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The Design of ViVA: a Mixed-Initiative Visual Vocabulary for Aphasia

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Abstract
In this paper, we present the design of ViVA, a visual vocabulary for aphasia. Aphasia is an acquired language disorder that causes variability of impairments affecting individual's ability to speak, comprehend, read and write. Existing communication aids lack flexibility and adequate customization functionality failing to address this variability and to satisfy individual user needs. We tackle these shortcomings by incorporating adaptive and adaptable capabilities in ViVA which is designed to assist communication for users suffering from aphasia. The visual vocabulary for aphasia implements a novel approach that organizes the words in the vocabulary according to user preferences, word usage and certain semantic measures, thus continuously tailoring the tool to the user's profile.

Keywords
Adaptive and adaptable interfaces, assistive communication tools, multi-modal interfaces

ACM Classification Keywords
K.4.2 Computers and Society: Social Issues—Assistive technologies for persons with disabilities; H.5.2 Information Interfaces and Presentation: User Interfaces - Evaluation/methodology, graphical user interfaces, prototyping, user-centered design.

Introduction

Designing technology that satisfies the needs and expectations of the intended user is a fundamental challenge in the field of HCI research. This is particularly challenging when designing technology for people with aphasia due to the variability of the resulting impairments. Estimated to affect 1 million people in the US alone, aphasia is an acquired disorder that impacts an individual's language abilities [15]. It can affect speaking, language comprehension and writing to varying degrees and in any combination in an individual as well as across individuals. Rehabilitation can reduce the impairment level, but a significant number of aphasics are left with a life-long chronic disability that influences a wide range of activities and prevents full re-engagement in life. There have been consistent efforts in improving the lives of those with aphasia through technology, but existing assistive communication tools fail to address the problems arising from the heterogeneity of the user population. This shortcoming has stimulated additional research efforts that show it is essential to seek flexible and customizable solutions [5, 14, 17].

An essential part of a communication tool is the vocabulary that it offers to the user. We present the design of a visual vocabulary for aphasia (ViVA) that relies on both adaptable and adaptive functionality to effectively meet the communication needs of individual users. We define an *adaptable* tool to be one that can be flexibly reconfigured by the user, whereas an *adaptive* tool is one that tailors itself automatically to an individual user profile based on usage characteristics or other factors. Like most disabled people, aphasic individuals tend to rely on consistency and stability within an interface. Thus, we believe that it is necessary to explore a mixed-initiative approach to customization, an effective blend of automation and direct manipulation [9]. This will enable the user to feel in control by making changes and anticipating ones that have been initiated by the tool while still allowing adaptive methods to help determine where and when changes are required.

Background

There has been some effort in designing adaptive assistive tools for elderly and cognitively disabled people, but none have proven to be usable by aphasic individuals. Those mainly include scheduling and prompting systems that aim to reduce the burden of caregivers [6, 8, 10, 15]. Most assistive systems for people with aphasia focus on essential therapeutic efforts and the recovery of basic language functions, and thus do little to leverage the skills of individuals with some residual communicative ability [3]. By contrast, there have been relatively few systems for non-therapeutic purposes for less severely affected individuals, such as systems that support daily activities like email or social interactions [7, 14].

Our first attempt at providing a practical daily-communication aid resulted in the development of a hybrid communication system where a desktop computer is used for compositional tasks such as appointment scheduling and a personal digital assistant (PDA) is used as a portable extension so that phrases can be used for communication outside of the home [5]. The multi-modal interface combines images, text and speech audio to compensate for the heterogeneity in language impairments across individuals. The system also provides some support for customization. For example, the PDA can be used to collect images and sounds that can be imported in the system's icon library. The findings from the system's evaluation confirmed the need for better customization capabilities and revealed that limitations specific to vocabulary breadth, depth and retrieval are a fundamental problem.

ViVA: Visual Vocabulary for Aphasia

A communication aid that can successfully adapt to individual user needs should provide a flexible and expressive vocabulary. Although initial vocabulary sets can be formed from words frequently needed by the target population, no packaged system has the depth or breadth to meet the needs of every individual. In addition to expressiveness, vocabulary organization and retrieval are major problems in existing assistive technology. Most of the existing visual vocabularies have a lexical frame based on a simple list of words. The words are organized either in hierarchies which tend to be too deep, complicated and non-intuitive or in categories that result in excess of browsing and scrolling. As the need for customization and flexibility has become apparent, it is important to build an easy to construct and maintain visual vocabulary that rests on a framework of a well-structured computerized vocabulary.

We have developed a multi-modal visual vocabulary that relies on a mixed-initiative design and enables the user to compose sentences and phrases efficiently. The visual vocabulary for aphasia (ViVA) implements a novel approach that organizes the words in the vocabulary in a context-aware network tailored to a user profile which makes finding words faster. ViVA is designed to reorganize and update the vocabulary structure depending on links created between words due to specific user input and system usage. In order to provide meaningful links between words automatically, we are also utilizing three word association datasets based on WordNet [13]—a word evocation dataset and word proximity and dependency datasets [4, 11]. We chose WordNet, a ubiquitous computerized lexicon, as a framework for ViVA because it was created to mimic the systemic organization of language in a human mind. Like

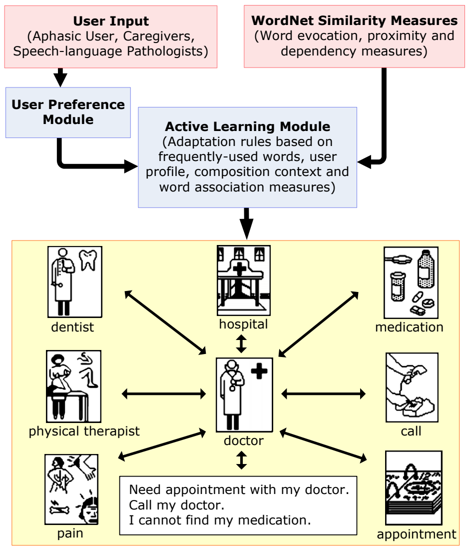

figure 1. The visual vocabulary organization is shaped based on user input and word association measures. For example, the vocabulary network centered on the word *doctor* may look as shown above if the user has in the past composed phrases with the words *doctor* and *medication*, and *doctor* and *appointment*. Because *doctor* may bring to mind *hospital* and *pain*, those words are linked to it as well.

many of the vocabularies created for use in assistive technologies, it is organized in a hierarchy, but a word is defined according to the relationships that connect it to surrounding, related concepts. Thus, concepts within

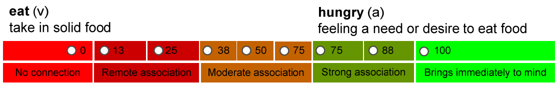

figure 2. In the evocation online experiment, subjects are asked to rank how much one word brings to mind another.

WordNet are specific to individual meanings and not just to words (for example, "bank," a geographical feature, is different from "bank," the financial institution).

The vocabulary is managed through two modules. The user preference module (see Figure 1) keeps track of customizations input by the aphasic user or by other authorized individuals such as a caregiver or a speech-language pathologist. Taking advantage of the adaptability of the application, the user can add and remove words, group them in personalized categories (for example a "Favorites" folder), enhance words with images and sounds, and associate existing phrases and sentences with a concept.

Trained on word association measures (linear proximity and similarity measures derived from corpus-based word co-occurrence), the statistics collected from the usage of the vocabulary and the user preferences, an active learning module (see Figure 1) predicts links between words with the goal of making appropriate suggestions during sentence composition. Thus, words relevant to the user's profile or the context of the communication surface faster. For example, if the user wishes to compose the phrase "I need an appointment with my doctor." and she searches for the word "doctor" first, the vocabulary network centered on "doctor" may look as the one shown in Figure 1. The links between the words may exist because the user has previously composed sentences using "doctor" and "medication", and "doctor" and "appointment". The words "hospital" and "doctor", for example, may be linked due to prediction based on known word association measures and usage. In addition, the user may be able to find the phrase "Need appointment with doctor" right away if she had already composed it in the past and had linked it deliberately to the word "doctor".

Current and Future Work

We have created a ViVA prototype which we plan to test in three main stages briefly described below. We are also currently enhancing the core vocabulary data so that it is richer with meaningful links between words even before the user starts utilizing the visual vocabulary.

Collecting Evocation Data

To compensate for the common inability of people with aphasia to evoke the word for a concept, we assist the user with word association measures that will help her find the correct word by navigating through related words. Evocation is one such measure that has been linked to cognitive phenomena (for example semantic priming) that illustrate the associative strength between concept in semantic memory and its value [4]. Thus, we are interested in extending the original evocation set [4] which consists of word pairs rated by humans according to how much the first word brings to mind the second one. To do so, we first created a list of pairs of words retrieved from the intersection between the vocabulary of a popular commercial assistive device for people with aphasia, the Lingraphica [12], and the top 5000 synsets (set of a word's cognitive synonyms provided by WordNet) derived from word frequencies in the British National Corpus. These pairs will be rated by human subjects through an online Mechanical Turk experiment [2]. Each participant is asked to rate 50 pairs according to evocation (see Figure 2 for an example of the setup). The validity of a subject's ratings is controlled by incorporating in the task pairs from the original evocation dataset with already known average ratings. This experiment allows us to collect additional evocation data on words which are frequently used on average and are also relevant to our target population. The experiment is currently underway.

ViVA Evaluation

It is challenging to evaluate an adaptive tool in short laboratory studies and asking users to incorporate an early prototype in their everyday life can lead to frustration, especially when they are cognitively disabled. Thus, we will first evaluate how the system adapts to an individual user's profile by using proxy user data gathered from randomly chosen blogs of elderly people [1]. We use the postings of elderly people as proxy data because those individuals are within the age range of higher risk of suffering from stroke and thus aphasia. Even though they probably lead more active lives than those disabled by aphasia, they have similar social interaction and world views. We collected random paragraphs from five different bloggers on everyday topics such as cooking and family. The text from each blogger was broken into one thousand sentences. We then extracted the nouns, verbs and adjectives from each sentence and created word pairs. Those word pairs are used as training usage data for the visual vocabulary. After training, we will examine how ViVA performs given new sentences composed from the same blogger. We will analyze whether user-specific and more meaningful word links have been forged after the simulated usage of the vocabulary. This part of the evaluation is currently underway.

During the second stage of our planned evaluation, we will examine the interface design and functionality of ViVA with non-disabled elderly subjects during a controlled laboratory experiment. Compared to aphasic individuals, senior citizens are easier to communicate with and recruit as participants. As mentioned earlier, they are relevant subjects for initial evaluation because they experience cognitive decline, have a similar lifestyle and fall within the age range of people with higher risk of suffering from stroke and thus aphasia.

Finally, we will, of course, evaluate ViVA with persons with aphasia. In this stage of our planned work, we will collect quantitative and qualitative data through laboratory-style experiments and a field study where a few participants will be asked to incorporate a high-fidelity working prototype of ViVA in their daily life. We will also interview the participants and their caregivers to understand how the system affects a person's ability to communicate.

Discussion

Taking an adaptive and adaptable approach to designing a multi-modal visual vocabulary will ensure that ViVA addresses the communication needs of our heterogeneous user population. One of a few inherent challenges in our work is finding a balance between automatically managing the vocabulary and providing a stable and dependable interface. We will strive to reach such a balance by collecting and analyzing data from a carefully planned iterative evaluation.

An additional challenge in our work is involving individuals with communication difficulties in participatory design research. By involving elderly participants in the early design and evaluation stages, we make the development process more efficient, but we need to scrutinize the results cautiously ensuring that they can be generalized for the target population.

Individuals suffering from aphasia tend to be older and often have suffered from a stroke. As a result, they are likely to have other perceptual, motor and cognitive impairments, which also affect their ability to use computer technology effectively. We are not concerned with this challenge just yet, but as we move along in the development of ViVA we need to consider choices of hardware and interaction methods for future functional prototypes.

Our work will result not only in a new communication tool for people with aphasia, but also in new insights for the research community into helping those who suffer from this disability through technology. In addition, we expect that the lessons learned during the design and evaluation of ViVA will have some broader applications and contributions. We suppose that our results will narrow the existing gap in understanding how mixed-initiative tools can assist users with other language and communication impairments. Finally, our mixed-initiative approach to addressing customization and flexibility in a communication system will very likely be applicable to other domains such as in the design of tools for the elderly and educational tools for children and for foreign language learners.

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