

Improving Vocabulary Organization in Assistive Communication Tools: a Mixed-Initiative Approach

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ABSTRACT

Navigating a vocabulary consisting of thousands of entries in order to select appropriate words for building communication is challenging for individuals with lexical access impairments like those caused by aphasia. Ineffective vocabulary organization and navigation hurt the usability and adoption of assistive communication tools and ultimately fail to help users engage in practical communication. We have developed a multi-modal visual vocabulary that enables improved navigation and effective word finding by modeling a speaker's "mental lexicon", where words are stored and organized in ways that allow efficient access and retrieval. Due to impaired links in their mental lexicon, people with aphasia have persistent difficulties accessing and retrieving words that express intended concepts. The Visual Vocabulary for Aphasia (ViVA) attempts to compensate for some of these missing or impaired semantic connections by organizing words in a dynamic semantic network where links between words reflect word association measures based on WordNet, human judgments of semantic similarity, and past vocabulary usage.

Keywords: Assistive Communication, Aphasia, Semantic Networks, Adaptive Tools, Visual Vocabularies

1. INTRODUCTION

Aphasia, an acquired disorder that impacts an individual's language abilities, affects close to one million people in the United States alone [15]. It is often acquired as a result of stroke, brain tumor, or other brain injuries. The resulting impairments to the ability to understand and produce language vary in severity and can affect an individual in any combination. Even though rehabilitation can alleviate the level of impairment, a significant number of people with aphasia are left with a life-long chronic disability that impacts a wide range of activities and prevents full re-engagement in life.

Technological tools can assist communication for people with language impairments, but current solutions share a key disadvantage: vocabulary organization and navigation impair effective word finding and phrase construction due to deep hierarchies or extensive flat word collections. We have developed a prototype for a multi-modal visual vocabulary communication tool that implements a novel approach to word organization which enables the user to browse for words efficiently. The visual vocabulary for aphasia (ViVA) organizes words in a context-sensitive network enhanced with semantic measures and tailored to a user profile. ViVA is designed to reorganize and update the vocabulary structure automatically according to user preferences and system usage statistics. This paper describes the design of the vocabulary, presents experimental results from an initial evaluation, and outlines plans for further research.

2. BACKGROUND

Designing technological tools to assist people with aphasia is particularly challenging due to the variability of resulting impairments. Thus, some researchers have advocated addressing the heterogeneous needs of the user population by providing flexible and customizable solutions [5, 16]. There has been consistent effort in designing adaptive assistive tools for people with cognitive impairments, but none have proven to be usable by aphasic individuals. Such tools mainly include scheduling and prompting systems that aim to reduce the burden of caregivers (e.g., [8] and [13]). There have been relatively few systems for non-therapeutic purposes for less severely affected individuals, such as systems that support daily activities like cooking, photo management and social interactions [2, 6, 14].

In an attempt to fill some of this void, Boyd-Graber et al. developed a hybrid communication system where a desktop computer is used for compositional tasks such as appointment scheduling and a personal digital assistant is used as a portable extension to assist communication outside of the home [5]. The interface combines images, text and speech audio and provides some support for customization. The findings from the system's evaluation confirmed the need for better customization capabilities and revealed that limitations specific to vocabulary breadth and depth, and word retrieval are a fundamental problem. 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 requirements of every individual. Furthermore, most existing assistive communication vocabularies have a lexical organization scheme based on a simple list of words. Some word collections are organized in hierarchies which often leads to deep and confusing searches; others are simply a list of arbitrary categories which causes excessive scrolling and a sense of disorganization. To address these issues, it is important to build a well-structured computerized vocabulary that can be easily maintained and enhanced, and that offers improved navigation and word retrieval.

3. DESIGNING VIVA

We have designed a visual vocabulary for aphasia (ViVA) that is both *adaptable*, able to be customized by the user, and *adaptive*, able to dynamically change to better suit the user's past actions and future needs. This mixed-initiative approach enables 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. The vocabulary's adaptable component allows the user to add and remove vocabulary items, group them in personalized categories, enhance words with images and sounds, and associate existing phrases with a concept. The adaptive component updates the vocabulary organization based on vocabulary usage statistics, user preferences and a number of semantic association measures (see Fig. 1). For example, if the user wishes to compose the phrase "I need an appointment with my doctor" and she searches for *doctor* first, the words *medication* and *appointment* may surface (see Fig. 1), because they have been linked to *doctor* due to past usage, while *hospital* and *doctor* could be linked due to prediction based on known semantic measures. In addition, the user may be able to find the phrase "Need appointment with my doctor" right away if it has been composed in the past. Thus, the vocabulary tailors the word organization according to both user-specific information and general knowledge of human semantic memory.

People with aphasia, especially those impaired by anomic aphasia, experience persistent difficulties accessing and retrieving words that express intended concepts. To help these users find the words they need, we appeal to the psychological literature on speakers' "mental lexicon", where words are stored and organized in ways that allow efficient access and retrieval. Currently, ViVA compensates for some of the missing semantic connections in a user's mental lexicon by incorporating links between words based on evocation. Evocation is a word association measure that indicates how much one concept brings to mind another one. It is particularly valuable for vocabulary navigation because it encodes cross-part-of-speech associations which most existing assistive vocabularies lack. We compiled our own dataset of evocation through an online experiment posted on Amazon Mechanical Turk (AMT) [3]. Using machine learning techniques, the structure of WordNet (a large-scale lexical database) [10], and an initial collection of evocation ratings [4], we generated a list of word pairs with predicted high evocation ratings. These pairs were then rated for evocation by AMT workers. During a period of three months, we collected ratings for 107,550 word pairs. The ratings from untrained online annotators correlated well (0.60) with those collected by Boyd-Graber et al. [4] from trained annotators.

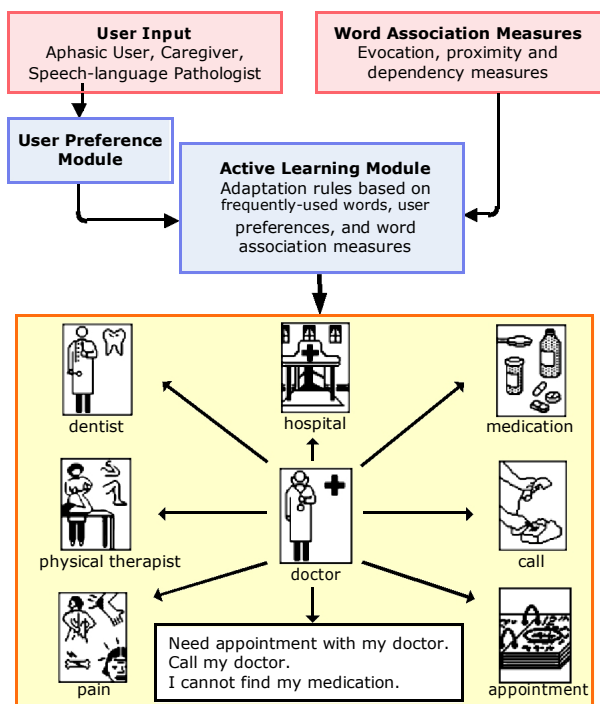


Figure 1. Schematic of components of proposed vocabulary.

4. INITIAL EVALUATION

As a first step to evaluating ViVA, we assessed how it adapts to a user's profile by using simulated usage data in the form of sentences gathered from blogs of elderly people from the Ageless Project [1]. We investigated how ViVA performs in connecting words to construct a sentence compared to the vocabulary hierarchy of Lingraphica [9], a popular assistive device for people with aphasia. We first trained ViVA with simulated usage data extracted from one blogger's profile. We then examined how it constructs new sentences from that same profile.

The links in ViVA's vocabulary network which reflected evocation and simulated usage shortened the browsing paths between approximately 44% of the words that appeared next to each other in a sentence from the usage sets (the rest of the paths were the same length as in Lingraphica). Using logistic regression, we predicted additional links between words which improved the results by extra 7.6% on average. On average, 22% of the paths became shorter by two or more steps due to ViVA's vocabulary organization. A naïve baseline test showed that our improvement in shortening the distances between related words cannot be achieved simply with a random increase in the density of the vocabulary network [11].

We also ran a pilot study with able users in which participants were asked to find the missing words in a number of phrases using one of two vocabulary conditions – ViVA and Lingraphica. The results revealed that it took significantly longer to find the missing words in ViVA than in Lingraphica. Significantly more words were skipped with Lingraphica. Finally, significantly fewer clicks were required to connect words in ViVA than in Lingraphica and users agreed that navigating the vocabulary through related words helps them find the target word faster [12].

5. FUTURE WORK

The preliminary evaluation of ViVA's prototype shows the potential of our alternative vocabulary organization to adapt and suggest useful words based on semantic measures and usage statistics. Next, we plan to investigate how people with aphasia respond to the proposed adaptive vocabulary. We will run evaluation studies with aphasic participants which will compare sentence construction using ViVA's vocabulary organization and the hierarchical vocabulary organization found in Lingraphica [9]. Previous research suggests that adaptive approaches are likely to benefit users with impairments even more than able users. This is due to evidence that user acceptance of adaptive interfaces is partially dependent on how much time and effort the user could save by using adaptation [7]. Thus, we will be looking to answer questions such as what the effect of adaptation on user's cognitive load is, what the tradeoff between improved navigation and changing vocabulary structure is, and whether ViVA facilitates or impedes vocabulary exploration and learning.

6. CONCLUSION

We presented the design of the visual vocabulary for aphasia (ViVA) which addresses vocabulary organization and navigation problems prevalent in existing assistive communication tools. ViVA implements adaptable techniques in order to allow the user to customize the tool and adaptive techniques to be able to tailor the vocabulary organization to better fit usage patterns and user needs. To assist people with aphasia in finding words efficiently, we exploit theories of human semantic memory and create a dynamic semantic network reflecting known word association measures and human judgment of semantic similarity. Results from an initial evaluation of the adaptive capabilities of ViVA demonstrate the potential of the proposed approach to vocabulary organization which we plan to investigate further involving users with aphasia.

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