Enhancing Comprehension of Web Information for Users with Special Linguistic Needs

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Abstract

In this paper we review the special linguistic needs of language disordered users who are potential users of the world wide web hypertext system. For the web to be a true information highway, there must be facilities to enhance the comprehension of those users who have special requirements, and who will benefit enormously from appropriately aided access to the web. We provide some guidelines for the development of such facilities.

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Introduction

The web is fast becoming a day-to-day necessity in the modern world. Amongst the most important research issues regarding it relates to its usability. It is now accepted that the web will be used widely, in the near future, by users coming from varied socio-economic backgrounds and those with special linguistic needs. In the face of increasing amount of information transfer with high information load on communication networks, it is important that the information retrieved is as specific as possible, and presented in a manner which closely matches the user's thought-process. We must address these usability issues for language disordered users and recognise their importance because: i) a growing population of such users is computer literate and uses the Internet; ii) the Internet offers a vital source of information on all sorts of issues and an external link to these subjects; and iii) commercial application of the Internet will benefit. We need to understand what language disorders are and how they affect the performance of individuals in the context of working with hypertext, and consequently how the resulting issues can be resolved. For patients who suffer with language disorders, for example as in illnesses including dysphasia and dementia, several issues with regards to the structuring of the Internet system need to be addressed.

In this paper we will describe the nature of language disorders, and the problems encountered by language disordered users while using hypertext software. Some of the description would be broader to distinguish language problems encountered by elderly normal users or those under stress from those encountered by users with special linguistic needs. We

will also explore the methods through which we should develop user interfaces such that: (i) the search techniques are easier to use and yield good results; (ii) the information layout is easy to understand, and (iii) the system may learn more about the habits and information needs of the user.

Nature of language disorders

It is important to dissociate language from speech, and stress that the thrust of our discussion is towards language disorders and not speech disorders. Speech refers specifically to the physical component of our communication using language, and therefore speech disorders are concerned with dysprosody, weakness of speech musculature, problems with articulation and programming movements, and with the phonological component of language. Language disorders, on the other hand, are concerned with the syntax and semantics of language, lexical richness, and mapping disorders. In most cases, speech and language disorders coexist, e.g. dysarthria with dysphasia. User interaction with the Internet does not involve speech tasks, however, it requires considerable syntactical and semantic knowledge about retrieving and inferring information. We will discuss the problems encountered by language disordered individuals in later sections. At first we should like to discuss the nature of language disorders. We will discuss word-finding problems, sentence -level problems, and psycholinguistic factors in language use for two language disordered populations: Dysphasia and Alzheimer's disease.

It is important to discuss syntax and word-finding problems encountered by language disordered users. Evidence on these has been gathered by researchers through observation of their speech, reading and writing abilities. Linguistic decision making tasks are clinically used

to elicit responses which identify those grammatical structures which are difficult to use or unavailable when tested.

Dysphasia

Dysphasias may be defined as:

> Impairment due to brain damage, of the capacity to interpret and formulate language symbols; a multimodal loss or reduction in decoding conventional meaningful linguistic units (morphemes and larger syntactic units); disproportionate to impairment of other intellectual functions; not attributable to dementia, sensory loss or motor dysfunction; manifested in reduced availability, reduced efficiency in applying syntactic rules, reduced auditory retention span, and impaired efficiency in input and output channel selection, (Wertz, 1985, p. 2).

Dysphasic patients suffer with lexical and syntactical problems. We first summarise some generic characteristics of word-finding problems for these category of subjects.

word finding.

- Vocabulary of such subjects is reduced in comparison with normal controls (Berndt & Caramazza, 1980).
- Verbal output consists of open-class lexical items including nouns, adjectives and main verbs, and there is a very limited use of closed class items including pronouns, articles, prepositions, auxiliary verbs and conjunctions, the so called function words.
- Selective loss of vocabulary also takes place in auditory comprehension and reading.

- The qualitative dimension of the impairment depends on the word searched for: abstract or concrete, noun or verb, etc.
- The quantitative aspect of the impairment depends on the type and severity of the disorder.
- Syntactic cues are more important for the understanding of sentences for posterior dysphasic, whereas semantic cues are more important for anterior dysphasics (Wagenaar, Snow & Prins, 1975.
- Open-class and closed-class lexical items are accessed differently in normals and dysphasics (Garrett, 1980). Word recall for searching information is especially difficult for semantic dysphasics who stretch the semantic boundaries of words, e.g. the word ‘chair’ may be referred by them as either table, seat, sofa, *or* bed.
- The imageability of words is important to dysphasics for their understanding and use (Bock & Warren, 1985).
- Factors including semantic specificity, givenness, perspective, conceptual focus, empathy, familiarity, and salience will be important in word-retrieval tasks.

Word finding problems are considerably important from the point of view of searching information on the web. Since most available search engines have limited intelligence and concept searching capabilities, the search facilities in the present form are inadequate for dysphasic users. We will later discuss some suggestions on improving the state-of-the-art systems to accommodate user handicap with formulating exact queries. We first discuss syntax problems of dysphasic subjects in the context of reading and understanding web information.

syntax.

User inability to comprehend the syntactical component of written information can lead to little or no understanding of retrieved information. Dysphasic patients suffer with wide ranging problems related to the understanding of written information. Unfortunately, such problems may be difficult to detect or measure precisely even with proper language testing (Berndt & Caramazza, 1980). Some generic aspects of syntax related difficulties in dysphasia are outlined below:

- Syntax problems are common in motor dysphasias where the syntactic component is damaged, and less frequent in sensory dysphasias where the semantic component is damaged.
- Most motor dysphasics have difficulties with word-finding, word-order, compound sentences, use of grammatical morphemes, and use of closed-class lexical items.
- In verbal production, subjects exhibit dysfluency, reduced phrase length, structural simplification and absence of grammatical markers in expected context (Byng, Kay, Edmundson, & Scotts, 1990).
- Dysphasics rely heavily on the semantic information in a piece of text for its understanding (Kolk & Grunsven, 1985).
- Motor dysphasics look for the most common, the most expected interpretation of sentences, therefore depriving themselves of the possibility to comprehend more sophisticated and uncommon verbal messages, i.e. avoidance tactics (Heeschen, 1980).
- Dysphasic subjects perform poorly on reading-understanding tasks where more than one preposition is used to specify the relationship between lexical items (deRenzi & Vignolo, 1962), e.g. “Put the red small rectangle on the white large circle next to the yellow small circle.”

- Some linguistic structures are particularly deficient in dysphasic performance on spoken and written tasks, e.g. interrogative auxiliary, 3rd person singular verb, etc. (Goodglass, Gleason, Bernholtz & Hyde, 1972).
- The understanding of reversible sentences is particularly impaired.
- Some subjects exhibit mapping problems, i.e. mapping words to a phonological matrix (Caramazza & Berndt, 1978).
- Dysphasic subjects do not have their own grammar (Howes, 1964; Zipf, 1932).

In the above description we have briefly reviewed word-finding and sentence processing problems of dysphasic subjects. These difficulties are major obstacles in the way of dysphasic understanding of web information. In following sections we will discuss the management of these problems in detail. We next discuss another class of population with language disorders and their language problems with web information. Alzheimer disease is one of many diseases that lead to dementia. In this disease, the health of the subject progressively deteriorates. This is in contrast to dysphasia where the subject's health and their quality of language may slowly improve with time after stroke or trauma. The following section briefly introduces the features of language disorder in Alzheimer's disease (AD).

Alzheimer's disease

When Alois Alzheimer (1907) first described the disease, he reported word-finding deficits, paraphasias and comprehension impairment. Dementia is characterised by the breakdown of intellectual and communicative functioning accompanied by personality change. Communication disorders are a common feature of dementia (Bayles, Kazniak & Tomoeda, 1987; Kempler, 1991), being present in 88-95% of sufferers (Thompson, 1987). They are particularly pronounced in probable Alzheimer's disease (AD). Cummings Benson, Hill, and

Read (1985) estimate that nearly all AD sufferers experience language impairment. The use of web by such subjects will depend on the severity of their illness: little or no help may be needed by early AD users whereas it may be impossible for late AD users to work with a computer. The majority of AD users however have moderate difficulties with language processing, both in production and comprehension, which may be considered here. We list below some generic features of word-finding problems suffered by these subjects.

word finding.

- Word-finding difficulties are the most common symptom of Alzheimer's disease.
- AD subjects tend to stretch the semantic boundary of words and may often substitute words of low semantic specificity "place-fillers," (e.g. thing, do, it, he). It is not so much the loss of vocabulary, but the inability to retrieve correct words which makes it difficult for them to speak or write properly. Kempler (1988) supports the argument that AD patients' comprehension abilities are superior to their production abilities, thereby confirming that they can retrieve words in a passive manner more easily.
- Word-finding problems in AD subjects results due to disruption in lexical retrieval and lexical knowledge, accompanied by visual-perceptual problems.
- Different lexical components and their internal processing may be affected depending on the severity of the disease (Kempler & Zelinski, 1994, p. 337).
- AD patients are deficient in their proper use of open-class lexical items, especially with nouns.

AD subjects' syntax problems are listed below.

syntax.

- The semantic component of language is most disturbed in AD, hence syntax impairment is not a distinguishing feature of this class of language disorders.
- There is no straightforward evidence for syntactic language deficits. However, Emery (1986) notes that some AD patients also suffer significant syntactic deficits (e.g. they perform poorly in tasks such as: “The dog was bitten by the cat”; Which animal bit and which was bitten ?) This implies that some AD patients have problems with reversible sentences and those in which information depends strictly on the semantics of the structure.
- Alzheimer’s patients perform poorly when there is a delay between the presentation of the text material and their response to a performance task, i.e. AD subjects have working memory deficits (Kempler & Zelinski, 1994, p. 343).

The above discussion presents two important arguments: first, the nature of language disorder in dysphasia and AD is very different, and second that the disorders are primarily related to word-finding and sentence understanding impairments. It may be argued that some of the difficulties encountered by language impaired subjects are very similar to other web users who are old or under stress. In this vein, it is important to dissociate the nature and severity of dysphasic and AD language disorder from age or stress related sub-normal performance and thus argue that additional tools are required for specifically solving the problems of language disordered subjects in the context of web use. In favour of this argument, some characteristics of word-finding problems encountered by subjects under stress or through age related memory deficits are listed below.

- Word-finding problems are usually experienced by normal subjects over the age of sixty-five (Burke, Mackay, Wothley & Wade, 1991). Normal adults above this age also produce sentences in writing which are syntactically simpler, (Kemper, 1992).
- Kempler and Zelinski (1994) argue that lexical knowledge is not degraded with age. However, there is an increased delay in its retrieval.
- The errors made by normal adults are generally circumlocutions (e.g. “tea drinking pot” for “kettle”) rather than semantic approximations as in the case of AD subjects (e.g. “plate” for “kettle”). This indicates that the semantic boundaries between words remain intact with ageing.
- Word-finding problems in normal adults can be attributed to working-memory deficits. Kempler and Zelinski (1994) note that:

- Word-finding problems in normal ageing are of a different kind than those observed in dysphasia and dementia, e.g. in dysphasia the selection of both open and closed class words depends on their frequency, whereas in normals, only open class lexical items are accessed depending on their frequency. For normal adults, they appear to be more dependent on the lack of concentration and working memory deficits.

In addition, some features of syntax change with age are noted below.

- There is little change in our knowledge of syntax as we grow old, (Kemper,1987).
- In case the working memory is reduced with age, as is often speculated, then only a limited amount of information is processed in parallel leading to problems with compound sentences and clauses (Craik & Simon, 1980).

- Normal and language disordered subjects are vulnerable to anxiety and computer messages may cause confusion and panic (Cook, 1969).
- Lack of focussed attention may cause misunderstanding when reading text (Preece, Rogers, Benyon, Holland & Carey, 1994).

Two important conclusions may be drawn from the above discussion: a) language disordered patients have lexical impairments and often use compensatory mechanisms in contrast with normal subjects whose language restrictions are primarily due to lack of concentration, memory deficits and linguistic preference for simpler structures (Cohen, 1993); and b) the variety and severity of language disorders in dysphasia and AD is greater than any observed normal limitations, and therefore special consideration is needed in the context of facilitating web use. In this paper we will focus on two specific issues: understanding information as a part of the screen reading task; and hypertext navigation and the use of search engines to retrieve a particular piece of information. The following section first discusses the key factors affecting the understanding of hypertext for language disordered users.

Understanding information: key factors

The understanding of web information can be mentally exhausting for language disordered users. Preece et al. (1994) discuss an extended information processing model (ref: page 64). It consists of an information processing cycle with four stages: input encoding→ comparison with stored templates → response selection → response execution. The input messages (in our context, visual representations of words and sentences), are first encoded into an internal representation. These internal representations (e.g. word-forms) are then compared with the already existing templates, thereby giving the reader an understanding of what appears on the

screen. On the basis of this understanding, a response is generated. The overall process is heavily dependent on two key factors: memory and attention. There are several word level and sentence level problems which emerge when the functioning of this normal model is disrupted. These problems should be discussed generically rather than for every individual disorder. We list below a set of generic language related problems encountered by language disordered users when reading hypertext in its current form. Most of the problems discussed here may seem to be generic for all types of text including paper based material. A close inspection will however reveal that this problem is rather compounded for hypertext where different text links come from different authors and a single piece of text may not be necessarily uniform in its writing style. In addition, a large quantity of information on the Internet is not uniform with respect to its formatting and presentation thus making it difficult for users with special linguistic needs to adjust to this change.

Word level problems with reading hypertext

(i) Most of the words used in the text are unknown to the user, too technical or abstract to encode. It should be remembered that the active vocabulary of subjects with language disorders is much reduced compared to normal adults.

(ii) The same word appears with many different meanings, e.g. Trade as in "His trade ...," "He trades ...," and "His *trade*-union ..."

(iii) Most of the words used are of low frequency, not familiar to the user.

(iv) Words are of increasingly high semantic specificity, e.g. gloomy instead of dark.

(v) The words have low imageability content, e.g. increase, append, further, etc.

(vi) Words are difficult to pronounce and spell, e.g. connoisseur.

(vi) Words are addressed as "It," "That," etc., without reinforcing their original reference.

(vii) Adjectives are ambiguous or imprecise, e.g. "He was a big man," How big ?

(viii) The meaning of the word is over-contextualised, e.g. joy-riding.

Sentence level problems with reading hypertext

(i) Most of the sentences are passive than active.

(ii) The sentences are reversible: these can be easily misunderstood.

(iii) The sentences are long and compound.

(iv) The order of words in the sentence does not assist its understanding, e.g. "The toy stood beneath the pile of books."

(v) The sentences have more than one meaning, e.g. "He was near the bank."

(vi) The information in the sentence is not a real world possibility, but intended metaphorically, e.g. "The information superhighway is the life and blood of modern organisations."

(vii) The meaning of sentences is not clear, e.g. "Yahoo servers are the way forward."

(viii) Most of the words within the sentence are semantically unrelated, e.g. "Love, money, and power keep the world going round."

(ix) Sentences are self-contradictory and cause confusion, e.g. "Netscape is the best software available, though quite useless for modern purposes."

(x) The words are used in an abstract manner, e.g. "The subject of computing cannot be confined within fixed boundaries. We should move the school to new horizons."

(xi) The sentences require detailed processing with respect to temporal and spatial information in them, e.g. "The diamond he had discovered three years before the First World War, lay buried on an island next to the Japanese colony in the China Sea, beside a small pool of water, which had only ten small crocodiles left *by* the year *1967*."

(xii) The information content is either imprecise or uncertain, e.g. "Time travel was possible in the twenty fourth century."

The above list highlights a few of the problems that might be encountered users with language impairments when reading hypertext. It is important to realise that the reading process would be slower and response times longer. Hence, too much information input at any one particular time would be obstructive to the reading performance, as for example when sentence structures contain too many propositions (Kintsch & Keenan, 1973). The size and presentation of information are important issues: reading a larger piece of text requires attention and detailed information processing, whereas a much smaller piece may be confusing. Also, proper structuring of the information is necessary to direct attention at relevant paragraphs. We will discuss some of these issues in later sections. At present it is suffice to say that ideally uniform standards are needed for information presentation to language disordered users. How this may be accomplished is something to consider in detail in the near future.

Psycholinguistic factors and text understanding

Language disordered subjects in Alzheimer's disease and dysphasia often exhibit psycholinguistic disturbances. Caplan (1993) describes a subject's inability to understand sentences after having recognised individual words in it, as a primary psycholinguistic disturbance. Such disturbances occur when one or more language components are directly affected. In such cases language disordered patients do not understand relationships between individual words. Normally in order to understand the sentence "James put the money in the bank", the user must have the implicit information: "James has money, and money can be deposited in banks". The second part of the sentence is more difficult to process since the word bank has more than one meaning. The understanding of sentences would be tremendously helped if they consist of unambiguous words within their expected contexts.

Swinney (1979) has investigated the role of context for accessing word-meanings. Swinney finds that all words related to previously occurring words are activated, and are more easily accessible. For the sentence cited above, words such as money and river, become easier to access later in the sentence if the word bank was understood earlier. Hence, paragraphs with self-contained messages and a small set of related vocabulary, would be easily understood if context helps (Tulving & Gold, 1963). It should be noted here, however, that the repetition of limited vocabulary may lead to a loss in its meaning over a period of time (verbal satiation).

Psychologists have distinguished between, “semantic memory,” which comprises of specialised knowledge a person has about items and events, and “episodic memory,” which builds on life’s experiences. As a result of illness, these memories may be affected. The disorder can often by category-specific, e.g. all information and concepts related to certain classes of objects may be lost. Hence, in order to facilitate the subject’s understanding of the meaning of a word, not only its definition is required, but also its functional role and relationship with already known objects should be specified. The loss of episodic memory weakens the subject’s understanding of where they have previously come across a particular word. In order to facilitate the understanding of words, their functional definitions, which may be available on request, should include related information (e.g. a car should be defined as: a vehicle with four wheels, used for driving on roads, carries passengers, consumes fuel (petrol or diesel), needs parking, stays in garage, etc.). This information cannot be provided for every single word since it would be impossible to store and retrieve it on a regular basis. It should be however recommended for user specific short active vocabulary that appears in a particular text.

The human language processing system constructs phrase markers (a ‘parser’) to derive propositional meaning (Caplan, 1993). The subject may also understand the sentence by

observing the linear order of words in a sentence (heuristic rule) and/or through relating the meaning of the words to the real-world possibilities (lexico-pragmatic rule). When these rules are used, active sentences such as “The batsman hit the ball” are easier to understand than passive sentences such as “The ball received by the batsman was hit”. Propositional meaning is also difficult to extract if the nouns used in a sentence are of the same type making it reversible (both concrete or both abstract), e.g. “John saw Ted”. It is important to keep these rules in mind while developing written material for use by language disordered individuals.

Finally, a word on the understanding of verbs in sentences. It has been proposed by Garrett (1980) that verbs are most important to the understanding of the thematic relationships between other lexical items in a sentence. So what happens when in the same paragraph the user comes across sentences such as: “He wanted to drive the car ... He used to drink ... and with his potential and drive ... he bought her a drink ?” The words ‘drink’ and ‘drive’ have been used both as a noun and a verb. Most of the dysphasic subjects are deficient in their understanding and use of verbs, taking them merely to name an action, Jones (1986). This deficiency may not be apparent in their verbal production in terms of word-frequencies when compared to normal subjects (Holmes and Singh, 1996). In the above example, both verbs could be easily mistaken as nouns, rendering the sentence incomprehensible. It is important, therefore, to avoid repeating the same word in the same sentence as of two different lexical categories, e.g. nouns and verbs. Also, the verbs should be used in a descriptive manner, e.g. “He pulled the horse to the ground” should be written as “He pulled the horse down on the ground.” The verb ‘pull’ makes more sense in the second case when accompanied by the direction word ‘down’.

In the above sections we have discussed word-level and sentence-level difficulties encountered by language disordered subjects. Some of the psycholinguistic factors, including sentence semantics, were also discussed. In the course of this discussion, in some cases we have made some suggestions on how we may solve these difficulties. However, we have not discussed non-linguistic factors which influence information understanding when using the Internet. This is the topic of our further discussion.

Media effects

It is important to understand media effects on language understanding. Typical differences between paper and computer screen media come from the different characteristics of static paper and dynamic screens. Muter and Maurutto (1991) describe some attributes of computer based text and list some features which differ between paper book and computer reading:

- Distance between the reading material and the reader.
- Angle of the reading material.
- Visual angle of characters.
- Character shape.
- Actual size of characters.
- Characters per line, lines per page, and words per page.
- Inter-character spacing.
- Interline spacing.
- Left justification versus full justification.
- Margins and the use of frames.
- Resolution.
- Familiarity with medium.
- Intermittent versus continuous light (Wilkinson, 1986).

- Interference from reflections (Daniel & Reinking, 1987).
- Absence versus presence of incidental location cues (Wright & Lickorish, 1984), etc.

Researchers have steadily reported that reading from paper was faster than reading from screens, but no significant difference in comprehension was found (Kak, 1981; Gould & Grischkowsky, 1984; Cushman, 1986; Wilkinson & Robinshaw, 1987). However, in writing essays, users of the hypertext version scored significantly higher marks than users of the paper book (Egan, Remde, Landauer, Lochbaum & Gomez, 1989). Moreover, Muter and Maurutto (1991) find that reading continuous text from large and high resolution screens resulted in no significant difference in speed and comprehension from reading from paper, but skimming and scanning was still better in paper.

In addition, there are some important differences between hypertext and ordinary computer text. Hypertext is different since: i) it requires navigation and planning; (ii) all text nodes are not known in advance and there is no content menu for information that exists; (iii) hypertext can be condensed to detail information at different levels and the user can be thus helped with reducing information overload; and (iv) different hypertext node structures can be generated for the same information depending on specific requirements. Hence, user performance on text reading and understanding is easier to manipulate by enhancing the structure of hypertext than what may be possible with ordinary computer based text. Hypertext also offers a number of visual and auditory mechanisms which can be used for improving text understanding and decision making. There are several implications of these differences for language impaired users. First, it is evident that hypertext requires navigation and planning in a more dynamic environment for which specialised software agents should be developed to

assist language impaired users. Second, hypertext information is arranged hierarchically and its exploration may be assisted by coherent text node labelling. In the absence of a visual representation of how information is arranged, language impaired users will find it difficult to navigate the system. Finally, a hypertext system should streamline and limit the quantity of information it provides to a user with language disorder -- the vastness of the cyberspace can be deterring for such users!

Solving problems

In the previous sections we gained some basic understanding of language disorders in terms of difficulties with formulating search queries and understanding text. In addition, we have also discussed sentence level problems, psycholinguistic factors and media effects which affect the understanding of hypertext when reading it. Some initial suggestions at this stage for solving these problems are summarised in Table 1.

Table 1

In Table 1 we have classified the generic language disorders as lexical retrieval problems, memory deficits, attention deficits and reading and planning deficits. The result of the first two deficits is the inability to formulate proper search queries. The last two deficits lead to difficulties with understanding information and taking decisions on them. For each category we have made recommendations most of which may be achieved using an intelligent natural language processing tool and a multimedia system. In the following sections, we aim to discuss further issues related to the problems highlighted before and make suggestions on the direction of research which should be undertaken to address these issues. We first discuss the query formulation problem (sections 4.1 and 4.2) followed by the text understanding problem.

Facilitating searches through IR models

It is well known that many users of text retrieval systems have difficulty in formulating search queries which are both precise and comprehensive (Bing, 1987), and some have gone so far as to suggest that conventional free-text retrieval systems (i.e. those retrieving only exact matches with search queries using boolean and proximity connectors) place impossible demands on users (Blair & Maron, 1985). Many alternatives to the conventional model have been proposed, often based on different methods of relevance ranking, and are the subject of considerable debate (see Savoy, 1994 for a recent review).

The two main measures of information retrieval are ‘recall’ and ‘precision’. These have clear analogues in terms of the connectivity of hypertext links. That is, high recall on an information retrieval query corresponds to a high degree of linkage to relevant documents. Similarly, high precision implies few irrelevant documents retrieved which is analogous to the presence of few links to irrelevant documents in a hypertext system. These demands may be reduced in a more visually oriented hypertext system. However, it is likely that there will be some limiting boundary conditions with respect of the complexity of the choices offered, beyond which even hypertext systems will be unusable, particularly for classes of users with special linguistic needs.

Mapping disorders are the most common reason for the inaccessibility of query words for a web search. A number of language impaired users, and even normal older adults, often complain that they can literally see the words in their mind, but cannot label them. This phenomenon is caused by the failure of the mechanism which translates semantic messages into phonological shapes. Since it is feasible to class ideas into a set of categories (e.g. real objects (animals, organisations, places, etc.), actions (motion, rest, etc.), and so on), it is

possible to represent these concepts as visual icons, which may be clicked by the web user to narrow down the choice to the final word or related words searched for. Although it is realised that a considerable amount of previous research has been futile in its attempt to achieve any standardisation with respect to labelling concepts with icons, a limited number of concrete concepts can still be labelled. This strategy may be employed in two modes: when the subject has no idea of any related words and the search starts from scratch; or when some initial stages may be skipped and the search could start from a specified level.

It is important that hypertext documents are structured using domain knowledge. When navigating to a target, users provide the system with the contextual information which may be used to construct such a search for them. One of the aims should be to use the contextual information derived from the observation of user behaviour and construct local searches, and to construct hypertext links. For example, take the example of legal information retrieval. An existing workstation software (Greenleaf, Mowbray & Tyree, 1992) allows hypertext links to trigger stored searches. Thus, every legislative section has a ‘Noteup’ button near the section title, which triggers a stored search using synonyms (for the various forms in which section numbers might appear) and two proximity connectors. As a result, without ever thinking about searching, users can execute searches which would be beyond the sophistication of most users. These stored searches will be, of course, created and inserted automatically. Such a stored search presented to the user via the same interface is dynamically computed using hypertext links. This is in contrast with the ‘normal’ hypertext links which are pre-computed on the basis of static document properties. The ability to dynamically enhance the hypertext structure allows the sophisticated use of properties such as local document collection synonyms and word concept clusters (Bustos & Gedeon, 1995).

Query formulation

Query formulation presents a unique challenge for semantically impaired patients. Such patients are vulnerable to semantic misinterpretation of words and often stretch word boundaries to include unrelated topics. Hence, information on ‘lamps’ may be searched with the keyword ‘light’. At present web search engines are limited in their concept searching abilities and rankings are exclusively dependent on the query words used. In addition, they allow searches for items which may be non-words. The overall system can be improved, therefore, if: i) queries are confirmed by refining them through user interaction; and ii) checking for non-words. The latter is easy to implement using a dictionary and a spell check tool. The first one however requires query agreement between the user and the system and some web system intelligence for the semantic integration of individual query words.

Several search engines offer a browsing ability. This is often useful when the user wants to examine a broader range of topics under specific categories by clicking on specific sub-headings. In most cases, this is time consuming for several users and a direct search strategy is preferred. Unfortunately, current search engines do not offer a search refinement strategy before the search is carried out based on the assumption that the user is capable of precisely defining the key word. This is a weak assumption for language disordered users and therefore a more effective strategy would be to reach an agreement with the user on what is searched before the actual search itself. This agreement can be achieved through the web system:

- Confirming a concrete noun with visual representation.
- Confirming a verb with video action.
- Presenting a set of synonyms and words within the range of the same context.
- Suggesting spelling mistakes and confirming non-words.

- Identifying the correct meaning of words in particular contexts.
- Employing intelligent search strategies (Marchionini, 1989).

In addition, the web search system must also offer *semantic integration* of individual query words. The concept of semantic integration, though natural in its consequence, is difficult to achieve in practice. For example, the multi-word user query "car engine cold" requires some form of semantic integration to search for information on "why does the car engine have problems starting on a cold day ?" The latter is one natural language representation of the original query and translation to this form is currently limited in its use by most search engines. There are two separate issues here: how does the system respond to a natural word query intelligently; and is it at all possible for it to arrive at the latter natural representation if only individual keywords are supplied. The first issue is currently witnessing a large amount of interest. The second, more important and definitely more difficult, is of even more interest for language disordered users whose natural word queries are fragmented at best. Without semantic integration of individual query words, search engines will continue to operate on individual word frequencies and yield less than satisfactory results.

The issue of information ranking is of critical importance too. An optimal query is at best workable if the required information is ranked very low. Most search engines are capable of retrieving thousands of documents but experience shows that even normal users do not bother to check more than forty to fifty titles at any one time. This problem is compounded for language disordered users. Intelligent ranking systems are therefore absolutely vital for advanced Internet search engines. Most commercial tools use the boolean technique which is based on the presence or absence of query words in searched documents. This approach is rather weak in many applications leading to several new engines now claim modern search

capabilities including concept searching. Our previous experimental work on surveying search engines has shown that the word “concept” has been used irresponsibly in most cases where all the engine was doing was to use synonyms with a thesaurus. It is increasingly important that future research addresses the automatic understanding of concepts and their generation through novels methods including neural networks.

The second problem with the use of Internet and hypertext relates to the understanding of web information and navigation in web space. There are three important areas of research related to information understanding: (i) information layout; (ii) user interface; and (iii) information quality in terms of its composition. These areas have been widely researched and ACM conferences on intelligent user interfaces regularly report on current developments. The quality of information content is very much a research area for the coming future, i.e. the development of tools or procedures which may enhance text composition with natural language processing techniques. The above issues are discussed in latter sections.

Reduced information content

Language disordered patients with memory deficits can have difficulties with large amounts of screen information. There are two major approaches to reducing information content. First, by extracting natural language on demand depending on the context (Dale & Milosavljevic, 1996), and second by modifying the content of existing documents based on some degree of understanding of the document content. This is done by the provision of a fine grained hypertext structure, where the resolution will be at the natural language syntax level rather than document /component level, based on the statistical analysis of language disorders. In this vein, it is important to understand the potential abilities of language disordered users when confronted with large amounts of hypertext information. Some initial experimentation

by Singh on the reading abilities of normal subjects has shown that different readers adopt user specific reading strategies depending on whether the knowledge is processed in a deep or shallow manner. This choice is dependent on several factors including: causal connection between text nodes, local and global cohesion of text, and text layout (Colley, 1987). It is important that hypertext information is structured to facilitate a deep understanding of the subject matter.

Information presentation on screen

There are some clear advantages to computerised media when compared to paper (McNight, Dillon & Richardson, 1989; Egan, Remde, Landauer, Gomez, Landauer, Eberhardt, & Lochbaum, 1989; Shneiderman, 1987; Yankelovich, Meyrowitz & van Dam, 1985).

- Provision of interactivity and connectivity.
- Dynamic text presentation.
- Easy information search.
- Easy update.
- Parallel presentation with other media.
- Multiple windows and other various capabilities from dynamicity.

In addition, since Internet is based on the concept of linking information between different sources using text nodes and uses hypertext, other advantages for both information designers and users include:

- Detailed information may be embedded at various levels and therefore information content may be reduced during presentation.

- The planning aspect for retrieving information becomes very important, i.e. hypertext navigation is fundamentally different in its approach to other computer based texts.
- The readability factors are under the control of information provider who may manipulate them with relative ease.

Readability factors

It is important that the text layout facilitates the reading abilities of language disordered subjects. We recommend the following:

characters.

- Uppercase seems to be better for searching (Vartabedian, 1971; Clauer, 1977), and lower case for reading continuous text (Rudnicky & Kolers, 1984).
- Variable character width may help faster reading than a fixed width (Beldie, Pastoor, & Schwartz, 1983).
- A proper combination of upper and lower case may be better for reading continuous text (Mills & Weldon, 1987).

formatting.

- Increasing interline spacing and decreasing horizontal spacing may be better for reading performance (Wilkins & Nimmo-Smith, 1987).
- Variable interline spacing seems to prevent visual fatigue (Lunn & Banks, 1986).
- Hyphenation at the ends of lines seems to cause slower reading (Nas, 1988).

contrast and colour.

- Positive polarity (dark characters on a light background) is preferred by readers and may help reading (Bauer & Cavonius, 1983; Bauer, 1987), and result in less visual fatigue (Cushman, 1986).
- To maximise discrimination between colors, the difference in hue and lightness should be maximised and differences in saturation should be minimised (Laar & Flavell, 1988).

screen.

- High resolution ratio may result in better visual search (Harpster, Freivalds, Shulman & Liebowitz, 1989).
- Large screens may enhance text processing (Lansdale, 1988; de Bruijn, de Mul & van Oostendorp, 1992).
- Multiple windows seem to be better for information relocation (Tombaugh, Lickorish & Wright, 1987).

dynamic presentation.

- Paging may be better than scrolling (Kolers, Duchnicky & Ferguson, 1981; Schwartz, Beldie & Pastoor, 1983).
- Highlighting techniques sometimes help (Nes, 1986; Shneiderman, 1987; Tullis, 1988) and sometimes disturb (Fisher & Tan, 1989).
- The reading efficiency of Rapid Serial Visual Presentation (RSVP) is close to that of normal page reading (Juola, Ward & McNamara, 1982).
- Times Square Format (TSF) seems to be as good as RSVP (Kang & Muter, 1989)

In addition, Dillon (1992), Mills and Weldon (1986) and Muter (1996) have also summarised some factors affecting readability. In summary, computerised information presentation can provide services to users which have not been possible with paper. Computers can mimic the static properties of paper. Furthermore, they support not only the dynamic properties of information like animation, but also dynamic properties of reading activity such as the use of scrolling and moving texts. WWW browsers and word processors are good examples of such properties. Especially, distributed information retrieval and universal presentation of WWW have significantly changed reading environments. The process of information understanding may be further facilitated by using auditory and visual cues.

User interfaces: auditory and visual cues

It is important to introduce, at this point in our discussion, a schematic model of how words are perceived when reading text. Crowder and Wagner (1992, p. 107) have presented a schematic model to describe this process. In this model there are different auditory and visual feature allocations in the memory. It should be noted that the auditory and visual features are acquired by subjects at various stages of their development, e.g. children know the word “toy” auditorily at an early age, but read it at a later age. It is therefore possible that the auditory features of some words may be intact in linguistically impaired subjects whereas their visual features may be lost, e.g. the picture of a train may only be recognised by its whistling noise. Audio features should be used therefore for word recognition in cases where visual representations are lost; where a system includes relevant audio/visual information, retention and persuasiveness are enhanced. The writing of hypertexts should also take into account the emphasis placed on certain words, which is ordinarily done in spoken language through prosodic cues, i.e. stress elements. Hence, stress on particular parts of a sentence may be

placed by using different font sizes or underlining, e.g. "WE rejected the offer," "We REJECTED the offer," and "We rejected the OFFER."

Focussing attention

Preece et al. (1994) discuss several methods of focussing attention at user interfaces. Some of the tools they recommend should allow structuring information, using spatial and temporal cues, and the use of colour and alerting techniques such as flashing and reverse video. The structuring aspect may be accomplished by segmenting the computer screen image into windows with different types of information using different colours for these. The aim should be to display important information in a prominent area to catch the user's eye, less urgent information should be allocated less prominent but specific areas of the screen where the user can find it, and information not needed on a regular basis should be made available on request only. In the context of reading hypertext, several linguistic signalling tools can be used by the author for focussing attention including "However," "Nevertheless," "On the other hand," etc. Finally, attention can be focussed using optimal font sizes, manipulating foreground and background colour, automatic scrolling, system messages and a menu system which facilitates a match between the user's knowledge in the head with the knowledge of the world. It is important to note here that tools for focussing attention and providing visual/auditory cues, though important in general, have special meaning for language disordered patients since these techniques may assist such subjects to use their compensatory mechanisms for understanding information and acting on it.

Research Issues

Text transformation

Unfortunately, the Internet consist of millions of users who create and distribute information on the communication highway. There are no standard formats, no guidelines, and above all no personal responsibilities for maintaining any standards. In this varied environment how do we work towards at least some form of uniformity of text composition ? Natural language processing tools seem to be the only way forward. NLP tools must be rigorously researched which not only understand text through syntax analysis, but have the capability to simplify phrase structures without the loss of semantics. This is one important area that we believe has a great potential for further research. Text simplification, a process of transforming original text into an easier to understand version, may be studied at: (i) word level - to use synonyms which are used in everyday communication; (ii) phrasal level - to reverse subject-object relationship for simplification, removal of redundant functional words, etc. and (iii) sentence level - to simplify compound structures into simple sentences, and possibly combine more than one structure to derive a simpler meaning.

Hybrid information presentation

When reading hypertext, comprehension is more important than speed. Comprehension seems to be a process which is extensively dependent on memory and focused attention than the reading speed. Hence the role of memory for comprehension should be facilitated, especially in the case of users with memory deficit. This objective can be achieved by giving users well formatted / structured information of low complexity, and minimising actions and interactions between readers and the computer in a well adjusted environment. In other words, the user interfaces supporting everyday reading should be able to maximise the benefits of both static and dynamic properties. One possible method is to build a hybrid model of

information presentation by integrating the static model and the dynamic model. This model supports book-like static reading and computer oriented dynamic reading.

Hybrid model = static model + dynamic model

= well adjusted ordinary window-based screen

+ moving text without user control

According to the Kang and Muter (1989) study, moving text using smooth pixel-by-pixel scrolling is as good as normal page reading. Chen and Chan (1990) found that moving text without user control was much better than with user control in speed and comprehension, and comprehension was improved with practice without-user-control. In addition, they found that large jumps of 5-9 characters were better than small jumps of 1 character.

Additionally, there are some guidelines from experiments in rapid serial visual presentation (RSVP), for example:

- about 12 characters per window on average
- two or three words per window
- idea-unit segmentation
- 250-500 msec blank between sentences

Hypertext navigation and context

In most language disorders, some patients also exhibit planning deficits on cognitive tasks. This may lead to hypertext navigation difficulties. A widely acknowledged problem with hypertext is that while it allows text to be broken down into small units, the means it provides for users to locate a particular unit are currently not sufficiently powerful (Lesk, 1989). When

the number of text units is large, queries achieve “too many hits” and swamp the user with an excess information. This problem is not different to that found in full text retrieval systems with sizeable collections of documents (Blair & Maron, 1985). It is not possible to create links to express every association of ideas that a user will wish to pursue. If that was attempted, users would be confronted with too many choices at every juncture, without adequate guidance as to which to follow.

Some hypertext links can be relatively easily created automatically from document information, for example when a document explicitly refers to another document. Provision of extra, domain significant (labelled) links is difficult and expensive. It is possible to (manually) label links and semantically differentiate them (deRose, 1989); but the labour is tedious, and in a complex domain, links soon proliferate beyond control. The structures created by the hypertext links are clearly crucial to successful traversal through hypertextual space, but are not in themselves the final solution. Some current research is focussing on providing means to users to break through the structural boundaries of hypertext links and locate information in a manner which is wholly or partly independent of those links. There are a number of ways in which this is being done. While some benefits are obtained, there are inherent limitations in each of the current methods of providing independent retrieval in conjunction with hypertext.

In most hypertext systems there is little emphasis on giving the user a holistic picture of the information space even though extensive navigational facilities may be available. In other words, the user needs tools to answer questions including: “Where am I ?” “What have I seen ?” “What else is there to see and how can I see it ?” These tools will not only guide a lost user in cyberspace but also allow him/her to make a better use of navigational facilities. In this context, both conceptual navigation through the ideas the material represents and physical

navigation between different material components should be considered. Conceptual navigation is at its weakest when users are unable to conceptualise their questions, a common problem with language disordered subjects. Similarly, physical navigation is at its weakest when the physical configuration of system components does not match the user's cognitive strategy. These issues must be researched taking language disordered subjects as the main theme.

Learning from user behaviour

Some computer intelligence towards learning user behaviour is of great importance. Computers are ideal for measuring various aspects of user behaviour, for example the speed of reading, text nodes processed in a given time, history of words used for searches, failed searches, and so on. It is possible to develop software tools that monitor user behaviour over a period of time. This information may be used by artificially intelligent software modules to modify information presentation and to trigger specific NLP processing to simplify information layout.

Conclusion

Scientific knowledge about solving language problems in hypertext systems is continuing to grow. Our knowledge in domains such as psychology, language pathology, linguistics, and human computer interaction can contribute to our current research on web solutions for users with special linguistic needs. However, the integration of domain knowledge from these areas is limited at present. Several important issues, such as information overload and unsuitability of the Internet tools, demand the integration of different technologies for solving such problems. There are reasonably good chances of success by taking our recommendations in this paper to the implementation stage and improving the usability of the system for language

disordered subjects. Several menu design and system configuration issues have been researched already for normal users and system development guidelines exist. In addition, as we have seen in this paper, language disordered users have language problems which are qualitatively and quantitatively different to the occasional problems of normal subjects and demand a different approach to their solution. The next step in this area should be to implement the recommended changes in a step-wise manner monitoring the degree of improvement made for a group of language disordered users during a trial period.

This paper has discussed only some of the important issues relating to the use of the Internet via the World Wide Web in its current form by users who suffer some language problems. There is a large community of people with language disorders, many of whom we know do not live in hospitals but struggle for a healthy social life in our society. The Internet has a major role to play in their lives as a communication link to the external world, and as a therapeutic tool to help them overcome their language deficits. This paper has only identified the tip of the iceberg. We need to integrate our knowledge in several areas relevant to hypertext use, for example as in language disorders and natural language processing, to comprehensively address the issues raised. Here we have identified the problems experienced by language disordered WWW users whose source may be technical and/or psychological. Further work is needed to address specific problems in detail and develop generic tools for supporting information searching and presentation. It is certain that the near future will witness much interest in this research area raised as the telecommunications industry prepares to cater to a wider variety of users. We are optimistic that the discussed field of applied research has much to offer in the coming years, both in theory and in practice.

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Table 1. Some disorders affecting language: recommendations for web information

Disorder	Effect	Recommendation
Lexical retrieval	imprecise queries	visual and auditory cues semantic integration of multi-words concept based icons synonym usage dictionary usage user confirmation of non-words
Memory Deficits	imprecise queries reading impairment	exploitation of semantic priming text simplification context manipulation for understanding understanding vocabulary limitations key information reinforcement
Attention deficits	slow reading speed frustration with the task	screen layout improvement information reduction colour manipulation, e.g. Stroop effect (Stroop, 1935), sentential stress
Reading and planning deficits	Incomplete understanding navigational problems	use of non-reversible sentences simple phrases and sentences local and global text cohesiveness causal relationship between paragraphs unambiguous link explanation hypertext nodes embedded to suit user learn about user's planning limitations