Teaching Graphic Symbol Combinations to Children with Limited Speech During Shared Story Reading

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Abstract

The aim of this study was to determine the effect of an intervention strategy on the production of graphic symbol combinations in children with limited speech. Four children between the ages of 6;5 and 10;8 (years;months) with limited speech participated in the study. A single-subject, multiple probe design across three different types of semantic relations was used. Generalization to untrained exemplars was also monitored. Results were mixed across the 4 participants: 2 participants learned to combine symbols across different types of relations, maintained these skills post intervention, and generalized their skills to untrained combinations; and 2 participants showed less consistent evidence of learning. The effects, as measured during structured probes, were strong for one participant, moderate for another, and inconclusive for 2 others. Responses during shared story reading suggested that the measurement probes might have underestimated participants' ability to combine symbols.

Keywords: Aided communication; Augmentative and alternative communication; Graphic symbol combinations; Matrix strategy; Shared story reading

When children do not develop sufficient spoken language to meet their communication needs, graphic symbols such as Picture Communication Symbols™ [1] (PCS) may provide them with a way of expression that is alternative to or augments speech. Children relying on graphic symbols for expression often struggle to acquire the production of multiword messages (Smith, 1996; Soto & Toro-Zambrana, 1995; van Balkom & Welle Donker-Gimbrère, 1996). Research findings further indicate that young children with typical development who are able to combine spoken words are not automatically able to transfer this skill to graphic symbols (Smith, 1996; Sutton & Morford, 1998; Sutton, Trudeau, Morford, Rios, & Poirier, 2010; Trudeau, Sutton, Dagnais, de Broeck, & Morford, 2007). Older children with higher receptive (spoken) language skills and presumably better metalinguistic skills do seem to be able to produce combinations of symbols that mirror the pattern of spoken combinations, yet this process seems to demand cognitive-linguistic skills that are not necessarily required when producing spoken combinations (Smith, 1996; Sutton et al., 2010; Trudeau et al., 2007). Studies with children using AAC also suggest that receptive language abilities are associated with children's ability to combine graphic symbols (Sevcik, 2006). Factors that may contribute to the challenges experienced in producing graphic symbol combinations include (a) the non-linguistic and iconic nature of many graphic symbols (Smith, 2006), (b) a limited graphic symbol vocabulary with a predominance of nouns (Sutton, Soto, & Blockberger, 2002), (c) slow rate of communication and co-construction by partners, precluding the need or opportunity to produce longer utterances (Brekke & von Tetzchner, 2003), and (d) a lack of models from competent users of the same expressive modality (von Tetzchner & Grove, 2003). The cognitive and linguistic demands that are placed on the communicative dyad when communicating with graphic symbols are not always well-understood and may often be underestimated (Light & Lindsay, 1991; Thistle & Wilkinson, 2013). Boyer, Trudeau, and Sutton (2012) showed, for example, that graphic symbol sequences are not automatically interpreted as sentences by young children with typical development (aged 3 years), although older children (aged 6 years) with more advanced language skills had the ability to do so. Demands on working memory when recalling symbol locations are not always considered (Dukhovny & Soto, 2013; Thistle & Wilkinson, 2013), and the extent to which graphic symbols from commercially available symbol libraries are guessable by children with and without disabilities from different linguistic backgrounds may, at times, be overestimated (Dada, Huguet, & Bornman, 2013). Many aspects of graphic symbol communication, including the expression of multisymbol messages, may require direct teaching, because these skills often do not seem to develop without intervention.

A limited number of intervention studies have targeted the expression of graphic symbol combinations. Studies have shown that the use of aided input (i.e., adult models of word combinations using graphic symbols) within natural contexts is effective to promote the expression of imitated and spontaneous multi-graphic symbol combinations in children who require AAC (Binger, Kent-Walsh, Berens, Del Campo, & Rivera, 2008; Binger, Kent-Walsh, Ewing, & Taylor, 2010). In both these studies, researchers taught familiar partners (parents and educational assistants, respectively) to model utterances consisting of two graphic symbols to children with severe congenital speech impairments during shared storybook reading. Following each model, questions and expectant delays were used in both studies to elicit two-symbol responses from children; verbal prompts to do so were also incorporated into the latter study. Results of both studies indicated that the intervention was effective, as evidenced by changes in level and trend as well as by the percentage of nonoverlapping data (PND), across all participants. Because aided input techniques attempt to simulate the natural language environment that surrounds children acquiring speech, these techniques tend to be less specific in the exact models provided by adults and the exact combinations acquired by the children. The studies by Binger et al. (2008, 2010) did not directly monitor the children's understanding of their own productions and the meaningfulness of these productions.

Another intervention study that targeted the expression of graphic symbol combinations employed a hybrid intervention technique wherein indirect, naturalistic strategies were combined with teaching strategies that were more direct. Nigam, Schlosser, and Lloyd (2006) used the mand-model technique combined with a matrix strategy to target specific two-symbol combinations in structured teaching contexts. Two of the three participants showed a clear effect of the intervention as evidenced by PND as well as changes in level and trend, across the four sets of combinations targeted.

Matrix training strategies aim to facilitate recombinative generalization, referring to the ability to correctly respond to or produce novel combinations, the elements of which were previously taught in different combinations (Goldstein, 1983). This ability is fundamental to developing true language skills whereby individuals can understand and express novel utterances that they have not previously heard or expressed (Suchowierska, 2006). Researchers have successfully used the matrix strategy to facilitate generalized understanding and expression of semantic relations in children both with and without disabilities (e.g., Goldstein, 1983; Remington, Watson, & Light, 1990; Romski & Ruder, 1984; Striefel, Wetherby, & Karlan, 1976). In each case, researchers drew up a combination matrix, whereby a set number of lexical items fulfilling one specific semantic role was systematically combined with each of a set number of lexical items fulfilling another semantic role. Researchers then taught a limited set of strategic combinations from the matrix, and participants were able to generalize their responses to the remaining combinations.

Researchers have typically used matrix strategies in structured teaching contexts. These controlled environments have enabled researchers to show a direct link between the specific instruction given and the specific combinations acquired by the child. The implementation of matrix strategies in naturally-occurring interactive situations has not yet been explored. The study by Nigam et al. (2006), for example, used a formal teaching context wherein children were required to comment on an adult’s actions; and they did not measure whether participants could produce the combinations outside of this context in response to, for example, different elicitation materials. The present study proposed to extend the research on interventions aimed at fostering expressive graphic symbol combinations. We targeted specific two-symbol semantic relations that occur commonly among early two-word combinations (Brown, 1973) in order to maintain control of the input provided, and to ensure that there was correspondence between the stimulus used and a participant’s production. We used a matrix to generate intervention and generalization items; however, rather than teaching these structures in a decontextualized situation, we incorporated the intervention items into a story. Shared story reading is a common activity for parents/teachers and young children in many societies and represents a natural context within which language and literacy skills can be fostered (Snow & Ninio, 1986). The repeated reading of stories to children and their retelling of the stories that have been read to them can assist children to acquire new vocabulary (e.g., Arnold, Lonigan, Whitehurst, & Epstein, 1994; Dale, Crain-Thoreson, Notari-Syverson, & Cole, 1996; Hargrave & Sénéchal, 2000) as well as new syntactic structures (e.g., Bradshaw, Hoffman, & Norris, 1998; Whitehurst et al., 1988), and to incorporate these new words and sructures into discourse (Canut, 2001). Shared story reading provides a context where the vocabulary for interaction can be predetermined relatively easily, as the story pictures and text define the semantic content to a large degree. This is particularly useful in communication interactions supported by graphic symbols, where appropriate vocabulary and symbols for interaction need to be determined a priori. Story reading also involves the attention to graphic stimuli (i.e., pictures, text). Incorporating graphic symbols into this activity would thus seem contingent with the actions already taking place. Researchers and clinicians have successfully used story reading as a context for aided AAC interventions targeting various language skills (see Wood & Hood, 2004, for a review), including the production of symbol combinations (Binger et al., 2008, 2010). By incorporating specific semantic relations generated from a matrix into a more naturalistic context (i.e., shared story reading), we aimed to increase the external validity of the intervention as well as participants' motivation. We also used a least-to-most prompting hierarchy to elicit the production of symbol combinations from participants. The prompts were based on techniques used in naturalistic language teaching strategies and included expectant time delay (Halle, Baer, & Spradlin, 1981), questions, mands and models (Warren, McQuarter, & Rogers-Warren, 1984) as well as physical assistance to produce the symbol combinations (Angelo & Goldstein, 1990).

The research question posed was whether an intervention strategy that targeted two-symbol combinations using a hierarchy of prompts during shared story reading could facilitate the production of target and nontarget graphic symbol combinations in response to picture stimuli (not used in the story) by children with limited speech. Our hypothesis was that such an intervention strategy would indeed be successful in enabling children to produce such combinations.

Method

Participants

The ethical committee of the relevant higher education institution approved the study prior to commencement. We also obtained consent from the Gauteng Department of Education to recruit participants from schools catering to learners with special needs – schools within easily reachable distance. We obtained consent from the principals and governing bodies of five schools to recruit participants from the learners at the school. The directors of two centres for children with special needs (run as nongovernment organizations) also gave consent to allow us to recruit participants from among the children attending the centres. We than asked speech-language pathologists (SLPs) and/or class teachers to identify possible candidates from their classes or caseloads. Selection criteria were as follows: (a) English receptive language skills equivalent to at least a 30-month level, as determined by the Peabody Picture Vocabulary Test Revised (PPVT-R; Dunn & Dunn, 1981) or Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007), (b) English-medium education[2] for at least 1.5 years, (c) aged 10;11 or below in order for the stories used to be appropriate; (d) limited speech (defined as less than 30% intelligible in the semantic context – unfamiliar listener condition of the Index of Augmented Speech Comprehensibility for Children (I-ASCC; Dowden, 1997); (e) able to accurately direct select graphic symbols on a 21-item overlay; (f) able to correctly identify at least 75% of the graphic symbols used during intervention in response to the spoken word, with paired-associate training provided if necessary; (g) no history of the ability to combine graphic symbols; (h) functional vision and hearing; and (i) able to concentrate on a 10-min-long story. The latter three criteria were determined from parent, teacher, and SLP reports.

Teachers and SLPs at five schools and one center identified 10 possible candidates. Parental consent and child assent was obtained before screening commenced to determine whether the children complied with the selection criteria. All parents and children gave consent/assent. The researcher (first author) obtained background information from the parent, teacher, and SLP and also administered the PPVT-R (Dunn & Dunn, 1981) or PPVT-4 (Dunn and Dunn, 2007) as well as the I-ASCC (Dowden, 1997). Three children had scores lower than 30 months on the PPVT-4 and were therefore excluded. The researcher then assessed the ability of the remaining seven candidates to identify the symbols used in the study by providing each child with the communication board designed for the study (see description under Materials) and verbally requesting him/her to point to each of the 21 symbols in random order (e.g., *Show me BOY*). Incorrect responses were immediately corrected, in anticipation of the next step (training).

None of the participants achieved 100% correct identification, and therefore were provided paired-associate training of the symbols not correctly identified. The researcher pointed to the specific symbol while labelling it (e.g., *This picture shows RUN*). Symbols that were taught in this way were retested and retrained up to five times. All participants achieved 100% accuracy within one to two training sessions. The researcher then retested all 21 symbols. The cut-off for inclusion in the study was 75% or more correct on the retesting of all 21 symbols.

Although it would have been valuable to obtain a formal measure of cognitive functioning of the participants, the suitability of locally developed and international tests for children from the various linguistic and cultural groups in South Africa has been questioned. The suspected use of IQ testing in South Africa in the past for exclusionary and discriminatory purposes also makes the use of such testing a contentious issue.

Seven participants from four schools for learners with special needs met all of the the selection criteria. However, we subsequently had to exclude one participant due to noncompliance, while two others started combining symbols in the initial baseline phase prior to any intervention, in spite of reports from parents, teachers and therapist that they had not combined symbols before. These two participants had been using communication books each containing over 500 PCS symbols, but the arrangement of the symbols in the books (based on topics and parts of speech) may have precluded them from combining symbols. Due to an unstable baseline, we had to exclude them as well. In the end, four participants from three schools remained. Initially, we attempted to recruit participants whose home language was English; however, not enough participants could be recruited who met this criterion. Only 7% of all South African school pupils speak English at home, yet English is the dominant language in the education system (Davis, 2013) and parents often prefer historically better-resourced

English-medium schools[3] for their children (De Klerk, 2002). Participants were thus included even if English was not their home language, as long as they had received 1.5 yrs of English-medium education and also complied with the selection criterion for comprehension skills in English. Reports from parents, teachers, and SLPs indicated no concerns about vision or hearing. Other participant characteristics are summarized in Table 1.

Participant 1. Participant 1 was a girl, age 6;5. She attended an English-medium Grade R[4]/Grade 1 combined classroom at a public school for children with physical and/or learning disabilities. She made use of an electric wheelchair (self-operated) at home and a nonmotorized adapted buggy at school, which she could not propel herself. She occasionally made use of a communication book containing 360 PCS symbols. She pointed to one symbol at a time.

Participant 2. Participant 2 was a boy, age 8;0. He was attending Grade 1 at an English-medium public school for children with physical and/or learning disabilities. He used an electric wheelchair at home and at school, which he operated independently with his right hand. He had previously been given a communication board and book with PCS symbols containing vocabulary related to four or five categories (e.g., School, Home, I need/want). At the time of the study, these were no longer used, presumably because they had been too limiting.

Participant 3. Participant 3 was a boy, age 7;9. He was attending Grade R at an English-medium public school for children with physical and/or learning disabilities at the time of the study. He was ambulatory. His teacher used PCS symbols in class to illustrate themes that she taught (e.g., she would print PCS symbols of farm animals when teaching this theme). He was thus exposed to PCS, but had not been encouraged to use them for expressive purposes, and did not have a personal communication board or book.

Participant 4. Participant 4 was a girl, age 10;8. She was attending the junior English-

Table 1

Participant Characteristics

No	Age[a], gender	Disability	Home language and proficiency[b]	PPVT-scores	LDS	I-ASCC No context	I-ASCC Sem. context	Comprehension of targeted relations	Compr. of graphic symbols	Main communication modes
1	6;5 F	Spastic quadriplegia, suspected genetic condition (undiagnosed)	English	SS: 99 %ile: 47 Age eq: 6;1	294 c.a.w. 5	0%	3%	A-A: 9/10 P-P: 9/10 A-E:10/10	100% on 2nd trial	Answering yes/no questions, facial expression, pointing and eye-gazing to objects and people in the environment, limited number of gestures, infrequent use of communication book with 360 PCS symbols
2	8;0 M	Spastic quadriplegia following near-drowning incident at age 3	English and Northern Sotho Capabilities in Northern Sotho: 30/35 items (86%) correct[c]	SS: 73 %ile: 4 Age eq: 5;0	189 c.a.w. 139	13%	27%	A-A: 10/10 P-P: 10/10 A-E: 10/10	100% on 2nd trial	Single spoken words, vocalizations, word approximations
3	7;9 M	Cerebral Palsy (spastic quadriplegia with more involvement on left side)	Northern Sotho 17/35 items (49%) correct[d]	SS: 26 %ile: <0.1 Age eq: 2;6	185 c.a.w. 79	3%	17%	AA: 6/10 P-P: 8/10 A-E: 7/10	76% on 2nd trial	Vocalizations and word approximations, pointing to objects and people, some Makaton gesture approximations, miming, idiosyncratic gestures
4	10;8 F	Cerebral Palsy (spastic quadriplegia)	Tshivenda 24/35 items (69%) correct[e]	SS: 31 %ile: <0.1 Age eq: 3;4	158 c.a.w. 14	0%	7%	A-A: 8/10 P-P: 9/10 A-E: 10/10	95% on 2nd trial	Vocalizations, word approximations, pointing to objects and people, infrequent use of PCS boards in class

Note. SS = standard score; age eq = age equivalent; c.a.w. = clearly articulated words; A-A = agent-action; P-P = possessor-possession; A-E = attribute-entity. [a]Age at beginning of the study. [b] As tested by receptive subtests of Sotho Expressive Receptive Language Assessment (Bortz, 1997) for Participants 2 and 3 and the Venda Expressive Receptive Language Assessment (Bortz, 1997) for Participant 4. [c] A total raw score equivalent to 86% correct equates to Z score 1.54 and percentile 93.9 for 3.9-4.2-year-old isiZulu speaking children. [d] A total raw score equivalent to 49% correct equates to Z score -1.64 and percentile 5.1 for 3.9-4.2-year-old isiZulu speaking children. [e] A total raw score equivalent to 69% correct equates to Z score 0.10 and percentile 53.9 for 3.9-4.2-year-old isiZulu speaking children.

medium class at a double-medium (English and Afrikaans) public school for children with physical disabilities. She used a wheelchair at school (not self-propelled). At home, her mother carried her when she needed to change location. Participant 4 used two communication boards with 20 and 24 PCS symbols, respectively, to communicate in class. She usually needed prompting to use the boards, and would point to one symbol at a time. She did not use any boards at home; yes/no questions were used to clarify messages.

Design

We used a multiple probe design across behaviors, targeting three different types of semantic relations (agent-action, possessor-possession, and attribute-entity) in intervention. The study included a baseline phase during which the production of the combinations was monitored by means of probes for at least three consecutive sessions before intervention began. Intervention then commenced on the first type of semantic relation, while the other two remained in baseline. Although we attempted to systematically vary the order in which the three types of relations were taught across participants, the loss of three participants resulted in the order being only slightly varied across the remaining four participants. We probed the production of the combinations (as well as generalization to untaught combinations) during the intervention phase.

We set both a teaching and a learning criterion. Intervention ceased on the treated semantic relation when either of the following conditions were met: once a participant's score increased by at least two correct answers (i.e., 40%) for two consecutive probes as compared to baseline average (with a minimum of three probes conducted during intervention), or after a maximum of nine intervention sessions. We made the decision to cap the intervention sessions in order to prevent participants' boredom and fatigue (from repeated rereading the same story) from negatively influencing the results. Ten intervention sessions would have corresponded to two academic weeks (workdays excluding weekends). However, as probes were conducted during every second session starting on the first intervention session, the number of intervention sessions needed to be uneven. Hence, we decided on nine sessions.

Materials

We chose three types of semantic relations for the study, namely agent-action, possessor-possession, and attribute-entity. Brown (1973), based on data from children from a variety of language backgrounds, identified these relations as ranking amongst the five most frequently-occurring relations in children's early two-word combinations. Making use of the matrix strategy (Nelson, 1993; Nigam et al., 2006), we systematically combined two words fulfilling a specific semantic role with five words fulfilling another semantic role for each of the three types of semantic relations targeted. This resulted in 10 combinations per type of semantic relation. Of these, five were used as intervention items, while the remaining five formed the generalization set. The combinations are provided in Table 2.

We acknowledge that some of the combinations are ones not typically used or heard (e.g., *DOG LAUGHS*). Constraints such as the ease with which words making up the combinations could be represented with symbols that were easily recognizable and distinguishable, and the need for a specific subset of the combinations to be incorporated into a short story with a simple story line, did influence the set of combinations that were used.

The researcher constructed a communication board comprising of 21 graphic symbols (17 PCS symbols and four hand-drawn symbols) derived from the three matrices (Appendix A). She organized the graphic symbols according to the Fitzgerald key (Fitzgerald, 1959) and color coded the background of each category. Categories were (a) Who (agents) and Whose (possessors), coded in purple; (b) Verbs (actions), coded in pink; (c) Adjectives (attributes),

Table 2

Summary of Combinations Targeted During Intervention and Used to Test Generalization

Semantic relation	Intervention items	Generalization items
Agent-action	The dog cries	The dog falls
	The dog sleeps	The dog runs
	The boy falls	The dog laughs
	The boy runs	The boy cries
	The boy laughs	The boy sleeps
Possessor-possession	The girl’s hat	The girl’s shoe
	The girl’s nose	The girl’s tummy
	The girl’s hand	The bunny’s hat
	The bunny’s shoe	The bunny’s nose
	The bunny’s tummy	The bunny’s hand
Attribute-entity	Dirty shirt	Dirty car
	Dirty pants	Dirty aeroplane
	Dirty teddy	Broken teddy
	Broken car	Broken shirt
	Broken aeroplane	Broken pants

coded in blue; and (d) What (objects), coded in yellow. The communication board was used for all participants during the probe test as well as during story reading.

The researcher developed three stories. Each of these was used to teach the expression of a specific type of semantic relation. One story contained the five agent/action combinations, one the five possessor-possession combinations, and one the five attribute-entity combinations. Each combination was incorporated twice in the story to allow two opportunities to target each item. A graphic artist illustrated the stories (Appendix B). Participants did not have access to the communication board or the stories to practice the two-symbol combinations outside of the intervention.

The probe test was developed to probe the participants' ability to express the semantic relations (both those targeted during intervention and those used to test generalization, as illustrated in Table 2) using graphic symbols during baseline, intervention, and postintervention. Material consisted of 30 A4 colored pictures -- 23 hand-drawn by the researcher and 7 taken from Black Sheep Press™ (2004, 2006) -- depicting each of the 30 semantic relations (e.g., a dog sleeping, a dirty shirt).

Procedures

The researcher scheduled sessions as frequently as school and family schedules allowed, but not more than one per day. The average number of sessions ranged from 3 to 4.5 per week for the respective participants. Sessions were conducted individually at the schools that the participants attended (in separate therapy rooms) and in participants' homes (in bedrooms or lounges). All sessions were video recorded. The camera was positioned in such a way as to clearly capture both the researcher's and the participant's actions. The average duration required for data collection (baseline and intervention phases) was 6 weeks.

Baseline phase. During baseline, the researcher conducted three consecutive probes using the probe test, in order to determine participants' ability to produce the 30 symbol combinations (both intervention and generalization items in Table 2) before intervention commenced. She placed the 30 probe test pictures illustrating each of the combinations in random order. The items were administered in three groups of 10, interspersed with short breaks. Only one trial was given per item. Participants were seen individually and had the communication board available on a table or lap tray. The participant was required to respond using the communication board. The researcher showed the probe test pictures one by one and each time asked an open-ended question or gave a mand for a response, followed by a time delay of up to 10s. For example, the researcher presented a participant with a picture of a broken car, and asked *What is this*? to elicit a response.

If the participant did not respond within 10s, it was considered as no response. If the participant started responding within 10s, the researcher allowed him/her to complete the response. After a response, the researcher waited an additional 3s before moving on to the next picture, to ensure that the participant had completed his/her response. A response was scored as correct if the participant pointed to at least both target symbols on the communication board (in any order). The researcher acknowledged any response in a neutral way (e.g., *I see. Oh.*). The responses were not corrected and no prompts for elaboration or direct models were given. Noncontingent encouraging feedback (e.g., *You are working hard*) was provided intermittently, to encourage the participant to continue.

The aim of the baseline was to establish a stable pattern for participants' ability to produce the target relations – a pattern that was not likely to change without the introduction of intervention. We predicted that participants would be consistently unable to produce the combinations and therefore would score 0% consistently on the initial baseline probes. This prediction was mostly confirmed by the data (see Figures 1-4). Three consecutive data points at the same level of performance (0%) was regarded as a stable baseline, and intervention therefore commenced on the first type of semantic relation, while the other two types of semantic relations remained untreated and were monitored with baseline probes. Baseline probes for these relations coincided with intervention probes on the semantic relation that was being treated, because all 30 items of the probe test were administered every time. Probes were conducted after the first intervention session that targeted the first type of semantic relation and, subsequently, after every second intervention session targeting that type of semantic relation. Once intervention started on the second type of semantic relation, the baseline probes continued for the last semantic relation at the same intervals.

Intervention phase. During this phase, the researcher administered the intervention and conducted probes to monitor the effect of the intervention. During an intervention session, the researcher read the story containing the semantic relations to the participant, while showing the illustrations. The participant had the communication board available on a lap tray or table. When a combination targeted in intervention appeared in the story line, the researcher used a hierarchy of prompts to create an opportunity for the participant to express or learn to express the particular combination by pointing to the appropriate graphic symbols on the communication board. The procedure consisted of the following five prompts:

Prompt 1: Drawing the participant's attention to the story illustration depicting the specific combination (e.g., an illustration showing a boy running) by pointing and verbalizing (e.g., *look*, *uh-oh*, etc.) and pausing for 10s;

Prompt 2: Asking an open-ended question to elicit the combination (e.g., *What is* *happening here?*) while pointing to the target illustration, followed by a 10s pause;

Prompt 3: Requesting the participant to express the combination using the communication board (e.g., *Tell me with your board*) followed by a 10s pause;

Prompt 4: Providing an aided model of the combination by pointing to the relevant symbols on the communication board while verbalizing the combination, followed by a request to imitate the aided model (e.g., *The {boy BOY} {runs RUN}. Can you show me that?)* followed by a 10s pause;

Prompt 5: Providing physical assistance to help the participant point to the relevant symbols on the communication board to produce the combination. This entailed hand-over-hand assistance to produce the combination.

Participants could respond in different ways to the prompts. The way the researcher reacted to these responses also followed a predetermined procedure. The types of responses and the researcher's reactions are set out below:

- A correct response (including a self-corrected response) to Prompts 1-5 was affirmed and reinforced by an aided model (i.e., the researcher pointed to the correct sequence of symbols on the board while verbalizing). A response was considered correct if the participant pointed to at least both symbols on the communication board (in any order) that made up the combination.
- If no response was obtained within 10s of a prompt being given, the researcher provided the next prompt.
- A related nontarget response to Prompts 1-4 was affirmed (e.g., when a participant commented, usually nonverbally, on a different aspect of the story). The participant was then redirected and given the next level of prompting (e.g., *Yes, the boy will throw the*

ball again, but look, what is happening here? [researcher points to story illustration of dog running]).

- An unintelligible response to Prompts 1 or 2 was followed up with Prompt 3. Unintelligible responses to Prompts 3 and 4 were followed by the next level of prompting.
- A partial response (e.g., participant responded with *DOG* rather than *DOG +RUN*) or a response that expressed at least one of the target concepts in a different modality (e.g., miming *SLEEP* when asked about the illustration of the dog sleeping) to Prompts 1-3 was affirmed, and then followed by giving Prompt 4. Partial/different modality responses to Prompt 4 were followed with Prompt 5.
- Incorrect responses (e.g., participant pointed to *HAT* when shown the illustration of the dog sleeping) to Prompts 1-3 were negated (e.g., *No, this is not a hat)* and a 1s pause was given to see if any attempt was made at self-correction. If no self-correction was attempted, Prompt 4 was given. Incorrect responses to Prompt 4 were followed with Prompt 5.

On the first, third, fifth (and, where needed, seventh and ninth) sessions during the intervention phase, probes were conducted by means of the probe test. As during baseline probes, all 30 items (including intervention and generalization items in Table 2) were administered in a random order during the probes. On days when both the intervention procedure and probes were conducted, probes were always conducted after the intervention procedure, in order to immediately test the participants' ability to apply the symbol combinations skills that had been targeted in intervention to a picture description situation. Similar procedures were used in the study by Dada and Alant (2009).

When participants achieved two consecutive 0% scores on the intervention items during probes directly after intervention commenced, or when a drop in performance on the probes was seen on the intervention items during the intervention phase, the following treatment boosting procedure was implemented before the following intervention probes. After the researcher had read the story to the participant, and before she conducted the probe test, (a) the participant was briefly reminded of the combinations learned by giving him or her two aided models, whereby the researcher verbalized the target combination while simultaneously pointing to the relevant graphic symbols on the communication board (e.g., *Remember what we learned in the story. We learned about the {GIRL girl's} {HAT* hat} *and the {BUNNY bunny's} {SHOE shoe*}; (b) the correspondence between the probe test pictures and the story illustrations was clarified, by giving two examples of corresponding images (e.g., while showing the probe test picture and story illustration, *Look, this is a bunny and this is also a bunny*.). Only single words (no word combinations) were used to clarify the correspondence; and (c) the participant was encouraged to remember what was learned in the story when completing the probe test. These steps were repeated after completing the first 10 items of the probe test, and again after the next 10 items were completed.

Postintervention phase. For the first and second type of relation targeted in intervention, probes on intervention and generalization items continued after intervention had ceased. These postintervention probes were conducted on days during which intervention probes were conducted on the semantic relation treated at that stage.

Procedural Integrity

The procedural integrity of a randomly selected proportion of both the intervention sessions and probe test sessions was determined for each participant and each phase. An independent observer (speech-language pathologist) viewed 22% of video recordings of the intervention procedure and 29% of the video recordings of the probe test, scoring the adherence to procedures. At least 20% of the sessions for each phase for each of the participants were selected for scoring procedural integrity. The percentage of steps adhered to was calculated for each session. The procedural integrity of the intervention procedure varied from 91% to 100% across the four participants and the three intervention phases, with overall integrity at 98%. Procedural integrity of the probe test ranged from 93% to 100% across the three participants and the four phases (baseline and three intervention phases), with overall integrity of 99%.

Coding

As the researcher needed to manipulate material such as probe test pictures or storybooks during probes and storytelling, respectively, she did not score data during the sessions. Rather, score sheets were used to transcribe the participants' response to each item on the probe test from the video recordings made. The transcription was done on the same day as the recording was made. Each response was subsequently classified as correct (i.e., containing both of the target symbols) or incorrect. For descriptive purposes, participants' responses to the various levels of prompting employed during shared story reading were also captured from the video recordings of intervention sessions using a data recording sheet.

Data Reliability

The independent observer transcribed the participants' graphic symbol responses during the probe test for each of the video recordings observed, and classified each response as correct or incorrect. Point-by-point agreement of classification of responses was calculated by dividing the total number of agreements by the total number of agreements and disagreements. Agreement on the classification of responses per participant ranged from 90% to 100%, with an overall agreement of 99%.

Data Analysis

The percentage of correct responses per semantic relation was calculated and depicted graphically per participant per relation and per session. Graphs were inspected for trend and level within and across phases. Improvement rate difference (IRD) was calculated to determine the effect size of the treatment (Parker, Vannest, & Brown, 2009). According to Parker et al., IRD values of .7 and above show large effects, while values of .5 or below show small or questionable effects. Values between .5 and .7 indicate moderate effects. Confidence intervals (CIs; 85%) were established using the NCSS™ two proportions test module (Hintze, 2007), to determine the certainty with which the effect size could be regarded as true. The CIs calculated were based on bootstrapping, as recommended by Parker et al. I t needs to be acknowledged that IRD is a nonparametric calculation based on nonoverlapping data between adjacent phases. As such, high IRD values do not necessarily imply clinically significant change. In order to obtain an impression of the progress participants made during shared story reading, all correct responses (i.e., those containing at least both target symbols) to the first level of prompting were graphed as well.

Results

Figures 1 to 4 show the performance for each of the participants during the baseline, intervention, and postintervention phases on items targeted during intervention as well as generalization items, as measured by the probe tests. It should be noted that the set of intervention and generalization items consisted of only five items each per semantic relation. This meant that one item correct or incorrect resulted in a 20% change on the graphs. Figures 1-4 also show the participants' responses to the first level of prompting during intervention (grey bar graphs). It should be noted that the absence of grey bars during the baseline and postintervention phases does not indicate a 0% performance, but rather that there was no measurement of performance, because the shared story reading was only conducted during the intervention phase. Table 3 presents the percentage of correct items in response to the probe test, as well as the IRD with corresponding CIs per participant per phase.

Participant 1

Figure 1 shows immediate, clear changes in level upon introduction of the intervention for both generalization and intervention items on all three types of semantic relations targeted. Taken together with the values provided in Table 3 (percentage of correct responses during intervention as compared to baseline, IRD values for each relation targeted, as well as the omnibus IRD that was calculated by contrasting the overall improvement during all three intervention phases with the overall improvement during all three baseline phases), this suggest that intervention was very effective in promoting the expression of graphic symbol combination skills.

After introduction of intervention on the first type of combination (attribute-entity), slight activity was seen in the baseline probes of the second type of combination (Session 6), with similar activity being observed in the baseline of the third type of combination (possessor-possession) upon introduction of intervention to the second type of combination. This may suggest a slight carry-over effect reducing experimental control.

Postintervention, Participant 1 maintained performance between 60 and 100% correct on the first two types of combinations targeted.

As shown in Figure 1, Participant 1 responded correctly to the first level of prompting (drawing attention to the story illustration depicting the combination followed by a time delay of

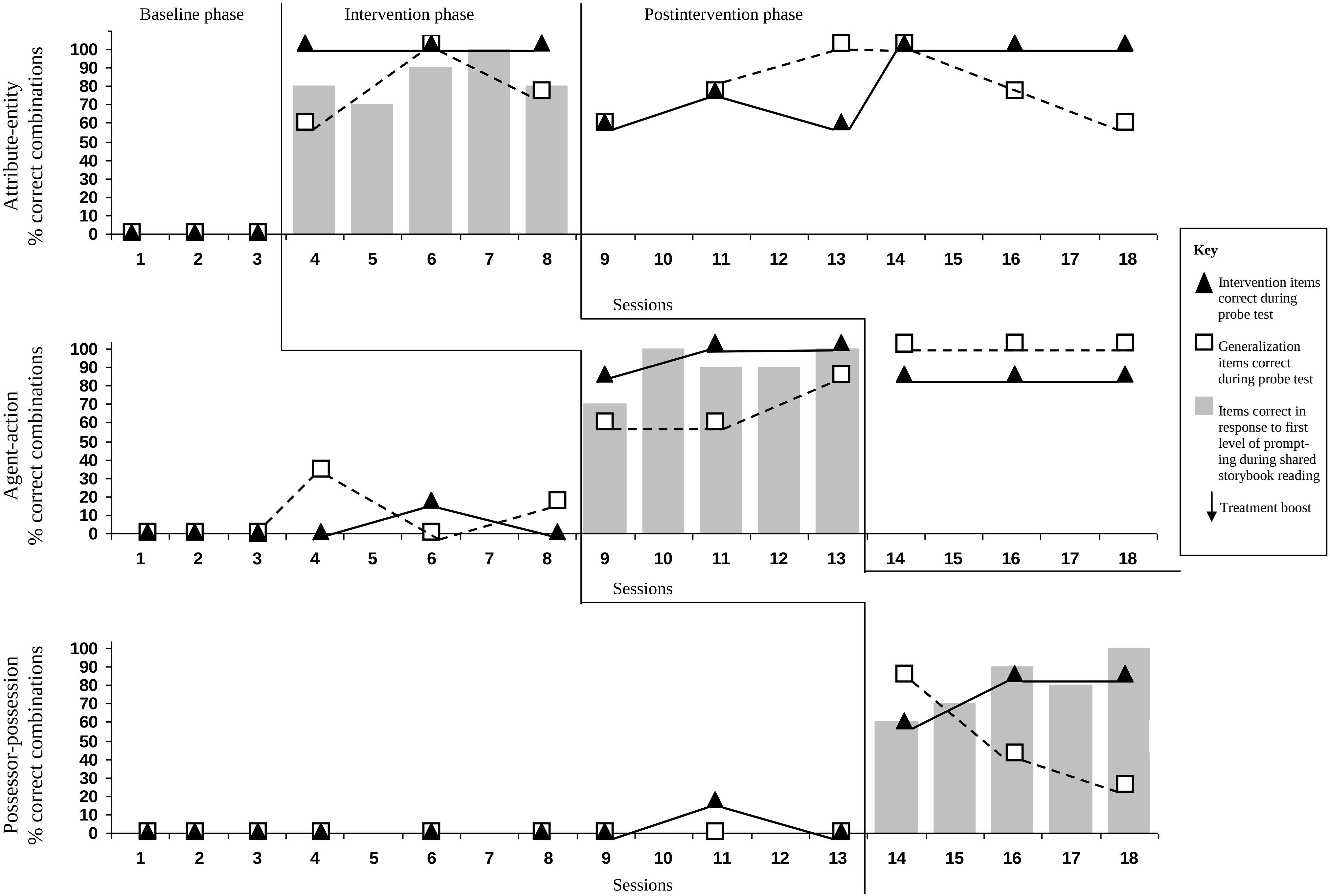

Figure 1. Percentage of correct symbol combinations expressed by Participant 1 across the three types of targeted relations

10 s) in most instances (average 85% of the time). She thus learned very quickly during the intervention and was able to apply what she learned in intervention to the probe task, as performance during shared story reading and during the administered probes was very similar.

Participant 2

Figure 2 shows immediate level changes for intervention and generalization items on all three types of semantic relations once intervention was introduced. During the intervention phase, drops in performance occurred on the attribute-entity (Session 8) and the agent-action combinations (Sessions 11 and 13), which are probably attributable to extraneous factors. Session 8 was the first session conducted at home rather than at school, and during Sessions 11 to 13 the participant was suffering from a cold. During Sessions 13, 15, and 17, the treatment boost procedure was employed, and performance on the agent-action combinations increased. A corresponding increase was also observed on the attribute-entity items that were monitored post-intervention. Either the treatment boost thus had a positive effect on both intervention items and items that were previously learned, or the improvement might have been due to improved health. The last three probes conducted during Sessions 18, 20, and 22 show performance between 80% and 100% correct on the intervention items, and performance between 60% and 100% correct on the generalization items. Together with the values presented in Table 3, the graphs suggest that the intervention effectively promoted the expression of both taught and untaught graphic symbol combinations.

Some correct responses were observed in the baseline for the agent-action combination when intervention was introduced to the attribute-entity relations. Once again, this may suggest some carry-over effect that compromised experimental control. The baseline for the possessor-possession combinations was relatively stable except for two correct responses in Session 2

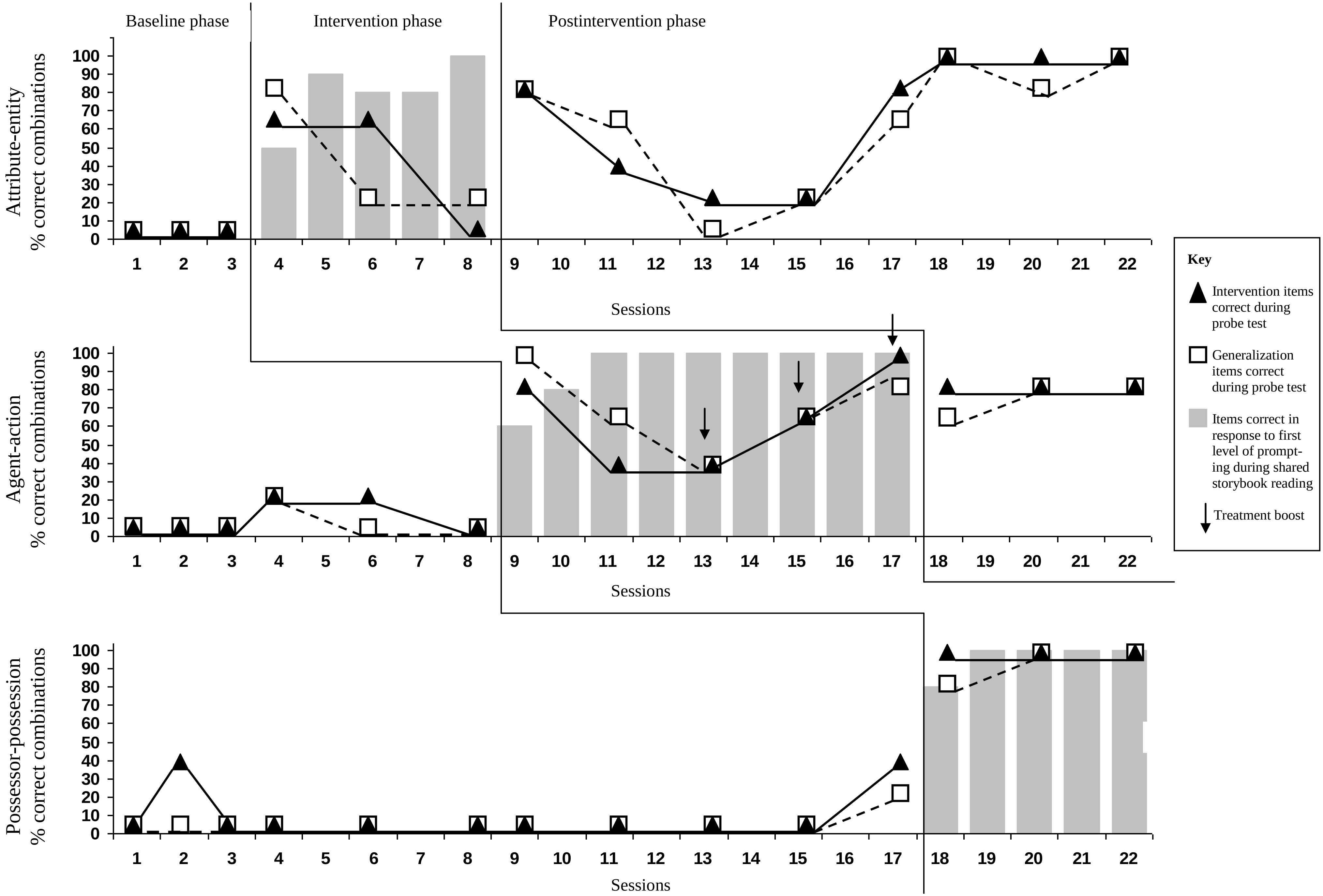

Figure 2. Percentage of correct symbol combinations expressed by Participant 2 across the three types of targeted relations

(before any intervention was introduced) and two correct responses during the last baseline session, resulting in a rising baseline for the intervention items. However, level and trend change are still clearly visible.

From Figure 2, it is clear that the percentage of correct items in response to the first level of prompting was generally high (average: 91%, range: 50%-100%). Participant 2's performance on the probe test mostly mirrored his performance during shared story reading. However, during some sessions (e.g., Sessions 8, 11, and 13), performance during shared story reading was clearly better than performance on the probe test.

Participant 3

From Figure 3, it is apparent that Participant 3 had initial difficulties in the production of symbol combinations (both intervention and generalization items). Intervention had a minimal effect on the first type of combination targeted (agent-action), with a mean of only 8% of intervention items correct and 16% of generalization items correct during the intervention phase. Intervention seemed to have a delayed effect on the second type of combination targeted (possessor-possession) – baseline probe performance (0%) changed in level after five intervention sessions (see Figure 3, Session 17). A clear effect with immediate level change was observed only for the last type of relation targeted (attribute-entity). The treatment boost procedure was used during Sessions 8, 10, 12, and seems to have elevated performance slightly in Session 12. A clearer effect seems evident during Sessions 17, 19 and 24, as can be seen by elevated performance during all of these sessions. Percentage correct as well as IRD values (see Table 3) suggest a low or questionable effect of the intervention on this participant's ability to produce the intervention items, with a slightly better effect on generalization items. Performance post-intervention on the first type of combination was similar to that during intervention, while

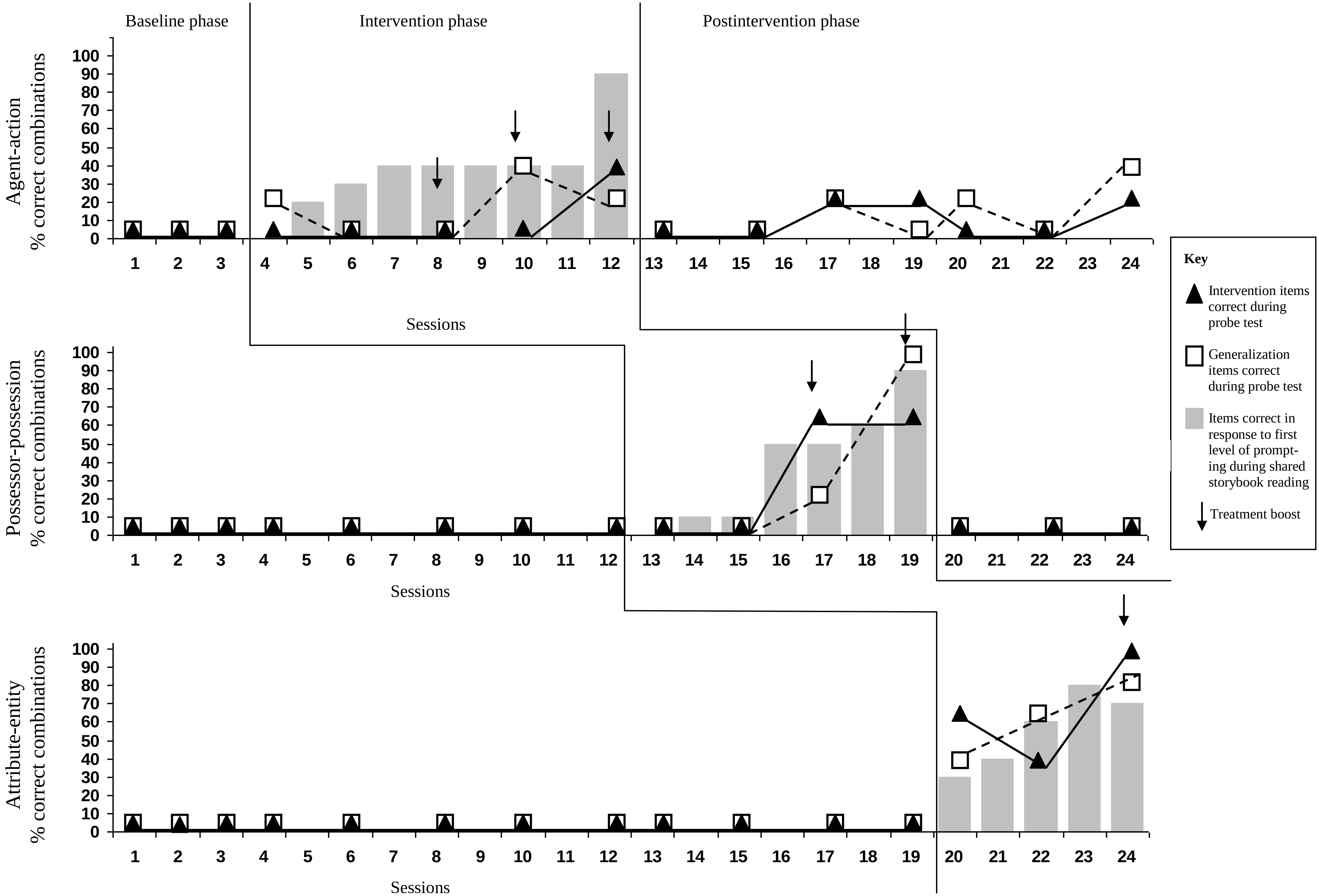

Figure 3. Percentage of correct symbol combinations expressed by Participant 3 across the three types of targeted relations

the slight effect observed during intervention on the possessor-possession combinations returned to baseline performance after intervention.

Participant 3 had difficulties responding correctly to the first level of prompting during story reading in the initial intervention sessions of the first two types of targeted combinations. He mostly needed an aided model in order to imitate a correct response (Level 4 of the prompting hierarchy). Overall, he responded correctly to the first level of prompting 42% of the time. Performance on the probes seemed to correlate quite well with his performance during shared story reading, although there was some discrepancy on the first type of targeted combination, where performance during shared story reading did not seem to transfer to performance during the probes.

Participant 4

Figure 4 shows that, although some sessions during the intervention phase show considerable improvement in performance, the effect was not consistent, and the patterns of performance were highly variable, with returns to 0% correct following performance at 80% or higher (e.g., during Sessions 10 and 17). The treatment boost procedure did not clearly improve performance, as indicated by the returns to baseline performance in spite of the use of the boost. Percentage correct and IRD values (see Table 3) show that the intervention was not effective to promote the production of semantic relations in response to picture stimuli and that generalization did not effectively take place.

Performance postintervention returned to 0% on the first type of targeted combination during most probes. For the second type of targeted combination, performance declined from 60% to 0% correct.

Participant 4 often responded correctly to the first level of prompting during shared story

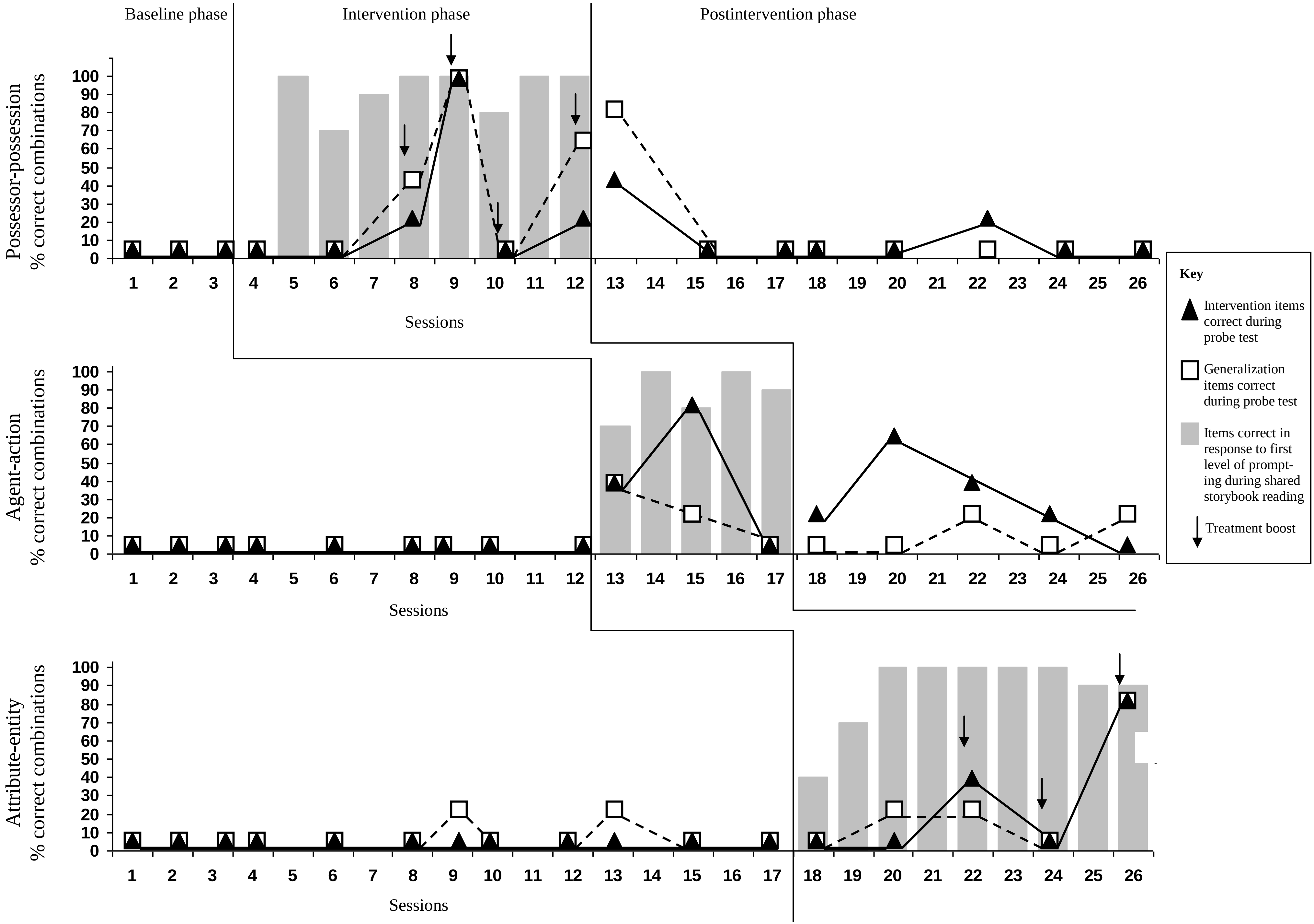

Figure 4. Percentage of correct symbol combinations expressed by Participant 4 across the three types of targeted relations

reading. Only during the first intervention sessions targeting the possessor-possession and attribute-entity combinations, respectively, did she respond correctly to less than half of the opportunities provided. Overall percentage of correct responses to the first level of prompting was 86%. Her performance during shared story reading seems to contrast starkly with her weak performance during probes.

Influence of Order and Type of Semantic Relation

Due to the fact that the order in which the semantic relations were provided was not counterbalanced as fully as possible, we compared the average number of items correct (across all four participants) during the intervention phases for each of the different types of relations, and also for the order in which the relations were presented. The average number of items that participants correctly expressed during the intervention probes was 51% for the agent-action combination, 58% for the attribute-entity combination and 57% for the possessor-possession combination. When comparing the first, second, and third relation targeted, participants achieved an average of 46% correct for the first relation targeted, 57% correct for the second, and 66% correct for the third type of relation. This tendency to improve with each subsequent relation targeted was evident for Participants 2 and 3 specifically, as can be seen from level and level changes (Figures 2 and 3) as well as mean percentage of items correct during intervention phases (Table 3).

Discussion

From the results of the probe test, it is evident that Participants 1 and 2 readily learned to combine symbols through the prompting procedure used during shared story reading. Post-intervention, these participants also maintained the skills they learned and generalized their skills to untrained combinations from the matrix. Their performance during probes is congruent with

Table 3

Probe Test Results: Mean Percentage of Items Correct and IRD With Corresponding CI per Participant, per Phase

	Semantic relation (presented in order in which intervention was applied to the semantic relation)		Mean percentage of items correct			IRD (Baseline intervention)	85% CI (Bootstrap)
			Baseline	Intervention	Post-intervention		
Participant 1	Intervention	AE	0%	100%	83%	1.00	[1.00, 1.00]
		AA	3%	93%	80%	1.00	[1.00, 1.00]
		PP	2%	73%	-	1.00	[1.00, 1.00]
		Overall	2%	89%	82%	1.00	[1.00, 1.00]
	Generalization	AE	0%	80%	80%	1.00	[1.00, 1.00]
		AA	10%	67%	100%	1.00	[1.00, 1.00]
		PP	0%	47%	-	1.00	[1.00, 1.00]
		Overall	3%	64%	86%	1.00	[1.00, 1.00]
Participant 2	Intervention	AE	0	40%	68%	.67	[.33, 1.00]
		AA	7%	64%	80%	1.00	[1.00, 1.00]
		PP	7%	100%	-	1.00	[1.00, 1.00]
		Overall	6%	67%	71%	.91	[.82, 1.00]
	Generalization	AE	0	40%	63%	1.00	[1.00, 1.00]
		AA	3%	68%	73%	1.00	[1.00, 1.00]
		PP	2%	93%	-	1.00	[1.00, 1.00]
		Overall	2%	67%	65%	1.00	[1.00, 1.00]
Participant 3	Intervention	AA	0	8%	9%	.20	[.00, .40]
		PP	0	30%	0%	.50	[.25, .75]
		AE	0	67%	-	1.00	[1.00, 1.00]
		Overall	0	30%	6%	.50	[.33, .67]
	Generalization	AA	0	16%	11%	.60	[.22, 1.00]
		PP	0	30%	0%	.50	[.25, .75]
		AE	0	60%	-	1.00	[1.00, 1.00]
		Overall	0	32%	8%	.67	[.50, .83]
Participant 4	Intervention	PP	0	23%	8%	.50	[.17, .83]
		AA	0	40%	28%	.67	[.33, 1.00]
		AE	0	24%	_	.40	[.00, .80]
		Overall	0	27%	15%	.50	[.29, .71]
	Generalization	PP	0	33%	10%	.50	[.17, .83]
		AA	0	20%	8%	.67	[.33, 1.00]
		AE	3%	24%	_	.43	[.12, .80]
		Overall	2%	27%	9%	.49	[.27, .70]

their performance during shared story reading. In contrast, Participants 3 and 4 showed limited progress, as evidenced by poor or erratic performance on the probes. Participant 3 clearly had initial difficulties in the production of the combinations, but performed better with each new type of combination targeted, as can be seen from the levels and level changes in Figure 3, and the mean percentage of items correct in the three intervention phases given in Table 3 (8% of items correct on average for the first structure targeted, 30% for the second structure, and 67% for the last structure). His responses during shared story reading showed a similar pattern, as can be observed from the levels depicted in Figure 3. However, these effects were not maintained post-intervention. Participant 4 showed inconsistent performance on the probes, although her responses during shared story reading were mostly correct with minimal prompting.

Various factors may have contributed to the discrepancies in performance between the four participants. Participants 1 and 2 both had English receptive language skills at an age-equivalent level of at least 5;0. Their comprehension of the targeted combinations was 97% and 100% correct, respectively, and they correctly identified all 21 PCS symbols used in the study on the second trial (see Table 1 for these details). They were also exposed to English at home. In contrast, Participants 3 and 4 had receptive language skills at an age equivalent of 2;6 and 3;4, respectively. Comprehension of the spoken form of the targeted combinations was weaker (70% and 90% correct, respectively, as compared to 97% and 100% correct for Participants 1 and 2; see Table 1). They were also able to identify fewer of the graphic symbols prior to the commencement of intervention (see Table 1). Receptive language skills have been suggested to be an important factor in the production of graphic and other symbol combinations for children using AAC (Binger et al., 2010; Sevcik, 2006). The ability to produce graphic symbol combinations was specifically associated with receptive language skills equivalent to an age level of at least 24 months in school-aged children using AAC (Sevcik, 2006). Previous research on matrix training strategies also revealed that lexical item knowledge positively impacts on the ability to learn syntactic rules (Goldstein, 1983). It may seem reasonable to conclude that Participant 3's more limited ability to identify target symbols prior to intervention (76% correct, i.e., 5 of 21 symbols incorrectly identified) could have negatively influenced his performance. An analysis of the errors he made indicates that two of the symbols he could not identify seem to have led to more frequent errors on combinations containing these symbols as compared to combinations of the same type containing other symbols.

Although all four participants received their education in English, Participants 3 and 4 were not exposed to English at home. Additional to the demands of learning to use expressive modalities to replace or supplement speech, the participants were also contending with a receptive second language as instructional medium. This may have resulted in a number of language and communication-related stressors, which may have limited their ability to fully meet the demands of yet another one (graphic symbol combinations) within the limited time of the current study.

Participant 3 was also the only one who had no experience using graphic symbols for expression. This may explain why he needed more prompting to express the combinations during shared story reading and responded predominantly with single symbol utterances during the probes as well. It is clear that he acquired each new type of combination faster than the previous targeted one, suggesting that an extension of the intervention sessions may have resulted in more convincing performance. In spoken language development, the ability to utter single words typically precedes the ability to produce word combinations; and word combinations tend to appear only once the expressive vocabulary has reached a size of 50 to100 words (Bates, Dale, & Thal, 1995). Whether children using AAC follow similar or alternative routes in language development is still a matter of debate (Gerber & Kraat, 1992; Nigam et al., 2006; von Tetzchner & Grove, 2003). Extrapolations from typical language development are further complicated by the fact that children whose speech is severely limited often use a variety of modalities to express themselves, such as vocalizations, word-approximations, gestures, and signs as well as pointing to objects, people, and graphic symbols. It still seems unclear whether expression through single graphic symbols specifically (rather than expressive use of symbols per se, regardless of modality) typically precedes use of graphic symbol combinations.

Results from the current study compare less favourably with results from other intervention studies (Binger et al., 2008, 2010). Differences in task parameters between these studies and the current investigation may account for poorer performance by Participants 3 and 4 in the current study. In the current investigation, measurement probes consisted of requesting participants to label 30 pictures. The format of the measurement may not have been very motivating for participants, because the activity consisted of a test. In contrast, the story reading activity provided opportunities for meaningful contributions to the storyline. Furthermore, during the administration of the probe test, no contingent feedback was given to prevent learning taking place from the test itself. Participants therefore did not know whether their responses were correct or not. Rather, noncontingent encouragement was given to encourage participants to continue the procedure. However, providing rewards (or encouragement) independent of performance may disadvantage learning (Basil, 1992). During shared story reading, feedback on the correctness of responses was given, and participants were prompted until the correct response was produced. The task requirements were thus clear. This may explain why Participant 4 in partiuclar showed a discrepancy between responses given during probes and those given during shared storybook reading. While she frequently responded correctly to the first level of prompting during shared storybook reading, she responded mostly with single symbol utterances during probes. As no corrective feedback was given, she may not have been aware that symbol combinations were expected.

The first level of prompting (i.e., drawing attention visually and verbally to the story illustration depicting the specific combination) may have been too subtle to be interpreted as a request for a response, specifically by Participants 3 and 4, and this may have delayed their learning. Other studies (Binger et al., 2008, 2010) used aided modelling before expecting a response from the participants; this may have improved learning. In the current study, the focus was on prompting output before an aided model was given. Although the randomized comparison group study by Romski et al. (2010) suggested that, for toddlers with significant risk for speech-language delays, prompting aided output facilitated expressive language development to a greater extent than did providing aided input, more recent data (Romski et al., 2011) show that a combination of aided input and prompting output is even more effective than prompting output alone. Binger and colleagues used such a combination in their interventions, and may therefore have promoted learning of symbol combinations more effectively.

It is difficult to draw any definite conclusions regarding the effect of the order and the type of relation targeted, due to the fact that order was not completely counterbalanced across participants. The results suggest that the type of relation did not directly affect the ease of learning, but that for two participants, performance improved with each subsequent relation targeted.

Limitations

Results of the study are complicated by the fact that only a weak effect could be detected for two of the four participants during the probe tests. Although responses during the shared story reading suggest that participants acquired the relations within that context, lack of baseline data regarding the performance during this context prevents drawing any definite conclusions. It does however seem that performance during the probe tests did not always fully reflect the gain in skills that took place during shared story reading. The fact that the context within which intervention took place differed from the context within which the measurements were taken may have played a significant role. The validity of the measurements may well have been affected by reactivity from the participants (particularly from Participant 4), because the repeated probes may have had an inhibitive effect due to lack of contingent reinforcement and lack of clarity of task requirements (Gast & Ledford, 2010). Furthermore, probes were conducted directly after the intervention sessions, and not before. This may have led to measuring short-term carry-over effects rather than true learning, and could explain why, for some participants, the target skill returned to baseline after intervention (e.g., on the possessor-possession combination for Participant 3).

Heterogeneity among the participants (specifically, with regard to receptive language skills and home language) also seems to have contributed to variability on the results. A more homogenous sample in future studies could address more clearly the effects of, for example, receptive language skills and English as an additional language.

Carry-over effects noted for Participants 1 and 2 may suggest that the three behaviors were not completely independent of each other, which reduced experimental control. Due to receptive language skills at age equivalent levels of 6;1 an 5;0, respectively, Participants 1 and 2 may not only have learned generalized responding to one type of semantic relation (e.g., agent-object), but seemed to also start applying this principle of two-symbol combinations to other types of relations. While this may clinically be a welcome outcome, it makes the multiple baseline design across behaviors an unsuitable choice, as change in each behaviour should only occur once intervention is introduced, in order to show the causal link between intervention and behaviour change. A multiple baseline design across participants may have circumvented this problem.

Only three data points were collected for the initial baseline and for many of the intervention phases as well. Although three data points are seen as adequate, five data points provide for more convincing evidence of effect (Kratochwill et al., 2010). In addition, only five intervention and five generalization items per semantic relation were targeted. This small number of items meant that one item correct or incorrect resulted in a 20% level change. The measurement units by which behaviour change was determined were thus broad and not that sensitive to small incremental changes. One consideration for the small number of items was the fact that all items (ie., both intervention and generalization items) for each of the three relations were tested during every probe test. An increase in item numbers may have made the test very lengthy and lead to increased reactivity from participants.

Setting a teaching criterion of nine sessions may have ended the intervention sessions prematurely, before participants benefited adequately from the intervention. This might have contributed to the fact that only two participants showed maintenance of the skills postintervention. Post-intervention probes were only conducted for two of the three types of targeted combinations and only for a maximum of 5 weeks and a minimum of 1 week after invention ceased on a particular combination. Long-term effect of the intervention was not determined. Furthermore, the social and ecological validity of the intervention was not formally determined. While the use of story reading as an intervention context aimed to at least use a naturalistic context for intervention, the involvement of parents, teachers and therapists in developing or approving the goals and procedures of the study was beyond the scope of this investigation, and must be regarded as a limitation.

Only one instructor (the first author) provided the intervention to all participants. Although the physical location varied, intervention was only conducted within the shared story reading context. This limits the external validity of the intervention. The small number of participants is a further limitation. At the same time, similar studies have targeted graphic symbol combinations using a story reading context (Binger et al., 2008, 2010) or a matrix structure of target items (Nigam et al., 2006). This study thus adds to a growing body of evidence as to the success of these interventions in promoting symbol combinations.

The fact that several participants were lost further meant that the order in which the relations were presented was not systematically counterbalanced across the remaining participants. As a result, order effects may not have been controlled.

Directions for Further Research

Incorporating specific graphic symbol combinations generated from a matrix into a storybook reading activity can be a successful way of prompting children using AAC to produce specific symbol combinations and may promote generalization to untrained exemplars, as evidenced by the results of Participants 1 and 2. However, the gains made in expressing symbol combinations during story reading may not automatically reflect in more formalized test situations. Future studies may consider monitoring the results of interventions more indirectly, thus reducing the risk of reactivity to testing.

Successful AAC intervention requires that AAC strategies, techniques, and aids are incorporated into everyday communicative activities and that communication partners are skilled in encouraging their use. The success with which the matrix strategy can be incorporated into other everyday communicative activities that children using AAC typically engage in should therefore be investigated. Furthermore, parents and educational assistants have been successfully taught to foster graphic symbol combinations during shared story reading (Binger et al., 2008, 2010). The effectiveness and ease with which various communication partners can implement the matrix strategy to promote graphic symbol combinations may also warrant further investigation.

The influence of receptive language skills on the learning of symbol combinations was not specifically controlled in this study. Although there is support for the influence of receptive language skills on the ability of children with and without disabilities to produce graphic symbol sequences (Sutton et al., 2010; Trudeau et al., 2007; Wilkinson, Romski, & Sevcik, 1994), the influence of this parameter on the learning process has not yet been formally determined, and future studies may be designed to investigate this relationship.

The ultimate aim of interventions that target the production of graphic symbol combinations is to increase the ability to independently and meaningfully generate graphic symbol combinations for communicative purposes in everyday situations. While matrix strategies have proven helpful to introduce a limited number of specific combinations and foster the generalization to very specific other combinations, additional measures may well be needed to encourage generalized and functional graphic symbol combinations skills. Age appropriate core vocabulary may be of particular importance in promoting more generalized production of combinations in different functional contexts. Symbols for words such as *MORE* and *WANT* can easily be combined with a number of other symbols, resulting in combinations that are appropriate in different situations (Banajee, Dicarlo, & Stricklin, 2003). Easy access to such words on a communication aid may be pivotal to enhance symbol combinations.

When searching for evidence-based intervention strategies, interventionists and researchers need to differentiate between short and long-term goals. Strategies that prove helpful to achieve short-term goals (e.g., the production of graphic symbol combinations) may not necessarily foster linguistic skills that are more complex (e.g., morphology and syntax). Longitudinal studies could shed more light on the overall process of expressive language development through graphic symbols, and give an indication of facilitative and inhibitive factors at various stages within this process. Decisions regarding the design of aided AAC systems and choice of intervention strategies and when to phase out or change these, need to be informed by a long-term perspective of language development through aided means.

End Notes

[1] Picture Communication Symbols are a registered trade mark of Dynavox Mayer-Johnson, Pittsburgh, PA.

[2] English-medium education implies that the language of instruction is English only.

[3] In English-medium schools, the language of instruction is English only.

[4] Grade R or Reception is a noncompulsory year of schooling (one year prior to the commencement of formal schooling) for children typically aged 5-6 years.

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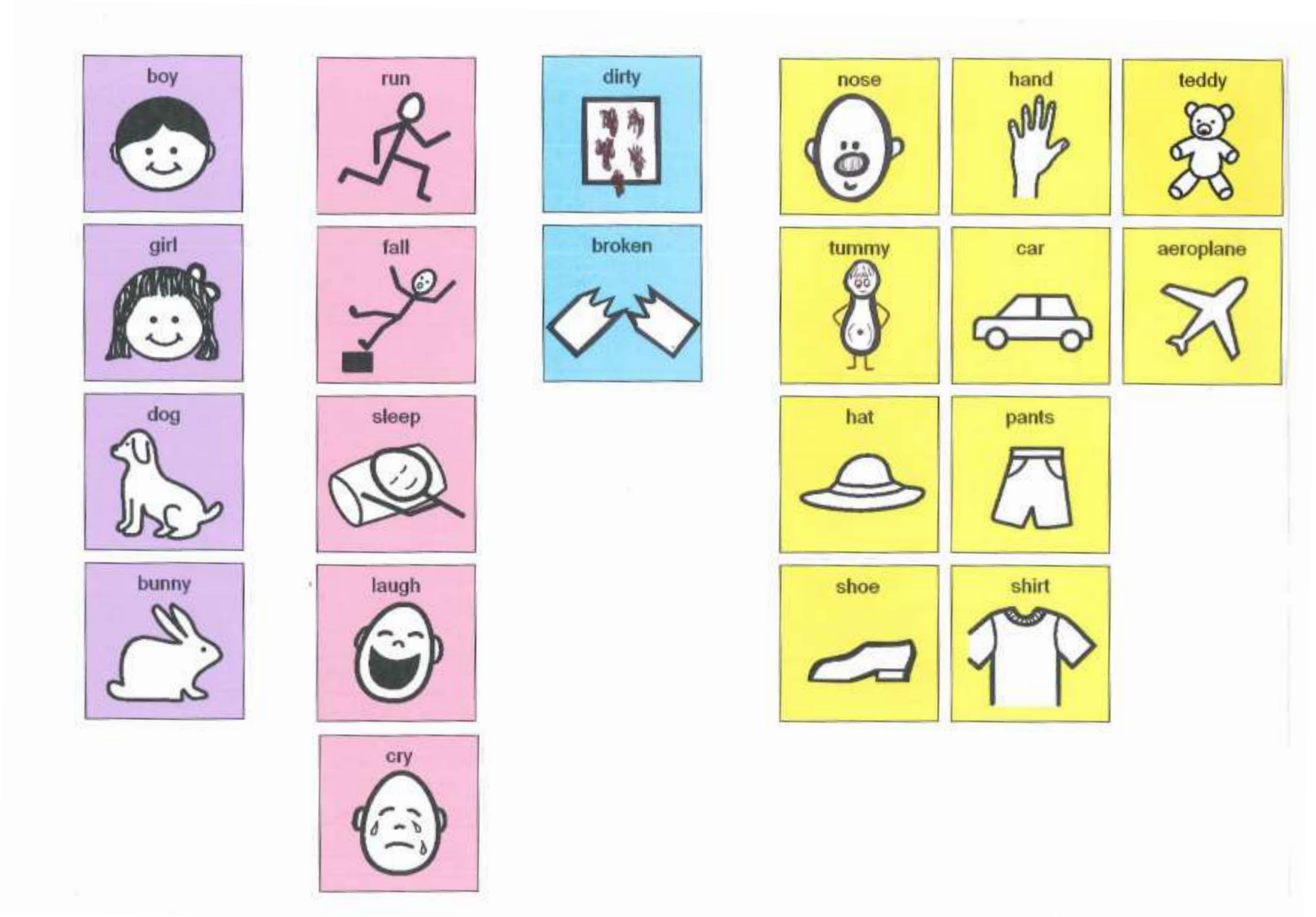
Appendix A

Communication Board



Appendix B

Example of a Story and Illustration

Story 1: Agent-action

This is a dog. The **dog sleeps**. Here comes a boy. The boy has a ball. He wants to play. Come and play, dog. The boy throws the ball. **The dog runs**. He brings back the ball. The **boy laughs**. He likes playing with the dog. The boy throws the ball again. **The dog runs**. Oh no! The ball is stuck in the tree! The boy climbs up the tree. Oh no! The **boy falls**. He climbs up the tree again. Oh no! **The boy falls** again! Oh-oh! **The boy cries.** He can't get the ball! Here comes Daddy. Daddy sees that the **boy cries**. Sorry! Daddy is tall. He takes the ball down from the tree. Hooray! **The boy laughs**. He is so happy. The boy and the dog play in the garden for a long time. Then they are very tired. The boy goes inside the house. The dog lies down in the grass. Shshsh! **The dog sleeps**.

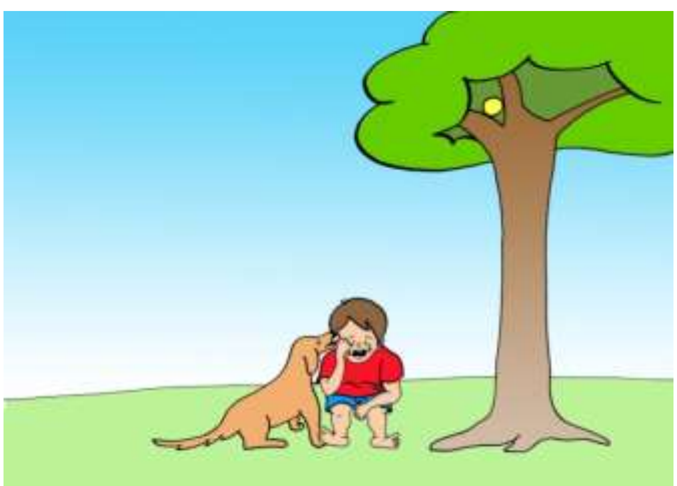


Figure A1. Example of an illustration

(Please see Tönsing, 2012 for the other two stories.)

Note. Text in bold denotes intervention items