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SYSTEMATIC REVIEW OF RESEARCH

Tangible Symbols as an AAC Option for Individuals with Developmental Disabilities: A Systematic Review of Intervention Studies

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Abstract
We reviewed nine studies evaluating the use of tangible symbols in AAC interventions for 129 individuals with developmental disabilities. Studies were summarized in terms of participants, tangible symbols used, communication functions/skills targeted for intervention, intervention procedures, evaluation designs, and main findings. Tangible symbols mainly consisted of three-dimensional whole objects or partial objects. Symbols were taught as requests for preferred objects/activities in five studies with additional communication functions (e.g., naming, choice making, protesting) also taught in three studies. One study focused on naming activities. With intervention, 54% (n = 70) of the participants, who ranged from 3 to 20 years of age, learned to use tangible symbols to communicate. However, these findings must be interpreted with caution due to pre-experimental or quasi-experimental designs in five of the nine studies. Overall, tangible symbols appear promising, but additional studies are needed to establish their relative merits as a communication mode for people with developmental disabilities.

Keywords: Augmentative and alternative communication; Developmental disabilities; Tangible symbols; Systematic review

Introduction
Individuals with developmental disabilities who have limited or unintelligible speech are often taught to use one or more AAC options as a means of communication (Beukelman & Mirenda, 2013). One common AAC option for this population involves the exchange of graphic symbols (Frost & Bondy, 2002). For example, the person might select a line drawing of a preferred toy and hand it to a listener as a means of requesting that object. When using this type of exchange-based communication system, learners might be taught to exchange line drawings, photographs, or perhaps even three-dimensional tangible symbols.

Rowland and Schweigert (1989) described tangible symbols as permanent objects that can be touched and manipulated. Tangible symbol systems used in AAC interventions have included the use of real objects, miniature objects, and partial objects (Beukelman & Mirenda, 2013). Examples of tangible symbols include (a) a real toothbrush to represent brushing one’s teeth, (b) a plastic fork to represent food/eating, (c) a toy school bus to represent the end of the school day, (d) a small piece of yarn to represent hat or mittens, and (e) a short section of a drinking straw used for requesting drinks (Rowland & Schweigert, 2000; Trief, 2007).

Tangible symbols would seem particularly applicable in AAC interventions for individuals with developmental disabilities who are also blind or have significant visual impairment. Persons with developmental disabilities, who are also blind/visually impaired, might be able to learn to discriminate among tangible symbols of differing shapes and to...
associate specific shapes (e.g., a long wooden rod versus a round metallic circle) with different communicative purposes (e.g., touch the long wooden rod to request a pencil versus touching the round metallic circle to request coins for a vending machine). If so, tangible symbols would represent a viable AAC option for this population.

Tangible symbols might also be applicable in AAC interventions for individuals with developmental disabilities who do not have visual impairments. In line with this suggestion, Rowland and Schweigert (2000) argued that tangible symbols place relatively low demands on learners’ memory and representational skills, compared to other AAC options, such as manual signs or abstract graphic symbols. The possibility of lessening such demands could be an important consideration, in light of evidence suggesting that many individuals with developmental disabilities, with and without visual impairments, have significant memory and representational skill deficits (O’Reilly & Carr, 2007). While such conceptual arguments would seem persuasive, an important question is whether there are empirical data to support the use of tangible symbols in AAC interventions for persons with developmental disabilities with and without visual impairments.

In their survey of the AAC field, Beukelman and Mirenda (2013) described a range of tangible symbols (e.g., whole objects, miniature objects, and parts of objects) and noted a number of publications documenting their use in AAC intervention. However, as yet, there do not seem to be any systematic reviews into the use of tangible symbols as an AAC option for individuals with developmental disabilities. A systematic review to address this gap in the literature would therefore seem useful.

The objectives of the present review were (a) to delineate the range of tangible symbols that have been taught to persons with developmental disabilities for communication purposes, (b) to document the range of communication functions/skills that have been taught with tangible symbols, (c) to outline the range of instructional procedures that have been used in conjunction with AAC interventions involving tangible symbols, and (d) to gain an overall view of the success of these interventions. A review of this literature could be helpful in advancing evidence-based practice and stimulating future research into the use of tangible symbols within AAC interventions for individuals with developmental disabilities.

Methods

We systematically searched for studies evaluating the use of tangible symbols within AAC interventions for individuals with developmental disabilities. Identified studies that met pre-determined inclusion criteria were summarized in terms of participants, types of tangible symbols used, the communication functions/skills targeted for intervention, intervention procedures, evaluation design, and results of the intervention.

Search Procedures

We initially searched four electronic databases in April 2013 (ERIC, PsycINFO, Google Scholar and Psychology and Behavioural Sciences Collection). Search terms were “tangible symbols” or “tangible cues” or “tactile symbols.” These search terms were entered as free text words into search fields. The search was restricted to English language, peer-reviewed articles. Two additional search strategies involved (a) reviewing the reference lists of articles identified from the electronic database search for other relevant studies, and (b) searching for additional studies by entering the surname of researchers who had authored studies identified in the initial database search. The search was updated in June, October, and November of 2013.

Screening and Inclusion Criteria

To be included in the review, the study had to explicitly focus on providing an AAC intervention that involved the use of tangible symbols to at least one individual with a developmental disability. A developmental disability included autism and autism spectrum disorder, developmental disability, developmental delay, intellectual disability, or a combination of impairments (e.g., intellectual disability plus vision impairment). Tangible symbols were defined as three-dimensional objects that were used as communication referents and included the use of (a) real (whole) objects, (b) miniature objects, and/or (c) parts of the actual referent. The review was limited to symbols meeting this definition because such symbols are quite distinct from the use of manual signs or two-dimensional textures or graphic symbols, which appear to be more commonly used in AAC interventions for individuals with developmental disabilities (Wendt, 2009). Studies using two-dimensional symbols were included only if participants were first taught to use three-dimensional tangible symbols and then transitioned to the use of two-dimensional symbols. Studies into stakeholder perspectives (e.g., teachers, speech-language pathologists, and/or parents) regarding the selection or use of tangible symbols were excluded (e.g., Bruce, Trief, & Cascella, 2011; Trief, Bruce, & Cascella, 2010; Trief, Bruce, Cascella, & Ivy, 2009).

Each study returned from the search was screened against the inclusion criteria by the first author. She read the abstract of each record and decided if the study did or did not meet the inclusion criteria. The second author independently replicated the search strategy and the screening process. There was one disagreement regarding whether or not one of the articles returned from the electronic search should be included. This disagreement was resolved by discussion. This process resulted in the initial inclusion of seven studies. The second author repeated the search strategy
and the screening process in June 2013, which resulted in the identification of one additional study. The first and second authors repeated the search in October 2013 with two additional search terms (real objects and object symbols). No new studies were identified in this latter refined search. A final study that met the inclusion criteria was completed by the present team of authors in November 2013 and was therefore included in this review, for a total of nine studies.

Data Extraction and Coding

For each included study, we extracted data on the following variables: (a) number, ages, and diagnoses of participants; (b) the types of tangible symbols used; (c) the communication functions/skills targeted for intervention; (d) the intervention procedures; (e) the design used to evaluate the effects of the intervention; and (f) the main results of the intervention. Data extraction from the first seven studies was performed by the first author and checked by the second author to assess accuracy of data extraction. In cases of disagreement on extracted data, articles were re-examined by the first and second authors collectively until consensus was reached. Only the second author extracted data from the two additional studies, which were identified in June and November of 2013.

The seventh author checked the accuracy of data extraction and the resulting summary of each study for the final set of nine studies. For this, the seventh author followed a checklist that included six questions:

1. Is this an accurate description of the participants?
2. Is this an accurate description of the tangible symbols?
3. Is this an accurate summary of the skills taught?
4. Is this an accurate summary of the results?
5. Is this an accurate summary of the procedures?
6. Is this an accurate summary of the evaluation design?

This approach was intended to provide a check on the accuracy of the data extracted from each study and the resulting summary of each study. It has been used elsewhere (e.g., Lang et al., 2011) as a measure of inter-rater agreement when extracting data (e.g., number and ages of participants, target skills, intervention procedures, and intervention results) from permanent products (published journal articles). In terms of inter-rater agreement, there were 54 items on which there could be agreement or disagreement (9 studies × 6 questions per study). Agreement was obtained on 51 items (94%). In the three instances where aspects of the summaries were considered inaccurate, a consensus was reached between the second and seventh author. Changes were then made in light of the consensus reached. Specifically, changes were made to the description of the communication functions/skills in the Trief (2007) study; the age of the participant in the Parker, Banda, Davidson, and Liu-Gitz (2010) study; and the percentage of children showing gains in the Trief, Cascella, and Bruce (2013) study.

Results

Tables I and II provide a summary of the nine studies. In Table I, the studies are listed by year of publication and summarized in terms of (a) the number and ages of participants, (b) the nature of the tangible symbols that were used, (c) the function/purpose of the communication skill(s) taught, and (d) the results of the intervention. Table II provides a summary of the studies’ intervention procedures and the designs used to evaluate the effects of the intervention. In Table II, intervention procedures were described in terms of the specific techniques employed, based on the glossary found in Duker, Didden, and Sigafoos (2004). The evaluation designs were classified as experimental (e.g., multiple-baseline across participants), pre-experimental (e.g., pre-post, ABCDE or B-only design), or quasi-experimental (e.g., the study involved intervention and comparison groups, but participants were not randomly assigned to groups). A narrative summary of each study is provided below to provide a qualitative supplement to the summaries in Tables I and II.

In the first study, Rowland and Schweigert (1989) provided AAC intervention to nine students attending public school classrooms. Chronological ages were not provided for seven students, but the other two students were 4;5 (years;months) and 6 years of age when intervention began. The nine students were described as having severe cognitive delays in addition to vision and hearing impairments. Levels of intellectual functioning were not specified. The aim of the intervention was to teach the students to use tangible symbols as an alternative communication mode. Requesting was the main communicative function targeted for intervention (e.g., requesting an offered object or activity, requesting more materials for an activity), but the report also mentioned communication skills that appeared to be a blend of naming and requesting (e.g., labeling objects that were desired). Tangible symbols were also used to facilitate transitions (e.g., informing the student regarding the next activity in the classroom routine). The tangible symbols were three-dimensional objects with a similar texture to the corresponding real object or which were associated with the real object. The 4;5-year-old student, for example, was provided initially with three tangible symbols: (a) a cup (to use for requesting a drink), (b) a plastic sandwich bag (to use for requesting bread), and (c) a wrapper from a package of crackers (to use for requesting crackers). Students received 10 to 18 months of intervention (M = 14.5 months). The intervention procedures were not precisely described for each student, but generally appeared to involve engaging students in daily structured training sequences and employing response prompting and reinforcement. Training occurred across a range of classroom activities. For example, in the

Augmentative and Alternative Communication
Table I. Summary of the key features for each of the nine studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Number/age of participants</th>
<th>Tangible symbols</th>
<th>Skills taught</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rowland and Schweigert (1989)</td>
<td>9 (pre-school and school age)</td>
<td>Three-dimensional objects of similar texture to real objects or related to real objects</td>
<td>Requesting, choice making, naming</td>
<td>Participants learned 16–98 symbols in 10–19 months</td>
</tr>
<tr>
<td>Turnell and Carter (1994)</td>
<td>1 (8)</td>
<td>Three-dimensional objects that were a part of corresponding real objects</td>
<td>Requesting</td>
<td>Participant learned three symbols to 80% correct within 30 sessions</td>
</tr>
<tr>
<td>Rowland and Schweigert (2000)</td>
<td>41 (3–18)</td>
<td>Three-dimensional and two dimensional symbols</td>
<td>Requesting, naming</td>
<td>35 of 41 participants learned to request with tangible symbols</td>
</tr>
<tr>
<td>Trief (2007)</td>
<td>25 (4–16)</td>
<td>28 whole objects or parts of objects affixed to cards</td>
<td>Naming/requesting</td>
<td>5 of 25 students learned 28 symbols, 10 learned 1–20, and 10 did not learn any symbols</td>
</tr>
<tr>
<td>Lund and Troha (2008)</td>
<td>3 (12–17)</td>
<td>Three-dimensional objects or parts of objects affixed to cards</td>
<td>Requesting</td>
<td>Participants reached 80% correct in 10–26 sessions</td>
</tr>
<tr>
<td>Parker et al. (2010)</td>
<td>1 (7)</td>
<td>Three-dimensional parts of objects affixed to cards</td>
<td>Requesting</td>
<td>Participant reached 80–100% correct in two to four sessions for each of four PECS phases</td>
</tr>
<tr>
<td>Ali et al. (2011)</td>
<td>4 (7–14)</td>
<td>Three-dimensional whole objects, parts of objects, or samples of objects affixed to cards and placed in communication books</td>
<td>Requesting</td>
<td>All four students reached 100% correct in three to four sessions, then learned to locate the partner and discriminate between symbols</td>
</tr>
<tr>
<td>Roche et al. (2013)</td>
<td>2 (9–11)</td>
<td>Three-dimensional miniature figurines compared to exchanging line drawings and a direct selection response</td>
<td>Requesting</td>
<td>Participants reached criterion in 5–17 sessions and most often chose tangible symbols</td>
</tr>
<tr>
<td>Trief et al. (2013)</td>
<td>43 (3–20)</td>
<td>55 tangible symbols consisting of whole objects or parts of objects affixed to cards (e.g., a real spoon to represent lunchroom, a small plate to represent food)</td>
<td>Requesting, naming, choice making, directing the actions of others, transitions</td>
<td>Pre–post test showed no change in correct responses, but in-situ data showed increase from first (26%) to last month (46%)</td>
</tr>
</tbody>
</table>

Note. Ages and age ranges are indicated to the nearest whole years.

Table II. Summary of the intervention procedures and designs used in the nine studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Procedures</th>
<th>Evaluation design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rowland and Schweigert (1989)</td>
<td>Offering preferred objects/activities, response prompting, and natural reinforcement</td>
<td>Pre-experimental; pre-post design</td>
</tr>
<tr>
<td>Turnell and Carter (1994)</td>
<td>Expectant look, time delay, response prompting (modeling), and natural reinforcement</td>
<td>Experimental; multiprobe multiple baseline design across three responses</td>
</tr>
<tr>
<td>Rowland and Schweigert (2000)</td>
<td>Time delay, response prompting, prompt fading, error correction, and differential reinforcement</td>
<td>Pre-experimental; pre-post design</td>
</tr>
<tr>
<td>Trief (2007)</td>
<td>Verbal cueing, response prompting, and error correction</td>
<td>Pre-experimental; open trial, B-only design</td>
</tr>
<tr>
<td>Lund and Troha (2008)</td>
<td>Modified PECS protocol</td>
<td>Experimental; multiple baseline across participants design</td>
</tr>
<tr>
<td>Parker et al. (2010)</td>
<td>Modified PECS protocol</td>
<td>Quasi-experimental; single-case ABCDE design</td>
</tr>
<tr>
<td>Ali et al. (2011)</td>
<td>Modified PECS protocol</td>
<td>Experimental; multiple probe multiple baseline across participants design</td>
</tr>
<tr>
<td>Roche et al. (2013)</td>
<td>Interrupting preferred cartoon movies, pausing (time delay), and then prompting a correct response with verbal and physical prompts</td>
<td>Experimental; multiple baseline design across two participants with an embedded alternating treatments design</td>
</tr>
<tr>
<td>Trief et al. (2013)</td>
<td>Manualized protocol in which tangible symbols introduced across a range of classroom activities for various communication purposes</td>
<td>Quasi-experimental; intervention and comparison group</td>
</tr>
</tbody>
</table>
playroom, the 6-year-old female student was (a) offered a choice of preferred playroom equipment, (b) assisted to physically touch each piece of equipment, (c) assisted to touch an array of corresponding tangible symbols, and then (d) assisted to return her hands to a neutral position before selecting a tangible symbol from the array. Once a tangible symbol was selected, the student was given access to the corresponding object/activity, which was presumably intended to function as natural reinforcement. The three outcome variables were (a) pre- versus post-intervention scores on the Wisconsin Behavior Rating Scale-Revised (Song et al., 1980) and Callier-Azusa Scale H (Stillman & Battle, 1986), (b) the number of tangible symbols acquired to criterion (80% correct over three consecutive days), and (c) generalization of tangible symbol use. This latter measure was derived from monthly classroom observations. The results from the two standardized measures indicated generally positive changes from the pre- to post-intervention scores, although no analyses were conducted to determine if any of these changes were statistically significant. The number of tangible symbols acquired per student ranged from 16–98 (M = 43). Generalization was reported as the proportion of observation intervals with the use of tangible symbols in the first five sessions versus the last five sessions. This comparison showed an increase for six of the nine students. However, in many cases the proportional increases were minimal (e.g., a .01 increase) and, again, no analyses were conducted to determine if any of these increases were statistically significant. Still, with respect to the main dependent variable (the number of tangible symbols acquired), the outcomes of this study could be seen as positive in that all students appeared to have learned to use at least 16 tangible symbols after the intervention compared to having no such tangible symbol use prior to intervention. However, this claim needs to be interpreted with caution because the study did not include a control group or even any control conditions (e.g., an initial baseline phase prior to intervention). The positive results with respect to number of tangible symbols acquired must, therefore, be seen as promising yet tentative, due to lack of an experimental design.

In the second study, Turnell and Carter (1994) provided intervention to an 8-year-old boy with a severe intellectual disability, athetoid quadriplegia, seizure disorder, and moderate hearing loss. Intervention focused on teaching the child to use tangible symbols for requesting access to three preferred leisure objects/activities: riding a bike, playing with a spinning toy, and using a walking frame. A yellow handgrip, identical to the handgrips on the bike, was the first tangible symbol taught. For the second activity (spinning toy), the tangible symbol was a red square holograph that was similar to the spinning toy in color and texture, yet reduced in size. The third tangible symbol (for the walking frame activity) was a padded blue vinyl square with a metal rod, which matched materials of the walking frame. Each symbol was mounted on a 12 × 13 cm card. The child received baseline and intervention phases, with the onset of intervention staggered across the three activities, in line with the requirements of a multiprobe multiple baseline design (Kennedy, 2005). At baseline, a preferred object was placed in view, but out of reach. The tangible symbol card for that object/activity was placed within reach along with two distractor symbols (e.g., a card with a sponge affixed to it). The teacher made eye contact and looked expectantly while waiting 10 sec. If the boy selected the correct symbol within 10 sec, he was given access to the corresponding object/activity for 5–10 min. If no correct response occurred within 10 sec, the object was removed. Intervention trials were similar to baseline trials except that if the boy did not make a correct request within 10 sec, he was prompted to select the correct tangible symbol before gaining access to the preferred object/activity. To prompt a correct response, the teacher looked at and touched the correct symbol (i.e., modeling). If the child did not respond to this, the teacher physically assisted the child to touch the correct symbol. Once the child touched the correct symbol, regardless of whether the teacher prompted the response or not, access to the corresponding object/activity was provided. It is important to note that a number of procedural modifications were made to the intervention. These modifications were based on an analysis of the child’s errors during the initial intervention sessions to request the bike. For example, the tangible symbol and distractor symbol were placed farther apart from each other and in a position where the boy did not have to cross his midline to select the correct tangible symbol. These modifications were intended to compensate for the child’s poor motor control. With these intervention procedures and modifications, the percentage of trials with a correct response increased from 0% in baseline to 80–100% within 25 sessions. Acquisition was slowest with the first symbol (bike required 25 sessions) compared to the second symbol (spinning toy required 6 sessions) and the third symbol (walking frame required 5 sessions). Use of the three tangible symbols also generalized to a different setting and to a different communication partner. The newly acquired requesting skills were maintained for 1–3 weeks after intervention. A strength of this study is the use of the multiprobe multiple baseline design, which convincingly demonstrated that the intervention procedures and modifications were most likely responsible for the increase in correct use of the tangible symbols; however, the study’s external validity must be considered limited because intervention was provided to only one child. Generality is further limited because the participant was taught only three tangible symbols for a single communication function (requesting access to preferred leisure objects/activities).

In the third study, Rowland and Schweigert (2000) collected data on 41 public school students (24 boys and 17 girls). The students ranged from 3–18 years of age, with a severe intellectual disability, severe motor impairment, and communication needs to be interpreted with caution because the study’s external validity must be considered limited because intervention was provided to only one child. Generality is further limited because the participant was taught only three tangible symbols for a single communication function (requesting access to preferred leisure objects/activities).
Tangible Symbols

The students were described as having (a) autism (n = 9), (b) developmental delay (n = 32), (c) hearing impairment (n = 8), (d) intellectual disability (n = 9), (e) medical fragility (n = 6), (f) orthopedic impairment (n = 23), (g) seizure disorder (n = 8), (h) vision impairment (n = 23), or (i) a combinations of these conditions, which is why the above numbers exceed the total sample size. AAC intervention was indicated because the students had “little, if any, conventional communication skills” (p. 64). The intervention aimed to teach these students to use tangible symbols for “symbolic” communication (p. 63). The symbols mainly represented highly preferred objects. Examples included (a) a few raisins glued to a card to represent/request snacks, (b) a wooden cutout in the shape of an apple to represent the school cafeteria, and (c) car keys to represent going out. Intervention began by teaching the children to select tangible symbols to request preferred objects/activities. Additional communicative functions (naming objects and commenting) were targeted as students made progress in learning to request. Two-dimensional symbols (e.g., color photographs) were introduced to some students. The teaching procedures were not described in detail for each child, but appeared to have included time delay, response prompting, prompt fading, error correction, and differential reinforcement. For example, in the presence of preferred objects, the teacher would ask (and simultaneously produce the manual signs for the phrase) What do you want? The teacher would then wait for the student to select the tangible symbol corresponding to the available object. Correct requests were reinforced by giving the student the requested object. If necessary, the teacher would direct the student’s attention to the array of tangible symbols and assist him or her in selecting the correct symbol. After 3 years, the students were assessed to determine how many tangible symbols they had acquired. Prior to starting intervention, none of the 41 students reportedly used any tangible symbols. With intervention, 35 students acquired from 12–40 symbols to the criterion of 80% correct over two consecutive sessions. Post-hoc analyses suggested the non-responders showed limited intentionality, were difficult to engage, and showed inconsistent use of informal communication behaviors, which were also difficult to interpret. Overall, the results for acquisition were mixed in that most (n = 35; 85%), but not all of the 41 students learned to make requests with tangible symbols. However, these findings must be interpreted with caution because the study did not employ any type of experimental design or controls. In addition, 6 of the 41 students did not respond to intervention, suggesting the approach will not be effective for a fair percentage of students who require AAC intervention.

In the fourth study, Trief (2007) worked with 25 students who ranged from 4–16 years of age. The students were described as having multiple disabilities, which involved combinations of severe cognitive delay, physical disabilities, and vision impairment (10 of the students were blind). Levels of intellectual functioning were not specified, but all of the students were described as having little or no expressive language. The tangible symbols were 28 whole objects or parts of objects, each representing a different activity. For example, the front face of a kitchen timer was the tangible symbol for break time and a toothbrush was the tangible symbol for brushing one’s teeth. Symbols were affixed to 10 × 15 cm cards. Intervention aimed to teach the students to select tangible symbols that corresponded to the activity that they were about to begin. Intervention was conducted on a daily basis over an entire school year. The teaching procedures involved an initial verbal cue by the communicative partner (e.g., It’s time for music.) followed immediately by the presentation of two tangible symbols, one of which represented the verbally designated activity (e.g., MUSIC). Students were prompted to touch/look at the two symbols and then select and hand over the correct symbol to the communicative partner. Incorrect selections resulted in removal and then re-presentation of the tangible symbols; a procedure that could be repeated up to five times. A daily record was kept of the number of correct symbol selections by each student, compared to the number of opportunities provided. These data indicated that the percentage of correct responses increased from 3% in the first month of intervention to 73% in the final month; however, not all students showed evidence of learning. Indeed, while 5 students were reported to have learned to use all 28 symbols and 10 students learned from 1–20 symbols, the remaining 10 students did not learn to use any of the 28 symbols correctly. These latter 10 non-responding students were described as being “the most severely delayed in cognitive, motor, and visual skills” (p. 617). The authors noted that the most frequently used symbols were also the most iconic symbols. Overall, the results should be viewed as mixed because 10 of the 25 students did not learn to use any tangible symbols despite a lengthy period of intervention. The positive findings for the other 15 students must also be interpreted with caution because it is not clear what criteria were established for deciding when a symbol had been learned. In addition, the study appears to be an open-trial (intervention only) design, which limits the ability to attribute student gains to the intervention. A third limitation is that it was not clear what communicative function(s) was taught. Selecting the toothbrush symbol prior to engaging in brushing one’s teeth, for example, could be viewed as a request (after selecting the symbol, the student then accessed the corresponding activity), but one might also view this as a type of naming/transitiing task (naming the next activity in the classroom routine). In any event, it is not clear what, if any, reinforcement was contingent upon correct responses. It is possible that access to the corresponding activities did not function as reinforcement for the 10 students who did not learn, which might explain their
lack of progress. Still, the positive results for 15 of the 25 students suggest a promising approach (i.e., teaching students to select the symbol corresponding to the next scheduled activity) for incorporating a large set of tangible symbols into the daily classroom routine.

The fifth study, by Lund and Troha (2008), involved three students aged 12, 13, and 17 years. All three were described as blind and having cognitive impairment and severe language delays, but the levels of intellectual functioning and communication impairment were not specified. Each child was taught to use a single tangible symbol to request a preferred object/activity. For one student, a marble covered by masking tape was used to request computer access. This symbol shared features with the real computer mouse. The second student’s tangible symbol was a piece of plastic with rice in it, which sounded like a preferred toy (a rain stick). The tangible symbol for the third student was a piece of cloth to request access to a pillow. Intervention was conducted in three phases, based on procedures developed by Frost and Bondy (2002) for the Picture Exchange Communication System (PECS). Specifically, in Phase 1 students were taught to pick up the tangible symbol and hand it to the communicative partner in exchange for the corresponding real object. To teach this skill, the student was prompted using hand-over-hand guidance, the least-to-most prompt hierarchy, and time delay (Duker et al., 2004). In Phase 2, the communicative partner moved away from the student, and thus the student had to select the tangible symbol and locate the communicative partner so as to complete the exchange. This was taught using similar prompting tactics to those used in Phase 1. In the final phase, students were taught to select the correct symbol from a two-symbol array that now included the target symbol and a distractor. This symbol discrimination was taught using physical guidance to interrupt attempts to select the distractor and then a slight nudge towards the location of the correct symbol. Intervention began after an initial baseline phase when the teaching procedures were not implemented. Baseline was longer for each successive student, in line with the requirements of a multiple baseline across participants design (Kennedy, 2005). None of the students showed any independent/correct requests with the tangible symbols during baseline. With intervention, each of the three students learned the initial (Phase 1) exchange to criterion (80% independent) in 10, 17, and 26 sessions, respectively. Two of the three students also reached 60% to 80% correct in Phase 2 (travel to the communicative partner), but only one student progressed to the third (symbol discrimination) phase, where he reached 80% correct. Two major strengths of this study are the experimental design and adaptation of an evidence-based intervention protocol (PECS; Frost & Bondy, 2002). The results suggest a promising approach for extending the use of the PECS approach to blind students who require AAC, but replications with additional participants are needed to assess the generality of this PECS adaptation.

In the sixth study, Parker et al. (2010) also adapted the PECS protocol (Frost & Bondy, 2002) for a 7-year-old girl. The student had autism and a rare inherited eye disease associated with severe vision impairment (Leber’s congenital amaurosis). She was described as having an intellectual disability, but her level of intellectual functioning had not been formally assessed. Her communication skills were assessed as being at the 12-month level and consisted of some “vocalizations as well as rocking back and forth on a swing to indicate ‘more.’” (p. 4). The researchers used three-dimensional whole- or partial-objects glued to laminated squares as the tangible symbols (e.g., lid from a canister of clay to represent playing with modeling clay). Her tangible symbols represented preferred objects/activities and the intervention followed the initial phases of the PECS protocol. Due to her vision impairment, however, the PECS protocol was adapted by using auditory cues to orient her to the presence of preferred objects (e.g., rustling the snack wrapper) and to the location of the communication partner (e.g., the partner might have said: I am going to your desk with the toy.). The student was also allowed to touch the tangible symbols prior to making a symbol selection, so as to facilitate the discrimination between available symbols. The effects of intervention were evaluated by comparing performance during a no-intervention baseline phase to her performance across five sequential intervention phases: (a) initial exchange, (b) distant partner, (c) symbol discrimination and learning new symbols, (d) constructing multi-symbol requests (e.g., I WANT + TOY), and (e) generalization to shops in the community. During baseline, the girl never correctly used tangible symbols to request preferred objects. With intervention, she reached 87% correct on making the initial exchange within three sessions and then 100% in finding the distant partner. For the third intervention phase (symbol discrimination) she reached the 90–100% level in four sessions and maintained this high level of performance as new tangible symbols were taught. Multi-symbol requests were made with varying degrees of accuracy (approximately 70–97% correct) and were also used at this level in the generalization setting. In total, the girl learned to use 24 different tangible symbols to request preferred objects. However, the sequential intervention design is pre-experimental and thus does not rule out threats to internal validity, such as history, maturation, and practice. Still, there were large and immediate changes from baseline to the initial intervention phase and a high level of performance was quickly reached and maintained within each subsequent intervention phase. These trends are highly suggestive of a strong intervention effect. The study extends the results of Lund and Troha (2008) by progressing to the additional sentence-construction phase of the PECS protocol and by teaching a relatively large vocabulary of 24 tangible symbols.
symbols; however, the study’s external validity is limited, in that the intervention was provided to only one participant.

The seventh study, by Ali, MacFarland, and Umbreit (2011), involved four students who were 7, 8, 13, and 14 years of age, respectively. The students were each diagnosed with moderate cognitive disabilities and also were blind or visually impaired. Three students also had autism and one had cerebral palsy. The students received intervention in their classroom by staff members who were trained to implement the PECS protocol (Frost & Bondy, 2002). Intervention aimed to teach the students to use tangible symbols to request preferred foods, toys, and/or activities. The intervention sequence followed the first three phases of the PECS protocol: Phase 1, initial exchange, Phase 2, move to the communicative partner, and Phase 3, discriminate between two tangible symbols. The tangible symbols consisted of three-dimensional whole objects, partial objects, or samples of objects affixed to cards. From three to six preferred objects/activities and at least one nonpreferred object/activity were identified and corresponding tangible symbols created. For intervention, the PECS protocol was modified in light of the students’ visual impairments. Specifically, for Phase 1, the student was given a small sample of a preferred object/activity to gauge interest/motivation. If motivation was present (e.g., the student ate the food sample or played with the toy), then an instructional trial was implemented. This consisted of first allowing the student to explore/touch the offered preferred object (e.g., moving the preferred object close, letting the student touch the preferred object, pairing object presentation with an orienting noise, and, for food items, allowing the participant to smell the offered item). To teach the initial exchange, participants were physically assisted (by a second staff person who stood behind the student) to remove the corresponding tangible symbol and hand it to the communicative partner. Prompts were faded and errors corrected using backward chaining and the backstep strategy described by Frost and Bondy. When the student had made the initial exchange, the communicative partner made a few praising comments and, importantly, provided access to the corresponding real object/activity. For Phase 2, the communicative partner moved away from the child (about .75 m) and the second staff person prompted the student to remove the tangible symbol and move to the communicative partner to complete the exchange. Similar prompting and error correction tactics were used in Phase 3 to teach students to discriminate between two tangible symbols (one representing a preferred object/activity and one representing a nonpreferred object/activity).

The effects of this intervention were evaluated in a variation of the multiprobe multiple baseline across students design described by Kennedy (2005). Specifically, each student received the same experimental sequence (baseline, Phase 1 intervention, Phase 2 intervention, Phase 3 intervention, and maintenance), but the students started the baseline phase at different points in time and their baseline sessions spanned differing periods of time. During baseline, the students never made a correct request. With Phase 1 intervention, correct requesting increased to 100% within three to four (10-trial) sessions. With Phase 2 intervention, all four students quickly came to make requests from the distant partner, reaching 100% within one to eight sessions. Performance in Phase 3 was generally in the 60–100% correct range. A high level of performance (80–100% correct) was observed during the final maintenance phase when prompting was discontinued. During this final phase some trials were conducted outside the classroom to assess generalization, which was 100%. These data provide a convincing demonstration that the intervention procedures were effective in teaching the students to use from three to six tangible symbols. The students learned to use the symbols to request access to preferred objects/activities from a present and distant communicative partner and to discriminate between symbols for preferred versus nonpreferred objects/activities. These requesting skills were maintained and generalized to a second setting. In line with the findings of Lund and Troha (2008) and Parker et al. (2010), this study is important in demonstrating another successful adaptation of the PECS protocol for use with four blind or visually impaired students and tangible symbols.

In the eighth study, Roche et al. (2013) provided intervention to two boys. The boys were aged 11;10 and 9;4. Both boys had been diagnosed with autism and had expressive language ages of less than 2 years on the Vineland Adaptive Behavior Scale, second edition (Vineland-II, Sparrow, Cicchetti, & Balla, 2005). Intervention focused on teaching the children to request access to six preferred cartoon movies (e.g., Finding Nemo, Shrek) shown on an Apple iPad™. The study was designed to compare acquisition of, and preference for, three response options: (a) tangible symbols, (b) exchanging line drawings, and (c) directly pressing the play function on the iPad. The tangible symbols consisted of miniature figurines that were made to resemble each cartoon’s main character (e.g., a red clown fish for the Disney movie, Finding Nemo). The line drawings (picture exchange option) consisted of colored line drawings of the main character (e.g., a line drawing of a red clown fish for Finding Nemo). The direct selection option consisted of directly activating the play function on the iPad screen. The children received baseline, intervention, and a choice phase. Intervention was staggered across the two children in a multiple baseline design (Kennedy, 2005). Acquisition rates were compared during intervention using an alternating treatments design (Kennedy, 2005). In baseline, a movie was started and then paused after 1 min. The tangible symbols or line drawings or iPad were placed in reach depending on whether it was a tangible, picture exchange, or direct selection trial, respectively. After a 10 sec pause, the trainer recorded
responses and the movie was re-started for another 3 min. Baseline sessions consisted of six trials, one for each movie and two trials for each response option (i.e., two trials for the tangible symbols, two for the exchange of line drawings, and two for the use of a direct selection response). Intervention sessions were similar to baseline except that if the boys did not make a correct response within 10 sec, they were prompted to select the correct tangible symbol (or line drawing or to activate the play function on the iPad) before restart- ing the movie. Prompting involved a verbal cue and physical guidance. After intervention, 48 choice trials were implemented to assess whether the boys showed a preference for the tangible symbols, line drawings, or direct selection response. For these 48 trials, all three options were within reach and the child could choose which option to use for each trial. During baseline, neither boy made any correct responses. With intervention, the boys acquired all three responses to criterion (100% correct over three sessions). One boy (Leroy) reached criterion with each option in either 5 or 6 ses- sions. The other boy (Max) reached criterion with the direct selection response in 7 sessions and with the picture exchange and tangible symbols in 16 and 17 ses- sions, respectively. During the choice phase, Leroy used tangible symbols 71% of the time, whereas Max used tangible symbols 48% of the time and the line drawings 33% of the time. The results suggest that tangible sym- bols were learned at comparable rates to exchanging line drawings and direct selection. Tangible symbols appeared to be preferred by Leroy and to a lesser extent by Max. Overall, this study supports the findings of Turnell and Carter (1994) and suggests that tangible symbols might be a viable and preferred option for some children with developmental disabilities who do not have vision impairment.

In the final study, Trief et al. (2013) monitored tangible symbol use in 43 students who were from 3–20 years of age. All were blind or visually impaired and mainly nonspeaking (91%). More than half (62%) of these students were unable to walk independently. Levels of intellectual functioning were not specified. Another group of 10 similar students was also moni- tored. This group of 10 children did not participate in the field study and were described by the authors as a nonintervention comparison group. For students in the intervention group, the authors provided teachers and therapists with a set of 55 standardized tangible sym- bols. This set was derived from a survey of school staff and expert consultation (Trief et al., 2009). The symbols consisted of whole objects or parts of objects. Symbols were made from corrugated cardboard and affixed to white cards with the corresponding printed word added to the bottom of the card. For example, a cardboard spoon was used as a tangible symbol for the school lunchroom. The 43 field-study students received intervention for 7 months. For intervention, teachers and therapists were “encouraged to introduce the sym- bols for a variety of communicative functions, including requesting and labeling an activity, person, or object; choosing between two activities or objects; and direct- ing the behavior of others” (p. 184). Symbol knowledge was assessed with two types of tests. First, pre- and post-intervention testing involved presenting two symbols and asking Where’s [name of symbol]? Second, in situ testing occurred on a daily basis during the intervention. In situ testing involved presenting two symbols and asking the student to Show me [name of symbol]. These in situ tests were implemented immediately after a teacher or therapist had introduced the symbol during a classroom activity. Results for the stu- dents in the field study group were discrepant across the two testing methods. Specifically, the pre-post tests showed a decrease in the number of participants who demonstrated at least one correct response, from 10 students at pre-testing to seven students at the post-test. None of the students in the nonintervention comparison group made any correct responses. In contrast, in situ test results, conducted only with the students in the field study group, revealed an increase in the mean percentage of correct responses over the interven- tion period from 26% in Month 1 to 46% in Month 7; however, overall performance did not exceed chance (50%) level responding. These discrepant findings make it difficult to judge the overall effects of the inter- vention. It is also difficult to determine exactly how the teachers and therapists introduced symbols to the stu- dents, which would therefore make it difficult to repli- cate this seemingly naturalistic intervention approach. Another limitation is that there do not appear to have been any inter-rater agreement checks on the students’ responses, making the data collection of unknown reli- ability/accuracy. Furthermore, while the inclusion of what seems to be a control group is laudable, these 10 students did not receive the second type of testing, which limits comparison of them to the 43 students who received the intervention. A final limitation is that the results for the in situ tests are reported only in terms of mean percentage of correct responses and not in terms of the number of students making correct responses, which is how the data were reported for the first type of testing. Thus, it is not possible to determine the number of students who showed improvement in situ over the course of intervention. Overall then, despite a relatively large sample of students and a large set of tangible symbols, it remains unclear how many students learned to use tangible symbols, how many different tangible symbols each student learned to use correctly, and what communicative functions the students expressed via tangible symbols.

Discussion
We identified nine studies reporting on the use of tangible symbols as an AAC option for 129 individuals with developmental disabilities. Our preceding summary and analysis of these studies point to several aspects of the existing literature that merit discussion.
This discussion is intended to assist readers in drawing some tentative conclusions with respect to the use of tangible symbols within AAC interventions for individuals with developmental disabilities.

First, in terms of participant characteristics, the nine studies included a total of 129 individuals ranging from 3–20 years of age. All participants were students attending preschools, elementary schools, or secondary schools, which is also where the interventions were implemented. The 129 students had varying combinations and degrees of the following diagnoses: (a) developmental delay, (b) intellectual disability, (c) autism, (d) physical impairment, (e) hearing impairment, and (f) vision impairment/blindness. However, in many studies the degree of intellectual disability was not specified. Still, it appeared that nearly all participants had some degree of intellectual disability as well as complex communication needs, meaning they had little or no spoken language (Beukelman & Mirenda, 2013). Overall, these 129 students could be viewed as candidates for AAC intervention because most had limited or no speech due to developmental disability. They might also be viewed as logical candidates for use of tangible symbols, given that most were blind or visually impaired and appeared to have significant intellectual disabilities that likely meant concomitant memory and representational skill deficits. However, participants’ memory and representation skills were not directly assessed, so this potential indication for the participants (i.e., that tangible symbols are less taxing on memory and representational skills compared to other types of AAC symbols) remains conceptually appealing, but empirically unanswered.

Second, in terms of the tangible symbols used, most studies used three-dimensional whole objects or partial objects. In seven studies, it appears that the symbols created were unique and individualized for the purpose of the study. In two studies (Trief, 2007; Trief et al., 2013), symbols were drawn from larger sets of standardized symbols. There may be advantages and disadvantages to the use of individualized versus standardized symbols. The individualized approach, for example, might increase the symbols’ relevance to individuals and their communicative partners, whereas the use of symbols from larger sets of standardized symbols could enhance replication efforts and assist unfamiliar listeners in deciphering the communicative message being expressed when the individual selects a particular symbol. The use of standardized or individualized symbol sets might be an important variable that could influence acquisition of such symbols for communicative purposes, but there appear to be no studies that have addressed this issue.

Whether specifically created or standardized, none of the studies appeared to have systematically measured, controlled, or assessed the iconicity, concreteness, and/or realism of the symbols. Trief (2007) reported that more iconic symbols were most frequently learned, but this claim appears to have been based on a post-hoc analysis and it is unclear how iconicity was assessed. Overall, none of the studies were specifically designed to experimentally investigate the effects of symbol iconicity, concreteness, and/or realism on intervention outcomes. This is surprising, given that a higher degree of iconicity, concreteness, and realism are purported advantages of tangible symbols (Bruce et al., 2011).

The seeming neglect of iconicity, concreteness, and/or realism might reflect the fact that most participants were blind/visually impaired, and that iconicity, concreteness, and realism are often conceptualized more generally in terms of how much the symbol looks like the corresponding referent. However, the ease with which one might learn to discriminate among any set of tangible symbols by feeling for differences in their shape rather than by sight, for example, could also potentially be influenced by the symbols’ relative iconicity, concreteness, and/or realism. For example, using a part of a toothbrush handle might be less iconic, concrete, and realistic than using an entire toothbrush as a tangible symbol for requesting that one’s teeth be brushed (Trief, 2007, p. 617).

The seeming neglect of symbol iconicity, concreteness, and/or realism might alternatively reflect the fact that most symbols were mainly created/selected to represent students’ preferred objects/activities and classroom activities. This functional/ecological approach is consistent with evidence suggesting that functionality (symbols representing highly preferred objects/activities) is generally more important than iconicity, at least when teaching initial requesting skills (Schlosser & Sigafoos, 2002). If preferred and/or concrete objects/activities are being introduced it is recommended to choose iconic rather than opaque symbols. Although opaque symbols for preferred objects can be learned, it usually takes more time to do so.

Third, in terms of the communication skills taught, eight of the nine studies targeted requesting. In the one other study (Trief, 2007) requesting was not explicitly mentioned, but might have been covered under more general functions (e.g., naming activities prior to engaging in the activity, regulating one’s own actions, and directing the actions of others). Indeed, requesting was the only targeted function in five studies (Ali, MacFarland, & Umbreit, 2011; Lund & Troha, 2008; Parker et al., 2010; Roche et al., 2013; Trewell & Carter, 1994). Three studies (Rowland & Schweigert, 1989, 2000; Trief et al., 2013) targeted requesting plus one or more additional functions/skills (e.g., naming objects/activities, protesting, and confirming). The overall focus on requesting is consistent with the argument that requesting is highly functional and of considerable benefit to the individual because it enables him or her to express wants, needs, and preferences (Reichle, York, & Sigafoos, 1991). One might, however, question the extent to which the requests taught in these studies were functional, because only one study (Parker et al., 2010) checked for a correspondence between what the student requested with a tangible
symbol and what she then actually selected (i.e., in most cases the student was given the corresponding item by the communicative partner). In this one case described by Parker et al., the student appeared to show a high degree of correspondence, but other studies have found this to be a problem (Reichle, Sigafoos, & Piche, 1989; Sigafoos, Ganz, O'Reilly, Lancioni, & Schlosser, 2007; Sigafoos & Kook, 1992). Fortunately, these studies have also demonstrated effective instructional procedures for ameliorating correspondence problems, which might be equally applicable with tangible symbols.

Fourth, in terms of the intervention approaches, the studies generally used well-established systematic instructional procedures (Duker et al., 2004), such as response prompting, time delay, and differential reinforcement (e.g., Roche et al., 2013; Rowland & Schweigert, 1989, 2000; Trief, 2007; Turnell & Carter, 1994). Three studies using a modified PECS protocol (Ali et al., 2011; Lund & Troha, 2008; Parker et al., 2010). Trief et al. (2013) used a manualized intervention protocol (see http://www.aph.org/advisory/2013 adv06.html).

Fifth, in terms of intervention outcomes, 54% (n = 70) of the 129 students appeared to make progress, as defined by learning to use at least one tangible symbol for communicative purposes. More specifically, outcomes for each individual study could be classified as positive (all participants learned at least one tangible symbol), mixed (some, but not all participants learned), or negative (none of the participants learned). With this classification scheme, six studies had positive outcomes (Ali et al., 2011; Lund & Troha, 2008; Parker et al., 2010; Roche et al., 2013; Rowland & Schweigert, 1989; Turnell & Carter, 1994), and three studies had mixed results (Rowland & Schweigert, 2000; Trief, 2007; Trief et al., 2013). Overall, the results suggest that systematic instruction was generally effective for teaching participants to use tangible symbols for requesting preferred objects.

Sixth, our summary of the designs used in these studies (Table II) revealed that the majority of participants (n = 119, 94%) were enrolled in studies with pre-experimental or quasi-experimental designs. Indeed, only four studies – with a mere 10 students – employed experimental designs capable of providing a rigorously convincing demonstration of an intervention effect (Ali et al., 2011; Lund & Troha, 2008; Roche et al., 2013; Turnell & Carter, 1994). Thus, the other studies were capable of providing only suggestive evidence of an intervention effect. This means that the generally positive outcomes noted before must be interpreted with caution. Still, data from the four experimental studies, combined with the suggestive evidence from the other five studies, would seem to support a conclusion that tangible symbols are a promising AAC option for individuals with developmental disabilities, perhaps especially for people who are also blind/visually impaired.

Because of this promise, additional research into the relative merits of tangible symbols is warranted. There are four obvious issues that future studies should investigate. First, it would seem useful to evaluate the effects of symbol iconicity, realism, and concreteness on intervention outcomes. Another area for future research would be to compare the relative advantages and disadvantages of using standardized versus individualized symbols. Third, the memory and representational skill demands of tangible symbols should be studied to determine whether such symbols are in fact suited to persons with significant memory and representational skill deficits, regardless of whether or not these individuals have visual impairments. A fourth issue is whether tangible symbols are learned faster, maintained better, and preferred over other AAC modes such as manual signs, line drawings or photographic symbols, and use of speech-generating devices with line drawings or photographic symbols. Results from the one study that involved a comparison (Roche et al., 2013) found that tangible symbols compared favorably to the use of a picture exchange system involving line drawings. It was also the case that the participants in this study most often chose to use tangible symbols. However, the Roche et al. study was limited in that it involved only two participants. Future studies are needed to compare the use of other AAC options. To this end, it would seem to make sense to compare manual signs with tangible symbols, given that these two options are perhaps most relevant to individuals with developmental disabilities who are also blind/visually impaired. However, additional comparisons involving line drawings or photographic symbols might also be useful for participants with developmental disabilities who are not blind or visually impaired, but who do require AAC intervention.

Future research of the type outlined above might provide data that would enable clinicians to make better decisions regarding the use of tangible symbols within AAC interventions for individuals with developmental disabilities. For now, the existing review of nine studies suggests that tangible symbols are likely to be a promising AAC option for some individuals with developmental disabilities.

Note

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References

(Asterisks indicate that the reference is one of the nine studies examined in this paper)


