Considering the Effects of Second Language Learning on Generation

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Abstract

In this paper we discuss how generation issues affect the design of a computer-assisted language learning tool designed to teach written English as a second language to deaf users of American Sign Language. We discuss a dual-component linguistic model that attempts to reflect the generation process of the learners. The first model component captures the influence of the first language on the acquisition of the second. The second model component captures the process of second language acquisition itself.

The linguistic model helps the system identify errors along with their probable source(s). This information is crucial for effective correction. It is also useful in the response phase of the system to focus tutoring on the errors that are most beneficial to correct. In addition, the linguistic model can be used to tailor the system's realization of its response. In this way, the syntactic constructions generated by the system will provide understandable and positive exemplars of the language features currently being acquired by the learner.

Keywords

tailoring response generation, user modeling, computer-assisted language learning

1 Introduction

Our long-term goal is to develop a computer-assisted language learning (CALL) tool to help deaf students learn written English. The targeted students are users of American Sign Language (ASL), a language that is very different from English in its structure and discourse strategies. The approach we take is to view the student's learning of written English as a task in second language acquisition. In this respect, our effort is similar to other projects geared toward learning (English as) a second language.

We envision a system that would be used by a particular student over an extended period of time. A student would use the system as a tutor, entering texts (perhaps of several paragraphs in length) that he/she has written. The system would analyze these texts for errors, engage the student in a corrective tutorial dialogue, and offer possible corrected versions for some of the original input sentences.

To accomplish these goals, the proposed system must have several components. First, it must have the ability to analyze texts that are input by the student and determine what/where errors occur. Once the errors have been identified, the system must decide which of these errors it should concentrate on in its response to the student. Finally, the system must have the ability to generate appropriate corrective tutorial messages.

While at first glance, one might think that problems of Natural Language Generation only occur in the last phase of the system processing, we believe that a "generation" perspective on the entire process is extremely beneficial. For example, the problem of identifying errors in the original input text may seem like an issue of straight analysis, but it is not completely so. While an error might be recognized doing a syntactic parse of the sentence, in order for beneficial correction, both the specific error and its probable source should be identified.

Consider the following simple example: "My brother like to go...". It is clear that there is a problem in subject-verb agreement; however, does it occur because (1) the noun should be in the plural form, (2) the verb should be in singular

form, or (3) the student doesn't know that such agreement exists in the language? Depending on the reason for the mistake, different kinds of tutorial correction will likely be more helpful. Our belief is that in order to identify probable sources of errors, the developer must take into account the *student's* generation process. In other words, the eventual system must possess an understanding of what is causing the student to generate sentences that contain these mistakes.

In this paper we present a portion of our work that describes the student's generation process as it is affected by second language acquisition (SLA). Our linguistic model of the student's generation process essentially reflects those aspects of the second language that are currently being learned. This also has implications on the *system's* generation process. In particular we discuss two ways in which the system's responses can be tailored to the user. In deciding "what to say", the system's generation can be tailored to focus on those errors that involve language features that the student is in the process of acquiring. In deciding "how to say it", the system can attempt to use the constructions that are currently being learned (as well as those that have been mastered) and so provide the student with correct exemplars of the second language. This is particularly important for the tutor we are developing since a lack of understandable input / feedback is a serious problem for the deaf community.

After giving an overview of our project, we concentrate on how the student's generation process is represented in our system. We have developed a model of how the effects of the first language (in our case, ASL) can be accounted for in the analysis phase of our system, and are currently developing a model which captures the effects of language acquisition itself. We discuss how these models affect the system's decisions of both what to say (i.e., what errors to tutor the student about) and how to say it (i.e., what syntactic constructions to use in the realization of the system's message).

2 A Writing Tool for Deaf Students: ICICLE

The problem of low literacy skills among deaf people has been well-documented and affects every aspect of deaf students' education. Since data on writing skills is not well documented, we note that the reading comprehension level of deaf students is considerably lower than that of their hearing counterparts, "... with about half of the population of deaf 18-year-olds reading at or below a fourth grade level and only about 10% reading above the eighth grade level..." [Str88]. We have undertaken a project designed to act as a "writing tutor" for deaf ASL signers learning written English. The eventual system will analyze a text written by a student, identify errors in the text, and engage the student in a tutorial dialogue aimed at some subset of the errors identified.

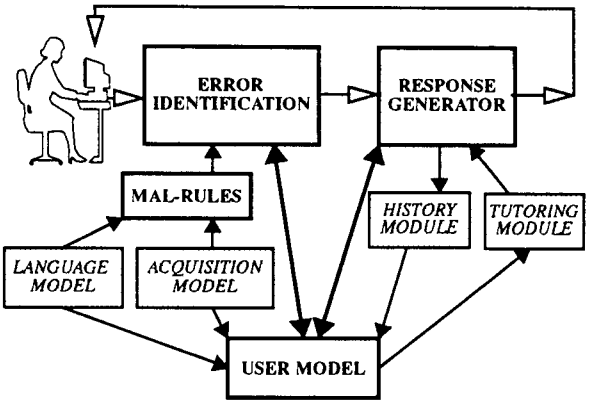

Figure 1 ICICLE Overall System Design

Figure 1 contains a block diagram of the overall system under development. The system, called ICICLE (Interactive Computer Identification and Correction of Language Errors), is designed to be a general purpose language learning tutor; however, we have focused on its application to deaf users of ASL acquiring written English, essentially as a second language.

In the ICICLE system, the input/feedback cycle begins when the student enters a portion of text into the computer. The student's text is first processed by the *Error Identification* component which is responsible for tagging all errors found in a given input. The possible effects of the student's first language on generated sentences is represented by the *Language Model* in Figure 1. Our methodology for developing this knowledge source is described in the next section. At present, Error Identification analyzes only one input sentence at a time. It first does a syntactic parse of the sentence using an English grammar augmented with error production rules called mal-rules [Sle82], [WVJ78]. The mal-rules expand the coverage of the grammar to include the errors that might be expected from people acquiring written English as a

second language. Thus these mal-rules capture expected language generation patterns from this population. Support for mal-rules will be developed within the framework of a probabilistic context-free grammar mechanism [Cha93], [All95].[1]

After using the expanded grammar to produce one or more syntactic parses of the input, the system selects a single parse using a scoring mechanism [MPS96] that takes into account a model of the acquisition process (labeled *Acquisition Model* in Figure 1 and further described in Section 4). Once a single parse is chosen, the errors are identified based on annotations associated with the mal-rules. If syntactic mal-rules were used in the parse, the sentence and any relevant annotations will be passed to the *Response Generator.* The Error Identification component may also contain semantic rules and discourse information that could add annotations for the Response Generator, though these are beyond the scope of this paper.

Now the Response Generator will take this information, along with data from the *User Model* (only a portion of which is described in this paper), and decide which errors to correct in detail and how each should be corrected.[2] This process includes determining which syntactic constructions should be preferred in the actual realization of the response. The Response Generator must also select an appropriate instructional strategy from the *Tutoring Module.*

Finally, the system's responses are presented to the student who then has an opportunity to enter corrections to the text and have it re-checked. During the system processing, information about the student's language usage over time (as well as user/system interactions) can be tracked and updated through the *History Module.*

While the overall system and its design encompass many important generation questions, we will focus on issues involving the Language Model and the Acquisition Model. We argue that these two models can be used to "explain" the student's sentence generation capabilities and should affect the system's response generation as well.

1. The current implementation of this phase does not yet include probabilistic information.
2. While in theory, instruction in ASL would be useful, the generation of ASL is well beyond the scope of this work.

3 Capturing the Effects of the First Language

A major proposal of our work is that a model incorporating possible effects of the first language should be included in the component that is responsible for identifying errors in the production of a second language. Such a model should indicate situations where the first language can have either a positive or negative influence. This claim is made based on an analysis of writing samples[3] collected from a number of schools and organizations for the deaf, concentrating on proficient ASL signers.[4] See [Sur93] for a complete discussion of this analysis as well as a detailed taxonomy of common language errors that were found.

During our error analysis, we were constantly searching for *why* the errors we found were occurring. Knowing the underlying reason for a mistake is crucial to the goal of providing effective tutoring. Our analysis and intuitions led us to the notion of *language transfer* to explain many of the errors we were finding. The term "language transfer" generally refers to the influence that knowledge of one language (L1) has on the production and/or comprehension of a second language (L2). Transfer can be positive (in the sense that it may speed the acquisition of the L2); however, it may also result in deviations in L2 production in places where the L1 and the L2 differ. While the existence of language transfer has been a rather controversial subject over the years (see [McL87], [GS83], [Sur91]), much recent research has provided convincing evidence that LT indeed occurs (see [McL87], [Gas84], [GS83]).

Given that transfer has been documented between spoken languages, it is reasonable to ask whether or not language transfer could occur between ASL (a visual-gestural language) and written English. At first glance, transfer may seem sur-

3. Other researchers (e.g., [PQ73], [QWM76], [RQP76], [QPS77], [KK78], [QP84]) studied errors in deaf writing. Our work differs in that we attribute many errors to language transfer (LT) between ASL and written English as is explained below.
4. We would like to thank John Albertini of the National Technical Institute for the Deaf (NTID), Bob McDonald of Gallaudet University, Lore Rosenthal of the Pennsylvania School for the Deaf, George Schellum (formerly) of the Margaret S. Sterck School, and MJ Bienvenu of the Bicultural Center for helping us gather writing samples.

prising since the components of ASL grammar and written English grammar are very different [Sto60], [BP78], [Pad82], [HS83], [KB79], [BPB83]. ASL grammar components include sign order, morphological modulations of signs, and non-manual behavior that occurs simultaneously with the manual signs [BC80], [Lid80], [Pad81], [KG83], [Ing78], [Bak80]. Written English grammar components include word order, morphological modulations of words, and punctuation, but nothing that clearly corresponds to the simultaneous manual/non-manual behavior found in ASL. On the surface, the fact that ASL and written English occur in different modalities seems problematic as well. However, there is some evidence that ASL is processed similarly to spoken languages (e.g., [Sac90]).

3.1 Characterizing Language Transfer

Because of the differences in grammar and modality between ASL and English, we have attempted to abstractly characterize how languages could differ in a way that is independent of the grammar components. By looking at language on a *feature* by *feature* basis, we have identified several language mis-matches that may lead to (negative) transfer.

First, languages may differ in *when* they mark a particular feature. As a result the marking of that feature in the L2 may seem redundant in the first language. For example, in ASL it is usual to establish tense at the beginning of a discourse segment or time frame, and then not to mark it again until the time frame changes. Of course, in English, tense is marked (on the verb) in every finite clause; so, some tense markings in English may seem redundant to an ASL signer. Transfer of such a feature (i.e., when to mark tense) might explain omission errors (in this case, of tense markings) in the L2. In fact, sentences containing these types of errors were common in our samples. Consider the following:

- "We *went* to see Senator Biden's office... Then we *go to see* the Vietnam memorial...."

This example is a particularly good illustration of a difficulty due to a question of *when* to mark tense, since the writer clearly knows how to form the past tense of "go" (because the appropriate past tense form appears in the sample).

Second, languages may differ in *how* they mark a feature. That is, two languages may express a concept in radically different ways and thus the mapping between the languages may be unclear. To illustrate this, consider the realization of the verb "to be" in ASL and English. Of course, "to be" is a standard verb in English. In ASL, however, "to be" is not lexicalized using a standard sign. Instead it is conveyed implicitly in a topic-comment structure.[5] For example, according to an ASL informant, to say "The shirt is red", the signer would typically sign $\overline{\text{SHIRT}}$ and mark it as a topic by raising his/her eyebrows, tilting his/her head and maintaining fairly constant eye gaze on the addressee, and then sign $\overline{\text{RED}}$, with a different head position, brow position and gaze.

Because of this vastly different method of realization, we might expect and often do find problems in sentences involving a main verb of "to be". Difficulties include both dropping the verb and confusing "have" and "be" as main verbs.[6] These errors are exemplified by the following:

- "Once the situation changes they _ different people."
- "... some birth controls *are* side-effect." (Possible Correction: "... *have side-effects*...")

A third way languages may differ is in regard to requiring morphological changes or additional lexical items for strictly syntactic reasons. For example, English requires a subject-verb agreement marking ("+s") on most verbs in the present tense when the subject is third-person-singular. This morphological marking often conveys no extra information. The situation of subject-verb agreement is more complex in ASL. When subject-verb agreement is marked in ASL, it involves

5. In a topic-comment structure, the topic is signed first, and then the comment is signed, grammatical signals marking the topic and comment. The grammatical markings for topichood involve raising the eyebrows, tilting the head, and maintaining fairly constant eye gaze on the addressee (unless directional gaze is needed for other grammatical purposes). The final sign of the topic is also held slightly longer than usual. When the comment is signed, the head position, brows and gaze change. "How they change depends on the type of comment that follows (e.g. [sic] statement, 'yes-no' question, command)." (p. 157) [BC80]
6. Because both having and being are expressed through the same grammatical structure in ASL, language transfer could explain why some ASL singers sometimes confuse the use of the verbs "be" and "have" in English.

a much different marking than what English requires. Also, the ASL marking is (generally) not empty of informational content. This could explain omissions of the morphological marking ("+s") on these verbs in the written English of proficient ASL signers. Consider the sentence:

- *"My brother like* to go..."

A final area of language transfer occurs when one language (say L1) has two or more words or phrases which correspond to a single word/phrase in the other language, and vice versa. For example, ASL uses the same sign (i.e., lexical item) for "other" and "another". Thus, language transfer might explain why an ASL learner of written English may have difficulty learning which word ("other" or "another") is appropriate to use in English.

3.2 Developing the Language Model

To summarize, part of our model of the learner's generation process includes a *Language Model* which captures the influence of the first language on the production of the second language. Our work in this area has included an analysis of writing samples from deaf writers who are proficient in ASL. The analysis supports the hypothesis that these people are using the natural and beneficial strategy of building on their ASL knowledge when acquiring English. Our findings also reveal that many of the error classes (perhaps as many as 76% of those found in our initial sample analysis) could be attributed to language transfer from ASL to English (if language transfer is defined in the way that we suggest). However, we do not claim that every instance of an error class that could be explained by language transfer must be. There are other factors at work as well.

What we do propose is that a Language Model that accounts for possible effects of the L1 on the L2 should be developed by comparing the two languages on a feature by feature basis. When any of the four mismatches we have described occur, mal-rules that encode the conflicting realizations should be included in the Language Model. Thus, the resulting model will contain annotated mal-rules that capture the errors we expect from second language learners. Presumably this model should capture the generation process of a learner who is using a model of their first language as a basis for generating in the second.

4 Taking the L2 Acquisition Process into Account

So far our description of the learner's generation process takes only the first language into account. If the system contained only this model, then it would predict that the student would make all mistakes invited by language transfer at every possibility. In fact, the set of errors a given student makes may be influenced by the L1, but that set changes over time as the L2 is acquired. A student stops making some errors and begins making others. At the same time the set of errors a student makes changes, so too does the set of constructions a student uses (appropriately). For example, generally a beginning student does not attempt to use a sentence that contains a complex sentential complement or a relative clause, until after he/she has mastered the use of simple subject-verb-object sentences. In this section we introduce a component which attempts to capture aspects of the second language acquisition process that affect the text the student is generating.

In acquiring English as a second language, there is considerable linguistic evidence that the acquisition order of English features is relatively consistent and fixed regardless of the first language [Ing89], [DB74], [BMK74]. In fact, a stronger version of this statement (i.e., that the language acquisition order is always fixed), is one of the central tenets of universal grammar theory (see for example, [Haw91] and [KH87]). While our belief is that for specific individuals this ordering may be influenced by some factors (such as the instructional situation or significant transfer from L1), these basic findings should play an important role in a model of second language acquisition.

A second area of research which may also shed some light on the acquisition process encompasses research in language assessment and educational grade expectations (e.g., [Ber88], [Lee74], [Cry82]). This body of research outlines sets of syntactic constructions (language features) that students are generally expected to master by a certain point in time. This work can be interpreted as specifying groups of features that should be acquired at roughly the same time. For example, one would expect that the group of features that differ between a first and second grade reading level should be acquired together (i.e., between first and second grade).

We have attempted to account for the preceding results in a language assessment model called SLALOM ("Steps of Language Acquisition in a Layered Organization Model"). The basic idea behind SLALOM is to divide the English language (the L2 in our case) into a set of feature hierarchies (e.g., morphology, types of noun phrases, types of relative clauses). Within any single hierarchy, the features are ordered according to their "difficulty" of acquisition, reflecting their relative linguistic complexity. The ordering within feature hierarchies has been the subject of investigation in work such as [Ing89], [DB74], and [BMK74].

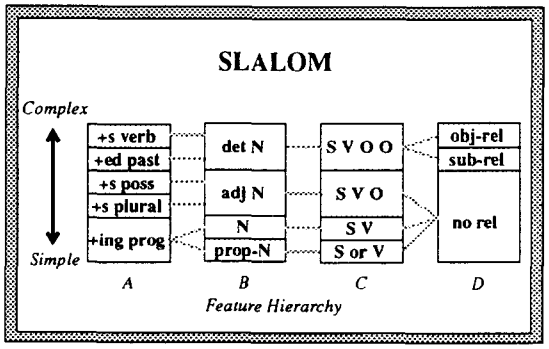

Figure 2 Language Complexity in SLALOM[7]

Figure 2 contains an illustration of a piece of SLALOM. We have depicted parts of four hierarchies in the figure: morphological syntactic features, noun phrases, verb complements, and various relative clauses. Within each hierarchy, the intention is to capture an ordering on the feature acquisition. So, for example, the model reflects the fact that the +ing progressive form of verbs is generally acquired before the +s plural form of nouns, which is generally acquired before the +s form of possessives, etc.

Notice that there are also connections among the hierarchies. This is intended to capture sets of features which are acquired at approximately the same time. These connections may be derived from work in language assessment and grade expectations such as found in [Ber88], [Lee74], and [Cry82]. So, for example, the figure indicates that while the +s plural ending is being acquired, so too are both proper and regular nouns, and one and two word sentences. During this time, we do not expect to see any relative clauses.

We anticipate that SLALOM, when fully developed, will initially outline the typical steps of second language acquisition. This model will then be tailored to the needs of individual students via a series of "filters", one for each user characteristic that might alter the initial generic model. For instance, it is possible that the specific features of the student's L1 will affect the rate or order of acquisition of the L2. In particular, one would expect features shared in the L1 and L2 to be acquired more quickly than those which are not (due to positive language transfer). Another possible filter could reflect how much and what kind of formal instruction the student has had in written English. For example, if the student's educational program stressed subject-verb agreement, this feature could have already been learned, even though others "before" it in the original SLA model may remain problematic.

In developing the language learning model and its filters, we plan to compare our initial model (derived from acquisition literature) with the writing samples that we have already collected.[8] We also expect to seek input from English teachers of deaf students. Additionally, we hope to collect samples of teachers' corrections and compare them to the models that will have been hypothesized.

Once the SLALOM model is complete for the population under study, presumably we will have a model of the order in which we expect our ASL users to acquire written English. Essentially, we will need to "place" a particular user in the model. With this placement we will have a model of (1) what features we expect the student has mastered and is using consistently -- these are features below the user's level in the model, (2) what features we expect the user to be using or attempting to use, but with limited success -- these are features at the user's level, and (3) what features we

7. We intend this figure as an illustration only. In particular our current research is focusing on identifying the precise hierarchies, orderings and syntactic features in the hierarchies, as well as relationships among the hierarchies.

8. Note that we have collected writing samples with some user information for the authors of each sample. While our analysis so far has been restricted to proficient ASL signers, samples from other deaf writers might help us determine what the ASL "influence" filter (for example) might look like since it would apply to one group of samples but not to another.

do not expect to see used (correctly) -- these are features above the user's level.

Essentially we can view the placement in SLALOM as highlighting language features (and corresponding mal-rules) that we expect the user to be using at a given point in time. Thus, it gives us a glimpse of the user's generation process by zeroing in on the mal-rules we expect him/her to be using at this point in their acquisition of English.

The initial placement of the student on SLALOM will most likely be based on an analysis of the first input sample. Once this initial determination is made, further input from the student, as well as feedback given during the correction and tutorial phases, could cause the system to update the user's profile in the model. It is important to note that although the default levels (i.e., cross-hierarchical connections) for the process of second language acquisition will be somewhat predefined, the model is flexible enough to allow and account for individual variations beyond those represented by the initial model and its filters. In other words, additional information about each student's language usage gathered over time should provide a better and more accurate reflection of the current set of language features they are acquiring.

5 Response Strategies

There are a large number of issues that must be dealt with in determining an appropriate response for a student. These include choosing which errors to respond to, selecting an overall type of response, and generating the actual English response itself. In this paper we focus on just two aspects of response generation that rely on our model of the learner's generation process. The first is determining which errors to respond to in detail, and the second deals with the kind of English syntactic constructions to use in the realization of the response.

Our decisions concerning both of these aspects stem from work in second language acquisition and educational research. This work indicates that as a learner is mastering a subject, there is a certain subset of the material that is currently "within their grasp". This has been called the *Zone of Proximal Development* (ZPD) by Vygotsky [Vyg86]. This general idea has been applied to assessment and writing instruction by [Rue90]. There is a similar principle outlined in [Kra81] with respect to second language acquisition. Intuitively the knowledge or concepts within the ZPD are "ready to be learned" by the learner. It is what he/she is currently in the process of acquiring.

We see our model of the user (including his/her placement in SLALOM) as capturing the ZPD with respect to second language acquisition. This has several implications on the responses given by the system.

5.1 Deciding the Errors to Focus On

According to the above literature, instruction and corrective feedback dealing with aspects within the ZPD may be beneficial. On the other hand, instruction or corrective feedback dealing with aspects outside of the ZPD will likely have little effect and may even be harmful to the learning process (in the sense that the user may become bored or confused by information that they are unable to comprehend or apply). Thus in our system we plan to concentrate on correcting errors that involve features that are at or slightly above the learner's placement in SLALOM. Thus, we will provide instruction on those aspects of the language that the user is ready to acquire.

As an example of the way SLALOM can be used in correction, consider the apparent similarity in the following two mistakes taken from different sources. The first was typed by one of the authors in an early draft of this paper: "That is, learners do not seem to acquired exactly one construction at a time....." A similar mistake is found in one of our writing samples from a student who is learning English as a second language. The student's writing is fairly good, but still contains many errors involving appropriate verb morphology: "It's very hard for me to tell you what I am think about XXX because..."[9]

Notice that the errors look very similar to each other. In the first sample the bare form of the verb should appear after the infinitive marker "to"; instead, the verb appears to be inflected with tense. In the second sample the +ing form of the verb should appear after the helping verb "am", but the bare form is included instead. Thus, in some sense, both instances could occur because the writer does not understand what form of the verb is required in the given circumstances. At first glance it may

9. We have replaced the name of the student's school with XXX to protect the identity of our sources.

seem appropriate to include tutorial dialogue explaining verb morphology in both cases.

However, if the level of English acquisition is taken into account via a model like SLALOM, significantly better correction can be given. For example, in the first case the user's placement in SLALOM would indicate that he/she has already mastered the appropriate verb morphology. Thus the error should be seen as a typo. It should be pointed out so that it can be corrected, but tutorial dialogue on appropriate verb morphology is certainly not necessary and would be inappropriate.

In contrast, the second writer would be placed at a very different level within SLALOM. In particular, his/her placement would indicate that he/she is still in the process of acquiring verb morphology; mistakes of the kind given in this sentence are rather common for this writer. As a result, tutorial dialogue explaining appropriate verb morphology is quite appropriate and has a good chance of having a positive effect on the learner's writing.

5.2 Tailoring Responses to the Student's Language Ability

One of the few areas of general agreement among *most* SLA researchers is that linguistic input at or near the user's current second language proficiency is beneficial for the acquisition/learning process [Kra82], [Tar82], [Vyg86], [Hat83]. This principle may be expressed in different ways, but the idea is essentially the same.

For example, in Krashen's "monitor" model of SLA [Kra81], [Kra82] he describes the learning process as a series of language level attainments. The level of the user's current ability in the second language is designated *i*. According to Krashen, in order to facilitate quicker progress, the most helpful input will include features of the *i+1* level.

For Tarone and others, this phenomena is referred to as *foreigner talk*. It describes the almost unconscious manner in which native speakers of a language automatically simplify their speech to accommodate second language learners. Input simplification is also a key premise in pidginization/creolization accounts of acquisition [Hat83]. For the most part, these types of simplification have been shown to be very helpful to the learner. However, Chaudron points out that there are a couple of "simplification" strategies that may not always be beneficial [Cha83].[10]

Given this evidence, it is very important for the ICICLE system to have the ability to generate text at or near the user's current second language proficiency. The syntactic complexity can no longer be left to chance or indirect constraints. Our intention is that the user's placement in SLALOM will help guide the kind of constructions that the system should use in its generated text. That is, the system should attempt to generate texts which use constructions that are at (or slightly above) the level he/she is placed in SLALOM.

Our initial investigations lead us to believe that this may be done within FUF, a functional unification-based text generation system [Elh93] through a dynamic ordering of alternative realizations (ALTs).[11] In other words, at ALT branches in the grammar, the alternatives will be ordered depending on the user's current placement within SLALOM. Those constructions that are at or slightly above the user's level will be preferred by ordering them before other potential realizations. If the user model is updated and the user's placement on SLALOM changes, a new ordering of the alternatives would reflect this change.

6 Conclusion

In this paper we have introduced a section of an intelligent computer-assisted language learning system that attempts to capture the user's current generation capabilities. This linguistic model is based on two components: a model of the user's first language (in our case, ASL) and a model capturing the user's progress in acquiring the second language. Having this dual model in the system helps us understand the user's input in terms of the errors that they make. In addition, the linguistic model can be used to provide corrective feedback that is most likely to be beneficial to the user.

7 Acknowledgments

This work is supported by NSF Grant # IRI-9416916 and by a Rehabilitation Engineering Research Center Grant from the National Institute on

10. He admits, though, that this may be due in part to *teacher talk*, a related communication phenomenon.
11. We have had contact with Michael Elhadad about the possibility of implementing machinery in FUF that will allow the kind of dynamic ordering we require.

Disability and Rehabilitation Research (#H133E30010). Additional support has been provided by the Nemours Foundation. We thank Xingong Chang for his work on implementing the mal-rule grammar for the ASL writing project. The implementation uses the bottom-up augmented context-free chart parser from [All95]. Thanks also goes to Karen Hamilton for her implementation of the database used for our error analysis.

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