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Tangible Symbols, Tangible Outcomes

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A 3-year study on the use of tangible symbols (i.e., objects and pictures used as symbols) by 41 children with a variety of handicapping conditions was conducted to follow up on an earlier study by the authors that revealed their utility for children who are deafblind. The vast majority of participants learned to use tangible symbols, allowing them to overcome the restrictions imposed by gestural communication. A number of the participants progressed beyond tangible symbols and learned to use abstract symbol systems, including speech. A few of the participants did not learn to use tangible symbols during the time span available for intervention. Data describing the progress of participants are presented. Participants are grouped according to outcome, and the characteristics of each group are discussed in terms of the communication skills of participants as they began intervention.

KEY WORDS: aided symbols, autism, early intervention, multiple disabilities, tangible symbols

Children without disabilities go through a period of communicating very effectively using gestures and vocalizations before they learn to use spoken words. Although such presymbolic communication can be extremely effective, it limits the communicator to the "here and now." Gestures may be used to make reference only to physically and temporally present topics—referents that may be pointed to, looked at, and/or touched. Symbolic communication, on the other hand, allows reference to physically and temporally distant entities. Symbols, in other words, can be used to refer to objects and events outside the bounds of the immediate context. Typically, children begin using abstract symbols in the form of spoken words within the first year of life.

It is now widely assumed that a generic ability to communicate, realized initially through presymbolic communication, is the basis for later language acquisition (Bates, Camaioni, & Volterra, 1975). However, previous research with individuals who have sensory impairments, mental retardation, and other severe disabilities has revealed that the acquisition of a gestural repertoire is not necessarily a sufficient basis for the acquisition of abstract symbolic communication (Rowland & Schweigert, 1989, 1998; Wilcox & Shannon, 1998). Many individuals with severe disabilities who spontaneously learn to communicate through gestures are not able to make the leap to communication using abstract symbols such as spoken words or manual signs (McLean, Brady, & McLean, 1996; Rowland & Stremel-Campbell, 1987). These individuals seem to stumble over the concept of a one-to-one correspondence between an arbitrary sound (i.e., a spoken word) or motion (i.e., a manual sign) and its referent. The problem that many individuals have in bridging the gap between gestures and abstract symbols may be affected by cognitive impairments involving memory capacity and representational ability. Other factors that may affect the use of speech or sign language for expressive communication include gross and fine motor limitations. The research reported here addressed the development of symbolic communication in children with multiple disabilities who experienced a variety of impairments that prevented them from using abstract symbols.

Previous Research

Some years ago, we conducted initial studies on the use of a conceptually concrete symbol system that we called a "tangible symbol system," described in this journal (Rowland & Schweigert, 1989) and elsewhere (Park, 1995, 1997; Rowland & Schweigert, 1990, 1996). Tangible symbols, as we have described them previously, include both three-dimensional symbols (objects) and two-dimensional symbols (photographs and line drawings). The use of objects as symbols was not entirely new when we began this research: it seems to have been an outgrowth of van Dijk's work with children who are deafblind[1] (1966, 1967), which,

[1]The term "deafblind," used in this paper to refer to individuals with significant hearing and visual impairments is an accepted term in the field of deafblindness in North America.

in turn, was based on the theories of Werner and Kaplan (1963). A number of authors have addressed the use of "objects of reference" (Bloom, 1990; Ockelford, 1992), most frequently within the context of "activity boxes," "anticipation shelves," or "calendar systems" (Joffee & Rikhye, 1991; Stillman & Battle, 1984; Umholtz & Rudin, 1981), often targeting individuals who are deafblind (Engleman, Griffin, & Wheeler, 1998). The use of object symbols is often restricted to receptive communication, with the symbols used strictly as cues for forthcoming activities. Picture symbols such as line drawings and photographs are more commonly used as symbols for both expressive and receptive communication (e.g., Bondy & Frost, 1994; Heller, Allgood, Ware, & Castelle, 1996; Johnson, 1994; Schwartz, Garfinkle, & Bauer, 1998), often in conjunction with a voice output communication device (Heller, Alberto, & Bowdin, 1995; Stephenson & Linfoot, 1996a, b).

Tangible symbols include both three-dimensional and two-dimensional symbols that are created to suit the sensory and cognitive abilities as well as the experiences of individual users. A three-dimensional symbol may be constructed from materials identical to those of which the actual object is made and that the user would routinely handle in interacting with it. Similarly, photographs may be taken or line drawings made of specific preferred objects, people, or activities. Tangible symbols do not come prepackaged in most instances, although an exception involves users who are capable of understanding generic line drawings or photographs that may be purchased commercially. Examples of tangible symbols associated with a continuum of levels of representation ranging from identical objects to line drawings are presented in Table 1.

Tangible symbols make relatively low demands on a user's cognitive abilities, including memory and representational skills, as compared to abstract symbols. They are permanent symbols, requiring only recognition out of an array of symbols, rather than recall from the user's memory. Tangible symbols are manipulable, so that they may be held by the user, given to a receiver, or placed next to the referent (Blachman [1991] suggested the importance of concrete manipulatives in symbol training). Their selection requires only a simple motor response, such as pointing, touching, picking up, and extending, or even eye-gaze (for users with severe orthopedic impairments). Tangible symbols bear an obvious perceptual relationship to their referents; thus, minimal demands are placed on users' representational skills, since the relationships between symbols and their referents are quite apparent. The above properties apply both to three-dimensional and to many two-dimensional symbols. Tangible symbols that are three-dimensional are unique in that they are also tactually discriminable and thus are especially appropriate for individuals without sight.

In summary, as we use the word *tangible*, it embraces two major properties. First, the symbols are tangible because they are permanent and can be touched or manipulated. Second, the symbols are tangible because there is a history of correspondence between each symbol and its referent that has a perceptual basis for the individual user. Even in the case

TABLE 1: **Types of Tangible Symbols and Some Examples**

Level of Representation		*Referent*	*Symbol*
Three-dimensional	Identical object	Raisins	A few raisins glued to piece of cardboard
	Partial or associated object	Bolt Shoe Bicycle Car/out	A bolt is shrink-wrapped onto cardboard backing Shoelace Handle grip Car key
	One or two shared features	Pretzel	Thermoform (thin plastic impression) of pretzel (shares shape and size with referent)
	Created association	Work table Cafeteria	Ribbed rubber mat is attached to table: a small piece of the mat serves as the symbol Wooden apple shape is attached to cafeteria door: a similar apple shape serves as the symbol
Two-dimensional	Colored photographs		Self-explanatory
	Black and white photographs		Self-explanatory
	Colored line drawings		Self-explanatory
	Black and white line drawings		Self-explanatory

where an association has been created between a tangible symbol and a referent (because there is no logical symbol available), a perceptual association exists for the user because the created symbol has been repeatedly associated with the referent through receptive exposure prior to its introduction as a symbol for expressive communication. All of the properties listed above suggest that tangible symbols may be a viable alternative for many individuals who do not appear to be readily able to acquire abstract symbols at their current stage of development.

Our approach to the use of tangible symbols embraces the receptive and expressive communication of a variety of functions in a systematic yet flexible sequence. This sequence accommodates the needs and abilities of individuals who may not be able to see, who may not understand pictorial representations, and who may use a variety of ways to indicate a symbol to the communication partner. Learning always takes place within highly motivating and functional routines and during the transitions between such routines. Systematic and unambiguous data must be collected to ascertain that the learner truly comprehends the meaning of each tangible symbol and is using the symbols communicatively. Detailed instructional strategies are described in Rowland and Schweigert (1990, 1996; www.tangiblesymbols.org).

Our earlier research conducted with children who were deafblind was extremely encouraging. All of the participants learned to use tangible symbols to one degree or another. We have managed to keep in touch with many of those participants over the years and have learned that a number of them eventually progressed to using more conventional and abstract symbol systems. Time and again, our experience has shown us that it is impossible to predict how far down the road toward conventional communication an individual with severe or multiple disabilities may progress if given appropriate, systematic, and long-term intervention.

The research reported here spanned 3 years. The overall objective was to "push the envelope" by examining a wide range of children who might benefit from using tangible symbols expressively. That is we wanted to determine whether children experiencing a broader range of disabilities than those who had participated in our earlier studies might benefit from using tangible symbols. This research addressed two major hypotheses: (a) that tangible symbols have applicability beyond that examined in our earlier work and (b) that some children who learned to use tangible symbols might subsequently learn to use abstract symbols.

METHOD

The project was designed to document the efficacy of tangible symbol systems instruction as a means of symbolic communication for a wide variety of children experiencing significant disabilities. We documented the performance of students who received direct intervention from project staff and also conducted follow-up observations to explore the maintenance of effects and the long-term potential for tangible symbols to serve as a bridge to the use of more conventional and abstract symbol systems. This research was accomplished in the midst of the typical activities that occur in public school classrooms and with all of the intervening variables that collide in the life of a child with significant disabilities. These settings provided all of the advantages and disadvantages of any "natural" research setting.

Participants

Participants were recruited from public schools in Portland, OR and Vancouver, WA. The project was explained to interested special education program supervisors. Teachers and speech-language pathologists in those programs then recommended children for the project each year. Our major criterion for participation was the spontaneous and meaningful use of 10 or fewer abstract symbols for expressive communication.

Fifty-two children were accepted into the project over the course of its 3 years, based on recommendations by teachers and speech-language pathologists and with parental consent. In the end, because of families moving or the physical instability of the child, a total of 47 children in 13 different classrooms and 9 different schools actually received direct intervention through the project.

Fifteen students were accepted into the project and received intervention in year 1; in year 2, 17 new students received intervention; and in year 3, 15 more received intervention On average, participants received 6.5 months of intervention. Of the 47 students who received intervention, complete sets of data (defined as at least four monthly videotapes of intervention completed) were available for 41, and the results reported here are based on the performance of those 41 students. The most common reason for incomplete data was high absenteeism on the student's part.

Demographics on the 41 participants appear in Table 2. Although their ages ranged from 3 to 18 years, the mean age was 6 years, and 29 of the children were 5 years of age or younger. Twenty-four of the students were males and 17 were females. The children as a group experienced combinations of the following major handicapping conditions: mental retardation (9), developmental delay (32), vision impairment (23), hearing impairment (8), autism (9), orthopedic impairment (23), seizure disorder (8), and medical fragility (6). Cognitive delay was demonstrated by all participants. (Typically, only children 6 years of age and older would receive a diagnosis of mental retardation[2]; for younger children with cognitive delay, a diagnosis of developmental delay[3] is more often made.) All but five children experienced multiple disabilities. In terms of etiology, a number of the participants had rare syndromes or genetic abnormalities about which little is known by either the medical or educational professions. Two children had experienced traumatic brain injury as young children, whereas the remaining 39 children had experienced disabilities from birth. By far the most prevalent etiology listed for this group of children was "unknown" (23). This is in part related to the young ages of many of the children: we would expect more precise diagnoses to be identified over time, as they mature. All participants were being educated in public preschool, elementary, middle, or high school programs. The type of educational setting is identified for each participant in Table 2.

The Communication Matrix (Rowland, 1996) was administered to all participants prior to intervention. This instrument describes seven levels of expressive communication; the highest level mastered by each participant prior to intervention is also provided in Table 2. The children referred to the project had little, if any, conventional communication skills. Receptively, their skills were generally limited to the comprehension of gestures, facial expressions, tactile signals, and perhaps tone of voice; most of them were not able to understand speech, printed words, or manual sign language. Expressively, some of the children could communicate very effectively through gestures, whereas others had no clearly interpretable intentional communication behaviors at all. Seven students used a few speech approximations; all seven had an average of three abstract symbols in their expressive repertoires, with a range of one to eight symbols, and two of the seven students had learned to use a small number of tangible symbols prior to this project.

Intervention Planning

Initial intervention sessions were devoted to building rapport between instructor and child. During the rapport-building sessions (usually four to five sessions), project staff would engage the children in social interaction in the midst of child-preferred activities. In these playful contexts, we noted the preferences each child displayed for specific types of toys and social interaction, and we could observe first hand the means with which they chose to express themselves. When the initial assessments, observations, preference probes, and rapport-building sessions had been completed, the intervention program was designed in conjunction with teachers and speech-language pathologists. Individualized intervention programs were developed for each child, structured around his or her favorite activities and materials. Intervention programs specified nine specific variables, described in the sections that follow.

Level of Representation

The Levels of Representation PreTest (Rowland & Schweigert, 1990) was administered to determine what level of symbolic representation, if any, was meaningful to the child. This instrument probes the child's ability to associate various types of symbolic representations (as listed in Table 1) with highly preferred referents through a matching task. Symbols were then created as appropriate for each child, using materials that were meaningful to the individual child. Children who progressed rapidly were retested periodically (using the Levels of Representation PreTest) to see whether they were ready to move on to a higher level of representation, including abstract symbols. All students without intentional communicative behavior (i.e., those at Communication Matrix Levels I or II) were initially taught to use presymbolic forms of communication, and tangible symbols were introduced as they mastered presymbolic behaviors.

Vocabulary

The vocabulary represented by the symbols always included items that were highly motivating to the child. Motivating materials were determined by conducting a preference probe involving the systematic presentation of choices of materials and the collection of data on the relative frequency with which each item was chosen. Preference probes were conducted periodically throughout intervention to keep abreast of the child's changing interests.

Array Size

Array size refers to the number of symbols presented at one time from which the learner makes a choice. Array size was manipulated carefully during the initial stages of intervention to assess each child's comprehension of symbols. Generally, intervention began with one-symbol arrays and moved rapidly to two- and three-symbol arrays, with some students ultimately selecting from a whole book full of symbols.

Communicative Function

In all cases, the function targeted initially was requesting. Some students moved on to other func-

[2]Oregon Administrative Rules definition for mental retardation: significantly subaverage general intellectual functioning, and includes a student whose intelligence test score is two or more standard deviations below the norm on a standardized individual intelligence test, existing concurrently with deficits in adaptive behavior and manifested during the developmental period.

[3]Oregon Administrative Rules criteria for developmental delay: the child experiences a developmental delay of 1.5 standard deviations or more below the mean in two or more of the developmental areas listed in OAR 581-015-0946(3)(a)(A)-(E).

TABLE 2: **Participant Demographics**

Participant	*Age (Yr)*	*Gender*	*Major Handicapping Conditions**	*Etiology*	*Educational Setting*†	*Communication Matrix Level*‡
1	5	M	OI, SD, VI, HI, DD	Unknown	SC/I	II
2	8	M	A, MR, VI, OI, SD. HI	Unknown genetic	SC/I	II
3	3	M	DD, VI, OI	Intrauterine stroke, microcephaly	SC	II
4	8	F	SD, OI, VI, MR	Unknown	SC/I	II
5	6	M	VI (Blind), OI, DD	Unknown	SC/I	II
6	11	F	OI, VI, MR	Unknown	SC/I	II
7	8	M	VI, (Blind), OI, MR	Cytomegalovirus	SC/I	II
8	4	M	VI, OI, DD	Acute neonatal hypoglycemia	Integrated	II
9	4	F	DD, VI (Blind), HI	Di-George syndrome	Integrated	III
10	4	F	SD, DD, OI. MF	Hydrocephalus, microtic anemia	SC/I	II
11	3	F	VI (Blind), DD	Structural neural abnormality	Integrated	II
12	3	M	OI, DD. MF	Chromosomal abnormality	SC	III
13	5	F	OI, DD, MF	Chromosomal abnormality	Integrated	III
14	4	F	VI, DD	Prematurity	SC/I	II
15	4	M	SD, OI, VI, DD	Traumatic brain injury	Integrated	II
16	18	F	VI (Blind), HI, MR	Unknown	SC/I	V
17	12	F	MR, VI	Cytomegalovirus	SC	III
18	3	M	DD, OI, SD	Unknown genetic	SC	II
19	4	M	OI, DD, VI	Unknown	Integrated	II
20	9	M	HI, VI. DD, MF	Congenital abnormalities	SC/I	II
21	3	M	DD	Down syndrome	Integrated	III
22	9	F	MR, A, VI, HI	Congenital static encephalopathy	SC/I	IV
23	5	M	DD, OI, VI	Traumatic brain injury	Integrated	III
24	5	M	DD, OI, VI	Unknown genetic	SC/I	III
25	3	M	SD, OI, DD. MF	Undiagnosed congenital syndrome	SC	III
26	5	F	OI, VI, DD, MF	Unknown	SC	III
27	3	F	SD, OI, DD	Metabolic disorder	Integrated	II
28	4	M	A, DD	Unknown	Integrated	III
29	3	M	A, DD	Williams syndrome	Integrated	III
30	10	M	MR, OI, VI, A	Unknown	SC/I	III
31	17	M	OI, HI, DD	Unknown	SC/I	V
32	3	M	OI, DD	Unknown	Integrated	III
33	14	F	VI, HI, MR	Unknown	SC/I	V
34	4	M	A, DD	Unknown	Integrated	IV
35	4	F	A, DD	Unknown	Integrated	III
36	3	M	DD	Unknown	Integrated	III
37	3	F	DD	Unknown	Integrated	IV
38	3	M	DD	Unknown	Integrated	III
39	5	M	VI, A, DD	Unknown	Integrated	III
40	3	F	OI, DD	Unknown	Integrated	IV
41	4	F	A, DD	Unknown	Integrated	IV

A = autism, DD = developmental delay, HI = hearing impairment, MF = medically fragile, MR = mental retardation, OI = orthopedic impairment. SD = seizure disorder, VI = vision impairment.

†SC = self-contained classroom, SC/I = self-contained classroom with reverse and/or mainstream integration opportunities. Integrated = integrated classroom (at least 50% of students without disabilities)

‡I = preintentional behavior, II = intentional behavior (not intentionally communicative), III = intentional presymbolic communicative behavior (unconventional). IV = intentional presymbolic communicative behavior (conventional), V = concrete/tangible symbols, VI = single abstract symbols, VII = combinations of abstract symbols (language)

tions if they were rapidly acquiring symbols using the current function, if the environment presented opportunities to use a new function, and if the child demonstrated a need or desire to use a new function such as comment/label, etc.

Presentation Format

Symbols were presented in many ways, depending on the visual scanning and motoric abilities of each child. For instance, in some cases, they were placed in front of a child on a table, approximately 10 inches apart; in others, they were attached to a strip of cardboard with a raised edge defining the limits of the array; and in still others, they were presented in a book with each page containing multiple symbols.

Indicating Response

The behavior that the child was expected to use to indicate a symbol varied according to the child's abilities. Some students pointed to or touched a symbol while gazing at the teacher; some picked it up and gave it to the teacher; others used eye pointing to select a symbol. We always required the student to gain the teacher's attention prior to indicating a symbol (otherwise, symbol use might have been ineffective because there was no receiver); if necessary, we would teach the student an appropriate attention-gaining behavior in order to accomplish this (Rowland & Schweigert, 1996). The means of gaining attention varied, as no one way was appropriate for all students or for all situations.

Symbol Combinations

All students began with one-symbol expressions, but some progressed to combining two, three, or four symbols into one expression.

Level of Assistance

When a child did not respond to an opportunity to communicate independently, assistance was provided on an individualized basis, always using natural environmental cues in preference to artificial, teacher-controlled cues. Each child's intervention plan specified the initial level of assistance to be provided in the absence of an independent response. If that initial level of assistance did not elicit the targeted response, then higher levels of assistance were provided. Physical assistance (which was considered the most intrusive level of assistance) was rarely used.

Comprehension Check and Correction Procedure

Except when there was only one symbol from which to choose (in which case, an incorrect choice of symbol was impossible), a correction procedure was built into each instructional opportunity. Generally, the student first indicated a choice of objects by touching, pointing to, or gazing at one item presented in an array of two or more items. Once the child indicated a choice gesturally, the symbol array was presented. The student was then asked to choose the corresponding symbol from the array before being given the desired object. If the student chose the wrong symbol, the teacher indicated the correct symbol, *but did not give the desired item to the child.* Instead, another opportunity would begin, with another chance to choose a desired object and the corresponding symbol. This procedure, built around highly motivating materials, a clear protocol, and immediate feedback as to accuracy, was designed to promote success. Some students experienced initial frustration with the added requirement of the comprehension check, but this frustration quickly disappeared with additional experience. If the frustration level appeared to exceed the students' motivation for obtaining the desired object or activity, we looked for more highly motivating choices to present. For students who progressed rapidly, the format shifted to a more natural sequence in which the student first indicated a symbol and then demonstrated comprehension by selecting the associated object. Comprehension checks were dropped on a symbol-by-symbol basis as acquisition criteria were reached for each symbol. Thus, a student might choose symbols from an array that included several symbols for which comprehension checks were no longer needed, as well as several other symbols for which they were still required.

Direct Intervention Programs

Direct intervention generally involved one-on-one instruction from project staff for one activity (lasting from 15–20 minutes) out of every day that the participant attended school; on average, direct intervention was provided for 6.5 months per student. Staff used highly prescribed and individualized approaches (as described previously), but they were provided in a naturalistic and spontaneous manner in the midst of activities that the child thoroughly enjoyed. Trial-by-trial data on the expressive use of tangible symbols were recorded by staff who conducted direct intervention programs and were analyzed at least weekly (often daily) to determine what changes needed to be made to the programs in response to the child's successes or difficulties. Programs were changed as often as was necessary to respond to a child's performance. The variables that might be adjusted in response to the success or failure of the child at any given step of intervention are listed in the Intervention Planning section of this report. If a child experienced repeated failure, his or her program would be adjusted in one or more ways to make it easier to achieve success. If a child were succeeding at the current level of intervention, the instructor would "up the ante" to promote further learning. As children progressed, a common goal was to shift the stimulus control of communicative behavior to increasingly natural cues (Halle, 1987; Rowland & Schweigert, 1993). It is important to note that a significant number of participants did not, initially, have clearly intentional presymbolic behavior (as evidenced by achieving only Communication Matrix Level I or II). For those children, initial intervention efforts centered around teaching them to use gestures or vocalizations to gain attention and to make choices or requests. At the same time, we introduced them to the receptive use of tangible symbols as cues for forthcoming activities. This training lasted, on average, 3.4 months. Once presymbolic behaviors had been mastered, tangible symbols instruction was introduced. A narrative description of a sample intervention protocol for a student who was learning to use tangible symbols follows.

Sample Instructional Protocol

In the playroom, the teacher waits for Sammy to gain her attention by tapping her on the arm. In response to Sammy's bid for attention, the teacher says and signs "What do you want?," and indicates an object array consisting of the slide, the therapy ball, and the tricycle. (If necessary, the teacher assists a student without vision to tactually scan the array of play equipment.) Sammy responds by pointing to or touching the desired item—in this instance, the therapy ball. Now that the teacher knows what Sammy wants, she indicates the display of tangible symbols for slide, therapy ball, and tricycle and again says and signs "What do you want?" (If necessary, the teacher assists a student without vision to tactually scan the array of symbols.) Sammy must respond by picking up the symbol for "ball" and giving it to his teacher. If correct, Sammy is provided with the opportunity to play on the therapy ball and interact with the teacher. Interspersed throughout the play time are frequent opportunities for Sammy to request more play on the ball or to discontinue play with that item. By the end of the play time, many such opportunities to use tangible symbols to make a request have occurred.

Correction procedures are instituted along the way as failures occur. For example, if Sammy picks up the "slide" symbol after indicating that he wants to play on the ball, the teacher says and signs "No," indicates the correct symbol (thus providing receptive exposure to the symbol), and begins another trial; Sammy is not provided with the ball until he chooses the ball symbol. If Sammy decides not to make a choice from the array offered, his teacher takes his behavior as an expression of "No, thanks, try again" and offers different choices of play equipment, as available.

Data Collection Systems

There were two major sources of child performance data. First, project staff took trial-by-trial performance data every time they conducted direct intervention programs. Second, videotapes of these programs were made monthly for each participant and analyzed by trained observers. Below we describe the two major data systems, the dependent variables associated with each, and the procedures implemented to assess interobserver reliability.

Direct Intervention Data

Project staff recorded data on the participants' targeted behaviors during the ongoing interaction each time they conducted the program. The trial-by-trial data tracked the acquisition of communicative behaviors by the child (i.e., specific tangible symbols or gestures). Within each session, the instructor took data on the child's performance for each trial or opportunity that occurred to use the targeted communication behaviors. The targeted behaviors and number of opportunities to demonstrate those behaviors varied from child to child. Each new symbol introduced was considered to be acquired when a participant selected the correct symbol without assistance from an array of at least three symbols for at least 80% of the trials that occurred over two consecutive sessions.[4] In addition to these acquisition data on the targeted communication behaviors, the direct intervention data provided information concerning six other dependent measures:

- Number of symbols acquired by each participant (according to the acquisition criteria above);
- Array size used by the child (i.e., the number of symbols presented together, from which the child selected symbols);
- Symbol combinations (i.e., the number of symbols that the child combined into one expression);
- Communicative function for which the symbols were used (i.e., request, comment/label, confirm/negate, or refuse/reject[5]);
- Rate of acquisition for each symbol (i.e., the number of sessions before acquisition criteria were met; the fastest acquisition rate possible was two sessions); and

[4]An exception was made for participants who had severe orthopedic and/or visual impairments that made it impossible for them to reliably scan displays of more than two items.

[5]Definitions of the communicative functions: *request*: child indicates a desire to obtain an object, to engage in an activity, or to acquire assistance from another person or chooses between items, activities, or people offered; *comment/label*: child identifies something or makes a remark about it for the purpose of sharing information rather than as a request, protest, or other intent; *confirm/negate*: child responds appropriately to a "Yes" or "No" question; *refuse/reject*: child indicates a desire for another person to cease an activity or remove an undesired object.

- Level of representation achieved as more abstract types of symbols were acquired (see Table 1).

Rate/Ratio Data System

Direct intervention programs were videotaped monthly, and the rate/ratio code (Rowland, 1990) was administered to the videotaped sessions. This observational system tracks the rate and type of communication produced by participants. The code is administered on a modified frequency basis, with the presence or absence of each category of behavior scored during each 30-second interval. The dependent variable coded was intentional[6] symbolic communication by the student, which was categorized as object symbols, picture symbols, manual signs, printed words, or spoken words (including word approximations).

Interobserver Reliability

Reliability assessments for the two major sources of data are described below.

Direct Intervention Data

Given that, during a typical school day, a total of approximately 12 hours of direct intervention were delivered by project staff to approximately 17 children on an individual basis, it was not possible to conduct reliability checks on a full 20% of the data. Reliability checks on the direct intervention data were thus conducted as follows. Initially, a reliability probe was conducted by the project coordinator during live observations of 40% of all direct intervention programs conducted during a period of 5 consecutive days. Interobserver agreement was computed as number of agreements/number agreements + disagreements with each trial as the unit of assessment. Agreement ranged from 71% to 100%, with a mean of 92%. Thereafter, the two instructional assistants coded student performance from the monthly videotapes made of each other conducting programs. The data collected from the videotapes were compared to data collected live during the actual intervention session. Reliability was assessed in this way on one session per participant per month. This amounted to approximately 10% of the sessions for the entire school year. The mean interobserver agreement on direct intervention programs was 90%.

[6]Criteria for intentionality included the following: the student is oriented toward another person (a "receiver"); the behavior appears to express an identifiable message that the observer can put into words (e.g., "I want that," "Leave me alone," "Look at me"); the student persists in the behavior or attempts another behavior if the receiver fails to respond; and once the receiver responds, the student appears to be satisfied and ceases the behavior.

Rate/Ratio Data

Reliability checks were conducted on at least 20% of the monthly videotaped sessions for each participant, spaced evenly throughout each school year. The mean kappa coefficient (an agreement statistic that takes into account the rate of both occurrences and nonoccurrences) was computed and averaged across each behavior category for each participant. A score greater than .60 is preferred (Cohen, 1960, 1969). The range of kappa scores was .59 to 1.00, with only 1 score of 70 falling below .60. The mean kappa coefficient was .89, a highly acceptable level of agreement.

RESULTS

To provide an overview of achievement across participants, Figure 1 shows the type of symbol (the level of representation) acquired by each participant over the course of direct intervention. Each participant is represented in this figure by one bar on the x-axis.

What emerges most clearly from this figure is the diversity of outcomes across participants. To make the ensuing discussion more useful, we report results henceforth for the three groups of participants who emerge clearly in Figure 1: those who acquired no symbols at all (Group I), those who acquired one or more forms of tangible symbols (Group II), and those who first acquired tangible symbols and subsequently acquired one or more forms of abstract symbols (Group III).

Direct Intervention Data

The data collected by instructional assistants during intervention shows further details on the varied performance of the students in the three groups. Table 3 presents, for each group, (a) the mean number of tangible symbols acquired before intervention (T_1) and at the conclusion of intervention (T_2); (b) the array size, symbol combinations, and number of communicative functions for which symbols were used at the conclusion of intervention (T_2); and (c) the number of abstract symbols used functionally before (T_1) and at the conclusion of intervention (T_2). (Individual student data are presented in Appendix A.) These data show clear differences between the three groups in terms of number of tangible and abstract symbols acquired and array size, with Group III outperforming Group II and Group II outperforming Group I on these measures. The remaining three measures show differences between Group III and the other two groups, which performed identically.

The number of tangible symbols acquired by T_2 varied widely, from none for Group I students to means of 12 for Group II and 22 for Group III. The mean array size was 1 for Group I, 7 for Group II, and 17 for Group III. Ten students in Groups II and III were using

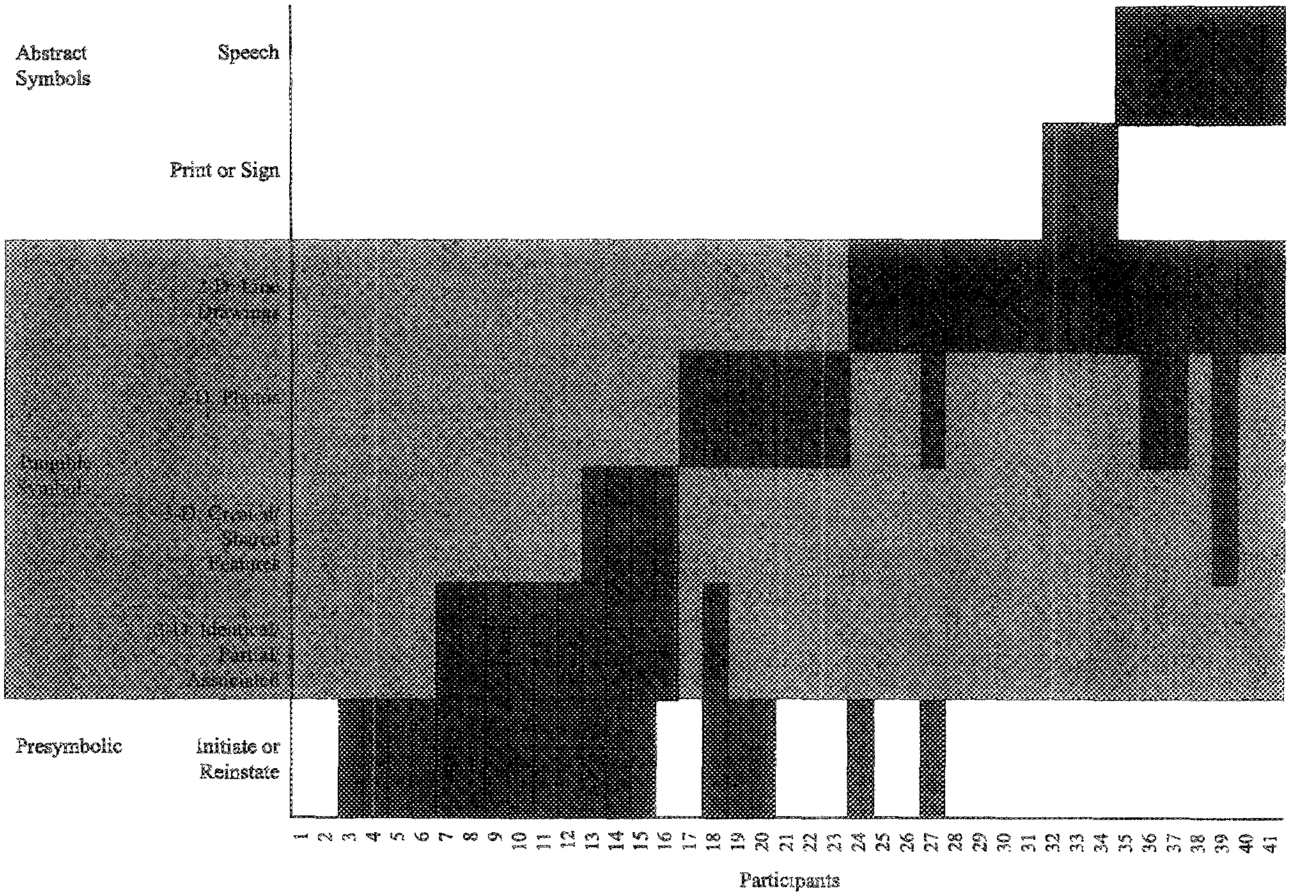

Figure 1. Levels of representation acquired during direct intervention by 41 participants.

communication books containing from 10 to 75 symbols by the end of the project. The length of symbol combinations averaged one symbol for Groups I and II and three for Group III. Eight students were using expressions of two or more symbols by the end of the project. The number of communicative functions for which tangible symbols were used averaged one for Groups I and II and two for Group III. All students initially learned to use symbols for the purpose of making requests, and most students continued to use tangible symbols for that one communicative function. However, nine students (two in Group II and seven in Group III) learned to use tangible symbols to express two or more communicative functions.

Table 3 also shows the number of abstract symbols used functionally by the Group III students at the start and conclusion of intervention, which increased from a mean of 2 to 40. Two students (32 and 33) began using manual signs and one student (34) started to use printed words by the end of intervention. Seven students (35–41) at initial contact had demonstrated some minimal and meaningful speech or speech approximations, consisting primarily of single word utterances. Assessments at the start of their involve-

TABLE 3: **Mean Direct Intervention Data at T_1 (Before Intervention) and T_2 (Conclusion of Intervention) for Groups I, II, and III**

	Number of Tangible Symbols Acquired: T_1/T_2	*Array Size at T_2*	*Symbol Combinations at T_2*	*Number of Communicative Functions at T_2*	*Number of Abstract Symbols Acquired: T_1/T_2*
Group I	0/0	1	1	1	0/0
Group II	0/12	7	1	1	0/0
Group III	0/22	17	3	2	2/40

ment with the project revealed that, although they had a few speech approximations, most of their expressive communication was conducted through gestures rather than speech. The direct intervention data show that for the students who initially had some speech, the mean spoken vocabulary was only 3 words at the start of intervention but increased to a mean of 53 different words by the end of intervention. For many children, meaningful speech began to appear only in conjunction with the use of the associated tangible symbols, and throughout intervention these children used speech only rarely unless their tangible symbols were present. However, four students began to use speech as their primary communication mode, at which point direct intervention shifted to the fading out of the tangible symbols.

An especially illuminating measure of learning from the direct intervention data is the acquisition rate. The acquisition rate is the number of sessions required to reach acquisition criteria for a new symbol (minimum 80% independent responses during two consecutive sessions using at least a three-symbol array, unless a two-symbol array was necessitated by sensory/orthopedic impairments, in which case the criterion was increased to 100% independent responses during two consecutive sessions). The fastest rate possible given our acquisition criteria was two sessions. A beginning and ending acquisition rate was calculated for students in Groups II and III by averaging the mean number of sessions required to learn the first symbols versus the last symbols acquired by each student. The mean acquisition rate and range for first and last symbols for the three groups appear in Table 4. (Individual student data appear in Appendix B.)

For most of the 35 participants who acquired some symbols, the acquisition rate for new tangible symbols decreased dramatically from the start to the conclusion of intervention. In Group II, the mean acquisition rate dropped from eight sessions per symbol (ranging from 2–17) to three sessions per symbol (ranging from 2–9). In Group III, the mean acquisition rate dropped from four sessions per symbol (ranging from 2–9) to two sessions per symbol. All students in Group III became "one trial learners," with a postintervention acquisition rate of two sessions per symbol. Only 7 of the 35 students had a final acquisition rate of more than three sessions per symbol. Thus, what may have been a laborious process as the student first learned how to use symbols became a much more efficient process over the course of the intervention. We demonstrated a similar "learning to learn" effect in children who were deafblind in our earlier study (Rowland & Schweigert, 1989).

TABLE 4: **Mean Acquisition Rate (Number of Sessions Required for Acquisition) and Range for First and Last Symbols Acquired for Groups I, II, and III**

	First Tangible Symbols Acquired	*Last Tangible Symbols Acquired*
Group I	No symbols acquired	No symbols acquired
Group II	8 (2–17)	3 (2–9)
Group III	4 (2–9)	2 (2)

Rate/Ratio Data

The rate/ratio data provide a very different perspective on the communicative behavior of the participants, revealing the overall rate of use of different symbol types during an instructional session (regardless of whether acquisition criteria had been met), as judged by independent observers. Experience has shown that observational data of any sort taken on students with severe disabilities in typical classroom situations is uneven at best. To accommodate uneven performance over time, the rate/ratio data were collapsed into two data points for each student, representing mean performance for the first two monthly observation sessions versus the last two monthly observation sessions conducted during intervention. Thus, these two data points show progress over the course of intervention. Rate/ratio results are reported in proportions (i.e., the proportion of intervals during which a specific category of behavior was observed out of the total number of observation intervals). Thus, P(tangible symbols) denotes the probability or rate of intentional use of tangible symbols by the student, expressed as the proportion of intervals in which such behavior was observed out of the total number of observation intervals. Table 5 shows the means of two rate/ratio variables: P(tangible symbols) and P(abstract symbols) for the three groups. (Individual rate/ratio data are presented in Appendix C.)

All groups showed gains in the rate of tangible symbols use. However, there was no overlap between groups, with Group I progressing from a mean of .01 to .06, Group II progressing from .06 to .14; and Group III progressing from .18 to .27. Thus, the groups showed overall differences at both data points in the frequency of tangible symbol use, with Group III using tangible symbols more frequently than Group II and Group II more frequently than Group I. The data on use of abstract symbols by Group III participants show the rate of use more than doubling from .20 to .46. The rate/ratio data system also provides further details on the relationship between tangible symbols acquisition and the use of speech. (We reported the increase in spoken vocabulary demonstrated by these students in a previous section.) For the seven students who had some speech at the start of intervention, the rate of speech increased from a mean of .26 at the beginning to .49 at the end of intervention. (The relatively high rates of speech at the start of intervention are somewhat deceptive, since the initial use of speech gener-

TABLE 5: **Mean Rate/Ratio Data for Groups I, II, and III**

	P(Tangible Symbol)		*P(Abstract Symbol)*	
	Mean of First Two Sessions	*Mean of Last Two Sessions*	*Mean of First Two Sessions*	*Mean of Last Two Sessions*
Group I	.01	.06	.00	.00
Group II	.06	.14	.00	.00
Group III	.18	.27	.20	.46

ally involved the repetitive use of one or two words, often inappropriately.) During this same period, the rate of tangible symbols use increased on average from .15 to .28. Interpretation of these data must accommodate the fact that, for several students, the focus of intervention shifted toward the end to the acquisition of speech, as opposed to tangible symbols, and the rate of tangible symbols use declined. These data again suggest that speech acquisition was not impaired by the use of tangible symbols; indeed, rates of speech use climbed steadily throughout intervention.

Characteristics Related to Tangible Symbol Acquisition

We had accepted as participants a group of children with widely varying disabilities, with the avowed intent of better describing the sorts of children for whom tangible symbols might be useful. Participants were referred to the project based on the assessment of the teacher or speech-language pathologist that the student lacked a functional symbolic communication system. We have already discussed the varied outcomes of the participants. Goals and expectations for such widely varied students cannot be uniform, and the interpretation of the data is difficult in the absence of information about the characteristics of students who performed very differently over the course of intervention. Further study thus involved an analysis of the characteristics of participants that might help practitioners to plan for successful intervention, whether presymbolic or symbolic in nature, for a given child. Although we do not believe that there are any prerequisites for communication intervention, we do believe that a logical sequence of intervention would posit that an individual who understands how to use presymbolic behaviors for intentional communication will more readily learn how to use a symbolic system to communicate expressively.

We reviewed data from our initial assessments of the participants, attempting to shed light on the differences and commonalities among the children in each group. First, we examined the pre-intervention Communication Matrix levels of the participants. Figure 2 is a contingency table showing the relationship between the pre-intervention Communication Matrix level and the level of representation achieved during direct intervention. There is obviously a close but not perfect relationship between these two variables.

One child began intervention at Matrix Level I, showing no clearly intentional behavior of any sort. For her, intervention targeted presymbolic communication, and she was never successful in probes of her readiness to use symbolic communication. Fifteen participants were functioning at Matrix Level II, showing deliberate behavior that did not demonstrate communicative intent. For all of these children, intervention began with instruction in the use of presymbolic behaviors to communicate (i.e., gestures and vocalizations to reinstate interactions, gain attention, make choices or requests, and establish joint reference). This presymbolic instruction lasted for 3.4 months, on

Communication Matrix level pre-intervention	Group I (no symbols)	Group II (tangible symbols) 3-D only	Group II (tangible symbols) 2-D	Group III (tangible symbols + abstract symbols)
Level I (Pre intentional behavior)	1			
Level II (Intentional behavior)	5	[illegible]	[illegible]	
Level III (Presymbolic, nonconventional communication)		[illegible]	[illegible]	5
Level IV (Presymbolic, conventional communication)		[illegible]	[illegible]	4
Level V (Concrete/tangible symbols)		[illegible]	[illegible]	1
Level VI (Single abstract symbols)				
Level VII (Combinations of 2-5 abstract symbols)				

Figure 2. Contingency table showing relationship between pre-intervention Communication Matrix level and outcome for 41 participants.

average. Five of these children were not able to learn to use tangible symbols when they were introduced, and two of them did not acquire intentional presymbolic communication skills. However, 10 students who began at Matrix Level II did learn to use tangible symbols after the presymbolic instruction, with six using three-dimensional symbols and four using two-dimensional symbols by the end of intervention. Apparently, children without intentional presymbolic communication may require extensive efforts to establish presymbolic means of communication, but once the power of communication has been experienced, many of them may have the potential to acquire tangible symbols. All participants who achieved Matrix Level III (intentional communication using nonconventional gestures or vocalizations) or higher prior to intervention learned to use tangible symbols. Whether an individual child learned to use three-dimensional or two-dimensional symbols depended on their visual and cognitive abilities. Of the 25 participants who began at Matrix Level III or higher, 10 learned to use an abstract symbol system after they had learned to use tangible symbols. Thus, children functioning at Matrix Level III seem to readily acquire tangible symbols, and many of them are then poised to acquire an abstract symbolic system that is appropriate to their abilities.

Although the pre-intervention level of communication is illuminating, it fails to tell the whole story, as evidenced by the overlap between Groups I and II and between Groups II and III in Figure 2. Other variables that exercised an influence over the success of direct intervention were the child's level of engagement with the social and physical environments and the child's overall consistency of behavior. Children who were difficult to engage either in social interaction or in interaction with objects (access to which could be made contingent upon communication) presented great challenges in terms of the creation of contexts that were powerful enough to encourage them to communicate. Children whose behavior was inconsistent or difficult to "read" presented additional challenges to the success of intervention. Both behavioral consistency and the "readability" of the child's behavior are likely to be negatively influenced by poor overall health and by severe orthopedic impairment. However, it is clear from the handicapping conditions listed in Table 2 that orthopedic impairment, blindness, and medical fragility were not restricted to any one group.

Maintenance of Effects Following Direct Intervention

There were 24 students for whom we were able to complete a follow-up observation during the subsequent school year, approximately 1 year following the conclusion of direct intervention (elapsed time ranged from 8–12 months). One-hour observations were made of activities that the teacher considered to be most conducive to communication on the part of the student to determine which symbolic systems were currently being used by the students. At the conclusion of direct intervention, 21 of the 24 students observed had been using symbolic systems, whereas 3 were using presymbolic means (gestures) to communicate. At follow-up, the three who had been using gestures continued to do so. Of the 21 who had been using symbolic systems, 11 continued to use the same system, whereas 7 had progressed to using more abstract symbol systems, often in conjunction with the original tangible symbols. The remaining 3 students were no longer using any sort of symbolic system.

DISCUSSION

Needless to say, 3 years of intervention provided in public school settings for children with severe disabilities result in a large and unruly set of data. The scope of this project is both its strength and its weakness. The heterogeneity of the participants, the vicissitudes of working within 13 nonlaboratory classrooms, and the varied health status and attendance of the participants combined to make it difficult to extract comparable data across all of the participants. However, it is also these variables that make the results robust inasmuch as they reflect the realities of application in a "real-life" instructional setting. The limitations of the study are associated with those realities. Specifically, a no-intervention comparison group was not feasible for a variety of reasons, including ethical ones; intervention varied according to the individual skills and preferences of each participant, and the amount of intervention varied depending on the number of days that the child actually attended school. Finally, after we were able to document tangible symbol acquisition through our interventions, some teachers and speech-language pathologists began to introduce additional tangible symbol vocabulary in other contexts. These subsequent interventions, although a welcome outcome of our efforts, may have influenced the participants' later performance in our instructional activities: performance may have improved toward the end of intervention because of increased exposure to tangible symbols in general. (The data reported here, however, were derived only from our direct instruction programs.)

Clinical Implications

Broadly speaking, the results of this project suggest three major clinical implications. First, participants demonstrating a wide range of abilities learned to use tangible symbol systems as an effective means of communication, supporting the first of our initial hypotheses. Second, a number of students were able to use tangible symbols as a stepping stone to more abstract symbol systems, supporting our second initial hypothesis. Third, we have gained some insight into the relationship between presymbolic intentional communication and the acquisition of symbolic behavior.

Usefulness of Tangible Symbols for Individuals Who Experience a Variety of Handicapping Conditions

This project involved children with widely varying etiologies and handicapping conditions who had in common a lack of functional symbolic communication skills. Participants included some children who appeared to have no physical or sensory impairments but who experienced general developmental delay, as well as some who experienced autism and some with severe orthopedic impairments. The instruction provided amounted to 15 to 20 minutes per school day for an average of 6.5 months. Of 41 participants, only 6 failed to acquire tangible symbols during direct intervention, demonstrating that tangible symbols are useful for children demonstrating a broad range of abilities. Especially interesting is the fact that eight of the nine participants with autism were very successful.

We have commented earlier on the increasingly rapid symbol acquisition rates that most participants showed over the course of intervention. This accomplishment suggests the phenomenon of "fast mapping" (Crais, 1992), the ability to learn new symbols with very little exposure to them. Romski, Sevcik, Robinson, Mervis, and Bertrand (1995) demonstrated fast mapping in students with mental retardation who learned to use graphic symbols in a short-term (15-day) follow-up study. Fast mapping is also a feature of the teaching strategies promoted by Beukelman and Mirenda (1998). If we define fast mapping as the learning of novel symbols that occurs within the first three exposures to a new symbol, then 28 of our 35 participants who learned to use tangible symbols became fast mappers. Furthermore, five of them were able to fast map new three-dimensional symbols, a phenomenon not previously described in the augmentative and alternative communication (AAC) literature. The explicit association that can be made between tangible symbols and referents, combined with systematic instructional techniques, appears to facilitate fast mapping.

An unfortunate aspect of any "aided" communication system, including tangible symbols, is that access to the system may not be under the user's control. The one discouraging finding of this project was that three participants, as they made transitions to other school programs not involved with our project, were not allowed to continue communicating through tangible symbols or, indeed, through any symbolic communication system. Although this was not a widespread problem, it was deeply disappointing to us since, clearly, the children had an effective means of communication removed from them. Two of the three students whose symbol systems were abandoned could be characterized as having the most severe orthopedic impairments of any in the project, and reading their responses (such as eye-pointing to indicate a symbol) required focused attention; the third student was totally blind. The use of symbols by these three children was especially dependent on a high level of effort by a communication partner, which we suspect was a factor in the abandonment of the systems.

Bridging Function of Tangible Symbols

The bridging effect of tangible symbols was demonstrated by the students who progressed from using gestures to using tangible symbols for communication; by those who first learned to use one form of tangible symbols and then learned to use another form; and by those who first learned to use tangible symbols and then progressed to using abstract symbols for communication. As can be seen in Figure 1, progress through different levels of representation did not occur in a predetermined sequence, nor did it require experience with every level of representation.

The use of speech in conjunction with tangible symbols also deserves additional discussion. There has been a long-standing assumption that speech acquisition is not impaired by the use of AAC (Shane, 1981), based largely on anecdotal clinical evidence, and there is no research to suggest that AAC impedes speech acquisition (Reichle, 1991). Indeed, Silverman (1995) summarized 26 studies that showed either no impact on speech or an apparent increase in speech associated with the use of AAC. However, parents often raise the question of whether acquiring an alternative communication system will interfere with speech acquisition (Beukelman & Mirenda, 1998; Romski & Sevcik, 1996; Siegel, 1996). As described earlier, seven students entered the project with some minimal speech or speech approximations. For all seven students, both the rate of speech and the size of their spoken vocabularies increased dramatically over the course of intervention. Follow-up observations revealed that, for five of these students, speech subsequently became their primary mode of communication. For the remaining two, although speech continued to develop, the use of tangible symbols appeared to augment and support speech development. The data clearly suggest that the introduction of tangible symbols did not cause students to abandon the speech they were using, nor did it prevent them from acquiring new spoken vocabulary. In fact, their overall level of communication increased, as did their use of speech. This apparent generic ability to use symbols that transfers to other symbol systems confirms the suggestion made by Stephenson and Linfoot (1996b) that a child who learns to use one form of representation may be predisposed to use another form in the same context. The data clearly show that the acquisition of tangible symbols seemed to serve as a bridge to the acquisition of more abstract symbols, including speech, for many participants.

A brief anecdote will show how a "tried and true" communication system may aid in the acquisition of a more sophisticated one. For one child with a diagnosis of autism, a consultation with project staff was requested by the new teacher in the fall after our intervention. This session allowed us to examine whether there remained a need for tangible symbol use, as the child was now communicating through speech. Her picture communication book had been faded out and she was readily producing three- to four-word spoken utterances to request various activities, needs, and wants throughout her day. An instructional program was designed to help her learn to say "help" when she needed it. Despite multiple sessions of verbal prompting and modeling, the child did not independently begin to make the spoken request for help; instead, she would resort to guiding her partner by the hand to the relevant activity or would become frustrated. We suggested that a picture symbol for "help" be introduced. A hierarchy of prompts was instigated, and within three sessions the child was independently requesting "I want help" appropriately using picture and speech. The picture symbol was subsequently dropped and the child continued to verbally request help independently across a mean of 84% of the available opportunities. This brief probe suggested that, although no longer her main mode of expression, tangible symbols might continue to assist this child to develop additional spoken vocabulary in the future.

Importance of Communicative Intent

The most important reason to consider tangible symbols for a communication system is the possibility that they will constitute a system that immediately expands the child's ability to communicate expressively. The success of such intervention is clearly related to the child's current ability to communicate intentionally. Bates, Camaioni, and Volterra (1975) distinguished between preintentional behavior that communicates (perlocutionary), intentionally communicative behavior that is presymbolic (illocutionary), and intentional symbolic behavior (locutionary), and proposed these as distinct stages in the development of communication. However, discussion of the importance of communicative intent as a basis for symbolic communication has only appeared recently in the AAC literature. Iacono, Carter, and Hook (1998) discussed the issue of intentionality in depth, suggesting the dangers of basing communication intervention on an over- or underestimation of the individual's intentionality. Stephenson and Linfoot (1996a) examined the relationship of communicative intent to the acquisition of graphic symbols and determined that when communicative intent is absent, the acquisition of a large number of graphic symbols is unlikely to occur. Warren and Yoder (1998) discussed the importance of timing intervention that targets linguistic (or symbol-based) communication in synchrony with an individual's maturational capability, and specifically the ability to understand representation. A child who does not understand that holding out an empty cup may cause an adult to fill the cup with more milk is not likely to learn to hold out a symbol for milk to request more milk.

The current functional communication skills of a child are far more relevant to communication intervention than are decisions based solely on a child's handicapping condition. As a group, the 41 participants of this study appeared more alike than not, sharing a lack of symbolic communication and a wide range of multiple disabilities. Indeed, there was no single handicapping condition among our participants that was exclusively associated with the outcome of intervention. Clearly, the participants who were less adept in terms of intentional presymbolic communication, as revealed by their initial Communication Matrix levels, were less prepared for symbolic communication and made slower progress toward this goal. Where presymbolic communicative skill was very low, extensive efforts (and in one case, all efforts) were directed toward helping children to become competent communicators using presymbolic means, prior to any attempt to introduce tangible symbols for expressive communication. Communication intervention should provide the participant with an immediate, effective, and meaningful way to communicate. When it is clear that the student is unprepared to embark on a symbolic means of communication, then intervention should center around strengthening presymbolic means of communication and providing receptive exposure to symbols. If we try to teach a student to use a symbolic system when she or he is unable to understand the meaning of the symbols or has no presymbolic means of communication, the result is likely to be frustration for both teacher and student. Once presymbolic communication strategies are in place, success in acquiring a symbolic system is likely to follow much more rapidly.

CONCLUSIONS

As important as providing a symbol system that is appropriate to the child's sensory and cognitive abilities is the provision of systematic instruction in how to use it. Systematic instruction requires a firm grasp of the child's current abilities, continuous collection of data that show whether the child is succeeding or failing to understand the use of symbols, and logical changes in instructional programs to promote steady progress. We have demonstrated that when individuals have the communicative intent necessary to learn to use a symbol system, and when instructional strategies are both systematic and flexible, children may learn to use tangible symbols in a relatively short time despite a history of failure to acquire other symbolic communication systems.

Ideally, an aided symbol system should be made available to the child in every context 24 hours a day so that the child can communicate at will. We were not able to manipulate the total environment of our participants; indeed, we were only present for 15 to 20 minutes a day, on average, and only on school days. In most cases, the documented successes of our intervention efforts had the desired effect of encouraging teachers and speech-language pathologists to pursue the use of tangible symbols in other contexts of the school day, and in some cases to encourage their use at home. We can only speculate as to how much more dramatic the improvements in the participants' communication skills might have been had they been given 24-hour access to tangible symbol systems.

We have also demonstrated that young children who are experiencing difficulties in acquiring speech may use tangible symbols as an immediately effective means of communication without jeopardizing continued speech development. Further research and demonstration efforts are needed to address more specifics about this relationship. We are currently exploring the utility of tangible symbols for young children with pervasive developmental disorders in greater depth. A more extended investigation of children such as the one described in the previous anecdote may add to our understanding of the bridging function of tangible symbols. In the interim, it is clear that tangible symbols are a means of communication that should be explored for many children with significant communication disorders.

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Apppendices A, B, and C follow on the next pages.

APPENDIX A

Direct Intervention Data for Each Participant Prior to Intervention (T_1) and at Conclusion of Intervention (T_2)

Participant	Number of Tangible Symbols: T_1/T_2	Array Size at T_2	Symbol Combinations at T_2	Number of Communicative Functions at T_2	Number of Abstract Symbols: T_1/T_2
1	0/0	1	1	1	0/0
2	0/0	1	1	1	0/0
3	0/0	1	1	1	0/0
4	0/0	0	0	0	0/0
5	0/0	1	1	1	0/0
6	0/0	1	1	1	0/0
7	0/4	2*	1	1	0/0
8	0/4	2*	1	1	0/0
9	0/14	3	1	1	0/0
10	0/6	2*	1	1	0/0
11	0/4	2*	1	1	0/0
12	0/5	3	1	1	0/0
13	0/3	3	1	1	0/0
14	0/14	3	1	1	0/0
15	0/11	4	1	1	0/0
16	2/24	24	1	2	0/0
17	0/6	3	1	1	0/0
18	0/12	3	1	1	0/0
19	0/5	2*	1	1	0/0
20	0/9	3	1	1	0/0
21	0/13	3	1	1	0/0
22	0/4	3	1	1	0/0
23	0/9	2*	1	1	0/0
24	0/21	3	1	1	0/0
25	0/2	3	1	1	0/0
26	0/12	2*	1	1	0/0
27	0/17	3	1	1	0/0
28	0/17	4	1	1	0/0
29	0/5	3	1	1	0/0
30	0/75	75	2	1	0/0
31	7/11	4	1	2	0/0
32	0/11	11	3	1	0/6
33	0/66	66	3	2	0/14
34	0/21	21	4	4	0/6
35	0/10	10	3	1	2/83
36	0/36	36	3	3	4/40
37	0/14	6	1	2	6/25
38	0/22	22	3	2	2/70
39	0/17	17	1	2	4/73
40	0/16	16	3	2	8/76
41	0/4	6	1	1	1/6

*Orthopedic and sensory impairments precluded use of three-symbol array.

APPENDIX B

Acquisition Rate (Mean Number of Sessions Required for Acquisition) for First versus Last Symbols Acquired by 35 Participants

Participant Number	*First Symbols Acquired*	*Last Symbols Acquired*
7	9	9
8	8	8
9	15	3
10	8	3
11	4	4
12	5	2
13	16	4
14	17	2
15	9	3
16	7	2
17	9	7
18	15	3
19	5	3
20	3	2
21	3	2
22	6	6
23	4	2
24	9	3
25	7	7
26	3	2
27	13	2
28	4	2
29	4	2
30	2	2
31	6	2
32	5	2
33	2	2
34	4	2
35	3	2
36	5	2
37	9	3
38	2	2
39	5	2
40	3	2
41	6	2

APPENDIX C

Rate/Ratio Data for Each Participant

	P(Tangible Symbol)		*P(Abstract Symbol)*	
Participant	*Mean of First Two Sessions*	*Mean of Last Two Sessions*	*Mean of First Two Sessions*	*Mean of Last Two Sessions*
1	00	.05	.00	.00
2	.02	.13	.00	.00
3	.00	.00	.00	.00
4	.00	.00	.00	.00
5	.00	.00	.00	.00
6	03	.15	.00	.00
7	.00	.03	.00	.00
8	.00	04	.00	.00
9	.00	.06	.00	.00
10	.05	03	.00	.00
11	.00	02	.00	.00
12	.06	.10	.00	.00
13	.00	.04	.00	.00
14	.00	.09	.00	.00
15	.05	.11	.00	.00
16	.00	.27	.00	.00
17	.15	.14	.00	.00
18	.05	.12	.00	.00
19	.00	.04	.00	.00
20	.04	.13	.00	00
21	.13	.22	.00	.00
22	.11	.22	.00	00
23	.16	.26	.00	.00
24	.11	.08	.00	00
25	.04	.11	.00	.00
26	.14	.47	.00	.00
27	.00	.23	.00	.00
28	.12	.10	.00	00
29	16	.20	.00	.00
30	.14	.13	.00	.00
31	.13	.27	.00	.00
32	.11	.12	.00	38
33	.19	.02	.12	.62
34	.41	.68	.03	.18
35	.17	.11	.02	.41
36	.30	.33	.04	.38
37	.15	.45	.48	.51
38	.05	.52	.32	.54
39	14	21	.39	.72
40	.20	12	.51	.68
41	.03	.18	.09	.20