

Comparison of Semantic Versus Syntactic Message Formulation: A Pilot Study

Rupal Patel
Katherine Schooley
Rajiv Radhakrishnan
Northeastern University

Abstract. Two prototype voice output communication aids were implemented to compare methods of graphic symbol message formulation; one emulated current devices that require syntactical ordering of icons (Default) and the other used semantic frames (iconCHAT). Message constructions of eight typically developing children (7-10 years of age) using both prototypes were compared in terms of accuracy, speed, complexity, and preference. Although there were slight differences in speed, all participants formulated equally complex and grammatically accurate sentences using both prototypes. These findings demonstrate that semantic frame-based message formulation may be a viable alternative to conventional methods based on syntax. Future research to assess whether these findings extend to children who use AAC is warranted. Outcomes and benefits of semantic composition are particularly relevant for children with emerging grammatical skills since semantic schemas provide scaffolding for constructing complete utterances that may in turn foster increased self-confidence and improved perceptions of communicative competence.

Keywords: Message construction, Semantics, Syntax, Symbol communication

Individuals with severe expressive communication impairments rely on alternative and augmentative communication (AAC). Rather than conveying information through spoken or written language, an

individual can use gestures, eye gaze or picture symbols to represent underlying concepts. The use of picture symbols as a method of communication has gained increasing appeal as advances in technology enable access to larger vocabularies on dynamic displays. When paired with voice output, these devices serve as a powerful means for expressing one's ideas when speech alone is ineffectual. Most commercially available voice output communication aids (VOCAs) use a linear (syntactic) approach to message construction. For example, to generate the message, "I want soda," the user selects a series of icons that follow the ordering rules of English (*I+ want+ soda*). This method of message formulation requires that the user have at least basic knowledge of syntax and thus may be challenging for those with linguistic and intellectual impairments. Additionally, given that children learning to use an assistive communication device may also be learning language simultaneously (Sutton, Soto, & Blockberger, 2002), the system may play a "central role in the language acquisition process" (Sutton et al., p. 192). Clinicians often attempt to compensate for the user's emerging or delayed linguistic skills by arranging vocabulary in a grid display organized by parts of speech to facilitate serial ordering of icons from left to right. However, no experimental research supports the notion that this vocabulary arrangement assists in language learning (Beukelman & Mirenda, 1998). At least in non-disabled adults, Nakamura, Newell, Alm, and Waller (1996) found that participants can generate

grammatically accurate utterances regardless of symbol arrangement. Thus, the use of syntactically ordered symbol arrays may actually limit morphological and syntactical learning by circumventing the need for developing of these linguistic skills.

Studies have shown that utterances formulated using AAC devices are markedly different than utterances produced through natural speech. Utterance length is typically limited to simple two- or three-word sequences (Bruno, 1989; Light, Collier, & Parnes, 1985; Udwin & Yule, 1990; Van Balkom & Welle Donker-Gimbrere, 1996; von Tetzchner & Martinsen, 1996). Atypical syntax is often a hallmark of even simple constructions (Grove & Dockrell, 2000; van Balkom & Welle Donker-Gimbrere) and more often for complex constructions with multiple clauses (Sutton, Morford, & Gallagher, 2004), thereby impacting message accuracy and grammaticality. Additionally, a review of commonalities in AAC message formulation across studies (cf. 1997, 1999) indicated that users often communicated in one-word utterances, and rarely used questions, commands, negatives, or auxiliaries.

Sutton et al. (2004) suggest that one factor contributing to limited grammaticality may be the design of the AAC display itself. The lack of morphological markers and function words, as well as the arrangement of vocabulary items may negatively influence the completeness of the utterances produced. Even when verbs and articles were readily available, users often neglected to use them in their constructions (Kelford-Smith et al., 1989; Soto, 1999).

Furthermore, communication partners may attempt to facilitate information exchange by “early interpretation” (Sutton, Gallagher, Morford, & Shahnaz, 2002, p. 206) of incomplete message constructions. This may lead to misinterpretation of messages

constructed with atypical syntax (Sutton et al.) resulting in communication breakdowns. Practices such as early interpretation do not foster grammatical completeness and thus may ultimately impact communicative competence (Blockberger & Sutton, 2003; Sutton et al.; von Tetzchner & Martinsen, 1996).

Message construction methods that provide linguistic cues regarding semantic and syntactic relationships may encourage more complete and sophisticated utterances. There has been a long-standing debate among linguists regarding the syntactic versus semantic underpinnings of written and spoken language (cf. Chomsky, 1965, 1986; Fillmore, 1968; Steinberg, 1993). While AAC methods of message construction typically follow the syntactical approach, perhaps meaning-based methods should be considered as an alternative approach for at least some users.

Case grammars focus on the relationships between the verb and all other sentence constituents. The semantic schema associated with each verb dictates the essential sentence constituents. The notion that the verb is central to message formulation has been supported by empirical evidence (Griffin, 1998; Griffin & Bock, 2000). The use of semantic schemas may facilitate message construction by making the rules of grammar more transparent and thus perhaps easier to learn. Semantic frames may also be effective for reducing keystrokes, easing the cognitive burden associated with message construction, and improving access to vocabulary.

The present study aimed to compare message formulation using a semantic frame-based approach versus the conventional syntactic approach. To pilot the stimuli and experimental protocol, we began with a group of eight typically developing children. To control for interface design and implementation issues, two prototype devices

were built, one in which messages were constructed using semantic frames (iconCHAT) and the other which required serial ordering of icons (Default). Message formulation using each prototype was compared using the following outcome measures: formulation rate, accuracy, complexity, keystrokes per utterance, and user preference.

Method

Participants

Eight typically developing children between seven and ten years of age (mean age 8 years, 5 months) were recruited from the Greater Boston area. There were four female participants (S1, S4, S6, S8) and four male participants (S2, S3, S5, S7), all of whom were native English speakers. Parental interviews indicated that all children had no documented speech, language, or hearing impairments and had at least average academic performance

and intellectual ability. Prior to data collection, informed written consent was obtained from each child's caregiver. In addition, verbal assent was obtained from each child. At the completion of the experiment, participants received an honorarium.

Materials

The iconCHAT and Default prototypes were implemented on a tablet computer. Icon selections for both prototypes were made using a stylus. For speech output, both prototypes used IBM speech for Java, with the IBM Viavoice core.

Prototype Systems

The iconCHAT prototype employed a semantic message formulation schema (Dominowska, Roy, & Patel, 2002; Patel, Pilato & Roy, 2004). Rather than selecting words based on serial ordering, a message was constructed by first selecting a semantic frame

Figure 1. iconCHAT screenshot while constructing the phrase “I wear red shirt.”

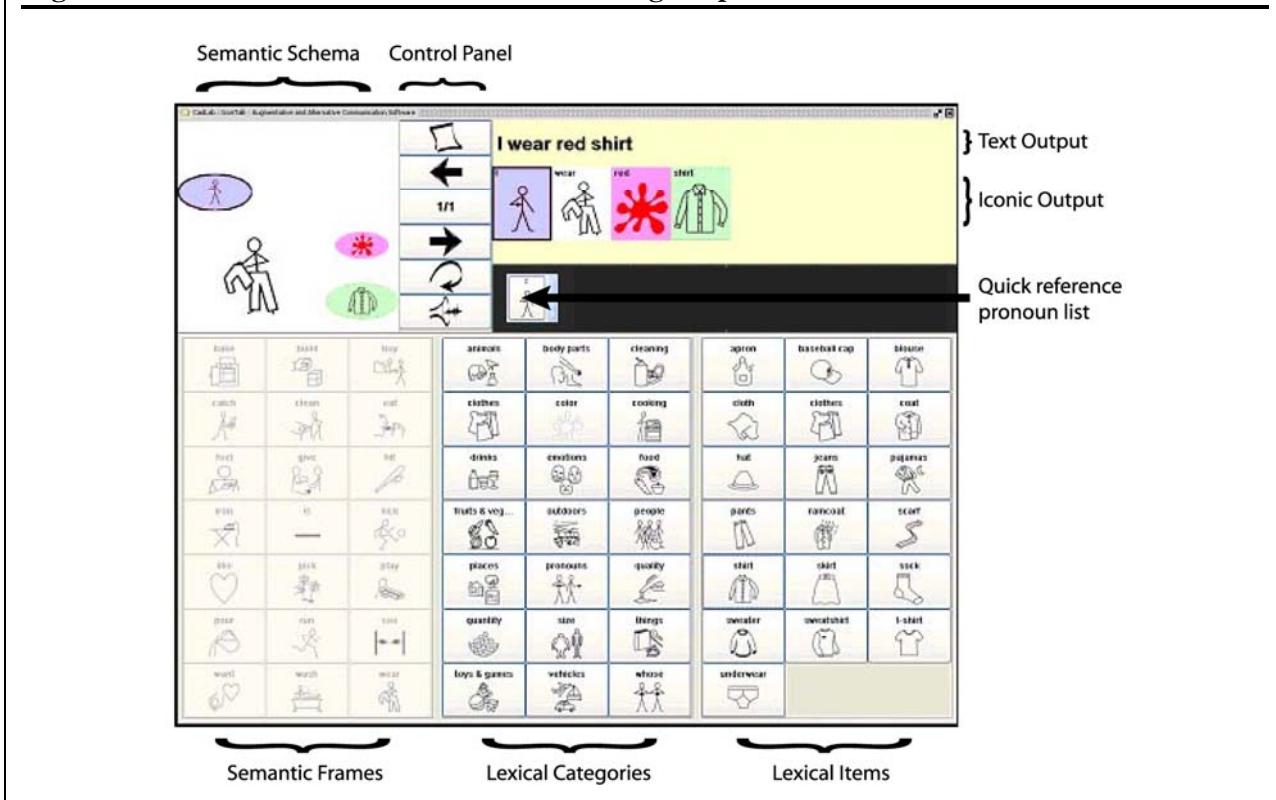
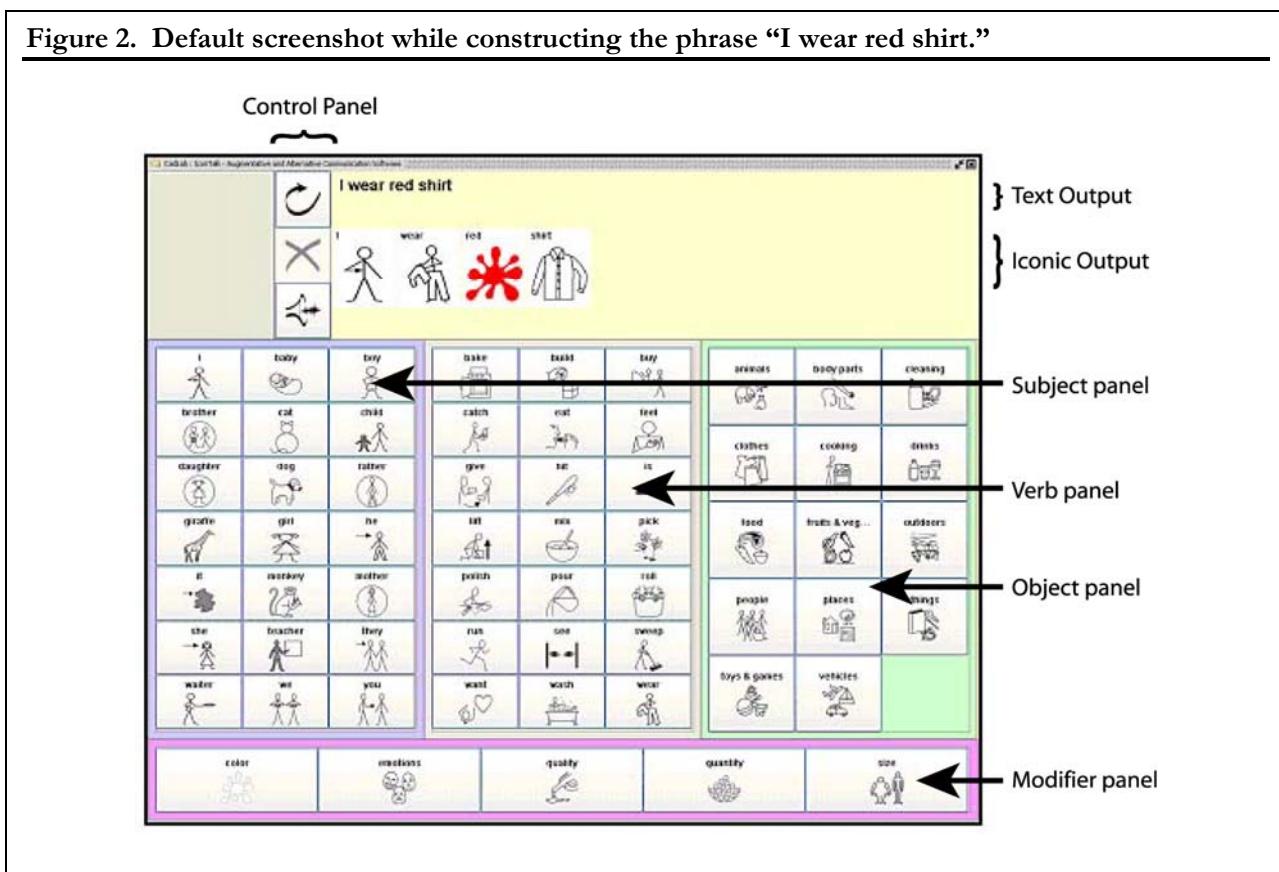


Figure 2. Default screenshot while constructing the phrase "I wear red shirt."



which is based on the predicate. This instantiates a frame with unfilled slots for specifying the agent, object, and other predicate-dependant components (based on case grammars in Fillmore, 1968). For example, to construct the sentence "I wear red shirt", the user first selects the "wear" frame. This frame minimally requires an agent that is performing the action and an object on which the action is performed. Either agent or object roles may also be further modified. The message-in-construction was displayed as a two-dimensional spatial schema to convey relationships between thematic roles. In addition, serial ordering of icons, similar to that used in conventional VOCAs, served as backchannel feedback of the speech synthesizer output.

Within iconCHAT, the vocabulary was arranged in three panels: semantic frames, lexical categories, and lexical items (see Figure 1). Once a semantic frame was chosen, the

lexical categories were made accessible. Choosing a category revealed specific vocabulary items within that category in the lexical items panel. Lexical items included a variety of agents, objects, or modifiers grouped by category. Additionally, a quick reference drop-down menu could be used for faster access to pronoun vocabulary. The control panel allowed for deletion of a word or message, reuse of previously constructed messages, and generation of spoken output using the text-to-speech synthesizer. See Patel, Pilato & Roy (2004) for a detailed explanation of the iconCHAT prototype.

The Default prototype emulated the message formulation technique available on most commercially available VOCAs. In particular, a message was constructed by serially ordering, from left to right, the constituent components. In English, the minimal sequence of selections would include subject + verb + object (SVO). Additionally, the

Figure 3. Sample picture stimulus for eliciting “Boy catch ball.”



subject and object roles could be further modified. Vocabulary in the Default prototype was organized in four panels: subject panel, verb panel, object panel, and modifier panel. The object and modifier panels had two levels of depth; the first displayed object (modifier) categories, and the second displayed items within that category. Selecting an object or modifier revealed its specific vocabulary items within that same panel. Agents, verbs, and object categories were arranged sequentially on the screen, while the modifier categories were arranged along the bottom of the screen (see Figure 2).

For the formulation “I wear red shoes”, the user would first select “I” from the subject panel, then “wear” from the verb panel, then “red” from the ‘color’ category within the modifier panel, and finally choose “shirt” from the ‘clothes’ category in the object panel. The control panel allowed for deletion of a word, traversing between layers of panels (i.e. to the topmost level of the modifiers or into the colors category within modifiers), and generation of spoken output using the text-to-speech synthesizer.

In order to ensure that the mode of message

Figure 4. Sample stimulus for eliciting “They build snowman.”



Figure 5. Sample three-step picture sequence for eliciting consecutive sentences.

construction (semantic vs. syntactic) was the only independent variable contributing to the measured results, several variables were held constant. Both prototypes had dynamic displays with similar visual components including identical overall display size, graphic symbol set, icon size, icon resolution, icon shape, spacing of icons, color coding scheme, font, and font size. Since iconCHAT and Default were implemented on the same tablet computer, the orientation and angle of display was also identical. Selection of icons was done directly via stylus, and activation feedback, in the form of light/dark shading, was identical within each prototype. In addition, the same type of synthetic voice output (IBM speech for Java, with IBM Viavoice core) was utilized for each prototype.

Both prototypes had the same vocabulary size and types of words available. Although many commercial systems include multiple pages of vocabulary, it was important to limit the vocabulary depth to two levels and to allow access to all vocabulary categories (i.e., subjects, verbs, objects, and modifiers) on the topmost level in order to fairly compare iconCHAT and the Default system. Both prototypes did not include grammatical

morphemes, function words, conjunctions, or articles. The vocabulary items embedded within each lexical category were identical for both prototypes.

Stimuli

Cartoon images of activity scenes were used to elicit simple sentence constructions using each prototype. Picture cards were chosen as stimuli in order to provide a simple context and to elicit active message formulation. Two stimulus lists (A and B) balanced in semantic and syntactic complexity were created to control for practice effects across prototype use. Within each list, there were 18 pictures, consisting of six individual scenes and four three-step sequences. The three-step sequences provided a means for assessing message formulation within a simple narrative. Presumably, some of the constituent components across the three sentences within a sequence would be constant and thus may be accessed easier or faster.

The child was shown each picture scene and was asked to use the prototype to describe what was happening in the scene. The child

was instructed to first verbalize the message to the experimenter in order to ensure that his/her vocabulary choices were possible. The experimenter prompted the child to think of another way to describe the scene if the vocabulary item(s) was not available. Otherwise, the experimenter simply encouraged the child to proceed with formulation. The order of use of the prototypes systems and the stimulus lists was counterbalanced across subjects. See Figures 3 and 4 for examples of individual scenes, and Figure 5 for an example of a three-step sequence.

Table 1 lists the simplest complete messages that can be constructed based on the pictures in each stimulus list. Agents such as "boy", "girl", "man", "woman", and "child" could be used in place of pronouns. Additionally, optional modifiers could be used to further describe subjects (agents) or objects.

After participants completed all phases of the study, a qualitative survey was administered to

assess ease of use and the satisfaction associated with both the iconCHAT and Default prototypes. The survey was composed of nine closed-ended questions and two open-ended questions. The closed-ended questions assessed overall perceived ease of use, ease of sentence construction, vocabulary search, and understandability of graphic buttons for each system. In addition, one question about iconCHAT asked whether participants used the colored ovals in the top left corner (i.e., the spatial schema) versus the colored rectangles on the right (i.e., the serially ordered icons) when formulating sentences. The open-ended questions asked which aspects of each system the participant liked and disliked.

Analysis

Each prototype captured a real-time log of the experimental session. The following dependant measures were calculated and analyzed for each message constructed:

Table 1
Simplest Message Formulations for Each Picture Stimulus

Stimuli List A	Stimuli List B
1. Boy catch ball.	1. They wash window.
2. They build snowman.	2. Girl ride horse.
3. Girl buy ice cream.	3. They eat cookie.
4. They pick tomato.	4. They fly kite.
5. She polish shoe.	5. They ride bicycle.
6. She sweep floor.	6. Monkey steal hat.
7. Boy see shirt.	7. Chef read cook book.
8. He wear shirt.	8. He stir batter.
9. He wear pants.	9. He bake cake.
10. She pour water.	10. Boy see dog.
11. She lift dog.	11. He want dog.
12. She wash dog.	12. He buy dog.
13. Woman roll dough.	13. She see birthday cake.
14. She bake pizza.	14. She blow candle.
15. She eat pizza.	15. They eat birthday cake.
16. Boy hit ball.	16. Man dig hole.
17. He run home.	17. He plant seeds.
18. He touch base.	18. He water ground.

1. *Construction time per linguistic unit* was calculated by dividing the total time for message construction by the number of linguistic units. Message construction time was measured from the initiation of a new message to the command for spoken output. A “next” button was implemented to control for inter-message discussion or breaks. After the experimenter showed the participant the picture stimuli, she asked the participant to indicate when he/she was ready. At that time, the experimenter selected the “next” button. The number of linguistic units corresponded to the number of individual vocabulary items (i.e. icons) within an utterance. For example, the utterance, “she buy ice cream”, was counted as three linguistic units although there are four words in the sentence. Within both prototypes, “ice cream” was listed as a single vocabulary item, meaning that there were three linguistic units in the utterance: “she”, “buy”, and “ice cream”. The available vocabulary was identical within both iconCHAT and Default.
 2. *Time per button click* was calculated by dividing the message construction rate by the number of button clicks to complete that utterance. Number of button clicks was counted from the first button pressed after initiation of the new message until the button commanding spoken output was pressed. This measure is differentiated from the calculation of linguistic units as button clicks apply to both vocabulary selection and activation of commands.
 3. *Button clicks per linguistic unit* was calculated by dividing the number of button clicks by the number of linguistic units in the utterance.
 4. *Percentage accuracy* was measured by analyzing the semantic accurateness of the subject (agent), verb (predicate), and object. If all three components were correct, then the message was considered 100% accurate. The participant was credited for only the main semantic constituents.
 5. *Complexity* was measured by analyzing the use of modifiers within constructed messages. One point was awarded for each optional modifier.
 6. Use of the *quick reference panel* was a binary measure that was analyzed only for the iconCHAT system, as Default did not have this capability. If the participant used the quick reference panel to select an agent or pronoun, she was credited one point per utterance. The measure was out of 18, since there were 18 utterances constructed.
 7. *Reuse of prior message constructions* was a binary measure that was analyzed only for the iconCHAT system, as Default did not have this capability. If the participant used a previously constructed message to reduce the number of keystrokes, she was credited one point per utterance. The measure was out of 18, since there were 18 utterances constructed.
- Paired *t*-tests were conducted to examine differences between the iconCHAT and Default prototypes in terms of time per linguistic unit, time per button click, and button clicks per linguistic unit. The remaining outcome measures could not be compared numerically since some features (e.g. the quick reference list, utterance reuse

button) were not available in the Default prototype.

Results

The heterogeneity of participant strategies for message formulation is evident in the results (see Table 2). While some participants were faster and required fewer keystrokes to formulate utterances using iconCHAT, others performed better using Default. All participants were 100% accurate in terms of grammatical completeness using both prototypes. Sentence structures used in both prototypes were either in the SVO, SVMO, or SVMMO forms. Furthermore, there were no significant differences between stimulus list A and B in terms of accuracy, speed, or number of keystrokes.

There were no statistically significant differences between the prototypes in terms of time per linguistic unit ($p = 0.21$). Although there was a statistically significant difference in time per button click [$t_{(143)} = 2.32$; $p = 0.022$] between the two prototypes, the difference was rather small. Participants required on average 5 seconds per button click using iconCHAT compared to 4 seconds per button click using Default. While six of the eight participants (S1, S2, S4, S5, S7, S8) accessed buttons slightly faster using Default, there was no difference in time per button click for the other two participants (S3, S6). There was also a statistically significant difference in the number of button clicks per linguistic unit [$t_{(143)} = -3.28$; $p = 0.001$] with iconCHAT requiring fewer clicks (average = 1.9 clicks per linguistic unit) compared to Default (average = 2.1 clicks per linguistic unit). This pattern was noted for all participants except S2 for whom the average button clicks per linguistic unit was identical for both prototypes.

Participants varied in the complexity of utterances they generated. When using

Default, S7 and S8 were keen on elaborating on messages using modifiers. In fact, they were the only participants who used SVMMO constructions ("He see one green shirt"). In contrast, S1, S2, S3, S4 and S6 formulated more complex utterances using iconCHAT.

When using iconCHAT, all participants used the quick reference panel to a large extent; five participants (S2, S3, S5, S6, S7) used the panel for all utterances, and the other three children used the panel for the majority of utterances. However, only one child (S5) reused a prior message construction.

Results of the qualitative survey varied across participants. Overall, two participants (S1, S3) thought that iconCHAT was easier to use, four participants (S2, S4, S6, S8) thought that Default was easier to use and the other two participants (S5, S7) rated both equally in terms of ease. Five of the eight participants (S1, S2, S3, S4, S5) said that they used the semantic schema as opposed to the serially constructed message when formulating sentences using iconCHAT. In the open-ended questions, six participants (S1, S2, S3, S4, S5, S7) mentioned relying on the "bubbles" (i.e., semantic schema) rather than the serial ordering display in iconCHAT. Additionally, all participants reported that they liked using the quick reference panel to access pronouns on iconCHAT. Four participants (S1, S2, S5, S7) mentioned that they liked how iconCHAT "showed what needed to be filled in." Some positive feedback regarding Default included "faster to learn," "liked the details (modifiers) along the bottom," and "liked having all the categories on one page." Overall, the children reported having fun at the task and "liked making sentences and hearing it talk." There was very little negative feedback for either prototype. Two participants (S2, S5) commented on the need for more vocabulary items on both prototypes. One participant (S2) noted that having to select the verb first was odd in the

Table 2**Quantitative Differences in Message Formulation Using iconCHAT Versus Default**

Participant (Age_Sex)	System	Avg. Time per LU ¹ (sec.)	Avg. Time per Button Click (sec.)	Ave. Button Clicks per LU	Avg. % Accuracy	Total Complexity Points	Quick Reference Panel	Prior Message Viewed
S1 (8_F)	I ²	14	7	1.9	100	5	16/18	0/18
	D ³	16	6	2.3	100	4	n/a	n/a
S2 (10_M)	I	11	5	2.0	100	6	18/18	0/18
	D	8	4	2.0	100	0	n/a	n/a
S3 (7_M)	I	14	7	1.9	100	7	18/18	0/18
	D	16	7	2.3	100	1	n/a	n/a
S4 (7_F)	I	11	6	1.9	100	5	17/18	0/18
	D	8	3	2.2	100	3	n/a	n/a
S5 (8_M)	I	10	4	2.2	100	7	18/18	1/18
	D	7	3	2.3	100	11	n/a	n/a
S6 (8_F)	I	6	3	1.8	100	9	18/18	0/18
	D	6	3	2.1	100	6	n/a	n/a
S7 (10_M)	I	7	4	1.8	100	8	18/18	0/18
	D	6	3	1.7	100	14	n/a	n/a
S8 (10_F)	I	7	4	1.7	100	5	17/18	0/18
	D	7	3	2.0	100	14	n/a	n/a

¹L.U. = linguistic unit²I = IconCHAT³D = Default.

beginning because it was “not what I’m used to” but that “it was cool though, I guess” because it “helped me.”

Outcomes and Benefits

The present study compared two methods of message formulation using graphic symbols in terms of accuracy, speed, and complexity of constructions with a group of eight typically developing children between 7-10 years of age. Two prototype VOCAs were implemented—one that required serial ordering of icons in terms of English syntax (Default) and one that used semantic frames (iconCHAT). Although individual participants differed along quantitative measures and in

their qualitative impressions of the two methods of message formulation, both prototypes were easily mastered by all participants. This group of typically developing children had no difficulty formulating grammatically and semantically accurate sentences using either prototype. Message formulation using the iconCHAT and Default prototypes differed somewhat in two ways. Although the time per button click was slightly faster using Default, fewer button clicks were needed per linguistic unit when using iconCHAT. These findings are relevant for users of AAC because fatigue is often a rate limiting factor (Smith, 1996). Some users with severe motor impairments may be willing to compromise time to conserve energy.

Message formulation using graphic symbols differs from both written language and speech (Nakamura et al., 1998; Smith, 1996; Soto 1997; Sutton & Morford, 1998). Most currently available VOCAs, however, impose written language (i.e., syntactical) norms as the benchmark. Results of the present study suggest that semantic-based approaches to message formulation are at least as effective in facilitating accurate and complete utterances for typically developing children. Future research to assess whether these findings extend to children who use AAC is warranted.

It is noteworthy that all participants were relatively adept at learning to use the semantic-based system despite its difference from the way they are used to composing written text. Similar to Nakamura et al.'s (1998) findings, we found that users can readily adapt to the organization of the visual display. This adaptation may be facilitated by the iconCHAT interface which provides backchannel feedback about message construction in two ways. First, a two-dimensional semantic schema illustrates the relationships between icons and second, the serial ordering of icons provides the user with feedback regarding the output of the speech synthesizer. Six of the eight children indicated that they relied on the semantic schema more than the serial ordering. They noted that the semantic schema was useful in cuing them as to what was required to make a complete sentence. This feature may be even more beneficial to children who use AAC given that their constructions are often limited to single word utterances and marked by atypical syntax (Bruno, 1989; Grove & Dockrell, 2000; Udwin & Yule, 1990; Van Balkom & Welle Donker-Gimbrere, 1996; von Tetzchner & Martinsen, 1996).

With regard to message complexity, there were individual differences in linguistic abilities and styles. While some children formulated elaborate utterances using

iconCHAT, others tended to rely on modifiers in the Default prototype. It should be noted that not all utterances in iconCHAT could be modified because only simple semantic frame structures were used in this initial usability test. For example, although the "eat" frame can take "agent," "count noun," "modifier," and "object" roles, the "count" and "modifier" roles were excluded for simplicity. In contrast, potentially all utterances could have been modified using Default since there were no restrictions on when modifiers could be used. It may be worthwhile in future implementations of iconCHAT to include a modifier panel along the bottom of the interface.

While simple sentence forms were used in the present study, using more complex sentence formulations (as in Sutton et al., 2004) may yield more striking differences between semantic and syntactic formulation techniques. Since iconCHAT enables a two-dimensional representation of the relationships between sentential constituents, message formulation via semantic schemas may make clausal ambiguities more apparent. For example, when constructing the message, "The girl who pushes the clown wears a hat" the semantic role assigned to "girl," "clown," and "hat" are tied to the placement of the icons. Semantic-based formulation may be especially useful for those children who struggle with grasping grammatical constructs since semantic frame facilitate complete sentence production through visual cues.

The quick reference pronoun list was a unique feature of iconCHAT and one that users appeared to like as indicated by their usage patterns. For children who use AAC, this feature may reduce the cognitive load and search time associated with filling the agent role.

Although the iconCHAT prototype also allowed for reuse of previously constructed

messages, only one participant used this feature. This may be due in part to several factors. First, consecutive trials in the present task always involved a different predicate, thus the reuse feature would not be beneficial. Second, because the utterances were so short and simple, the reuse function was not deemed as useful. Last, since typically developing children are not constrained by physical limitations, this cost saving measure may not have been particularly salient. Perhaps children for whom movement is strained, may benefit from this feature. Future extensions should include numerous stimuli with a smaller set of predicates.

Overall, the results of the present investigation are promising in that a semantic frame-based method of message formulation appears to yield accurate and rich constructions while requiring slightly fewer keystrokes in typically developing children. While these findings are encouraging, it remains to be assessed in children who use AAC with emerging language skills.

Limitations and Future Directions

In order to expand upon the findings from this set of typically developing children and to obtain data that is relevant to the direct stakeholders, future studies need to include children who use AAC. Similar to previous studies on message formulation (cf. Nakamura et al., 1998; Smith, 1996; Sutton & Morford 1998; Sutton et al., 2000), the stimuli and procedures were initially piloted on typically developing children to assess the effectiveness of the methodology in eliciting the desired outcome variables. For example, it was important to determine whether the cartoon stimuli were easily understood and whether they were effective in eliciting the target descriptions. Additionally, the two interfaces had to be proven equivocal in terms of design, layout and functionality such that message formulation was the only factor

being manipulated. Findings from the present study provide benchmarks for outcomes studied and suggestions for modifications to the stimuli and procedures. First, the stimuli should be expanded to include a broader range of sentence complexity in narrative and conversational contexts in order to highlight differences between the syntactic and semantic methods. Furthermore, to assess the usefulness of the reuse feature in iconCHAT, multiple stimuli with the same predicate should be included. User performance and preferences suggested that the two interfaces were relatively well matched in terms of graphical variables thus requiring minimal modifications in future extensions. If data from children who use AAC parallels the results found in the present study, then semantic message construction may prove to be an effective technique for some users. Particularly for children with emerging grammatical skills, semantic composition may provide greater scaffolding for constructing complete utterances. This in turn, may foster increased self-confidence, improve perceptions of communicative competence, and ultimately feedback to affording richer linguistic experiences for the child.

Acknowledgements

We would like to express our gratitude to Deb Roy for his involvement in earlier versions of the iconCHAT prototype, Julie Brayton for her assistance with data collection, as well as to the participants and their families for their time and enthusiasm for the study. This research was supported in part by the National Science Foundation (Grant 0083032) and the Department of Education, National Institute on Disability and Rehabilitation Research (Grant H133G040051).

References

- Beukelman, D., & Mirenda, P. (1998). *Augmentative and alternative*

- communication: Management of severe communication disorders in children and adults* (2nd ed.). Baltimore: Brookes.
- Blockberger, S., & Sutton, A. (2003). Toward linguistic competence: The language experiences of children with extremely limited speech. In J. Light, D. Beukelman, & J. Reichle (Eds.), *Communicative competence for individuals who use AAC* (pp. 63-106). Baltimore: Brookes.
- Bruno, J. (1989). Customizing a Minspeak system for a preliterate child: A case example. *Augmentative and Alternative Communication*, 5, 89-100.
- Chomsky, N. (1965). *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.
- Chomsky, N. (1986). *Knowledge of language: Its nature, origin, and use*. New York: Praeger.
- Dominowska, E., Roy, D., & Patel, R. (2002). An adaptive context-sensitive communication aid. In Center on Disabilities (Ed.), *Proceedings of the 17th Annual International Conference Technology and Persons with Disabilities*. Retrieved August 21, 2006, from <http://www.csun.edu/cod/conf/2002/proceedings/109.htm>
- Fillmore, C. J. (1968) The case for case. In E. Bach & R. Harms (Eds.), *Universals in linguistic theory* (pp. 1-90). New York: Holt, Rinehart & Winston.
- Goldman-Eisler, F. (1986). *Cycle linguistics: Experiments in spontaneous speech*. New York: Academic Press.
- Griffin, Z. M. (1998). *What the eye says about sentence planning*. Unpublished doctoral dissertation, University of Illinois at Urbana-Champaign, IL.
- Griffin, Z. M., & Bock, K. (2000). What the eyes say about speaking. *Psychological Science*, 11, 274-279.
- Grove, M., & Dockrell, J. (2000). Multi-sign combinations by children with intellectual impairments: An analysis of language skills. *Journal of Speech, Language, and Hearing Research*, 43, 309-323.
- Kelford-Smith, A., Thurston, S., Light, J., Parnes, P., & O'Keefe, B. (1989). The form and use of written communication produced by physically disabled individuals using microcomputers. *Augmentative and Alternative Communication*, 5, 115-124.
- Light, J., Collier, B., & Parnes, P. (1985). Communicative interaction between young nonspeaking physically disabled children and their primary caregivers: II. Communicative function. *Augmentative and Alternative Communication*, 1(3), 98-107.
- Nakamura, K., Newell, A. F., Alm, N., & Waller, A. (1998). How do members of different language communities compose sentences with a picture-based communication system? – A cross-cultural study of picture-based sentences constructed by English and Japanese speakers. *Augmentative and Alternative Communication*, 14, 71-79.
- Patel, R., Pilato, S., & Roy, D. (2004). Beyond linear syntax: An image-oriented communication aid. *Assistive Technology Outcomes and Benefits*, 1(1), 57-66. Retrieved August 21, 2006, from <http://www.ata.org/atob/ATOBWeb/ATOBV1N1/index.htm>
- Smith, M. (1996). The medium or the message: A study of speaking children using communication boards. In S. von Tetzchner & M. H. Jensen (Eds.), *Augmentative and alternative communication: European perspectives* (pp. 119-136). London: Whurr.
- Soto, G. (1997). Multi-unit utterances and syntax in graphic communication. In E. Bjorck-Akesson & P. Lindsay (Eds.), *Communication...naturally: Theoretical and methodological issues in augmentative and alternative communication* (pp. 26-32). Västerås, Sweden: Mälardalen University Press.
- Soto, G. (1999). Understanding the impact of graphic sign use on the message

- structure. In F. Loncke, J. Clibbens, H. Arvidsen, & L. Lloyd (Eds.), *Augmentative and alternative communication: New directions in research and practice* (pp. 40-48). London: Whurr.
- Steinberg, D. (1993). *An introduction to psycholinguistics*. London: Longman Group.
- Sutton, A., Gallagher, T. M., Morford, J. P., & Shahnaz, N. (2002). Interpretation of graphic symbol utterances. *Augmentative and Alternative Communication, 18*, 205-214.
- Sutton, A., & Morford, J. P. (1998). Constituent order in picture pointing sequences produced by speaking children using AAC. *Applied Psycholinguistics, 19*, 525-536.
- Sutton, A., Morford, J. P., & Gallagher, T.M. (2004). Production and comprehension of graphic symbol utterances expressing complex propositions by adults who use augmentative and alternative communication systems. *Applied Psycholinguistics, 25*, 349-371.
- Sutton, A., Soto, G., & Blockberger, S. (2002). Grammatical issues in graphic symbol communication. *Augmentative and Alternative Communication, 18*, 192-204.
- Udwin, O., & Yule, W. (1990). Augmentative communication systems taught to cerebral palsied children: A longitudinal study: I. The acquisition of signs and symbols, and syntactic aspects of their use over time. *British Journal of Disorders of Communication, 25*, 295-309.
- Van Balkom, H., & Welle Donker-Gimbrere, M. (1996). A psycholinguistic approach to graphic language use. In S. von Tetzchner & M. Jensen (Eds.), *Augmentative and alternative communication: European perspectives* (pp. 153-170). London: Whurr.
- Von Tetzchner, S., & Martinsen, H. (1996). Words and strategies: Conversations with young children who use aided language. In S. von Tetzchner, & M. G. Jensen (Eds.), *Augmentative and alternative communication: European perspectives* (pp.65-88). London: Whurr.