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SeeWord: Rethinking Interfaces
Insights from word-processing software for dyslexic readers

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Abstract: Dyslexia is a condition which varies widely between individuals and affects not only the sufferer's ability to read, but is also likely to affect sequencing ability; taking these as the initial framework for a system to help dyslexic readers to process text more easily on a computer screen, we have produced a system called SeeWord which allows easy and intuitive configuration of a visual environment. We argue that there are wider conclusions to be drawn about interface design generally, and especially about the two orthodoxies of direct manipulation and WYSIWYG.

Keywords: dyslexia, interface design, direct manipulation, WYSIWYG

1 Introduction

It is an entertaining cliché of stories about the computerised office that computers are frustrating, difficult to use and cause "computer rage" (BBC, 1999). As a result, some experts, such as Don Norman, suggest that computers have reached a dead-end of innate complexity and low usability, driven by socio-economic factors and a culture of technophiles. Norman suggests that the best, indeed the only, way to escape this dead-end is to radically rethink the entire paradigm: to abandon the unwieldy and overly complex "personal computer" and develop "information appliances", devoted objects within which the computer is invisible (Norman 1999).

While we accept many of Norman's points about complexity and the resulting confusion and frustration for many users, we would suggest that personal computers are now so deeply integrated into the lives of many people that an attempt to revolutionise computing by abandoning personal computers entirely would create more problems than it would solve. Instead, we argue, interface complexity is an important element in the daunting impenetrability of modern computer systems, and much can be done to simplify interfaces, changing the computer system that people perceive, to strip away much complexity and unnecessary functionality. We suggest that it is in fact the interface that very often causes the frustration with computers, and that the "personal computer" is not inevitably doomed to absurd complexity, but, by reconsidering the design of the interface, and questioning various dogmatic orthodoxies of current interface design, like Windows and WYSIWYG, it is possible to design a more usable and accessible system than is currently available.

Since dyslexic readers have particular difficulties with using computers, we felt that addressing the problems they experience with interfaces, to facilitate reading and writing activity, we would gain insight into some of the problems intrinsic to interface design in general.

Word processors are potentially of tremendous use for people with dyslexia; Jill Day notes, "The use of IT to support the writing process has liberated students with specific learning difficulties from the problems with print that have traditionally hindered their expression of ideas" (Day, 1994, 26). Yet it is clear that, unless design is thought through carefully, computers can be as much a hindrance as a help

In this context we re-examined what assistance might actually be offered to dyslexic computer users which addressed the effects of dyslexia, and we looked at ways in which access to word processors could be facilitated by reconsidering the interface design. This reconsideration involved deconstructing the current Word interface and metaphor using specific problems faced by dyslexic computer users as a framework and examining at a micro-level how a computer interface might support overcoming these problems.

The design aim thus became to create a dyslexic-friendly environment which enabled users to easily configure the system to suit their own, individual preferences and thus to access more fully the capabilities of word processing systems to help dyslexic readers to read and produce text more easily.

The experiences we have had designing this system for dyslexic readers encourage us to believe that there are conclusions to be drawn about interface design which may provide a framework to help everyone to use computers more easily.

We will begin by explaining the condition of "dyslexia" in more depth in order to give insight into the complexities of designing a "dyslexic-friendly" environment and to explain some of the specific difficulties we set out to address in the design of the interface. We will then describe the design process and the ways in which we sought to address the problems that dyslexic readers faced using traditional word processing systems. We will briefly report on the results of testing the system with dyslexic school children, and with university students. We will conclude with a discussion of the interface elements that we found hampered people's attempts to use word processing systems easily, and suggest that a more general deconstruction of accepted interface design orthodoxies might contribute to the design of new more usable interfaces for computers in general.

2 Dyslexia

Dyslexia is a condition which affects 10% of the population in the UK (Habib, 2000). It is commonly described by reference to its ultimate effect, ie: a difficulty learning to read and write. The British Dyslexia Association describes dyslexia as: "A specific difficulty in learning, constitutional in origin, in one or more of reading, spelling and written language, which may be accompanied by difficulty in number work" (BDA 2001).

Psychological investigations of the causes of dyslexia increasingly suggest that for many dyslexic readers the condition is caused by neurological differences from "normal" readers (Jenner et al, 1999), thus difficulty in learning to read is a specific result of an underlying neurological difference which affects other areas of their lives. Individual experiences of dyslexia are commonly on a continuum between phonological problems and visual problems; it is rare that there is a dyslexic reader who does not experience both. Nonetheless, the experience of the underlying impairment is mediated by other elements, for example memory (Snowling, 2001). The effect is that dyslexic readers can experience widely different symptoms of dyslexia.

Some of the experiences that people with dyslexia have when trying to read or write text are discussed below. We are not trying to list all possible symptoms, but rather to explain the issues that can most severely affect computer use and explain how we felt these could be ameliorated.

2.1 Visual Distortions

Dyslexic readers often report visual distortions which lead to eye strain, fatigue and headaches. Such distortions include the reader seeing lights moving around and behind the text and white spaces between words "flowing" downwards, distracting from the characters. People with dyslexia may also perceive letters as overlapping, blurred or may even see them moving (BDA X09). Certain frequencies of black text on a white background can cause extreme visual discomfort, including migraine, to people who are sensitive to 'pattern glare' (Wilkins and Nimmo-Smith, 1987). Another visual effect of dyslexia is the tendency to confuse similar-looking letters, thus some dyslexic readers confuse 'b' and 'd' or 'p' and 'q' (Willows and Terepocki, 1993). Finally, some dyslexic readers have difficulty with parafoveal vision, meaning that information presented at the periphery of the screen may be less useful than for other computer users; another problem with peripheral vision is that for some people, toolbars, rulers, scroll bars etc. appear as 'screen clutter', moving at the edge of vision and distracting attention from the text.

The literature on education and dyslexia indicates that often alteration of the visual environment has very positive effects on the dyslexic reader's ability to process text (Wilkins, 1995; Hornsey, 1994; Keates, 2000; McKeown, 2000). Special needs teachers, working with paper-based materials, use coloured overlays and larger text (Keates, 2000, 34; Hornsey, 1994, 52) and often encourage dyslexic children to use a piece of card to cover the text they are not reading at the time so that visual stress from the striped pattern of black on white is reduced, and the student can tell which line they last read (Mailley, 2001; Arkell, 1997; Keates, 2000). Changing the colour of the background and the text on VDUs is intended to mimic the effect of "Irlen overlays" which benefit many dyslexic readers/ sufferers from 'Meares-Irlen' syndrome for reasons which have not yet been adequately explained (Wilkins, 1995).

2.2 Memory and Sequencing

Dyslexic readers often have difficulty with short term and visual memory and with sequencing (McKeown, 2000, 5); they may have more difficulty than their peers in remembering recently presented information, the position they are at in a page or in accurately remembering ordered lists. Dyslexic children frequently confuse the order of the alphabet, months of the year and even days of the week. Helen Arkell illustrates the problems of poor visual memory with an example of a dyslexic reader who has glanced away from the page,

"those with poor visual recall will have forgotten the layout of the page and where they were in relation to a full stop or paragraph: they may even have forgotten whether they were on the right or left hand page and they will waste time reading a few lines here and a few lines there in search of their place."

(Arkell, 1997, 10-11)

Such difficulties make word processor use more difficult since designers of word processor interfaces often depend on "normal" memory. Thus, the sequences of steps needed before a formatting change can be made is complicated in three ways: first, the steps must be remembered, second, the *sequence* too must be recalled, and third, the position of the commands in the menu system must be remembered.

These difficulties make the design of a usable system for dyslexic computer users very complicated; in many educational institutions, special needs teachers set up computers for dyslexic students – an operation which is time-consuming, an inefficient use of specialised staff time and crucially makes the dyslexic user dependent on the availability of expert help, thus disempowering the individual.

3 Designing SeeWord

3.1 Design Approach

From the outset there were three fundamental problems which had to be addressed in designing the system:

- Wide user variation
- Difficulty with reading
- Limited ability with sequencing

The fact that dyslexia is a condition which differs from individual to individual constituted a central design problem. It meant that it was not possible to design a single "one size fits all" system for dyslexic users, rather that the system needed to be configurable to address flexibly the specific problems faced by individuals. In addition, there were two fundamental elements of dyslexia which had to be addressed at the very beginning of the design process: a reading deficit, which meant that dependence on text had to be minimized; and second, a difficulty with sequencing, which meant that the interaction with the system had to be as immediate as possible. Ironically perhaps, current word processor interfaces depend very heavily on both the ability to read text without difficulty and on the ability of the user to recall and follow long sequences of steps (to alter formatting preferences, for example).

Because dyslexia is such an individual condition, our strategy was to produce a system to enable people to easily explore various options and to find out if they could discover a set of conditions which enabled them to read and produce text subjectively more comfortably than they could using the standard default word processing interface. Once these initial difficulties had been addressed it was possible to move on to addressing the more specific difficulties dyslexic readers face when reading (either from paper or from computer screens).

Our design strategy involved extensive contact with dyslexic computer users in discussions about the difficulties they faced using computers. Dyslexic participants were also observed using computers and the difficulties they encountered were recorded. As it was clear that the difficulties encountered were rarely encountered by everyone in the group, but more commonly by a subgroup of the participants, it was decided to take a pragmatic, problem-solving approach and to address each problem independently, looking at features which computers have which might be enlisted as an aid.

In particular, computers may be able to help with the following common problems (list adapted from Willows and Terepocki, 1993, 34-35) number and letter recognition; letter reversals; word recognition; number, letter and word recollection; spelling problems; punctuation recognition; fixation problems, and ultimately word additions and omissions and the poor comprehension which comes as an almost inevitable consequence of these problems.

Some of these problems were addressed by enabling easy changes to the visual environment, manipulating the following parameters:

- Fore and background colour
- Spacing
- Font size
- Typeface
- Distinguishing letters more clearly by enabling the user to colour a problem letter differently
- Reducing the problem of visual stress and memory by using reading masks which leave only parts of the text showing
- Reducing visual clutter in the interface

3.2 Evaluation and Prototype Development

It is quite difficult to divorce a system that will run within MS Word from the design assumptions made by MS Word. Thus the first systems we developed were heavily influenced by, for example, the use of relatively complex dialog boxes with preview windows. When we reconsidered this design in the light of evaluation from users, we realised that the interaction would have to be far more immediate.

The current SeeWord prototype allows the user to alter fore- and background colour, text size, typeface, and the spacing between lines and characters. These alterations take place in the document as the user manipulates an interface object (a slider bar, typeface buttons) and thus the user can easily fine-tune the document to suit his or her personal preferences simply by a process of easily-reversible change. In addition, the system allows the user to colour 'problem letters', to use one of three 'reading masks' to block out areas of the text, to move a coloured line up and down the text in order to help the reader to keep their place and to easily switch in and out of full screen mode.

The huge amount of functionality available through the current Word interface is largely unnecessary in the context of SeeWord; for the purposes of using Word as a reading tool a relatively small subset of functions are necessary which means it is possible to remove the existing toolbars and replace them with a single simple toolbar, reducing screen clutter and apparent complexity immediately. The functionality available on the SeeWord toolbar was carefully chosen and extensively tested through user evaluations. In addition, once appropriate settings have been chosen and saved, the formatting toolbar can be removed from the interface.

Figure 1: Changing text size in SeeWord

In Figure 1 above note position of the 'thumb' in the slider bar has an immediate effect on the size of the text in the document.

The ability of the user to make small alterations to the screen colour, thus taking advantage of the plasticity of VDU presentation when compared to paper, is particularly important for those users who suffer from visual distortions caused by black text against a white background, or from Meares-Irlen syndrome which makes necessary the selection of a very specific hue in order to enable the reader to perceive the characters in the text without discomfort and visual distortion.

3.3 Testing Efficacy

In evaluations and user testing it became clear that not only was the SeeWord system easier to user than Word, it indicated a strong trend towards improving the ability of dyslexic computer users to read text from the screen.

We evaluated the system with two different groups of dyslexic users: school children in Dundee, and students at the University of Edinburgh.

In all cases the evaluators were able to select settings which they preferred to the word processor default settings (black text on a white background). During the evaluations in Edinburgh (which only examined fore-/background colour change) a number of students remarked to the evaluator that they had attempted to alter Word's background colour to produce a more congenial reading environment but that they had been unable to do so owing to the difficulty of making such alterations with Word's interface (of course, the developers of MS Word intended to allow people to format documents for attractive appearance, not to allow people to fine-tune their colour preferences to produce a visually comfortable environment) (Dickinson, L. 2002).

The school children in Dundee attended a specialist dyslexia unit and had all been diagnosed as dyslexic by conventional educational means; 6 boys aged 14-16 volunteered to take part in an experiment with SeeWord. The test involved 12 paired texts of 6 levels of increasing difficulty which the pupils were asked to read aloud both with default settings and with their own settings, selected after an hour 'messing around' with the SeeWord system and confirmed two days later. As the pupils read the texts, errors (mispronunciations, substitutions, refusals, additions, omissions, and reversals) were recorded by an observer. When the texts became too difficult for the pupil to continue to read without distress, the pupils were allowed to stop; this means that not all of the texts in all conditions were read by all the pupils (Gregor et al, 2003).

The trend of the data recorded suggested that the users benefited from the settings they had chosen with SeeWord.

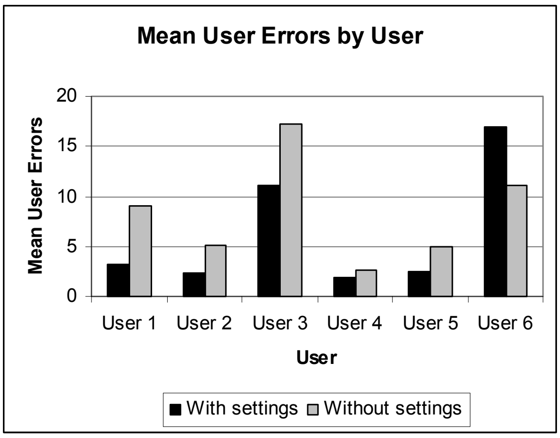

Figure 2: SeeWord Results: Errors by User

Figure 2 shows that all the pupils except user 6 made fewer errors with their settings. Despite this apparent pattern of improvement, a t-test performed on the individual user errors across conditions, failed to attain statistical significance ($t=-1.107$, d.f.=5, $p=0.319$).

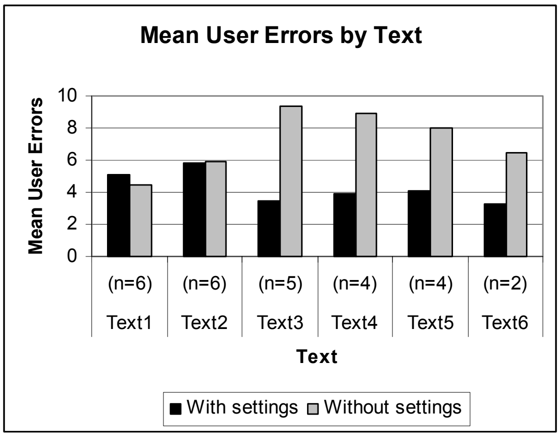

Figure 3: SeeWord Results: Errors by Text

The same trend of improvement is visible in Figure 3 where the mean number of errors is plotted against the 6 texts read by the pupils; the data show that individual settings appear to have little effect on the easiest texts (1 and 2) but have the most positive effect on more difficult texts. The improvement in performance between the with settings and without settings conditions is statistically significant ($t=-2.708$, d.f.=5, $p=0.042$, $p<0.05$).

In both the Dundee and the Edinburgh studies users subjectively rated the different settings in ways which seemed to relate more to visual comfort than to aesthetic appearance. One pupil commented "[I] can see it better. Black on white hurts my eyes.", and another remarked that the settings he had chosen "kept my eyes on the words instead of wandering about the page" (Gregor et al, 2003). The Edinburgh students reported selecting their settings for "contrast without much glare", "the contrast and the comfort when looking at the screen. With a white screen I seem to see changing patches of colour sometimes, so I was looking for something stable", "contrast between colours, words seemed more defined" (Dickinson, L. 2002).

Despite these positive subjective responses, however, Dickinson failed to find a significant relationship between successful reading and fore-/ background colour. The implications of her study, and the results of the Dundee study, need to be further examined: were the results in Dundee independent of colour alterations, and instead caused by text size or spacing or some combination of variables? Are the settings offered by SeeWord only of significant use to younger dyslexic readers despite the subjectively reported increase in reading comfort for both groups? Is the difference due to the methodological differences between experiments, contrasting reading aloud (Dundee) and reading silently (Edinburgh), thus contrasting reading errors (Dundee) with speed and comprehension (Edinburgh)? There are additional more detailed methodological questions, including the issue of whether, in retrospect, enough time was allowed to the Edinburgh students to become accustomed to the newly selected colour combinations (Dickinson, L., 2002).

The subjective responses of our participants have indicated that they definitely believe that the formatting changes help them to read. Research by others using filters and coloured lenses indicates that colour does have an effect on reading ability when measured correctly (Lightstone et al, 1999), the question is how to transfer this to the computer screen.

In addition, our evaluators can now confidently use the SeeWord system to configure the visual environment in a way that they could not before. This addition to confidence and to their perception of the usefulness of computers must be considered a tremendous success.

4 Insights into better interface design?

4.1 Direct Manipulation

In addressing the difficulties that dyslexic readers faced with recalling sequences of actions, and the effect that this difficulty has on the successful use of traditional word processors, we have dramatically increased the immediacy of the interaction with the system.

The immediacy of changes on the screen in response to user actions proved to be one of the most popular aspects of the new system. We choose to call this "direct manipulation" after the interface style discussed by Shneiderman (1983; 1998). Shneiderman describes direct manipulation as: "rapid incremental reversible operations whose effect on the object of interest is visible immediately" (Shneiderman, 1998, 205). While this term has come to be associated with WIMP systems like the Windows OS it should be clear from the comparisons above that far more <u>direct</u> manipulation is possible. Nielsen describes a similar method of interface interaction which he calls an object-oriented interface, "users achieve their goals by gradually massaging these objects… until their state, as shown on the screen, matches the desired result" (Nielsen, 1993, 58-9). The advantages of direct manipulation for fine tuning of formatting settings are quite clear, but in addition the immediate link between incremental user actions and on-screen changes increases user confidence tremendously (Shneiderman, 1998, 205-6).

It should be clear that with direct manipulation there is no sequencing: you simply carry out the manipulations on the relevant object, and watch the changes take place on the screen.

4.2 WYSIWYG (What You See Is What You Get)

For people suffering from visual dyslexia it is patently true that WYSIWYG has a detrimental effect on their ability to process text; manifestly, "what you see" does not work for these readers, in fact it could even be argued that visual dyslexia is *precisely* a problem with WYSIWYG. What visual dyslexic readers need to do is to configure the computer environment so that they can see comfortably what is on the screen. Often the colours they select appear strange to non-dyslexic readers, low contrast combinations of dark green and red, for example (Gregor & Newell, 2000; Dickinson, A. et al, 2002).

In fact, it is worth asking where the orthodoxy of WYSIWYG originated from. The rapid development of computer hardware has often left interface design a little behind; the excitement that greeted developers' ability to represent the document as if it were a sheet of paper, so that what you saw on the screen was essentially identical to what was printed out, has meant that there has been little subsequent examination of whether it is necessarily equally good for all users and all uses. Eye-movement research on reading from VDUs indicates quite clearly that the reading process is different on VDUs in comparison to paper (Kennedy & Murray 1996). That WYSIWYG became a guiding principle of software design is not surprising, but it is a questionable principle upon which to base all software design. As shown here, there are circumstances where it is not helpful, where indeed the ability to configure the visual environment taking advantage of all the facilities that computers allow is important. In this context, clearly it is advantageous to have a different view on screen from that which will be printed on paper: WYSINWYG (What You See Is Not What You Get).

5 Rethinking Interfaces

Our work with dyslexic readers suggests not only that direct manipulation is an important usability development, and that WYSIWYG should be questioned, but also that the methodological approach is a useful one. The methodology adopted for the SeeWord development can be represented as a framework with three major points:

- Identification of the essential barriers to computer use, ie: the fundamental design constraints, and then addressing them;
- Incremental introduction and testing of tools and utilities
- Modular development of system

Many users are, like dyslexic readers, excluded from successful computer use by barriers produced by inappropriate interfaces. For example, older adults often find computer use extremely complicated because of small button, text and target sizes which create a barrier to those with visual impairments; small targets are also a significant barrier for those with fine motor control difficulties. In addition, as people age their short term memory is likely to become less efficient than in younger people and this can mean that complicated menu systems and sequences of instructions become another barrier to computer use. There is also a greater risk of "getting lost" due to an accidental wrong button press or keyboard input.

The three step methodology that was used in the development of the SeeWord system could productively be applied to many other user groups who may be wholly or partially excluded from full use of general purpose computers by the complexity and often thoughtless design of their default interfaces.

First, by looking at the absolute barriers to full access for any given group of users and addressing these, we can design systems which enable more users to get started with the given software. For dyslexics, this was done by removing extraneous clutter, reducing reliance on sequencing ability and so on.

Second, once we can be more confident that the user can find their way around the system, we can incrementally introduce direct manipulation-based configuration tools and utilities and test them. The selection and design of such tools is based on a pragmatic view of what can be done using computers, based on knowledge of likely difficulties and a creative approach to alleviating them. Those which evaluation indicates work for some users are retained; bad hunches are removed. Of course there will be an overlap in facilities that are likely to be of use to different groups. For example, some of the support provided for dyslexic readers could also benefit older users: the ability to personally configure a computer environment would be very useful for those with age-related visual impairments which manifest themselves in a variety of ways.

Third, by incrementally developing systems in a fully modular way, the process can be flexible, adaptive and centred on real user need (not to be confused with expressed desire or user testing to tinker at the margins of existing interfaces).

The approach requires the developer to cast off many preconceptions and even some conventional wisdom; it means not accepting that doing nearly everything using menus is good; it may mean discarding the orthodoxy of WYSIWYG; ultimately it may mean acknowledging that really for some substantial user – and potential user – communities, we need to think beyond WIMP; it certainly means 'one size fits all' is inappropriate.

6 Conclusion

The iterative development of the SeeWord system continues, as the benefits are manifest. The next stages will be to optimise the direct manipulation facilities and to produce a production version. However, the principles have applicability in the wider context of the design of usable computer systems. While an examination of the problems faced by dyslexic computer users makes it clear that designers cannot assume system users will have "normal" memories, motor control or responses to visual displays, it is clear that enabling personalisation of a system can dramatically improve the experience of system use for users. Dyslexic users found the options offered in the SeeWord system, and the ease of using them, altered their experience of reading from the screen. Further research is needed to establish whether the design principles adopted here may have benefits for the design of interfaces for all sorts of users. Older people, for example, experience deteriorating memory ability, and people with poor vision might well benefit from easily being able to alter the characteristics of the display. If the recognition of individual diversity is accepted as a design axiom; designers build in genuine direct manipulation interfaces; intelligent decisions are made about what configurability is useful; thought out decisions are made about when WYSYWIG is appropriate, the potential exists to design systems which really will address many of the problems of excessive complexity that currently plague the computer industry.

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