analysis for the final CoPS suite of programs we obtained high rates for overall prediction (96%) and extremely good (ie low) rates of False Negatives (17%) and False Positives (2.3%) for certain validation measures. Other measures also showed CoPS to have very good prediction rates. [See Singleton, C. H., Thomas, K.V. and Horne, J. K. (2000) Computerised cognitive profiling and the development of reading. *Journal of Research in Reading*, 23(2), 158-180.)]

It should be noted that many tests do not publish a full analysis of their predictive accuracy. However, where there is evidence it is apparent that conventional tests do not meet the high level of accuracy obtained by the CoPS suite. Conventional tests have shown overall prediction rates as low as 75.6% for phonological measures (Catts, 1991). False Positive rates as high as 50% have been shown using intelligence measures (Fletcher and Satz, 1984). Other conventional screening devices have shown the following rates: False Positive 64%, 47% and 41%, False Negative 69%, 21% and 49% (Kingslake, 1982). 'Teacher-based' and 'test-based screening' have shown overall prediction rates of 74% when classified by teachers and 77% for classification by test battery. Combining both teacher's ratings and the test battery scores only increased the overall hit rate to 78%. Teacher judgements had a high rate of False Negatives at 87% and a False Positives at 14%. The False Positive rate for the test's prediction was 54% and the False Negative rate was 34% (Fletcher and Satz, 1984).

Following the validation and reliability testing, CoPS' original standardisation was on over 1,100 children. Many UK authorities have taken up the CoPS software as part of their official policy, including Powys County Council, Ceredigion County Council, Northamptonshire County Council, Perth and Kinross County Council, North Ayrshire County Council, Hampshire County Council, Carmarthenshire County Council, the States of Jersey and many more. Lucid CoPS is now used in over 8,000 primary schools in the UK and elsewhere in the world. To date, four foreign language versions of CoPS have been produced (Swedish, Italian, Norwegian and Arabic) and others are in development.

Independent research on the validity and application of Lucid CoPS was reported by Paddy Lee of Dublin City University in 1999, who concluded that "CoPS is a very useful, economic and user-friendly piece of software. It compares very well with traditional test packages (and) provides indicators for compensatory education." (p. ii). [See Lee, P. (1999). *Using and evaluating CoPS a computer based cognitive profiling systems used in the Assessment of Special Educational Needs (including Dyslexia) in 4-8 yr. Olds*. Unpublished M.Sc. thesis (Computer Applications in Education), Dublin City University.]

Dr Hiroko Fumoto, Senior Lecturer in Early Childhood Studies at Roehampton University, London, demonstrated the value of Lucid CoPS when used as an assessment tool with children from eight different language backgrounds, including Bengali, French, Gujarati, Japanese, Malayalam, Pushto, Tamil, and Urdu/Punjabi. [See Fumoto, H. (1998) *Cognitive assessment of children for whom English is an additional language*. Unpublished M.Sc.Thesis, Department of Psychology, University of Hull.]

Lucid Baseline

Lucid carried out extensive research and development for **Lucid Baseline** (standardised for ages 4 to 5 ½ years) during 1997-1998. Lucid Baseline (formerly called 'CoPS Baseline') is normative and standardised and is the only QCA Accredited Baseline Assessment Scheme that is fully computerised

for on-entry assessment of early years skills in England and Wales. For further information about validation of Lucid Baseline see Singleton, C. H., Horne, J. K. and Thomas, K. V. (1999) Computerised baseline assessment of literacy. *Journal of Research in Reading*, 22, 67-80.

LASS Junior and LASS Secondary

Lucid Assessment System for Schools (LASS) built upon our pioneering work on the Lucid CoPS program and are normative (statistically standardised) and adaptive (that is, the computer automatically adjusts the difficulty of the items to suit the ability level of the pupil. This means that assessment is faster and more efficient, and also prevents pupils becoming bored by items which are too easy or frustrated by items that are too difficult.). The LASS systems also incorporate attainment measures such as **reading** and **spelling** in addition to cognitive measures and an **ability** measure.

LASS Junior (standardised for ages 8 to 11 years) has a standardisation sample of over 1,000 children in eleven different schools in different parts of the UK. Since much of the development and validation work for LASS Junior was based on LASS Secondary (see below), a small-scale validation study was carried out for LASS Junior on 100 children.

The initial research to develop **LASS Secondary** (standardised for ages 11 to 15 years) was carried out over the period 1997 to 1999, using a total of 2,366 students attending 28 different secondary schools in the UK. The data obtained from these trials were subjected to item analysis, including determination of difficulty levels for each item (pass rates), which were then incorporated into the adaptive algorithm in the adaptive tests in the suite. In addition, timings, progression rules and discontinuation rules were calibrated. The eight tests in LASS Secondary have been standardised and the standardisation of LASS Secondary was carried out in 1998, using a representative sample of 505 students UK attending 14 schools in different parts of the UK. Further validation studies of LASS Secondary, comparing it with several conventional tests used for assessment of dyslexia and special educational needs, were carried out using a total of 251 students aged 11-15 years in 17 different secondary schools. The results revealed highly significant correlations between LASS Secondary measures and equivalent published conventional tests that are widely used by educational psychologists, indicating satisfactory concurrent validity. LASS Secondary measures were found to be more accurate in the identification of dyslexia when compared with equivalent published conventional tests. It was concluded that LASS Secondary is a reliable and valid assessment system for special educational needs and dyslexia. [See Horne, J. K. (2002) *Development and evaluation of computer-based techniques for assessing children in educational settings*. Unpublished Ph.D. Thesis, Department of Psychology, University of Hull.] LASS Junior and LASS Secondary are currently in use in over 6,000 primary and secondary schools in the UK, providing assessment of dyslexia, literacy skills, cognitive abilities and intelligence.

LADS and LADS Plus

The first version of **LADS (Lucid Adult Dyslexia System)** was released in July 2002 following a three-year programme of research at the University of Hull to develop computer-based test materials that would swiftly and accurately discriminate adults with dyslexia from adults without dyslexia. LADS quickly became a widely-used dyslexia screening tool in a variety of educational and occupational settings for persons aged 16 and over, but especially in universities and colleges.

The three dyslexia-sensitive tests in LADS were validated in three separate studies. The first involved eight centres catering for adults with dyslexia; two were in universities, three were in colleges of further education, and three 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). Statistical analysis revealed that all three dyslexia-sensitive tests in LADS distinguished significantly

between the dyslexic and non-dyslexic groups, and the overall program gave a better than 90% accuracy in identifying dyslexia. The second study involved 48 randomly selected university students, none of whom was known to have dyslexia, and revealed highly significant correlations between the dyslexia-sensitive tests in LADS and conventional measures of reading, spelling and working memory. No significant gender differences were found. The third study involved 38 university students (19 dyslexic and 19 non-dyslexic) who had been closely matched for intelligence. The results showed statistically significant differences between the groups on LADS test scores, indicating that LADS results are largely independent of intelligence. Full details of these data and results may be found in the LADS and LADS Plus Administrator's Manuals, and the findings were also reported in a research paper [see Singleton, C. H. and Horne, J.K. (2004) *Computerised screening for dyslexia in adults*. Paper presented to the 6th International Conference of the British Dyslexia Association, University of Warwick, March 2004.]

In addition to widespread use in universities and colleges, LADS has also been put to good use in other settings, including prisons and young offender institutions, where there are high levels of illiteracy and individuals are often found to be socially and educationally disadvantaged with poor verbal skills. In these settings, there was concern that although LADS was able to identify those with dyslexia, its susceptibility to 'false positives' may be higher than desired. False positives are cases where LADS classifies a person as probably having dyslexia, when in fact, they do not. These cases will undoubtedly have severe literacy problems but these problems could be due to causes other than dyslexia, e.g. lack of schooling, low verbal ability or social disadvantage. Thus there was clearly a need for a new version of LADS that would identify dyslexia more accurately in individuals with non-standard educational backgrounds, such as offenders and immigrants. During 2004-05, a research programme was carried out at HM Youth Offender Institution, Wetherby, in collaboration with the University of Hull and the British Dyslexia Association. The aim was to determine ways in which LADS might be modified to increase its screening accuracy when used with individuals who may have non-standard educational backgrounds. The project was carried out in three phases. Phase 1 was conducted during the Spring of 2004 and involved collecting data from an unselected sample of 116 male juvenile offenders aged 15-17 years at Wetherby YOI using LADS and conventional tests of reading and spelling. The results indicated that as a screening tool LADS was acceptable to this population and straightforward for staff to administer but that in its standard form it produced an unacceptably high incidence of false positives (i.e. cases that may have been wrongly classified as having a high probability of dyslexia).

Phase 2 was conducted during the summer and autumn of 2004 and involved assessing cognitive and literacy skills in a selected sample of 36 male juvenile offenders aged 15-17 years, 18 of whom had high probability of dyslexia and 18 of whom had low probability of dyslexia. The results showed that a very large proportion of the young offenders had low verbal ability, which is consistent with findings from similar studies. To a large extent, this is likely to be due to educational and social disadvantage as well as to lack of reading experience, which contributes significantly to vocabulary growth, especially after the primary stage of education. By contrast, the average non-verbal ability of participants in all phases of the study was found to be within the average range. These results indicate that in this population it is critical to have an instrument for identifying dyslexia which will allow for low levels of reading ability, low verbal intellectual skills and lack of educational opportunities. It was concluded that by incorporating a test of verbal ability into LADS and modifying the classification rules used by the program it should be possible to identify those young offenders who have dyslexia with a satisfactory degree of accuracy while reducing the number of false positives to more acceptable levels.

Phase 3 was carried out during early 2005 and involved administering a modified version of the computer-based screening test that incorporates a measure of verbal reasoning

(LADS Plus) to a new unselected sample of 62 juvenile offenders aged 15-17 years. The results indicated that about 31% of young offenders at Wetherby YOI have dyslexia, a figure that is reasonably consistent with comparable studies that have used cognitive tests (as opposed to check lists and rating scales). A further 32% showed borderline symptoms. The overall conclusions of this project were that computerised screening using the modified program LADS Plus is a practical and efficient solution for identifying dyslexia in juvenile offenders. The report of this project, entitled *Practical Solutions for Identifying Dyslexia in Juvenile Offenders*, was published in 2005 by the British Dyslexia Association. The report provides full statistical analysis of the data obtained in the project and may be download from the web at: <http://www.bdadyslexia.org.uk/downloads/juvenileoffenders.pdf>

Lucid Rapid Dyslexia Screening

Lucid Rapid Dyslexia Screening is an objective computer-based system for identification of dyslexia between the ages of 4 to 15 years, first published in 2003. The program gives the child three separate dyslexia sensitive tests, each of which takes about 5 minutes. The tests administered vary with the age of the child, but have been carefully selected and validated so that screening accuracy is maximised. These tests have been selected from the existing programs Lucid CoPS Cognitive Profiling System, LASS Junior and LASS Secondary. The first two tests measure the child's phonological processing and auditory working memory. For children aged 8 and over, the third test measures phonic decoding skills. Children under 8 years are administered a third test that measures their integration of visual memory skills with use of verbal labels and concepts. Each of the tests in Lucid Rapid Dyslexia Screening has been individual validated and standardised on national samples of over 2,000 children, and is already in widespread use in over 8,000 schools using the established computerised assessment suites Lucid CoPS Cognitive Profiling System, LASS Junior and LASS Secondary.

Lucid Ability

Lucid Ability is a computer program that provides swift and effective assessment of verbal and non-verbal reasoning skills. The tests in Lucid Ability were standardised on a total of 4223 children aged 4–16 years. Concurrent validity measures were obtained by comparing results of Lucid Ability tests with comparable conventional tests, with satisfactory correlation figures. Full information is given in the Lucid Ability Administrator's Manual.

Lucid ViSS

Lucid Visual Stress Screener (ViSS) is an objective computerised test designed to screen for visual stress (aka Meares-Irlen Syndrome) from ages 7 to 17 years. First published in 2007, ViSS gives an accurate and reliable indication of the existence and severity of visual stress and predicts those individuals who are likely to benefit from using coloured overlays or tinted lenses to reduce the symptoms of visual stress and make reading more comfortable. Visual stress is the experience of unpleasant visual symptoms when reading and also in some other visual activities. Symptoms include illusions of shape, movement and colour in the text, distortions of the print, loss of print clarity, and a general visual irritation. In the long term visual stress can result in sore eyes, headaches, frequent loss of place when reading and impaired comprehension. Research has shown that 15–20% of children and adults suffer from some degree of visual stress, which impairs the development of reading fluency. ViSS was developed as a result of a three-year research programme on visual stress conducted by Singleton et al at the University of Hull. At the outset of this research programme, there was no objective diagnostic test for visual stress. The reliability of subjective reports of symptoms has been questioned, especially where children are concerned. Diagnosis by positive response to the preferred treatment method, either the sustained voluntary use of a coloured overlay or immediate improvement

in reading rate when using an overlay, is usually regarded as the best option. The aim of the research was to create an objective, reliable method for identifying visual stress, especially in children, who may not always appreciate that they have this condition, despite suffering its effects.

Within the published research literature on visual stress there is consistent evidence that visual stress sufferers are impaired on visual search, especially in the presence of repetitive striped geometric patterns. Early empirical work concentrated on piloting prototype versions of a visual search task that might serve as a useful screening device for visual stress. Children who were found to have high susceptibility to visual stress on the computerised visual search task had significantly slower reading speeds than other children but otherwise there were no significant differences between groups. The children with high susceptibility to visual stress on the computerised visual search task were more likely to choose a coloured overlay, and use of the chosen overlay caused a significant improvement in reading speed. The outcome of this pilot work suggested that the computerised visual search task would be a suitable basis for screening for visual stress.

We then carried out a study of 60 unselected primary school children aged 9-10, who were tested with an improved version of the computerised visual search task. In this study, children whose response times were significantly affected by a visually stressful pattern during reading-like visual search had significant increases in reading rate with an overlay compared to children whose response times were not affected by the pattern. Contrary to expectation, visual stress susceptibility did not affect response times for non-visually stressful visual search. The results suggested that visual search task may provide a more appropriate and objective method for classification of visual stress in children. Later work focussed on refining the computerised visual search task and looking at its applicability in cases of dyslexia. In a study involving two unselected samples of children: 50 aged 7-11 years and 67 aged 11-17, the results provided validation of ViSS as a screening tool by confirming that primary and secondary school children who were classified by ViSS as having high susceptibility to visual stress had larger percent increases in reading rate with an overlay compared to those with low visual stress. The results also indicated that subjective reports of symptoms may not always be diagnostically effective with younger populations.

Another study compared children aged 7-14 who had received a formal diagnosis of dyslexia from an educational psychologist with an age-matched control group of normal readers. Dyslexic children identified as having high visual stress showed significantly higher percent increases in reading rate with a coloured overlay and reported significantly higher critical symptoms of visual stress, compared to dyslexic children with low visual stress. The same results were found for reading age controls, indicating that ViSS can be equally effective as a screening device with normal readers as well as with children with dyslexia. Compared to reading age controls, dyslexic children were found to have significantly higher susceptibility to visual stress, significantly larger percent increases in reading rate with an overlay, and significantly higher critical and non-critical symptoms of visual stress. Extrapolated to unselected population samples, the data also suggest that visual stress is more likely to be found in people with dyslexia than in people who do not have dyslexia. This is consistent with findings by Kriss & Evans (2005) and Singleton & Trotter (2005), and indicates that it is particularly important that children with dyslexia are screened for visual stress. Wilkins (2003) argues that individuals with dyslexia are more sensitive to the visual features of text, and consequently have greater susceptibility to reading-induced fatigue. This direct causal link between visual stress and dyslexia is supported by findings that reading under demanding visual conditions, such as with small print, leads to declines in reading performance by dyslexic individuals. [For further information on the development and validation of Lucid ViSS see Henderson, L-M. & Singleton, C.H. (2007) Visual search as a predictor of susceptibility to visual stress in reading. *Ophthalmic and Physiological Optics*. Singleton, C. H. & Henderson, L-M. (2007) Computerised screening for visual stress in reading. *Journal of Research in Reading*. Singleton, C. H. & Henderson, L-M. (2007) Computerised screening for visual stress in children with dyslexia. *Dyslexia: An International Journal of Research and Practice*.]

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