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Construction of Graphic Symbol Utterances by Children, Teenagers, and Adults: The Effect of Structure and Task Demands

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Purpose: This study investigated the impact of syntactic complexity and task demands on construction of utterances using picture communication symbols by participants from 3 age groups with no communication disorders.
Method: Participants were 30 children (7;0 [years;months] to 8;11), 30 teenagers (12;0 to 13;11), and 30 adults (18 years and above). All participants constructed graphic symbol utterances to describe photographs presented with spoken French stimuli. Stimuli included simple and complex (object relative and subject relative) utterances describing the photographs, which were presented either 1 at a time (neutral condition) or in an array of 4 (contrast condition).
Results: Simple utterances lead to more uniform response patterns than complex utterances. Among complex utterances, subject relative sentences appeared more difficult to convey. Increasing the need for message clarity (i.e., contrast condition) elicited changes in the production of graphic symbol sequences for complex propositions. The effects of syntactic complexity and task demands were more pronounced for children.
Conclusion: Graphic symbol utterance construction appears to involve more than simply transferring spoken language skills. One possible explanation is that this type of task requires higher levels of metalinguistic ability. Clinical implications and directions for further research are discussed.

KEY WORDS: augmentative/alternative communication, speakers with native proficiency, graphic systems

In augmentative and alternative communication (AAC) systems for young children who are not yet able to use the alphabet, words and concepts are represented by graphic symbols arranged on displays and devices that may incorporate synthesized or digitized speech. Use of graphic symbols rather than speech for expressive communication while language learning is underway presents unique challenges for the process of language acquisition that may impact the nature of the linguistic skills children ultimately acquire (e.g., Smith & Grove, 2003).

The few studies of the language achievements of individuals who rely on AAC systems for expressive communication suggest that they may experience difficulties with knowledge and use of the semantics (e.g., Bishop, Byers Brown, & Robson, 1990; Smith, 1990), morphology (e.g., Blockberger & Johnston, 2001; Kelford Smith, Thurston, Light, Parnes, & O'Keefe, 1989; Redmond & Johnston, 2001), and syntax (see Soto, 1999, for a review) of the environmental language, even in the absence of cognitive or language impairments (see Blockberger & Sutton, 2003, for a review). However, any generalization regarding an upper limit of language potential due solely to the need for an AAC system is called into question by the increasing number and visibility of individuals demonstrating sophisticated linguistic skills using AAC systems (e.g., see works in Fried-Oken & Bersani, 2000, and in Williams & Krezman, 2000).

One fundamental issue in exploring language acquisition in AAC is the nature of the relationship between spoken and graphic symbol utterance production: At what point in the process of utterance construction does the graphic symbol modality come into play? If graphic symbols are selected prior to sentence formulation, then utterances would be constructed directly in the graphic symbol modality. However, if graphic symbols are recruited after sentence formulation, then the spoken language model would be "translated" or transposed into the graphic symbol modality.

If utterances are constructed directly in graphic symbols without prior generation of a spoken utterance model, modality could influence their underlying structure. Different users of graphic symbols could therefore produce the same type of structures (different from the spoken word order), even across different languages. Graphic symbol productions would be regarded as linguistic in nature, with their own internal constraints and biases. This view is consistent with the *modality-specific* hypothesis, proposed to account for the observation that graphic symbol utterances differ from what one might expect on the basis of spoken word order (for reviews, see Smith & Grove, 2003; Soto 1999; Sutton, Soto, & Blockberger, 2002). The modality-specific hypothesis suggests that biases specific to the visual-graphic modality influence the construction of graphic symbol utterances.

In other visual communication systems, such as signed languages (e.g., American Sign Language), constituent relationships expressed by word order in spoken languages may be conveyed in alternate ways. For example, simple constituent relations (agent, patient, action, etc.) are often indicated by the placement or movement of signs in space relative to one another, and the order of the main constituents does not always reproduce the order of the spoken language used in the same community (e.g., Fischer, 1974; Nadeau, 1993). If a similar tendency exists when using graphic symbols, the proximity of symbols in an utterance could be a more important indicator of their relationship to one another than in spoken language (Sutton, Gallagher, Morford, & Shanaz, 2000).

An alternate view of the relationship between spoken and graphic symbol utterance production is based on the notion that utterances are first constructed in a spoken representation and then transposed into graphic symbols. The underlying structure of utterances would therefore be based on spoken language grammar, subsequently modified to fit the graphic symbol modality and the specific AAC system available. Graphic symbol production would thus be a *transposition* or *recoding* task (Smith, 1996; Smith & Grove, 2003) rather than a strictly linguistic one, in which the child needs to establish the functional (as opposed to linguistic) correspondence between the spoken (linguistic) symbols and the graphic representations. Observations of word order reductions and modifications would be explained, in this view, by the notion of *compensation*: In addition to coping with the graphic symbol modality per se (e.g., difficulty to represent visually some concepts without reference to other concepts), specific strategies may be necessary to bypass or compensate for the restrictions of the AAC system characteristics, such as the absence of grammatical markers or reduced production rate (Soto, 1999; von Balkom & Donker-Gimbrère, 1996). Compensatory strategies would be a natural consequence of the need to transpose spoken syntax into a sequence of graphic symbols.

Although often presented as two separate hypotheses, the modality-specific and the transposition/compensation positions are not mutually exclusive. Production patterns observed could be explained equally well in terms of inherent characteristics of the modality or in terms of consistent application of compensation strategies. The modality-specific hypothesis loses credence, however, when confronted by doubts concerning the linguistic nature of some graphic symbols. Most graphic symbols (e.g., picture communication symbols [PCS], Dynasyms, Rebus) do not have the properties of linguistic symbols (sublexical units, modifiable by morphological processes, etc.; see Smith & Grove, 2003). Parallels can be drawn between graphic symbol communication and signed languages (Smith, 1996; Sutton & Morford, 1998) but only up to a certain point. Both are transmitted in the visual modality, but signs can be modified (e.g., to convey morphological information), whereas most graphic symbols are fixed representations. Sign language users generate signs from their total repertoire (similar to speakers' generation of spoken words), whereas graphic symbol users select from among arrays that rarely (if ever) contain all their known words and concepts. Signed languages have sublexical units (similar to phonemes in spoken languages) that can be combined in new ways, but most graphic symbols cannot be decomposed in the same way into smaller, sublexical units. One notable exception to this limitation is Blissymbols (Hehner, 1980), in which each symbol is composed of basic meaning units. However, even this system does not have a level of analysis comparable with phonology, in which smaller elements would make up these basic meaning units (Smith & Grove, 2003).) Finally, signed languages are natural languages, developed through a community of native speakers, but graphic symbols systems have all been developed by adults and are taught to children rather than being acquired through natural interaction. These differences weaken the case for attributing linguistic status to graphic symbols and lend credence to the view that communicating with graphic symbols is more likely to involve transposition from spoken to visual modality.

Inherent in the compensation/transposition view, but rarely acknowledged directly in the literature, is the need for metalinguistic skills in constructing graphic symbol utterances. Metalinguistic awareness involves "conscious reflection on, analysis of, or intentional control over various aspects of language—phonology, semantics, morphosyntax, discourse, pragmatics—outside the normal, unconscious processes of production or comprehension" (Karmiloff-Smith, Grant, Sims, Jones, & Cuckle, 1996, p. 198). The concepts of analysis and control are central to some of the metalinguistic models proposed in the literature, including that of Bialystok (1986). According to this author, the level of analysis (the linguistic complexity of the materials to be analyzed) and level of control (the need to go beyond or disregard a salient characteristic of the stimuli to focus on another aspect of the message) determine the metalinguistic difficulty of a task. In producing graphic symbol sequences, the "speaker" must transpose from one modality to the other by recruiting metalinguistic abilities. To employ graphic symbols for communication, therefore, children require metalinguistic knowledge that would support cross-modality encoding. They must realize that spoken words themselves represent concepts and that the form of the message and its meaning are dissociable. They must also understand that graphic symbols can be used to represent words and concepts and are not simply a depiction of a global scene (Smith, 1996). This would be true, regardless of the limitations of the symbols or device (i.e., whether true compensation is at play). Metalinguistic skills would be recruited to analyze the form and content of the message (analysis) and to perceive this form as distinct from its content so that the underlying spoken message can be transposed into a sequence of graphic symbols (control). Metalinguistic demands would be influenced by variables, such as the complexity of the spoken utterance, that the speaker is trying to transpose, the limitations of the device or symbols available, and the pragmatic demands of the task.

Studies of graphic symbol utterance production to date have not been designed specifically to test hypotheses, but the results can be interpreted at least to some degree in light of the points of view presented above. Studies have explored production of graphic symbol utterances by participants with no disabilities and typical language development (Smith, 1996; Sutton et al., 2000; Sutton & Morford, 1998) and have found that children, adolescents, and adults frequently used different constituent orders when producing utterances using PCS and when using speech.

In one of the first studies of this kind, Smith (1996) taught 5 preschool-age children to describe pictures, first using speech and then using PCS. Although the children produced complete sentences to describe the pictures orally, most of their graphic symbol descriptions included only one or two symbols (48% and 35%, respectively). In a similar study, 32 children and adolescents (ages 6–13 years) were asked to describe unusual nonreversible single proposition events depicted in video clips (e.g., a man biting an envelope) using a PCS display and then using speech (Sutton & Morford, 1998). Adherence to English subject–verb–object word order in spoken productions was very high (97% or more), but graphic symbol utterances did not follow spoken English as closely (varying from 34% to 89% for the youngest and oldest groups, respectively). The most common pattern used when not following English, regardless of the age group, involved placement of the object immediately before the verb. Some of Smith's (1996) and Sutton and Morford's (1998) results seem consistent with the modality-specific hypothesis. When complete English utterances were not produced, the preferred pattern was not consistent with spoken English word order. Compensation should not have been a factor in these studies, because all symbols needed to perform the task were provided to the children. The results are also consistent with the notion that metalinguistic skills were at play, although they were not originally interpreted in this way. There was a large discrepancy between spoken and PCS production. The older children demonstrated better performance using graphic symbols even though the youngest children had mastered the structures in their spoken language.

Participants in two additional studies both differed from and adhered to the spoken language structure in their PCS productions. In a study with 80 Japanese-speaking adults and 43 English-speaking adults, Nakamura, Newell, Alm, and Waller (1998) observed a preference for the spoken language structures (i.e., subject–verb–object in English and subject–object–verb in Japanese) when using a graphic symbol display to answer questions about a short story. However, participants also produced responses that did not correspond to complete spoken sentences in both their oral and graphic symbol productions, suggesting that the type of linguistic task (i.e., answering questions) may have influenced the type of syntactic structure produced. These findings lend support to the transposition view rather than the modality-specific explanation and highlight the potential role of metalinguistic skills: Adults with fully mature metalinguistic skills, in a situation in which no compensation was needed (all symbols present), chose to adhere to spoken word sequence of their native language.

In a subsequent study (Sutton et al., 2000), English-speaking adults used a PCS display to describe complex propositions depicted in photographs (e.g., "The boy pushes the clown who wears a hat," and "The boy who pushes the clown wears a hat"). The display did not contain the relative pronoun "who." If the spoken word order was followed for both types of sentences (i.e., BOY PUSH CLOWN WEAR HAT), an ambiguous graphic symbol sequence would result. The majority (36 of 43) of participants produced different sequences to convey the two types of sentences. Most avoided the potential ambiguity by modifying the constituent order of the spoken sentences to maintain the proximity of semantically linked constituents (e.g., by pointing to HAT or WEAR HAT directly after the symbol for the person wearing it). (Other response patterns were observed but much less frequently, including juxtaposition of two simple propositions and production of sequences violating spoken English syntax.) Thus, in a situation in which direct transposition of spoken words to graphic symbols would yield ambiguity, adults bypassed the spoken word order to focus on meaning and produced graphic symbol sequences that were not ambiguous. Their well-developed metalinguistic skills permitted a high level of control when needed to compensate for the lack of grammatical markers when using PCS.

Adults who use AAC for daily communication produced a pattern of responses that differed from those of adults with no disabilities (Sutton, Morford, & Gallagher, 2004). When asked to construct PCS utterances to describe photographs for two types of complex propositions, 19 of 25 participants reproduced the constituent orders of the spoken sentences, even when this resulted in ambiguity between the sentence types. This finding challenges the idea that PCS have linguistic status and, thus, does not support the modality-specific hypothesis. If internalized "rules" of graphic symbol production existed, it would be reasonable to expect that individuals who use these symbols on a daily basis would be more likely to diverge from spoken word order than would people with no prior experience with graphic symbols. Although participants with no disabilities produced distinctive constituent orders for the two sentence types (Sutton et al., 2000), the AAC users may have judged the explicit marking of constituent relationships unnecessary because these relationships were clear in the accompanying photograph. Thus, it is not clear from these results whether the AAC users did not possess the metalinguistic skills needed to identify the ambiguity and to make the distinction between the two types of sentences, or whether they were aware but disregarded this aspect of the task for pragmatic reasons.

Taken together, the results of these studies suggest that the modality-specific hypothesis does not adequately explain graphic symbol utterance construction, and that this process is not solely determined by knowledge of spoken language sentence structures. Skills in addition to syntactic knowledge are needed; only the older children and adults (with no disabilities) consistently included all constituent elements in their graphic symbol productions (Sutton et al., 2000; Sutton & Morford, 1998). Children tended to follow spoken syntax more closely as they got older, but mature adult speakers were able to move away from the spoken model when it was pragmatically acceptable to do so (Nakamura et al., 1998) or when strict adherence to it would have resulted in message ambiguity (Sutton et al., 2000). The skills needed, in addition to linguistic skills, to carry out the transposition from an underlying spoken representation to a sequence of PCS appear to be metalinguistic in nature: In the studies to date, the structural knowledge required for the graphic symbol utterance tasks was well within the abilities of the participants, but only the older groups respected the target structures in their graphic symbol utterances.

Structural complexity (i.e., single vs. complex propositions) may be important in graphic symbol utterance construction. When compared with single clause utterances, complex utterances may be more difficult to convey in graphic symbols and require more extensive modifications of the spoken constituent orders. Some of the previous studies used single proposition sentences, whereas others used complex sentences, but the structural complexity has not been systematically contrasted in graphic symbol utterance production by the same participant groups. Structural complexity (single vs. complex propositions) therefore warrants direct investigation.

Further, the demands of the communication task may influence the selection and sequencing of graphic symbols to construct utterances. It is known that AAC users may take advantage of contextual support (e.g., shared knowledge or characteristics of the physical context), when available, in constructing messages, and speaking conversation partners do the same when interpreting AAC messages (e.g., Kraat, 1985; von Tetzchner, 2000). Thus, graphic symbol utterances may be constructed differently when the need for message clarity varies. The data currently available do not differentiate participants who are unable to distinguish sentence types and those who may be able but do not perceive a need to do so.

The current study extends previous work by examining the effects of utterance structures, task demands, and language development level of participants (reflecting metalinguistic development) on PCS utterance construction. The influence of structural complexity is explored by presenting both simple and complex sentence stimuli to all participants. The potential role of task demands is investigated by presenting the stimuli in two conditions that differ in their need for message clarity. The performance of participants with no disabilities and typical spoken language development is compared across a wide age range, from children who have mastered the basic syntax of their language but are still developing their metalinguistic skills to adults with full mature syntactic, pragmatic, and metalinguistic competence.

Method

Participants

The study received institutional ethics approval prior to the beginning of the recruitment efforts. Participants were recruited through ads posted in public places, day camps, schools, and universities across the greater Montreal area, or by word of mouth by members of the team. Compensation of $10 per visit was offered to each participant to cover for parking or transportation costs.

The participants were three groups of native speakers of French with no disabilities or language delays: children (mean age = 7 years, 8 months; *SD* = 6.7 months) beyond the period during which basic syntactic structures are typically acquired, teenagers (mean age = 13 years, 0 months; *SD* = 6.6 months) whose linguistic skills are usually well developed, and adults over 18 years of age (mean age = 27 years, 4 months; *SD* = 11 years, 0 months) who demonstrate fully mature linguistic competence. Integrity of receptive language skills was documented through the *Épreuve de compréhension de Carrow-Woolfolk* for children (Groupe coopératif en orthophonie—Région Laval, Laurentides, Lanaudière, 1995) and the *Échelle de vocabulaire en images Peabody* (EVIP; Dunn, Thériault-Whalen, & Dunn, 1993) for all groups. All participants' scores were within normal limits on these language tests. Comprehension of the specific stimuli used in the experiments was assessed indirectly through receptive experimental tasks, which are not reported in this article. All participants demonstrated consistent interpretation of PCS sequences (with voice output) depicting the syntactic structures used in this study (see below for detailed description of the structures). There were 30 participants in each group for a total of 90 participants.

Materials

The materials were spoken sentence stimuli, photographs, a graphic symbol display, and a tablet-style computer with software.

Stimuli. The stimuli were spoken sentences that were single or complex propositions (see Appendix A for the full list). Single proposition sentences were N1 V N2 structures, where N1 = the first noun mentioned, V = the action verb, and N2 = the second noun mentioned. Eight exemplars were constructed by combining four pairs of nouns (agent–patient: girl–clown, clown–girl, boy–clown, clown–boy) with two reversible actions (push, pull). The complex proposition sentences consisted of an expansion of the single proposition sentences through the addition of an attribute (hat or scarf). There were two types of complex propositions: subject (SS; "The clown who pushes the girl wears a scarf") or object (OS; "The clown pushes the girl who wears a scarf") relative clauses. The two structures differed only in the placement of the relative pronoun "who." In the absence of the word "who," both sentence types had the same ordering of main constituents, namely N1 V N2 W A, where W stands for the verb "wear" and A stands for the attribute (scarf or hat). Combining the different subjects, actions, objects, and attributes resulted in 32 complex propositions (16 SS and 16 OS).

Photographs. The photographs represented the situations described in the stimuli. For each stimulus sentence, a 4-in. (10.16-cm) × 6-in. (15.24-cm) photograph of Play Mobil figurines was taken. There were eight photographs for simple proposition sentences (e.g., a girl pushing a clown) and 32 complex proposition photographs. The photographs were arranged in binders for presentation during the task.

Graphic symbol display. A display was created containing the graphic symbols representing the people, objects, and actions shown in the photographs. It included the basic vocabulary for the descriptions (eight symbols: PUSH, PULL, WEAR, GIRL, BOY, CLOWN, SCARF, HAT) and symbols for the commands "delete" and "next" so that participants could modify the production of the utterances and indicate when they were done producing each sequence. The display incorporated ten 0.75-in. (1.905-cm) × 1.50-in. (3.81-cm) cells containing colored PCS (Johnson, 1981) with the written word underneath them. These cells were arranged in two rows of five symbols: The top row contained, from left to right, the symbols for the agents (CLOWN, GIRL, BOY) and the attributes (SCARF, HAT), whereas the bottom row included the symbols for the verbs (WEAR, PUSH, PULL) and the operational symbols (NEXT, DELETE). PCS were chosen because they are among the most commonly used graphic symbols in the local AAC community, and we wanted to facilitate interpretation of the results in the context of previous studies that have all used these types of symbols.

Computer and software. A graphic symbol authoring software (i.e., *Écrire avec des symboles;* Widgit Software, 2000) installed on a PC laptop computer was used to access the symbol display and a picture/word processing window concurrently. Specifically, the *Écrire avec des symboles* (Widgit Software, 2000) window was divided in four areas. The larger area (top right) was devoted to the picture/word processing window. Directly under that window (bottom right) was the symbol display described above. The top left of the screen contained arrows, which participants could use to move the cursor in the word processing window (this could also be done using the mouse or the touch screen). The bottom left corner contained Digits 1–4, which were used to label the symbol sequences in the contrast condition (see below). Graphic symbol utterances could thus be constructed, displayed, revised, and saved in a separate file for each participant for later analysis. Speech synthesis (IBM's ViaVoice synthesizer—"Jacques" voice) was used to produce the spoken label for each graphic symbol as it was selected and to repeat the whole sequence constructed when the "next" button was activated. Speech synthesis was included to give increased feedback to the participants and to make sure that response patterns could not be explained by symbol confusion (i.e., by hearing the spoken label, participants could self-correct if the word they heard was not the one they wanted to include in the sequence or if the finished sequence did not sound right to them). Use of voice output also mirrored the conditions of the comprehension tasks that were part of a broader research protocol.

Conditions

In the neutral condition, photographs and accompanying spoken sentences were presented one at a time, and the participant was asked to reproduce them using the graphic symbol display (see Appendix B for a translation of the exact spoken instructions provided to participants). In the contrast condition, photographs were displayed four at a time, the four accompanying spoken sentences were produced, and the participant was asked to create four different graphic symbol sequences using the same graphic symbol display.

Eight simple proposition sentences were used in each condition. There were 32 complex proposition sentences (16 SS and 16 OS) for adults and teenagers in each condition, and 24 (12 SS and 12 OS) in each condition for children.

Experimental Design

The experiment followed a 3 (age group) × 2 (condition) × 2 (syntactic complexity levels) mixed design. All participants completed four experimental tasks (i.e., each syntactic complexity level in two different conditions). The order of administration of the tasks was randomly determined for each participant. The order of presentation of the stimulus sentences in each task was also randomized so that items did not occur in the same order in each condition or for each participant.

Procedures

All experimental sessions were carried out by research assistants (students in speech-language pathology or linguistics) who were initially trained by the second author to ensure uniformity of the procedures. Research assistants worked in pairs, with one of them handling the materials and reading the instructions and stimuli from a binder, while the other followed along to make sure that no mistakes were made in the administration of the tasks.

Familiarization and training. Exposure to the materials was provided to ensure that all participants were comfortable with the materials and tasks and understood the examiner's instructions. These familiarization tasks included identifying the individual graphic symbols, selecting symbols on the display to copy sequences of 3–5 symbols, and describing photographs using the graphic symbol display. The training materials were the same as the materials to be used in the experimental tasks, but the specific combinations of figurines were different (i.e., they involved a boy and a girl, rather than a boy and a clown or a girl and a clown). Certain training and familiarization tasks were also used as pretests to determine the continued participation of individual participants and the specific experimental stimuli they would receive. All participants met a criterion for associating each symbol to its spoken label and for reproducing sequences of five symbols (five consecutive correct responses, or six of eight correct responses, whichever came first). They were also able to construct sequences of symbols to describe photographs (i.e., they understood the task), although the sequences constructed were not judged in terms of accuracy. Therefore, all participants completed all the tasks described below, although the number of items was reduced for the children to limit the testing time.

Task administration. The instructions and spoken sentences were read aloud by the research assistant acting as tester. On each trial, the tester read the stimulus sentence printed on the back of the photograph. The second research assistant followed on a separate response sheet and, in case of an error, asked the tester to start the trial again, ensuring that each spoken sentence was correctly presented. A review of 20% of the files to compile comments from the observer revealed 100% compliance with the experimental procedure. No time limit was imposed, allowing participants to revise their sequences and make changes if they wished to do so.

The software automatically recorded participants' responses and provided a printed copy of each symbol sequence constructed by each participant for each stimulus item. The second research assistant recorded by hand the symbol sequences produced by each participant during the testing. Following each testing session, the two records were checked for inconsistencies. This verification revealed 100% agreement between the automatic and manual data recording methods.

Data reduction. Working from the automatically recorded responses, each symbol sequence was coded according to the order of appearance of the corresponding word in the spoken sentence: N1 = the first noun mentioned; N2 = the second noun mentioned; V = the action verb; W = "wear" (*porte*); A = the attribute. This coding system was the same as the one used by Sutton et al. (2004), which has proved to be highly reliable (93% interrater agreement). As an example, in response to the stimulus sentence "*La fille pousse le clown qui porte un chapeau*" ("the girl pushes the clown who wears a hat"), the sequence of symbols FILLE POUSSE CLOWN PORTE CHAPEAU was coded N1 V N2 W A. The symbol sequence CLOWN POUSSE FILLE PORTE CHAPEAU would have been coded N2 V N1 W A. One research assistant coded the responses, and a second assistant verified all of them. Discrepancies were rare (interrater reliability above 90% for all tasks) and easily resolved by application of the objective coding criteria.

Coded data were then entered by two research assistants on an Excel spreadsheet. Any discrepancies between the two entries were resolved by returning to the original response sheet, ensuring that the data used for analysis were 100% accurate.

Using Excel formulas, the number of times that each participant and group used a particular symbol sequence was calculated for each sentence type and condition. For each structure (simple proposition, SS, and OS), the most common sequence produced within the adult group was identified. A conformity index (CI) was calculated for each participant for each structure by dividing the number of times that particular sequence was used by the total number of trials for each structure. All of these calculations were fully automated. Analyses of group data were then conducted using the CI as the dependent variable, using SPSS.

Individual patterns of production for each condition and structure were also analyzed. Participants were first classified as using a consistent pattern for each structure in each condition if 75% of their responses followed the same sequence. Participants who did use a consistent pattern were grouped on the basis of the specific pattern they did use. Again, all data were double-checked by a different research assistant before conducting the statistical analyses.

Results

For the simple propositions, the most frequent graphic symbol sequence produced by the adults, regardless of the condition, was N1 V N2 (100% of responses). For SS ("The girl who pushes the clown wears a hat") and OS ("The girl pushes the clown who wears a hat"), the most frequent productions were N1 W A V N2 (GIRL WEAR HAT PUSH CLOWN; 77.2% of responses) and N1 V N2 W A (GIRL PUSH CLOWN WEAR HAT; 71.9% of responses), respectively. These graphic symbol sequences were the standards used to score individual responses as same or different and to determine the CI for each participant and group. The CI group means and standard deviations in each condition are summarized in Table 1.

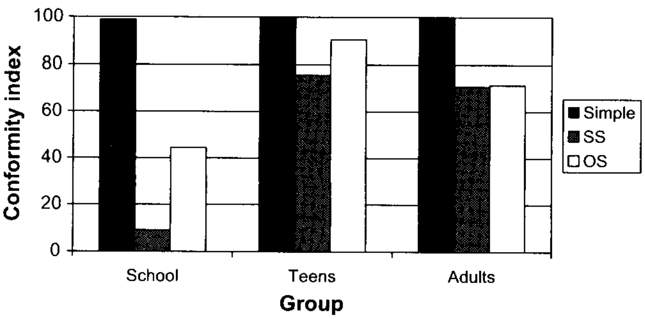
To assess the impact of age and condition on production of simple proposition utterances, a 3 × 2 mixed analysis of variance was conducted, with age (children, teenagers, and adults) as the between-subjects variable and condition (neutral and contrast) as a within-subjects variable, using CI as the dependent variable. No significant main effects or interactions were observed: All three groups performed close to or at ceiling on this task in both conditions, $F(1, 87) = 7.81$, $p = .32$ (see Figures 1 and 2).

To assess the impact of age and condition on complex proposition construction, a 3 × 2 × 2 mixed analysis of variance was conducted, with age (children, teenagers, and adults) as the between-subjects variable and structure (SS and OS) and condition (neutral and contrast) as within-subjects variables, using CI as the dependent variable. A main effect of age was observed, $F(2, 87) = 20.0$, $p < .001$. Post hoc Tukey tests revealed that the CIs for children were significantly lower (33.8) than for the other two groups (83.3 and 74.5 for teens and adults, respectively), $p < .001$, d(children/teens) = 1.09, d(children/adults) = 0.89. A main effect of structure was also observed, $F(1, 87) = 13.2$, $p < .001$, $d = 0.66$, with higher CIs on OS (69.4) than SS (58.3) sentences. A main effect of condition, $F(1, 87) = 6.0$, $p = .02$, $d = 0.45$, was also present: CIs were higher for the contrast (67.4) than for the neutral condition (60.3). There was a significant interaction between structure and condition, $F(1, 87) = 11.0$, $p = .001$. Further analyses showed that although

Table 1. Conformity index (and standard deviation) of children, teens, and adults for subject relative (SS) and object relative (OS) stimuli in the neutral and contrast conditions.

	Neutral condition		Contrast condition		
Variable	SS	OS	SS	OS	M
Children	9.2 (25.5)	44.4 (45.4)	29.7 (43.9)	52.0 (46.4)	33.8 (43.8)
Teens	75.6 (41.2)	90.4 (27.3)	81.1 (32.4)	86.0 (31.2)	83.3 (33.6)
Adults	70.8 (43.9)	71.5 (42.4)	83.6 (33.9)	72.3 (44.1)	74.5 (41.1)
Average	51.9 (48.1)	68.8 (43.2)	64.8 (44.4)	70.1 (43.1)	

Figure 1. Mean conformity index obtained by each age group for each structure in the neutral condition. SS = subject relative structure; OS = object relative structure.



CIs for SS increased between neutral (51.9) and contrast (64.8) conditions ($p = .001$, $d = 0.63$), performance on OS remained stable (68.8 in neutral, 70.1 in contrast; $p = .668$, $d = 0.08$). A significant interaction between group and structure, $F(2, 87) = 10.4$, $p < .001$, was also observed. This interaction was explained by a different pattern for children: Children obtained higher CIs for OS (48.2) than SS (19.4) structures ($p < .001$, $d = 0.79$), whereas adults and teens obtained CIs that were similar for both structures (d[adults] = 0.21; d[teens] = 0.42).

The second step of the analyses investigated individual patterns of responses. In response to the simple proposition stimuli, all but one of the participants produced an N1 V N2 sequence, regardless of the condition. One child produced N1 N2 V sequences on three of eight trials in the neutral condition and on six of eight trials in the contrast condition. For complex propositions, two trends were observed (see Tables 2 and 3). First, 26 or more of participants in each group used a consistent pattern for each structure and in each condition. Second, four sequences accounted for the patterns of 80% or more of participants (namely, N1 V N2 W A; N1 V N2 A; N1 W A V N2; and N1 A V N2). A few participants produced "WEAR" inconsistently but were still considered to be using a consistent pattern (N1 V N2 [W] A and N1 [W] A V N2).

The next level of analysis explored whether participants produced different sequences for SS and OS structures in each condition. In the neutral condition, 29 adults, 25 teenagers, and 13 children produced some form of distinction between OS and SS structures. A chi-square test confirmed a significant difference between the age groups; fewer children made a distinction between SS and OS structures, $\chi^2(2, N = 90) = 21.8, p < .001$.

Figure 2. Mean conformity index obtained by each age group for each structure in the contrast condition. SS = subject relative structure; OS = object relative structure.

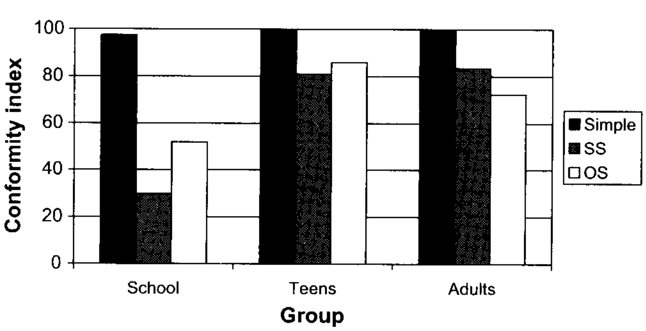


Table 2. Number of children, teenagers, and adults producing each response type on at least 75% of trials in neutral conditions for subject relative (SS) and object relative (OS) structures.

Variable	Children		Teens		Adults	
	SS	OS	SS	OS	SS	OS
N1 V N2 W A	9	12	4	27	2	20
N1 V N2 A	5	14	1	3		6
N1 V N2 (W) A	2	3				
N1 W A V N2	2		23		21	
N1 A V N2	6		1		6	
N1 (W) A V N2					1	
Other[a]	3					
No consistent pattern	3	1	1			2

Note. N1 = first noun mentioned in the spoken model; V = action verb; N2 = second noun mentioned in the spoken model; W = "wear" (*porte*); A = attribute.

[a]Two participants: N1 V N2 N1 W A; 1 participant: N1 A N2 V.

Table 3. Number of children, teens, and adults producing each response type on at least 75% of trials in contrast conditions for subject relative (SS) and object relative (OS) structures.

Variable	Children		Teens		Adults	
	SS	OS	SS	OS	SS	OS
N1 V N2 W A	6	13	1	25		22
N1 V N2 A	3	11	1	4		6
N1 V N2 (W) A	1	3		1		
N1 P A V N2	8		22		26	
N1 A V N2	6		3		4	
N1 (W) A V N2	1		2			
Other[a]	2	1				1
No consistent pattern	3	2	1			1

Note. N1 = first noun mentioned in the spoken model; V = action verb; N2 = second noun mentioned in the spoken model; W = "wear" (*porte*); A = attribute.

[a]SS: N1 V N2 N1 W A; OS: N1 V N2 N2 W A.

Among participants who did distinguish the two structures, the most common strategy was to move the attribute closer to the subject in the SS structure, therefore reserving N1 V N2 W A, or N1 V N2 A, for the OS structures. One adult chose a different strategy, using the symbol "WEAR" in SS structures (N1 V N2 W A) and omitting it in OS structures (N1 V N2 A). Two children produced sequences that would reflect the juxtaposition of two simple utterances rather than a complex utterance for SS structures (N1 V N2 N1 W A) while using N1 V N2 W A for OS structures. One child produced a sequence for SS structures systematically that did not conform to the word order of spoken French (N1 A N2 V). Two children, 1 teenager, and 2 adults were inconsistent in their productions on one of the two structure types, whereas 1 child was inconsistent on both.

In the contrast condition, 30 adults, 28 teens, and 21 children made some form of distinction between OS and SS structures. A chi-square test confirmed a significant difference between the age groups, with fewer children making a distinction between SS and OS structures, $\chi^2(2, N = 90) = 16.2, p < .001$. Among participants who did make a distinction, the most common strategy was the same as in the neutral condition. One child used the symbol "WEAR" for SS stimuli but not for OS stimuli. Two children and 1 adult produced sequences that would reflect the juxtaposition of two simple utterances rather than a complex utterance (i.e., SS: N1 V N2 N1 W A and/or OS: N1 V N2 N2 W A). One participant in each group used a consistent pattern for one structure but inconsistent for the other, whereas 2 children were inconsistent on both.

To evaluate the effect of condition on the use of distinctive response patterns for the two types of complex proposition stimuli, a chi-square analysis was conducted on the number of participants making a distinction between SS and OS in each condition. More participants made a distinction in the contrast condition, $\chi^2(1, N = 180) = 5.2, p = .022$. This effect was attributable to the children, $\chi^2(1, N = 60) = 4.3, p = .037$. The other two groups showed no difference between conditions in distribution of number of participants who responded distinctively for SS and OS stimuli.

All participants who did not make a distinction between SS and OS in the contrast condition (1 teen and 9 children) also did not do so in the neutral condition, regardless of the order in which they received the two conditions. On the other hand, the 1 adult and 4 of the 5 teens who did not contrast in the neutral condition had received this condition first, whereas the 17 children who did not distinguish between the two structures in the neutral condition were evenly distributed between the two testing orders (9 neutral first, 8 contrast first).

During the second phase of analysis, it was observed that the use of the symbol "WEAR" seemed to differ across the age groups. Although adults and teens showed a clear tendency to use the symbol "WEAR" in their productions (83% and 91% of sequences, respectively), the children employed this symbol less frequently (52% of sequences). This observation led to further questions regarding the children's low CIs in the initial analyses. Specifically, the question of whether the differences in CIs in the younger group may have stemmed from them omitting the symbol "WEAR" warranted further analyses. A second series of CIs was calculated in which "WEAR" was considered optional. In other words, for SS structures, both N1 W A V N2 (GIRL WEAR HAT PUSH CLOWN) and N1 A V N2 (GIRL HAT PUSH CLOWN) were considered to conform to the adult standard. For OS structures, both N1 V N2 W A (GIRL PUSH CLOWN WEAR HAT) and N1 V N2 A (GIRL PUSH CLOWN HAT) were considered to conform to the adult standard. In spite of an increase in CI values for all tasks, the significant differences remained the same with the modified criteria for conformity.

Discussion

Effects of Structural Complexity

The results revealed an effect of structural complexity on graphic symbol utterances. Almost 100% conformity was observed for simple proposition stimuli across age groups and conditions. When the utterances are short and simple, 7–8-year-old children possess sufficient linguistic and metalinguistic abilities to transpose them into graphic symbols. This is not surprising, given that the levels of linguistic analysis and control needed to complete this task are fairly low. Moreover, children in this age range have already been exposed to formal instruction in writing, and they should be familiar with the notion of transposing spoken language into a visual form. Compensation strategies were not required to complete the task because all spoken words, except the articles, were represented on the graphic symbol display. The task was therefore fairly straightforward for all participants (children, teens, and adults).

In contrast to the uniformity of responses on simple proposition utterances, complex propositions led to greater variability. CIs were lower (see Figures 1 and 2), a wider variety of structures were used, and some participants did not use any particular graphic symbol sequence systematically (see Tables 2 and 3). These findings were expected because the combinatory possibilities of symbols are greater for complex utterances, but the variability was even more striking for SS than OS stimuli. This may be due to the fact that for SS sentences, the order of the main constituents in the spoken model resulted in the attribute being further away from the character wearing it (e.g., "girl" and "scarf" in the sentence "The girl who pushes the clown wears a scarf") and resulted in a symbol sequence that could be considered ambiguous (GIRL PUSH CLOWN [WEAR] SCARF). As shown in Tables 2 and 3, the most frequent strategy used by the participants was to move the attribute closer to the noun to which it applies, thereby reversing the two propositions (GIRL [WEAR] SCARF PUSH CLOWN). These findings are consistent with previous results by Sutton et al. (2000) for English-speaking adults. This pattern of responses, as in the earlier study, could be explained by compensatory mechanisms (i.e., participants had to find a way to distinguish between two structures in the absence of a key constituent on the graphic symbol display) or by a bias toward proximity when constructing graphic symbol sequences, whether the need to distinguish between competing meanings is at play. However, performance on the complex utterance tasks may also be related to metalinguistic skills. As opposed to the simple utterances, which required both low analysis and low control, the complex utterances required higher linguistic analysis and higher control. These issues are discussed further below in relationship to the differences between the two conditions of the study.

It was observed that the symbol WEAR was used with less consistency than all other symbols in the production of complex utterances. Specifically, among adults, teens, and the majority of children, all symbol sequences for the complex proposition stimuli included two nouns, one attribute, and one action verb. Some participants included the symbol WEAR in their graphic symbol utterances, but others omitted it systematically or used it inconsistently or as a way to distinguish between SS and OS structures. Sutton et al. (2000) also reported omission of the symbol WEAR in 15% of sequences constructed by adults, similar to the omission rate by the adults in the current study (17%). One possible explanation for these observations is that WEAR was considered redundant because it was present in all the stimulus utterances and did not contrast with any other symbols (unlike the characters, actions, and attributes). If this were the case, optional use of the symbol WEAR could be considered a compensation strategy, because omitting a symbol would accelerate the construction of the symbol sequence. However, given the high omission rate among the children, it is unlikely that this phenomenon is due to a sophisticated compensation strategy. Alternatively, it could be argued that participants who omitted the WEAR symbol were transforming the spoken sentences into simple propositions (GIRL HAT PUSH CLOWN = "The girl with the hat pushes the clown"). A similar simplification process was observed in the productions of a few participants, who constructed two juxtaposed simple propositions in response to the complex proposition stimuli, thus avoiding any potential confusion between agent and patient of the action (GIRL WEAR HAT GIRL PUSH CLOWN). This explanation seems more likely given the high omission rate in children who, in the presence of a complex utterance, may have opted to simplify the form of the message while attempting to maintain its meaning.

Effect of Task Demands

The results show that increasing the need for message clarity can elicit changes in the production of graphic symbol sequences for complex propositions. Specifically, in the neutral condition, in which each sentence was presented with one photograph, participants were given a choice between using a low level of control (i.e., reproducing the spoken sentence without modifying it to ensure clarity) or a higher control level (i.e., modifying the spoken sentence to increase clarity of the message). To produce clear messages in the contrast condition, however, a higher level of control was required to bypass the spoken model to convey the intended meaning. In general, CIs were higher in the contrast condition (compare Figure 2 with Figure 1), and the distinction between SS and OS sentences was more consistent (compare Table 3 with Table 2). We find it interesting, though, that all but one of the adults and the majority of teens did not need the added task demands to construct different sequences for SS and OS sentences; they made a distinction in the neutral condition as well, especially if they had received the contrast condition first. Therefore, it seems that once a teen or adult participant was made aware of the potential ambiguity between OS and SS stimuli in the contrast condition, they generalized their strategy to the neutral condition. In addition, even when participants received the neutral condition first, teens and adults were likely to produce distinctive patterns for the two structures, primarily by moving the attribute closer to the agent in the SS sentences. From a metalinguistic perspective, the added demands of the contrast condition seem to have made it more likely for participants to achieve a higher level of conscious control and bypass the spoken form of the message to transmit a clearer meaning.

Developmental Patterns

Although all participant groups performed similarly on simple proposition stimuli, there were striking differences between the children and the other two groups on complex proposition stimuli. The children's CIs were lower than those of the older groups (see Figures 1 and 2), and the variability in their response patterns was greater (seven different patterns used by children to convey SS structures in the contrast condition vs. four and two for teens and adults, respectively; see Tables 2 and 3). The most frequent graphic symbol sequences produced by adults (and teens) were far less popular among the child participants. In addition, children were more influenced than adults and teens by the increased demands in the contrast condition. In fact, because most adults and teens were already expressing the distinction between SS and OS sentences in the neutral condition, it may be more accurate to say that the contrast condition allowed some children to demonstrate higher capabilities than were revealed by the neutral condition. However, a significant number of children (9 of 30) still used identical graphic symbol sequences for SS and OS sentences in the contrast condition. This finding indicates some of the limitations that may be encountered by this age group when dealing with graphic symbol sequences representing complex sentence stimuli. One possible explanation for this is that, although children 7–8 years of age can comprehend and produce complex sentences in their oral language (tapping into their linguistic skills), the added difficulty of having to transpose complex utterances into a graphic sequence (tapping into their metalinguistic skills) made the task more difficult for them. Because this limitation is not likely purely linguistic, the hypothesis that metalinguistic abilities could play an important role in the construction of graphic symbol sequences seems promising.

Further examination of participants' individual performance on the SS and OS sentences in the neutral and contrast conditions (see Tables 2 and 3) permits identification of three profiles. First, participants who made a distinction between SS and OS structures in both conditions (29 adults, 25 teens, and 13 children) could be said to have sufficient linguistic and metalinguistic skills to be successful in this task. Specifically, their metalinguistic abilities would allow adequate analysis of the linguistic input and voluntary control over their own productions to resolve a potential ambiguity by bypassing the spoken form to transmit the meaning in a novel form. Second, participants who made a distinction between SS and OS sentences only when the context made the ambiguity more explicit in the contrast condition (1 adult, 3 teens, and 8 children) also clearly possessed the needed linguistic skills to perform the task successfully. At the metalinguistic level, they demonstrated a high level of control (finding a solution to an ambiguity created by the interaction of form and meaning). However, this skill may not be easily accessed unless the ambiguity is made explicit in the context. Finally, a few participants (2 teens and 9 children) did not make a distinction between SS and OS sentences, regardless of the explicitness of the ambiguity. Because there is little doubt that these participants had sufficient linguistic skills to produce complex sentences, the difficulty seemed to be the detection or resolution of the ambiguity that resulted from the absence of the relative pronoun on the graphic symbol display. A closer examination of the language scores obtained by the children revealed that the subgroup of children who did not distinguish between SS and OS sentences (n = 9) had significantly lower standard scores on the EVIP than did the subgroup (n = 21) who made the SS/OS distinction, $t(28) = 2.13$, $p = .042$. Thus, although all children performed well within normal on the EVIP, children with the highest language skills seemed to be at an advantage on the experimental tasks.

The results do not permit stating with any level of certainty whether those participants who did not make the distinction were oblivious to the ambiguity or, alternatively, whether they were aware of it but unable to modify the spoken model to clarify the meaning in their graphic symbol productions. Both explanations would be consistent with the hypothesis that these participants had somewhat lower levels of metalinguistic abilities. The developmental trends observed in the distribution of the participants among the three categories of performance profiles would suggest that the great majority of adults and teens have achieved high levels of mastery, both linguistic and metalinguistic, whereas some children between 7 and 8 years of age are still refining the metalinguistic skills needed to succeed in transposing spoken sentences into graphic symbol utterances. This observation is consistent with findings by several authors indicating that metalinguistic skills develop gradually and that the early school years are an important period for metalinguistic development (van Kleek, 1982; see also Bialystok, 1986, for a review of this notion in relation to the concept of "word"). The fact that a few teenagers and 1 adult did not perform like the other members of their age group also points to individual variation in the way metalinguistic skills develop and are utilized.

Clinical Implications

The findings of this study reinforce the idea that graphic symbol utterances do not directly reflect knowledge of spoken language structures. The types of spoken sentence structures presented to the participants were well within their linguistic skills (i.e., structures typically mastered during the preschool years), but the youngest group did not consistently produce graphic symbol utterances reflecting mastery of the structures. Clinically, judgments of linguistic competence cannot be solely based on evaluation of production using graphic symbols. Additional assessment measures (e.g., comprehension of spoken sentences of different structural types) would be required to evaluate fully the child's linguistic knowledge (Blockberger & Johnston, 2001). Interventionists (e.g., speech-language pathologists, teachers) must be aware of this caution to reduce the risk of over- or underestimating linguistic skills.

The findings suggest that it may be unrealistic to expect young children to produce graphic symbol utterances for complex propositions consistently. Although production of single proposition graphic symbol utterances was stable among the 7–8-year-old participants, only two thirds (21 of 30) of the children produced different graphic symbol sequences for the two complex structures (SS and OS), and they did not all use the same sequence of graphic symbols (see Table 2). Caution may be required when interpreting graphic symbol sequences produced by young children, because they may not yet have mastered the skills needed to transpose their messages into graphic symbols clearly and consistently. Construction of graphic symbol utterances to convey complex propositions may merit direct attention in intervention so that more complex messages can be conveyed clearly and efficiently.

Although there was almost 100% agreement among the participants in the construction of single proposition utterances, all groups used more than one type of symbol sequence for the complex propositions. This finding suggests that clinicians should be open to the possibility that different types of graphic symbol utterances may successfully convey a message even if they do not conform to the spoken model, especially as the information content increases.

The finding that the contrast condition elicited performance that distinguished the two complex sentence types (SS and OS) more consistently than did the neutral condition highlights the important role of task demands in graphic symbol utterance construction and suggests that a more demanding context may reveal a higher level of skill. A common notion in the intervention literature is that language skills are facilitated in a supportive context (e.g., Paul, 2001), but these data suggest that better performance was observed when the context was not supportive (i.e., in the contrast condition). Clinically, using communicative situations that are more demanding may be helpful in eliciting best performance for assessment purposes (e.g., Nippold, Ward-Lonergan, & Fanning, 2005) and in providing contexts in which emerging or newly learned skills can be practiced.

The findings of this study underscore the potential role of metalinguistic skills in graphic symbol utterance production. The implication for clinical practice is that strengthening metalinguistic skills may be one important way to improve graphic symbol utterance production. Explicit assessment of metalinguistic skills may be necessary. Intervention to work on the concepts of control and analysis (Bialystock, 1986) seems particularly relevant for graphic symbol utterance construction because of the transposition across modalities that is required. However, it would be risky, on the basis of the results of this study alone, to state that a certain absolute level of metalinguistic skills must be attained prior to attempting to construct graphic symbol utterances for complex propositions. The participants in the study were all individuals with no disabilities who had no prior experience with graphic symbols as a means of communication. Young children who are exposed to graphic symbols for communication early in their lives because of their need for an AAC system may actually develop some of the metalinguistic skills necessary for constructing more complex utterances through their experiences with graphic symbols. An analogy can be drawn with the relationship of phonological awareness and early reading skills. It is known that phonological awareness skills predict early reading achievement and that learning to read improves phonological awareness (e.g., Goswami, 2003). Similarly, metalinguistic skills may facilitate constructing graphic symbol utterances, and practice in constructing graphic symbol utterances may enhance metalinguistic skills. Thus, children who employ a graphic-symbol-based AAC system from a young age may have had increased opportunities to develop some metalinguistic skills. It would be premature and inappropriate to draw conclusions about the metalinguistic skills of young AAC users based solely on the results of this study.

Future Directions

The findings of this study point to several avenues for future research. First, the findings confirm that, in children with no communication disabilities, oral mastery of a syntactic structure does not in itself lead to effortless transposition into the graphic modality, at least for complex propositions in which the AAC system may impose certain limitations. Expanding the investigation to include participants who are younger (and therefore at an earlier level of language development) than those included in this study would permit further exploration of this finding. For school-age children, linguistic and metalinguistic abilities interacted with the process of transposition into graphic symbol utterances for complex propositions. If these skills are at play in graphic symbol utterance production for younger children as well, it would be expected that younger participants, still in the process of mastering the syntax of their language, would respond differently than adults even when constructing simple utterances using graphic symbols (cf. Smith, 1996).

A second important aspect requiring further investigation is comprehension of graphic symbol sequences by participants of various developmental levels. Initial work in this vein (e.g., Sutton et al., 2002) has included only adult participants and noncanonical orders. Studies of how different graphic symbol sequences are interpreted would clarify how participants assign meaning to them. By exploring interpretations of graphic symbol sequences corresponding to both canonical (e.g., subject–verb–object) and noncanonical (e.g., object–subject–verb) spoken word orders, it will be possible to investigate whether similarity to spoken language structures leads to more consistent performance. Including participants with different levels of linguistic skill in comprehension studies, as well as in production studies, will permit a deeper understanding of the role of these skills in communicating with graphic symbols. Comparisons of comprehension and production performance will provide further insight regarding the nature of the processes involved in transposing between spoken sentences and graphic symbols, and whether one type of transposition is easier than the reverse operation.

A third important avenue for future work would be to explore similar questions with other types of graphic symbols. For instance, Blissymbols, which present visual (i.e., less transparent) and linguistic (i.e., combination of smaller meaningful units) characteristics that differ from PCS, could yield different patterns of responses than the ones observed here.

The notion supported by the findings of this study—that transposition across modalities is at the core of communication using graphic symbols—suggests that parallels could be drawn between learning to communicate using graphic symbols and learning to use a form of written language. Both graphic symbols and written language involve a visual representation of a spoken model. Although the relationship between the spoken model and the graphic or written code is not identical (written language is related to the phonology of the spoken language, whereas no phonological link exists between graphic symbols and the spoken language), the cross-modality transposition involved in both processes suggests the potential links between them warrant further exploration. The study of written language and its development is well developed and supported by models of processing and development. The use of such models in future studies may help provide a systematic framework that will broaden the understanding of the relationships between speech and graphic symbols.

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