HYPERTEXT TOOLS IN SPEECH AND LANGUAGE THERAPY[1]

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ABSTRACT

This paper investigates hypertext tools in communication disorders, particularly in aphasia assessment and therapy. The assessment of language comprehension abilities can be facilitated by evaluating patient performance on information retrieval tasks. Hypertext tools can be used to gather information about patients' planning abilities and the semantic understanding of the available information. The paper explores the use of hypertext for generating therapy material which works with traditional methods of aphasia therapy, and highlights its importance whilst evaluating verbal and non-verbal abilities. Patient performance on hypertext related tasks can be quantified with the proposed parameters which quantify the degree of language deficit through information retrieval and understanding processes. These parameters need to be tested for their importance in outcome management: whether they are sensitive enough to measure changes or not. The role of hypertext in developing therapy exercises is discussed. The advantages of hypertext tools in single case-studies is highlighted and an active role of hypertext applications in aphasia management is suggested.

INTRODUCTION

The quantification of the degree of deficit in aphasia, a language disorder, is important to guide therapy and help in rehabilitating patients. Aphasia assessment has been attempted on various verbal and non-verbal tasks, as in standard test batteries, and also in conversation at both pragmatic level (Crockford and Lesser, 1994) and at word frequency level (Singh, 1994, 1996). It has been recognized that most tasks fail to control psycholinguistic factors (Byng et al., 1990) and do not consider the planning aspects in language comprehension and production. Similar problems are evident in areas of developing therapy material for aphasic patients. It is, therefore, necessary to develop techniques which are more sensitive to measuring changes in patient performance on language related tasks. Furthermore, it is also needed to make this assessment, and provide related therapy, in an unsupervised manner to allow patients to work independently. Hypertext is a unique way of learning both the contextual and functional aspects of a particular piece of information.

Some work on assisting users in the hypertext scenario and making information retrieval more sophisticated in the health-care field has been recently published (Hersh, 1995). In this paper we propose how hypertext techniques can be used to generate exercises for assessment and drill-material for therapy in aphasia. The discussion is generally applicable to similar areas in the management of other communicational disorders. In this discussion, by the term "hypertext tool", we take a broader description to include procedures generated for assessment and therapy through hypertext as well as the development of specific software as user interface. These tools will be generated and modified by therapists. The suggested technique is arguably superior to the traditionally employed paper-based procedures.

APHASIA MANAGEMENT

The results obtained through hypertext tools can be used to guide therapy using any aphasia intervention theory although further investigation would be needed. It is possible to teach or stimulate the patient using repetition, naming and other structured tasks in conjunction with information retrieval tasks. The extent of the overall improvement in language use through treating lexical deficit alone is not very clear, although it may happen that semantic and syntactic features also improve as a result. There are two main methods of aphasia rehabilitation: firstly, treating aphasia as a loss of language, thereby re-teaching vocabulary and grammar to aphasic patients; secondly, treating aphasia as a loss of capacity to access the underlying intact knowledge of language, therefore using intensive verbal and auditory stimulation. In clinical practice,

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whilst selecting one of the above methods, it is equally important to plan treatment in a defined manner, (Connolly, 1989). This process can be facilitated through the use of structured unsupervised methods such as computer tools for therapy.

There are some serious limitations to the usefulness of currently used procedures with computers. Those exercises that concentrate on syntax, e.g. sentence completion, separation of correct and incorrect grammatical forms, and spelling tasks, do not provide users with on-line help in most cases. There are no available dictionaries or thesaurus and the user cannot relate his/her mistake to other contexts. In most cases, there are no visual or auditory cues to help patients make decisions. Those tasks that require semantic cues are seriously limited by the unavailability of detailed information about words, e.g. their graphic representations, and the relationships between words, (the picture of a tree in a garden showing that *trees* are found in *gardens*).

The most serious limitation with conventional approaches is that information is processed at a very shallow level. Most software packages do not allow patients to process information at more than one level. Hence, for generating an exercise on words ", river, trees, and banks", six sentences may be listed for each word successively. All sentences are available at the same time. This may result in shallow information understanding where patient draws the conclusion about the word "banks" based on other words which have been previously used, i.e. *river* in this case, and may draw the wrong conclusion due to semantic priming, e.g. *river-bank* instead of *money-bank*. Furthermore, conventional exercises may present too little or too much information at any one time in an unstructured manner which can be counter-effective. The items are also often presented in an unrelated manner which results in slow user learning.

QUANTIFYING PERFORMANCE

The use of hypertext tools in aphasia therapy can be initiated at three levels: the assessment of language disorders using hypertext, the development of therapy material using hypertext, and the feedback on the success of therapeutic procedures using a set of parameters that evaluate patient performance in a hypertext scenario. These issues will be discussed later. We willl first discuss the nature of hypertext applications, highlighting their differences with conventional systems and describing those features that are of particular relevance to their use by an unfamiliar user. It is important to note here that the role of hypertext in aphasia management depends invariably on the visual input to users (as in reading text), and since it is assumed that various input modalities (as in speech and auditory comprehension) access the same language components, hypertext systems are supposed to help in improving language use in general.

Hypertext is a structured way of presenting information. In most hypertext applications, the reading and understanding of information is the front end activity, which is supported by several internal language and non-language processes. Since aphasia is primarily a language disorder, we will focus on the language perspective. Further, since most aphasics can reasonably well read documents, we will not discuss reading impairments in aphasia here. The following discussion is therefore geared towards the understanding of written language through the various linguistic and non-linguistic functions involved.

The understanding of documented information can be considered at three levels: word-level, sentence-level and text-level. At any stage, one or more components of language may be active to supplement the necessary information, i.e. lexical, semantic, syntactic and phonological. Reading written language depends on the understanding of various words, and relationships between them. This understanding is filtered through various levels of conceptual entities (headings, subheadings, paragraphs, etc.). In order to understand text, language disordered users must manage a cohesive strategy towards integrating what they have learnt at various levels as they read through a document.

In the following discussion, we will use the term '*hypertext parameters'* to refer to various quantifiable variables that can be used to define patient performance on using, reading and understanding hypertext. These variables should be used for a hypertext-based language assessment, and for providing a feedback to therapists for evaluating the success of their training methods. We now describe a few of these parameters, which can be used to evaluate patient performance on hypertext-related tasks. The tasks themselves may involve finding information using hypertext, or understanding retrieved information and reading it. The proposed parameters are:

(I) *Information retrieval parameters*
- (a) Keyword relevance in a search, e.g. how relevant is the keyword "city" when searching for *London*.
- (b) Semantic relevance of a multi-word search, e.g. how well do the keywords "city, Britain, beautiful" integrate to search for *London*.
- (c) The levels of processing possible without forgetting previous results, e.g. search for "Mr X. at university "U" starting with the keyword "university".
- (d) Relevance of keywords selected to reach the next level of information, to the final search goal.
- (e) The number of failed searches.

(f) The time taken to formulate searches.

(II) *Information reading parameters*

(a) Time taken to read screens scaled to the content available.
(b) The number of back references made, and time spent at them.
(c) The number and type of references made to on-line facilities whilst reading information.
(d) Subjective ratings for the performance based on the relationship between information structure and layout with reference to its understanding by a normal user.
(e) The effect of varying colour and menu design on the speed of reading information, including several other human-computer interaction issues.

(III) *Information understanding parameters*

(a) Quantitative assessment of patients' understanding of key features in a piece of writing through questioning in a yes/no format.
(b) References made to items within the same conceptual framework, i.e. hence representing problems with that concept.
(c) Validity of inferences drawn to initiate new searches.
(d) The validity of proceeding to the next best piece of related information in a large document.
(e) The number of references made to semantically related entities (this should reduce through *semantic-priming*, i.e. if the word "coin" appears early in text, it should facilitate the understanding of all words related to the concept "money".

The above parameters can be used to quantify the degree of language understanding and planning deficit whilst using hypertext. Other relevant parameters can be explored by the assessor. Results obtained here can complement several other sources of assessment such as sentence understanding in Token Test (DeRenzi and Vignolo, 1962) and several other tests in aphasia with sections on reading comprehension (see Beech, Harding and Hilton-Jones (1994) for details on aphasia tests).

The development of parameters for evaluating hypertext understanding task performance suffers with similar limitations as those in the case of testing auditory comprehension of aphasics, i.e. it is impossible to confirm whether the understanding of information read or heard is complete. This limitation, therefore, requires that the user should be questioned at regular intervals whilst performing a task, about his/her understanding of what has been read and understood. A number of above mentioned parameters should quantify the severity of language disorders much more than is exhibited by the same patient on other tasks, and with several examinations a more consistent pattern of impairment will appear.

HYPERTEXT TOOLS

In the previous section we discussed some of the performance parameters which might be used for language assessment as through performance on reading and understanding hypertext information. These parameters, however, should be tailored to specific assessment tasks designed using hypertext. We now detail some of these tasks which may be designed using hypertext, and illustrate those areas of assessment which are thereafter possible.

(a) Tasks which assess the identification of words in and out of a particular context.
(b) Tasks which diminish the quality and quantity of visual clues available to the user to accomplish the task.
(c) Tasks which manipulate text parameters (e.g. sentence simplification, sentence length, semantic specificity of words, etc.) to quantify the degree of ease in understanding information.
(d) Tasks that involve various levels of processing, thereby stressing the working memory.
(e) Tasks that become more specific at every step.
(f) Tasks that relate linguistic words or concepts to their iconic/visual representation.
(g) Metalinguistic tasks.
(h) Tasks that explore the relationships between patients' understanding of words and new concepts.
(i) Tasks, as a part of the programmed instruction, where new topics or concepts are introduced in assistance with previously done exercises and existing knowledge.
(j) Tasks which explore the level of understanding of information, i.e. generalisation abilities to new situations.
(k) Tasks which differentially manipulate parameters to stress memory, language and concentration individually, to understand their relative contribution.

The assessment of patients through hypertext tools needs some effort towards building exercises in a programmed manner. These exercises should be graded for various levels of impairment. The amount of complexity and novelty should be increased in a step-wise manner. The assessment of aphasic adults should be carried out in two different manners

depending on whether they are being tested for the first time or whether it is regular test to quantify the degree of success achieved. Initial testing needs to be more exhaustive and broader in scope. This will establish those areas which are more seriously impaired and need immediate attention. On the other hand, assessment material for regular tests is more specific to estimate the degree of recovery as well as dependent upon previous performances on similar tasks.

For regular assessment of patients who are seriously impaired in their language abilities, and usually restricted to one or two word output in their speech, hypertext links should be available at a low level, e.g. between words *apple* and *orange*. As patients understand words such as apple, orange and banana, and infer these as being different kinds of fruits, hypertext links may be introduced from *apple* to *tree*, *jam* or *garden*. Assessment at this level will indicate the availability of potential vocabulary as well as the level of semantic formulation of relationships possible, i.e. whether the patient can relate *apple* to *tree* or not. For patients who are moderately or mildly impaired, the tasks produced for assessment should be more sophisticated. Hypertext performance parameters described earlier can be recorded for both simple and sophisticated tasks, depending on the severity of patients tested. In order to allow a global approach towards the usefulness of hypertext in structuring, it is possible to generate a universal assessment battery with various levels of assessment exercises for various classes of patients. Such a battery may include exercises which evaluate language, memory, and attention separately through hypertext material, or perform a more dynamic evaluation of the three together in a task, e.g. reading, understanding and making decision on a piece of text.

The recommended practice would be to set up the basic infrastructure to allow therapists to develop their own exercises as in a case-study with their personal knowledge of the patient involved. However, sufficient tools must be available to help therapists do this quickly. At present several useful exercises that test syntax and word-finding problems in aphasia are available with the widely used test batteries, e.g. BDAE (Goodglass and Kaplan, 1983), Western Aphasia Battery (Kertesz, 1979), MTDDA (Schuell, 1973) and PICA (Porch, 1964). Some other exhaustive test methods have also been developed by individual researchers and published. The available exercises in these tests can be meaningfully integrated using hypertext such that the patient proceeds from one related link to another, to solve similar linguistic problems.

Hypertext structures implemented with appropriate menus can also be used for functional evaluation and therapy, as done conventionally through FCP (Sarno, 1969). Functional tests evaluate subjects' performance on everyday tasks. These tasks are often conceptually related. Consider the following:

(I) How do you lock your door ? (key)
(II) How do you start a car ? (key)

The word key (concept *lock*) can be investigated for all its uses at the same time by having links from the word "key" to "car" and "door". Additional links for assessment may be created to unrelated items to test the subject's understanding of which links are appropriate to the task at hand. This procedure can also be employed in therapy. The understanding of hypertext information will depend on various structural parameters. In most aphasics, the ability to produce and comprehend long sentences is lost (Singh, 1996). Hypertext reading times and understanding with manipulated clause structure will be an indicator of how well subjects' language ability copes with the change in the length of sentence structures.

HYPERTEXT MANAGED THERAPY

Carrow-Woolfolk (1988) has described several intervention theories that are conventionally used: neuropsychological, behavioural, information process, linguistic, cognitive organization and pragmatic. Most of these, when used by therapists, can be easily supported through exercises generated using hypertext. Neuropsychological theories which aim to train other parts of brain to take over language functions could use built-in hypertext facilities to use musical notes to teach words and phrases to severely impaired patients who cannot speak more than two or three words (c.f. Musical Intonation Therapy, Sparks and Holland, 1976). Repetition exercises with pictures can be generated with hypertext. Behavioural theories which highlight programming through the sequential presentation of minimally different discrete tasks and consider each task to be prerequisite for subsequent tasks, are also suited for providing therapy using hypertext. Information process theories present stimuli that follow simple to complex, concrete to abstract guidelines. This approach can be integrated with hypertext applications to navigate the user through different screens for the required information by providing information in a sophisticated manner. The expansion of semantic relations, instead of combining words, which is an integral part of the linguistic theory, can also be implemented using hypertext. Hypertext is particularly suited for linking topics and words which are semantically related. The applications may also include several cognitive exercises, such as pattern analysis and categorization problems, to support the theory of cognitive organization. Finally, hypertext applications can be used not only for teaching language, but also in their social perspective. Therapists applying the pragmatic theory can generate therapy exercises that relate words and phrases to their functional use, e.g. the word *newspaper* can have a hypertext link to its purpose, i.e. *reading*. The functional role of language is most crucial and hypertext applications can handle this aspect more easily than traditional methods of programmed instruction by having links to specific examples.

The development of therapeutic material will depend on the approach adopted by individual therapists: stimulation approach implemented through repeated visual stimuli, or programmed instruction which emphasizes language teaching to patients (Darley, 1970). In both cases, a preliminary assessment should be made to identify those areas of language which are most seriously impaired which should be related to other information available about the patient. Hypertext applications can be used to provide auditory and visual stimuli. The level of stimuli can be incremented with each successive failure to understand information. Visual stimuli can also be made available in different interface windows for semantically related items so that their relationship is completely understood by the patient. Hypertext applications not only provide visual stimulus, but they can also allow the user to manipulate it in various ways. For example, clicking on different parts of a picture can be used to load appropriate pictures and commentary for the desired query (click on the picture of a *bicycle* anywhere to get information on wheels, peddle, chain, its make, etc.). This facility introduces patients to related concepts and features of an object to forge its complete understanding. Furthermore, the information is available both visually and as written text. The visual stimuli can be, at a later stage, diminished at regular intervals, if needed, to reduce user dependence on them.

The programmed instruction approach requires significant amount of effort on the part of the therapist to generate material. This drill material will be used by patients to learn language rather than try to recover their premorbid level of language understanding. Hypertext provides a structured manner in which language can be taught. There are several drawbacks with the paper version of teaching material. The patient can be easily daunted by the large amount of information given to him/ her. It would be difficult to cross-reference what has been learnt before and relate one piece of information with another. Picture cards that come with the exercise must also be separately stored and accessed. Furthermore, several facilities such as dictionaries, paper cards, etc. are accessed separately and soon the relationship between different parts of the exercise becomes confusing. The therapist, at the same time, has no way of recording the manner in which the matter was learnt and therefore has no feedback. It is also impossible to manipulate language functions as and when needed. These problems are eliminated with hypertext applications which can store voluminous information and trace user behaviour. The feedback is important to understand which parts of the document were easier to understand and which others require more work, through which the therapist can always refine the exercises and reading material.

There are several other advantages of using hypertext for therapy. First, the information is transportable. Second, it is modular and therefore can be refined by adding extra information without destroying the existing structure. Third, links can be dynamically generated between different pieces of information to teach different relationships between items. Fourth, hypertext links can be added to external servers on the World-Wide-Web which contain detailed information on several topics of interest. Fifth, therapy material can be put on the web for a large number of users to access. This will significantly reduce the time for preparing material for individual patients.

CONCLUSION

In this paper we have highlighted the advantages of using hypertext in aphasia therapy. The actual course of therapy depends very much on the severity and the type of language disorder, as well as the therapist's understanding of the best approach to follow. The course of therapy is usually slow and laborious. It is therefore important that there should be sensitive outcome measures that monitor patient performance in a dynamically structured way. Hypertext can be used for regular assessment and therapy of aphasic patients and exercises can be generated to vary language and non-language factors in a controlled manner. Hypertext related tools are further important because they allow patients to perform tasks in an unsupervised manner which can be monitored by a custom-made software. It also allows therapists to change the structure of the material, such as changing links and modifying information content, relatively easily. Several factors which affect learning, can be integrated in the same software, to improve the quality of therapy. We believe that with various hypermedia techniques now available at low costs, and with the falling costs of computer software and hardware, hypertext applications are the natural way forward for playing a key role in aphasia management.

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