Implications of Pragmatic and Cognitive Theories on the Design of Utterance-Based AAC Systems

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Abstract

Utterance-based AAC systems have the potential to significantly speed communication rate for someone who relies on a speech generating device for communication. At the same time, such systems pose interesting challenges including anticipating text needs, remembering what text is stored, and accessing desired text when needed. Moreover, using such systems has profound pragmatic implications as a prestored message may or may not capture exactly what the user wishes to say in a particular discourse situation. In this paper we describe a prototype of an utterance-based AAC system whose design choices are driven by findings from theoretically driven studies concerning pragmatic choices with which the user of such a system is faced. These findings are coupled with cognitive theories to make choices for system design.

1 Introduction

There are more than 3.5 million Americans with disabilities who cannot effectively use speech to communicate (Beukelman & Mirenda, 2005). There are many conditions that can result in such severe speech impairments including cerebral palsy, autism spectrum disorders, multiple sclerosis, amyotrophic lateral sclerosis (ALS), brain-stem stroke, Parkinson's disease, and traumatic brain injury (TBI). Any one of these conditions can have a negative effect on the quality of life of these people. The field of Augmentative and Alternative Communication (AAC) has, especially over the last ten years, dramatically enhanced access to communication for these individuals through the use of high-tech systems. These electronic systems allow the entering of text that is then converted to natural-sounding synthetic speech. While the population using AAC systems is quite diverse with regard to their linguistic and cognitive skills, here we focus on AAC systems for cognitively high-functioning literate adults with motor impairments.

Even with a focus on this population, the communication rates of people who use AAC systems differ greatly based on their motor abilities and available interface choices (Trnka et al., 2009). Nevertheless, overall communication rates are slow to the extent that they are acknowledged as one of the most problematic areas of AAC interactions. Rates of 10-15 words per minute have been identified as upper limits for letter-by-letter selection on a keyboard (e.g., Wobbrock & Myers, 2006)—a significant contrast to 130-200 words per minute for spoken communication. These slow rates and long pauses continue to be a major barrier to the social, educational, and vocational success, particularly when communicating with unfamiliar partners who have little or no experience in conversing with someone who uses AAC.

One method that holds a great deal of promise for enhancing communication rate is the use of systems that offer a selection of prestored messages. With these systems, a phrase or full sentence/utterance can be selected at once. In such systems, sometimes called utterance-based AAC systems, people compose whole utterances in advance and store them for later use. These systems appear to be best suited for situations where relatively predictable conversational routines take place. Examples include short, transactional exchanges in stores, restaurants, or other public places where services are provided.

Although it might appear that utterance-based technology could solve the problem of slow com-

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munication, at least in these predictable exchanges, the individual who uses these prestored messages must deal with additional challenges to use the prestored messages that have been stored in their system. Users must be able to: 1) remember that they have messages prestored that are appropriate for a given situation; 2) remember where these messages are stored; and 3) access the desired prestored messages with few keystrokes. In addition, it must be recognized that the prestored messages are not always going to exactly fit the communicative situation in which the user finds him/herself (e.g., a prestored message may not have enough information for the needs of the partner).This results in a fourth challenge to the user—to decide if it is better to use the message as stored, or either edit or construct a new one. Each challenge, or trade-off choice, directly affects communication rate.

An adequate solution to these challenges has proven elusive over the years, despite a long tradition of research in utterance-based technologies (e.g., Todman, 2000; Todman & Alm, 1997; Todman et al., 2008; Vanderheyden et al., 1996). What has been lacking is a design process that employs a theoretical framework (or perspective) dealing with conversation conventions, empirical evidence to identify priorities, and systematic testing to determine whether the design enables the communicator to achieve the goals of an interaction.

A hierarchy of conversational rule violations based on a series of experimental studies has a great deal of potential to positively influence the design of future utterance-based technologies. In this paper we first describe a set of such studies and the resulting hierarchy. We then discuss the implications of this hierarchy on the design of an utterance-based AAC system, while integrating considerations from cognition and Natural Language Processing. Finally, we present our partially implemented prototype system and describe plans for evaluating this technology.

2 Theoretical Background

To shed light on the design of future utterance-based technologies, studied conversational trade-off choices that a person faces when using an utterance-based system in goal-directed public situations with service providers who are unfamiliar with AAC, and how the particular choices made affect the attitudes and conversational behaviors of these providers (Bedrosian et al., 2003; Hoag et al., 2007; Hoag et al., 2004, 2008; McCoy, et al., 2007). We were interested in determining which message choices resulted in the most favorable attitudes and conversational responses leading to the success of the AAC customer's goal in these transactional exchanges.

Notice that no matter how well a user anticipates text need, it is inevitable that some prestored messages are not going to exactly fit the pragmatic context in which the user finds him or herself. Four public situations (i.e., bookstore, movie theater, small convenience store, hair salon) where such mismatches could occur were studied in a series of investigations. Possible pragmatic mismatches were characterized in terms of rule violations according to Grice (1975) who articulated a set of classic conversational maxims that implicitly guide people in exchanging information. Using videotaped interactions across experiments, these violations were scripted in messages that involved trade-off choices between prestored message use and real time message construction. Specifically, the trade-offs examined in these investigations were between speed of message delivery and a message with either: 1) repetitive information with repetitive words or phrases; 2) excessive information, with more information than was needed by the listener but where the information was still topically relevant; 3) inadequate information, lacking some of the information needed by the listener, or 4) partly relevant information, where some of the content was not topically relevant. An example of such a trade-off involved the message choice of a quickly delivered (i.e., 4 seconds) prestored message with excessive information or one that was delivered slowly (i.e., 90 seconds) to allow editing of the excessive information.

In essence, these experiments simulated situations where the user was faced with a choice: whether to quickly deliver a prestored message that was not exactly what was desired because of the pragmatic mismatch, or whether to take the time to edit the message so that it was exactly what was needed. The experiments looked at goal oriented situations with unfamiliar partners. This is an extremely important set of circumstances where the attitudes and actions of the communication partner can greatly affect whether or not the user can independently meet his or her goals.

The experimental hypothesis was that there existed a hierarchy of conversational maxims involving the maxims of speed, relevance, repetition, and Informativeness, such that adherence to some of these maxims would result in more positive evaluations by public service providers than others. With regard to the results of the experiments, similar hierarchies of conversational rule violations were found across experiments, such that some violations, regardless of degree or particular public setting, were indeed consistently responded to more or less favorably than others. Consistently at the bottom of the hierarchy (i.e., responded to least favorably in all experimental situations, and with less success in meeting the target customer's goal) were quickly delivered messages with only partly relevant information. The finding places a high priority on selecting entirely relevant messages. As such, it suggests the development of a system architecture that makes it easy and fast to retrieve entirely relevant messages and difficult to retrieve messages that are only partly relevant to the current exchange.

On the other hand, consistently at the top of the hierarchy were quickly delivered messages with repetitive information. These messages were responded to the most favorably and with much success in meeting the target customer's goal. The limited negative impact of the messages with repetition indicated that modification of system design to remedy this message flaw would yield less benefit for the user.

The other trade-off choices, the fast inadequate message, the slow adequate message, and the fast excessive message, occupied the middle of the hierarchy across the experiments, although their positions with regard to each other were not exactly the same. Thus, the implications of these findings for system design are a little less clear, but suggest that users given options to edit or easily construct messages with respect to Informativeness.

In sum, these findings have several important implications for future utterance-based technologies. A system design must provide a mechanisms to maximize the availability of situationally relevant prestored messages. Additionally, utterance-based technologies must be integrated seamlessly into an AAC system design that allows these prestored messages to be easily edited for their excessive or inadequate information. Finally, this design must also support the on-line construction of new messages, while still easily accessing prestored messages when appropriate.

3 Prototype Development

The research findings cited above, particularly those regarding the critical role of relevance in conversation, led to the underlying structure of the prototype we are in the process of developing. Specifically, we are interested in a prototype that will support relevant conversation in familiar routine exchanges with relatively predictable content, such as those that occur in public settings, as it is these types of exchanges that provide the best situations in which to use prestored text. Schank and Abelson (1977) suggested that people develop mental scripts in such familiar situations (e.g., going to a restaurant), and that these scripts (representing typical sequences of events) are accessed by people in order to act appropriately in these situations, and understand/interpret what is being said. Each script consists of a series of scenes (subevents) that previous experience has led one to expect to occur. According to the cognitive theory, when faced with a new situation (e.g., going to a new restaurant), a person can pull up his/her mental script and step through the scenes in order to participate appropriately.

We propose an underlying organizational structure for prestored utterances that leverages this mental script notion from cognitive science, as it nicely supports the Bedrosian, Hoag, McCoy, and Bedrosian findings about relevance. A slightly different notion of scripts has been used in previous research in utterance-based technologies (e.g., Dye et al., 1998; Alm et al., 2000). The notion referred to here is inspired by the early work of Vanderheyden (1995). In particular, in our prototype system the prestored utterances are organized (grouped and ordered) according to scenes within a script. For example, a "going-to-a-restaurant" script may have scenes associated with entering, ordering drinks, ordering entree, paying, etc. Associated with each of these scenes are the prestored utterances appropriate for use during that scene (e.g., utterances pertaining to entering might include, "Hello." "Fine, thank you.", "Non-smoking.").

Not only would this organization ensure the relevance of utterances to the current situation, but it would also significantly aid the user in remembering where these messages are stored so that they can be accessed. Essentially the user could direct the system to step through messages appropriate for each scene of a given script as he/she is actually experiencing the scene. The utterance-based system would have a "now point" which corresponds to the scene in which the user is currently located in the script. Utterances useful for the conversation during that scene are easily available using very few keystrokes. Moreover, because the script mirrors the way a user thinks about a typical situation and how it flows from one scene to the next, the interface could lead the user to utterances appropriate for the next scenes to be encountered. Thus, users do not need to remember exactly which utterances are stored; they need only to activate the appropriate scene in the script to be shown relevant messages that can be selected, as well as other scenes that may follow.

At the same time, this underlying structure can also provide time-saving benefits to the user with respect to entering text. This is in part because of its hierarchical organization [see Figure 1, influenced by Vanderheyden (1995)]. At the top of any given hierarchy, are the most general scripts which can be used in a multitude of new situations (e.g., a new type of restaurant that the user has never gone to). As shown in the figure, the most general script here involves a "going-to-a-restaurant" script with scenes containing "general purpose text". For instance, in the ordering scene, slot fillers appropriate for many different kinds of restaurants are shown. Below this script, are scripts that pertain to more specific types of restaurants (only two are explicitly shown in the figure). In these scripts, notice some scenes and text are inherited verbatim from above, but text may also be added to or modified as appropriate for the situation and according to the preferences of the user. By inherited we mean that one or more scenes, with the corresponding messages, from the most general script would automatically be made available in the more specific instances. Unavailable in other prestored text systems, this feature is a significant benefit to users, because they only have to enter the information one time at the highest level of the hierarchy, and yet they will have access to it again in other scripts further down in the hierarchy.

Another advantage of the inheritance is that it results in a consistent organization of messages across scripts. When accessing any script within the restaurant hierarchy, for example, not only can users expect to find the entering scene that was inherited from the "parent" script, they can also expect to find the prestored utterances "Hello" and "Fine, thank you" near the beginning of that scene. This illustrates a memory enhancement feature of this system that is not available in other prestored text systems – consistency in placement of messages from one particular script to another. Overall, this underlying organizational structure, which we will refer to as a deep structure, represents a significant change in the way that utterance-based systems in AAC have been designed. With respect to appearance, or surface structure, some current systems may have, for example, a restaurant "page" consisting of a grid of small rectangular boxes forming rows and columns across the computer screen. Although each box would contain a prestored message appropriate for use in a restaurant, there is no deep structure specifying how the messages on that page should be organized (grouped and ordered) nor how the messages might be related (the notion of consistency) to those stored on other pages. The only organizing principle is that these messages are "things I can say in a restaurant." If the messages are not ordered (either by row or column) in a way that steps the user through a scripted sequence of events for a given situation, the user must search through a set of messages, some of which are unlikely to occur at that stage in the interaction. This search process, which is likely to include irrelevant messages, may slow down the selection process and negatively impact the rate of communication. Even if health providers or manufacturers programmed messages in these boxes to follow such a sequence, this would still remain a surface structure "fix." The strength of our prototype is the deep structure—the machinery—such that the consistent location of the messages can be easily remembered and accessed in a few keystrokes to enhance communication rate. Additionally, the hierarchical advantage of the deep structure provides the user with a choice of scripts (depending on the specificity of the situation), and saves the user time and energy in entering text, making the user more independent in meeting individual communication needs.

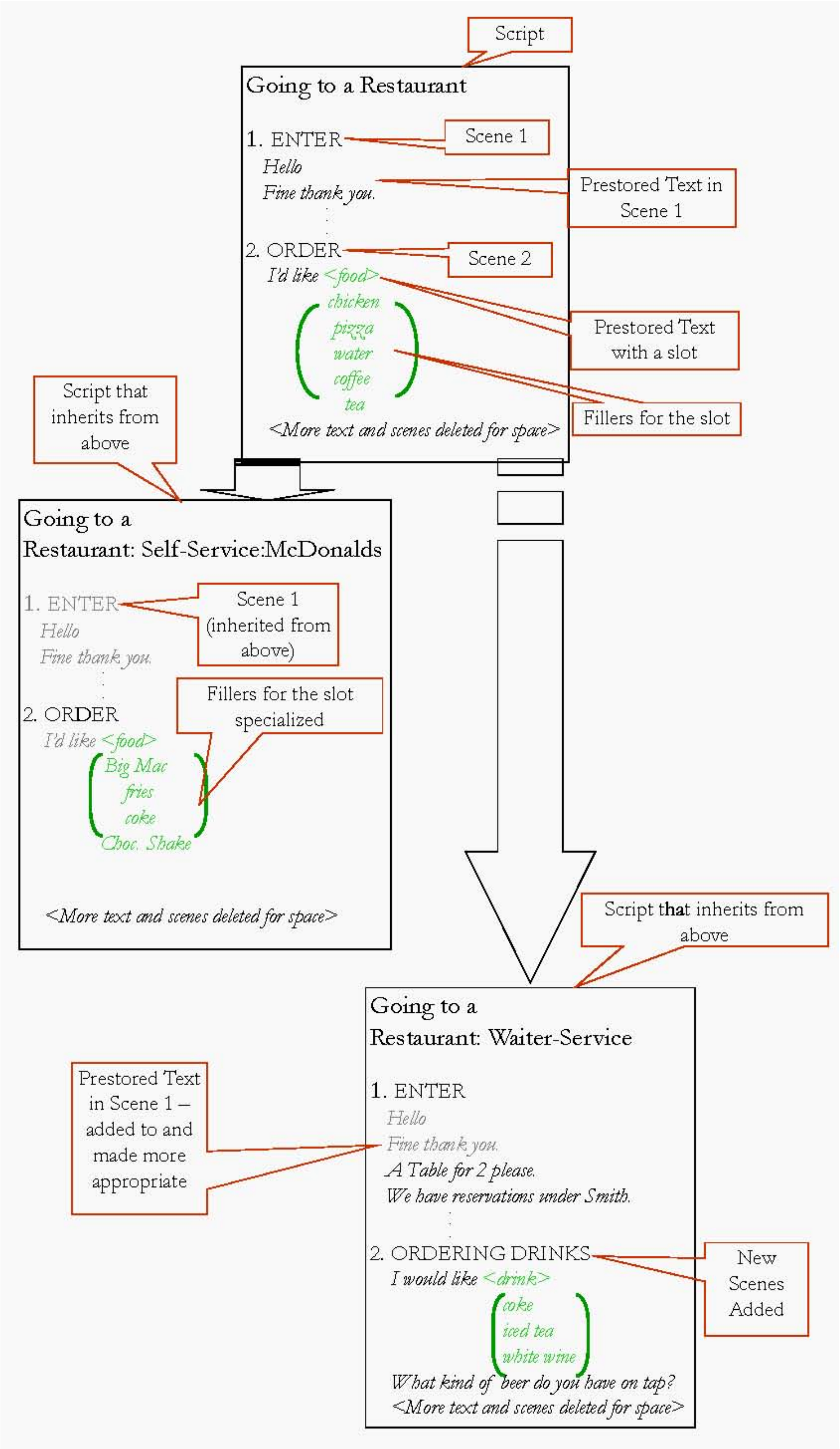

Figure 1: Hierarchical Script Representation

4 Communicating with the system

In this section we discuss the user interface and what the user does in order to actually communicate using the system which has been our focus to date. Future work will investigate issues in entering prestored text into scripts and adapting the scripts to the individual user. In a situation where the user anticipates using prestored text, he or she will be taken to a window menu where the desired script (and scene) can be selected. The user may then navigate to the script that best fits the actions in which he or she is about to engage. Upon selecting the script, the user will be taken to a screen such as that displayed in Figure 2.

The large window at the top is the display window. This is where the words of the utterances selected by the user to be spoken will be displayed. There is a clear button to clear the display window (on the left of the display) and a speak button (the arrow on the right-hand-side of the display) that causes the display window contents to be sent to the speech synthesizer to be spoken.

The next area of the display helps users keep their place and navigate within the chosen script. First is the scene map which is a numerical representation of the scenes in the current script. From this, for instance, users can see that the script they have selected contains seven scenes, and the scene they are currently performing is scene number one which corresponds to the “enter” scene. The number of the current scene is colored differently than the rest. Below the scene map is a line of tabs, under which are boxes containing prestored text that can be selected by the user. In this case, the text for the first five scenes of the script are displayed (or partially displayed). These scenes are named “enter”, “drinks”, “appetizer”, “soup/salad”, and “entrée”. Under each of these scene-name tabs is the list of possible prestored utterances associated with the scene. For example, there are three pieces of text displayed that would be appropriate for the “enter” scene. As is the case with the scene-map, the current scene (tab and utterances) is colored differently from the others so that it is more salient to the user.

Under the boxes are four tabs which bring up overlays with some general prestored text that might be needed at any time during the script. Asking for some assistance, talking with the waiter, small talk with the table mate, and quickfires are just some examples of the kinds of pages that might be accessible. Finally, at the bottom of the page are some navigation buttons for navigating in the device. Here we see buttons that allow the user to go to the device home page, move the script backward and forward, and go to a page containing a keyboard so a novel utterance can be composed.

The system is set up in a way that allows users to select text that they might need while perform-

Figure 2: View of Interface with "Entering Scene" Active

ing an action as they step through a scene. Thus, it is assumed that the user would select text in left-to-right order with the left-most scene being the active scene (i.e., the scene the user is currently performing). The user may select one of the boxes in the active scene, and the text would be automatically put up into the display window at the top. The speak button (arrow in the upper-right corner) is used to actually say the desired text. The user could select and speak any number of utterances in the active scene without any significant changes in the display. If the actions the user is performing have progressed to the next scene, then the user may navigate to the appropriate text in two different ways. First, the user could click on the scene map or displayed tabs to have the context shift to the new scene. Once selected that scene tab and associated text boxes will be shown on the left-hand-side of the device. Second, if the utterance that the user wishes to say is currently visible on the screen, the user may simply select that utterance. In this case, in addition to putting the utterance in the display window making it ready to be spoken, the screen will automatically scroll over to display the scene from which the utterance was chosen on the far left (revealing subsequent scenes to the right of it on the screen). Figure 3 displays an example of this kind of movement, resulting from the user selecting the "I'll have the nachos" text from the appetizer scene displayed in Figure 2. Notice that the scenes have been shifted over--the appetizer scene (scene 3) is now the active scene, and the text associated with the button is now in the display window.

Figure 3: Shifting scenes by selecting text from appetizer scene

Figure 3 illustrates another feature of the system – slot fillers that are specific to a script or scene. Notice that "nachos" is colored differently than the other words in this prestored text. This is an indication that it is a slot-filler and that other options for filling that slot are available. To edit that text, the user clicks on the highlighted word in the display window, and a window such as that in Figure 4 is displayed. The user may then select the filler he/she desires, and it will replace "nachos" in the display.

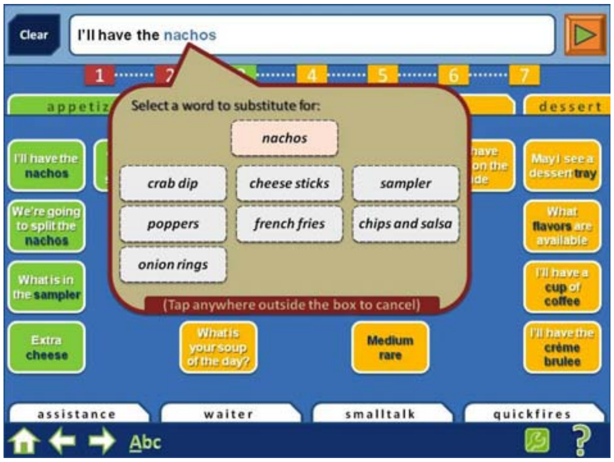

Figure 4: Editing a slot-filler

The system described is currently being implemented. Yet to be integrated is a facility that will enable more extensive editing of the text in the display window and the specifics of easy access to typing via an on-screen keyboard (for instances where the user wishes to type an utterance from scratch rather than using a prestored utterance).

5 Planned Evaluation

Two separate comparative efficacy evaluations will be conducted to test both the efficiency and effectiveness (Schlosser, 1999) of the prototype system in contrast to a differently organized prestored text system. In each evaluation, efficiency will involve a comparison of the two systems, in a training session, with respect to user learning variables (e.g., which system is learned faster, with less instruction time, fewer errors/trials). Effectiveness will involve a comparison, in a virtual public setting environment with a service provider as the partner, dealing with user behavior changes and satisfaction (e.g., which system results in faster rates of prestored message selection, goal attainment, more satisfaction) and partner attitude and behavior changes (e.g., which system leads to more positive attitudes toward the user, more effective conversational behaviors in meeting user goals).

In the first efficacy evaluation, typically speaking, nondisabled adults will be the participants, eliminating bias due to the fact that they will have had no previous experience using AAC systems. A randomized controlled trial will be employed whereby participants will be assigned to either the prototype system group or the standard system group. Each system will contain the same prestored messages, and the same virtual public setting will be used in each group. Results will be used to refine the training phase and modify the prototype software if necessary. In the second evaluation, a single subject experimental design involving an adapted alternating treatment design will be employed with cognitively intact, literate, adult participants who currently use prestored text systems. Although such a design would expose each participant to each system (i.e., the prototype system and the standard system), carryover effects are eliminated due to counterbalancing the order of the two conditions across participants, ensuring that there are two equivalent and functionally independent instructional sets for the conditions (Schlosser, 1999) (in this case, the instructional sets would involve two virtual public settings and corresponding prestored messages), and counterbalancing the sets between conditions.

6 Related Work

Storing and retrieving full utterances has been the focus of a long tradition of work; Todman et al. (2008) contains a nice overview of some of these systems. The ScripTalker system (Dye et al. 1998a) is closest in theory to our system wit perhaps the biggest difference being the variety of utterances available (and the fact that their prototype seemed more geared toward people with low literacy skills. While the overall architecture did rely on the notion of scripts, the actual utterances stored was one per task the user might want to perform. I.e., the scripts themselves were linguistic in nature. Similar uses were found in other work from that same group, for instance see (Alm et al. 1995) and (Dye et al. 1998). In contrast we target users with higher literacy skills and more variety in the prestored text they might want to have available. The script is used to organize the messages but there are many messages available within a particular scene.

Other work such as the Talk System (Todman & Alm, 1997) is intended for social conversation and the organization is quite different. As its intention is so different, one would expect the stored content to need to be updated very often in order to keep it current. This is in contrast to the relatively enduring nature expected in the types of conversations we envision.

Another notable system is the FrameTalker Project (Higgenbotham & Lesher, 2005) uses a looser notion of communication contexts. Our hypothesis is the structure used there does not impose enough organization over the utterances, especially in the type of situations we envision for use. The Contact system is a system that combines notions from both Talk and the FrameTalker projects.

Finally, Langer & Hickey (1997) describe a whole utterance system that retrieved utterances related to keywords via a keyword search on a large database of utterances. In contrast, our system would provide access to presumably a series of utterances relevant to the current situation.

7 Conclusions

AAC systems that use prestored text have a great deal of potential to speed communication rate and improve attitudes of unfamiliar speaking partners towards AAC users in public goal-oriented situations. In this work we applied empirical evidence summarized in a hierarchy of conversational rule violations (Bedrosian et al. 2000) to identify important principles of successful interaction with AAC text. We then attempted to match appropriate NLP technologies with these principles in order to develop a different viewpoint for an AAC system that used prestored text. Our design is based on schema-theory (Schank & Abelson, 1977) and enforces a structure over the prestored text that will minimize irrelevant text and constrain the rest of the text so as to facilitate remembering what text is stored while minimizing keystrokes needed to select the text.

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