# Cross Modal Generalization of Receptive and Expressive Vocabulary in Children with Down Syndrome

By

Tonia Nicole Davis

Thesis

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Interdisciplinary Studies: Communication Disorders and Neurodevelopmental Disabilities

May, 2014

Nashville, Tennessee

Approved:
Stephen Camarata, PhD, CCC-SLP
Paul Yoder, PhD

## ACKNOWLEDGEMENTS

This research was completed with the support of award number R324A080143 to Stephen Camarata and Mark Wolery (PIs) from the Institute on Educational Sciences (IES) and by the Scottish Rite Foundation of Nashville. Graphic services were supported by NICHD Grant P30 HD15052 to the Vanderbilt Kennedy Center for Research on Human Development. We also express gratitude to R. Joi Mitchell and Nick Bennett for data collection and preparation.

Children with Down syndrome (DS) display deficits in language acquisition that are greater than deficits in other aspects of development such as nonverbal cognitive skills. Deficits in vocabulary and morphosyntax have been identified in expressive and receptive modalities, although receptive language skills are generally stronger than expressive language skills (Chapman, Schwartz, & Kay-Raining Bird, 1991; Eadie, Fey, Douglas, & Parsons, 2002; Martin, Klusek, Estigarribia & Roberts, 2009). These deficits are particularly apparent in studies where children with DS are compared to peers with intellectual disabilities matched on mental age or IQ level (Abbeduto, Murphy, Cawthon, Richmond, et al., 2003; Chapman, 2006; Fidler, Hepburn, & Rogers, 2006, Roberts, Price, Barnes, Nelson, et al., 2007). Because vocabulary acquisition is a crucial element of language development in all children, but especially in those with delayed or inefficient language learning, additional research in the development of expressive and receptive vocabulary in children with DS is warranted.

In clinical language intervention, clinicians can potentially target either expressive and/or receptive skills because a child with DS is highly likely to display significant deficits in both modalities. For example, clinicians could ask children to name objects and/or point to pictures from a stimuli set or a storybook page. However, these activities may not be systematically coordinated or integrated in practice. Expressive and receptive vocabulary interventions have not often been studied simultaneously and in combination in populations with intellectual disabilities (Gillum & Camarata, 2004). A number of studies have considered the effects of expressive-only language intervention on expressive and receptive language outcomes in populations with language deficits (reviewed in Camarata, Nelson, Gillum, & Camarata, 2009). A few studies have considered the effects of sequential expressive and receptive language interventions, including vocabulary interventions (reviewed in Pettursdottir & Carr, 2011).

However, expressive and receptive language modalities have not been studied via systematic separation to explicitly examine cross modal generalization, wherein each modality is trained apart from the other on separate, independent vocabulary targets. Because receptive language is strongly associated with long term language outcomes and with subsequent literacy skills in populations with typical and atypical language (Thal & Tobias, 1992; Burgoyne, Duff, Clarke, Buckley, Snowling, & Hulme, 2012), there is an overarching need for systematic study of receptive language intervention on outcome. Of course, if children are able to make gains in receptive language as a secondary or incidental effect of expressive-only language intervention, then expressive language intervention exclusively may be a sufficient and an efficient program for training words. However, a study by Camarata et al. (2009) demonstrated that children with poor receptive morphosyntax (SLI-expressive/receptive) at the onset of therapy did not make progress through expressive-only language intervention. These findings suggest that receptive language must be explicitly taught for some populations with poor receptive language skills. Studies of children with DS or unspecified ID have largely found little to no evidence of generalization, but there are few studies that examine generalization in vocabulary (Baer & Guess, 1971, Guess, 1969, Schmaker & Sherman, 1970, Wolf & McAlonie, 1977).

"Cross modal generalization" is defined herein as when a target word is taught in one modality (e.g., expressive) and accurately identified via another modality without direct instruction in that modality (e.g., receptive). Explicit training is delivered in only one modality to test cross modal generalization. For example, after the word "clock" is trained receptively, the word "clock" is subsequently produced when a picture of a cowboy is presented (without direct instruction on naming). Or, an example of expressive to receptive generalization is seen when the word "cowboy" is taught expressively, and then "cowboy" is correctly selected from an array by

pointing when requested. Typically developing children show high levels of cross modal generalization at the word level, receptive-to-expressive as well as expressive-to-receptive (Bird, Chapman, & Schwartz, 2004; Dollaghan, 1985; Grey, 2003). However, children with SLI (Gray, 2003) and children with DS matched on MA (Bird et al., 2004) were not as successful as their typically developing peers. Children with intellectual disabilities do not show a similar propensity for bidirectional cross modal generalization at the level of morphosyntax (Baer & Guess, 1971; Guess, 1969; Wolf & McAlonie, 1977).

To date, there is a striking paucity of information on cross modal generalization in children with DS. An early study of cross modal generalization included two children with DS who unsuccessfully generalized morphological information regardless of taught modality (Guess, 1969). Studies of morphological generalization (for example, from comparative forms such as "bigger" to superlative forms such as "biggest") in children with DS and other intellectual disabilities have also demonstrated relatively high levels of target learning, but relatively low levels of generalization (Baer & Guess, 1971, Guess, 1969, Schmaker & Sherman, 1970, Wolf & McAlonie, 1977). Although generalization of morphology appears consistently low in populations with DS, a comprehensive literature identified three studies examining the effects of cross-modal generalization at the word level in children with intellectual disabilities, none included children with DS. Anderson and Spradlin (1980) and Bucher and Keller (1981) examined unidirectional cross modal generalization at the word level with variable results across different children. Keller and Bucher (1979) was published only as an abstract, so detailed findings are unavailable, but the authors determined that receptive-only intervention was insufficient for children with severe language deficits.

Given the inherent clinical advantage of training targets that readily generalize, and given the variability in disability typologies and across individuals of the same typology, systematic study of cross modal generalization in children with DS is warranted. Studying cross-modal generalization may have implications for efficient word learning strategies and the design of effective lexical or vocabulary interventions in children with DS. The purpose of this study was to examine whether children with DS generalize learned vocabulary, specifically nouns, cross-modally from expressive-to-receptive and from receptive-to-expressive modalities. Specifically, the two research questions were considered: (a) Do the children with DS generalize cross-modally from expressively-trained targets to receptive target identification? and (b) Do the children with DS generalize cross-modally from receptively-trained targets to expressive target identification? Secondarily, maintenance of generalization was explored.

## METHOD

### Study Design

A multiple probe design (Gast, 2010; Horner & Baer, 1978) was employed to examine cross modal generalization of targeted vocabulary words. The design consisted of concurrent multiple probe designs and included six sets of intra-subject replication (three expressive and three receptive sets). Five children with DS were taught vocabulary words that were absent in baseline expressive probes (0%) and at or below chance levels (< 25%) in receptive probes. Modality was randomly assigned at the word level so that half of the words were trained expressively and half of the words were trained receptively. Individual words were trained in only one modality: Targets were trained in either receptive or expressive modality exclusively; no cross modality training was delivered. Identification of vocabulary words was measured at baseline probes, during the intervention condition, and during follow-up probe conditions. Probe

conditions at baseline and follow-up included all targets vocabulary words, but probes during intervention included only active targets.

**Participants**

Participants included five preschool children with Down syndrome, ages 3 to 5 years with a mean age of 4;6 years. The children (four male, one female; assigned pseudonyms below) were recruited through the Bill Wilkerson Center of Vanderbilt University and from Nashville Metro Public Schools. Participants were identified through parent and clinician report as qualifying for language intervention services which was validated by subsequent standardized testing. All children who met eligibility requirements were included in the study. Inclusionary criteria were: (a) a diagnosis of Down syndrome through physician report, (b) ability to imitate vocally, and (c) a commitment to enrollment in intervention for 6-8 months.

Children's intellectual abilities were measured using the *Revised Leiter International Performance Scale* (Leiter-R, Roid & Miller, 1997). Of the five children in the study, four children scored in the low-average range with a mean of 75.75 (SD 1.26) and one child scored in the intellectual disability range with a score of 40. The inclusion of training items on the baseline levels of the Leiter-R may overestimate the nonverbal IQ scores of preschool aged children with ID. The baseline training items, which are counted toward the standardization score, may actually measure the child's ability to perform a task after a model rather than serve as an estimate fluid reasoning abilities (Roid & Miller, 1997). Caution should be used in interpreting the scores of the four children who could complete the training items with modeling but could not complete the untrained testing items on these tasks. Participants also received initial testing using the *Test of Auditory Language Comprehension-3 (*TACL-3, Carrow-Woolfolk, 2001), a receptive measure that includes grammar and vocabulary test items; the *Preschool Language*

*Scale – 3* (PLS-3, Zimmerman et al., 1992), an omnibus language test, the *Peabody Picture Vocabulary Test -4* (PPVT-4, Dunn & Dunn, 2007), a receptive vocabulary test, and the *Expressive One-Word Picture Vocabulary Test - 4* (EOWPVT-4, Martin & Brownell, 2010), an expressive vocabulary test. Of the five children, two children demonstrated receptive scores above expressive knowledge (Sam and Joy), one child demonstrated receptive scores equal to expressive (Nick), and one child demonstrated receptive scores lower than expressive (Tony), although numerical differences in receptive and expressive standard scores fell within each test's 95% confidence interval. The final child, George, had no correct responses on either receptive or expressive vocabulary measures prior to initiating the intervention procedures. These results are summarized in Table 1. Children are listed in the order in which they enrolled in the study.

**Vocabulary Selection**

A minimum of 16 vocabulary words were identified for each participant. A five-step process was employed to identify a set of target vocabulary words, individualized for each child, that were absent from the child's expressive and receptive vocabulary repertoire. First, a pool of words was selected and each child's parent indicated which words were absent from their child's repertoire. Second, the experimenter engaged each child in a word imitation task, to identify those words each child was unable to produce an intelligible pronunciation; the goal of this task was to ensure that a child's phonological limitations would not confound expressive generalization. Third, the child was asked to match one picture for each of the vocabulary words to an identical picture. The clinician did not name the vocabulary word; the child was asked simply to match the pictures. Only those stimuli that the child could correctly match were included. This task was included to ensure that the child had the necessary prerequisite matching

skills for each potential target so that receptive probes could be completed accurately and that errors in this modality could not be attributed to an inability to match or point to a target form.

Fourth, the child was asked to identify each word expressively and receptively. To test for expressive knowledge, the child was asked to name each picture. Only pictures that were not named correctly were selected for intervention (0% accuracy across four opportunities). To test for receptive knowledge, the child was asked to identify each picture from a set of four choices. Only pictures that were identified at or below chance level (<25% correct across four opportunities) were selected for intervention. These procedures ensured that all targets were absent from each child's expressive and receptive repertoire and that this absence was not due to an inability to match or point to a picture or due to an inability to intelligibly speak a target form. Finally, words were randomly assigned to a modality (expressive or receptive) and a condition (sets 1, 2, 3, or control). A sample process for one child in the study, Tony, is provided in Appendix A.

It is possible that contamination due to incidental cross modal learning could arise from employing real words in this study. So, a set of four untreated target nouns (two receptive and two expressive) served as a control set. Although these words were not taught during intervention, they were included in each probe session to control for incidental learning. Therefore six expressive words and six receptive words were taught per participant (twelve total), two expressive and two receptive words were untreated but monitored (four total) in each participant. Thus, a total of eight expressive words and eight receptive words were included in each probe session (sixteen total). Order of presentation of these probe sets was randomly selected for each participant and the pairs selected for the control condition was also randomly drawn. Baseline procedures included at least three sessions of probes on all sixteen words

(targeted and control) to establish a stable data pattern before the intervention condition was implemented.

**Language Intervention Procedures**

Intervention sessions were conducted in 1:1 (clinician:child) therapy setting at the Vanderbilt Bill Wilkerson Center by licensed speech-language pathologists. Children participated in an average of four sessions per week. During intervention, the clinician introduced targeted vocabulary words in a storybook context and a structured play context (Appendix B). The combined time for storybook and structured play was 12 minutes for one modality (24 minutes total per session). This combination approach was adopted because the goal of intervention was to ensure that targets were learned, not to evaluate the relative contribution of each component.

During the storybook context, the vocabulary words were verbally presented by the clinician at least 10 times per session while the clinician and child viewed a picture book and the clinician told a story. Immediately after the clinician said the vocabulary word during the story, the clinician prompted the child (a) in the expressive condition, to name the vocabulary word when shown a picture that matched the word or (b) in the receptive condition, to identify the vocabulary word by pointing to the picture that matched the word (receptive condition). The play context followed the storybook context. During the play context, the clinician and child interacted with a set of toys that matched the storybook and included the target vocabulary items. The clinician commented on the play, using each target vocabulary word at least 10 times per session. For the first two children in the study (George and Nick), the clinician also prompted the child to name (expressive target words) or point to the items (receptive target words). For the other three children, the clinician named the targets while commenting, but did not deliver

prompts to name or point. The clinician, play context, and reinforcers (see below) were identical across expressive and receptive conditions.

The clinician reinforced correct responses with verbal praise, smiles, or high-fives. For incorrect responses, the clinician delivered the correct response ("Uh-oh, it's a ___" for expressive or "uh-oh, here it is" and pointing to the correct picture for receptive). If the child then identified or produced the word correctly, the clinician reinforced the correct response. If the child made no response after prompting, the clinician waited a few seconds and then delivered the correct expressive or receptive exemplar.

**Probes**

In total, three types of probes were used: (a) daily intervention probes that were administered at the outset of each intervention session, (b) within-modality probes that were administered during separate, dedicated probe sessions, and (c) cross-modal probes that were administered also during separate, dedicated probe sessions. All probes were administered by the same examiner who also administered the intervention to each individual child.

**Daily intervention probes.** At the outset of each intervention session, the child was asked to point to pictures of the target vocabulary words (for those words targeted in the receptive condition) and to name the targeted vocabulary (for those words targeted in the expressive condition). Only those words targeted for intervention in that treatment session were included in an individual daily intervention probe. For receptive probes, the child was asked to point to a targeted vocabulary word from an array of four pictures. For the first two children, George and Nick, the array included one target item and three distractors, picture that were not ever target words. But for the other three children, the array included one same-modality vocabulary word (not the correct response in the trial) and two distractors. These changes were

made to test overgeneralization of within modality targets among each children's selections. For expressive probes, the child was asked to name an individual picture. Non-corrective feedback (e.g. "nice pointing!"; "thank you for talking") was given throughout the daily intervention probes. The order of probes delivered was randomized. After the child reached at least 80% correct responses across daily intervention probes for three consecutive sessions, the next probe condition was initiated as prelude to intervening on the next vocabulary set.

**Cross modal probes.** At baseline and at each subsequent probe condition, the child was asked to point to pictures representing the targeted vocabulary words (expressive-to-receptive generalization probe) and to name the targeted vocabulary (receptive-to-expressive generalization probe). For example, if a child had learned or was scheduled to learn the word "cowboy" receptively, the child would be asked, "what's that?" or prompted, "this is a_____." Cross modal probe data was collected once per probe condition, and at least three trials of each word were included each time vocabulary words were probed.

All words, including trained, untrained, and control sets of vocabulary, were included in the cross modal probe condition. Non-corrective feedback was used throughout the cross modal probe condition. In order to maintain motivation, "success words" were interspersed with the targeted vocabulary. These were words identified by the parent as well-known and motivating words for the child. Some examples of success words were favorite television characters including "Elmo" and "Barney." These success words functioned to maintain a high level of success during the probe task and as a measure of ongoing task compliance.

**Within-modality probes**. During within-modality probes, each word was probed in the same modality that it would be (baseline) or had been (follow-up) taught. For example, if a child had learned, or was scheduled to learn, the word "cowboy" receptively, the child would be asked

to “point to cowboy” as a within modality probe. Unlike daily intervention probes wherein session specific targets were probed, all words assigned to that participant, including trained, untrained, and control sets of vocabulary, were included in the within-modality probes. Non-corrective feedback and success items were used throughout the within modality probes.

**Quantifying Generalization**

Perhaps the most straightforward dependent measure of generalization would simply be to plot percentage of correct responses for the receptive and expressive targets, and this method is included in the figures for each participant. However, it is also useful to adopt a more stringent criterion for generalization that could more precisely evaluate generalization level. For example, the probability of simply guessing correctly on the receptive language probes is .25 (25%) because there are four choices presented. Although one could argue that *any* percentage greater than 25 reflects at least some generalization beyond chance levels, a more conservative approach is to calculate the probability of guessing correctly using the binomial statistic (Altman 1999, Zar, 1984). Using this method, we adopted a criterion of 67% correct responses (less than .05 probability that responses are attributable to chance guessing) for receptive targets, including expressively-taught, receptively-probed cross modal targets.

The probabilistic considerations for receptive to expressive probes are more complex, as the probability of guessing correctly is unknown and may vary from child to child, depending, at least in part, on the size of his or her individual lexicon. We adopted a 50% correct level to indicate that a word set taught receptively had generalized to the expressive modality. The rationale for this was that at least one of the words in the pair was learned fully, or that both words were learned partially in order to correctly name 50% of the expressive probes.

More broadly, success in generalization was defined as meeting criterion on the majority of legs of intervention (2 out of 3 legs). That is, the receptive to expressive generalization must have occurred in more than 50% of the probes in at least two out of three intervention legs to be counted as generalized from the receptive modality (treated) to the expressive modality (untreated). Similarly, at least two of the three legs must have shown at least 67% on the receptive generalization probes for an individual child to be credited with expressive (treated) to receptive (untreated) cross modal generalization.

**Inter-Observer Agreement**

IOA was determined for at least 33% of expressive and receptive probe conditions for each participant. IOA was conducted by an independent observer (another clinician or data analyst) by watching the session via videotape and recording the child's responses as either correct, incorrect, or no response. Words produced with articulation errors were marked "correct" as long as the response was intelligible. The observer's scoring was then compared to the treating clinician's record of the child's scores. The discrete nature of the probes made them readily identifiable to independent observation. IOA ranged from 95-100% across sessions for all participants.

**Procedural Fidelity**

Procedural fidelity was determined across 40-60% of intervention sessions and 40-60% of probe sessions for each participant. Procedural fidelity was measured by the independent observer either during the session or via videotape. The observer recorded the extent to which the intervention and probe condition trials were implemented as planned using a binary (implemented/not implemented) system. Implementation accuracy was calculated across each trial during intervention (20 trials) or across each discrete probe during probe sessions (48 trials).

The following items were recorded for each trial: *clinician secured child's attention, clinician delivered task directive correctly, response interval was the correct length, clinician praised testing behavior, appropriate corrective feedback was given* and *inter-trial interval was the correct length*. Procedural fidelity ranged from 98-100% across sessions for all participants.

## RESULTS

Plots of each child's responses at baseline (cross modal and within-modality probes), during intervention (daily intervention probes) and follow-up probes (cross modal and within-modality probes) are displayed in Figures 1-5. Each participant met receptive and expressive criterion (80%, three consecutive sessions) for each word set, leading to the conclusion that words were learned. Meeting criterion on these daily intervention probes was a prerequisite of the research questions. Participants took 7 to 35 sessions on an individual intervention tier to meet criterion.

### Cross-Modal Generalization

Cross-modal generalization was higher for expressive-to-receptive than for receptive-to-expressive. For expressive-to-receptive cross modal probes, the criterion for success was set at 67%. All five children demonstrated cross modal generalization on the expressive-to-receptive probes for the majority of tiers of intervention (2 of 3; Table 2). For receptive-to-expressive cross modal probes, the criterion for success was set at 50%. In contrast to expressive-to-receptive probes, no children reached criterion for cross modal generalization on the receptive-to-expressive probes for the majority of tiers of intervention, with average receptive-to-expressive generalization at 17% and individual children's averages ranging from 6% to 33%.

**Secondary Analysis: Maintenance**

Maintenance probes were administered for the first and second legs of intervention. Proportions of correct responses on the first maintenance probe after intervention are shown in Table 3. All five children showed some maintenance within the trained modality for vocabulary targets, even several months later (within-modality probes after intervention). Children also showed high levels of maintenance in untaught modalities for which generalization occurred in the probe immediately following intervention (cross modal probes after intervention) using the same criteria as the cross modal probes. That is, when children generalized successfully immediately following intervention, they continued to be successful at subsequent time points. And when children were unsuccessful immediately following intervention (such as in the receptive-to-expressive probes), they were also unsuccessful at subsequent time points.

**Auxiliary Analysis: Control Target Sets**

As one would expect in real word studies, there were a few cases in which some untrained words were produced or comprehended. Each child was probed at each probe condition on a set of four control words. The criteria for success used during cross modal and general probes for the intervention sets were also used for the control set. One child, George, demonstrated evidence of learning for one control word in both the expressive and receptive modalities. No other children demonstrated evidence of incidental learning to criterion in either modality. Therefore, these results show intervention effects well above the observed levels of incidental learning.

## DISCUSSION

Generalization is a ubiquitous problem both in clinical intervention research and in clinical practice, where learning in the clinic may not readily generalize to functional outcomes

at home or in the classroom (suggested in Siegel & Spradlin, 1985). Many children with disabilities show poor performance on generalization tasks even when they perform exceptionally well on explicitly learned tasks (Baer & Guess, 1971, Marion et al., 2012). The current study included an orthogonal test of expressive and receptive vocabulary learning wherein targets were taught independently with the express purpose of systematically testing cross modal generalization for vocabulary in children with DS. Broadly, cross modal generalization is often an assumed, but untested, outcome in clinical practice. Contrary to this assumption, the results of the current study indicate that cross modal generalization at the word level is not automatic in children with DS, particularly in the receptive to expressive direction. While all children, including those with and without disabilities, show considerable variability in expressive and receptive vocabulary (Bates, Dale, & Thal, 1995), it has long been established that children with typical language acquisition are capable of learning novel vocabulary in both modalities after only a few learning trials (Dollaghan, 1985; Grey, 2003). In contrast, the children in this study showed incomplete, partial cross modal generalization, particularly in the receptive-to-expressive generalization task, even after numerous training sessions and mastery in one modality across each replication.

Unlike previous studies of receptive and expressive vocabulary learning (for a review, see Petursdottir & Carr, 2011), the current study completely separated each language modality in order to examine the cross modal generalization. Vocabulary learning studies are often founded on a theoretical framework wherein expressive and receptive modalities are implicitly linked, or co-dependent, and that lexical storage is not complete unless the vocabulary item has been learned in both modalities (cf. Wynn & Smith, 2003). Another common assumption is that words learned expressively will incidentally generalize to receptive knowledge as well, an assumption

that is often valid in typically developing children (as in Dollaghan 1985). In this study, children with DS displayed learning in both modalities (individually) and relatively high levels of expressive-to-receptive generalization, but they did not demonstrate the levels of expressive-to-receptive generalization that one would expect if the modalities were truly co-dependent.

The literature includes a number of reports that generalization across settings and stimuli is difficult for children with intellectual disabilities, particularly when explicit cues are not provided (e.g., see the review in Ledford & Wolery, 2010). Although limited generalization occurs in most studies, generalization patterns are inconsistent and often quite low, which is consistent with cross modal generalization in the current report. Also, children with intellectual disabilities may have difficulty in the generalization of non-language tasks such as motor imitation in addition to language behaviors (Ledford & Wolery, 2010), suggesting that generalization is a more global problem extending beyond word learning. That is, difficulty in cross modal generalization in both expressive and receptive modalities is consistent an overall deficit in generalization abilities in children such as those with DS who display intellectual deficits.

**Clinical Implications**

Clearly, the expressive-to-receptive and receptive-to-expressive generalization patterns have clinical implications. On the one hand, because expressive vocabulary successfully generalized to receptive vocabulary across all children in the study for the majority of legs of intervention, it may be useful to initially focus on expressive skills with the hope of also incidentally gaining receptive skills. However, generalization criteria were below criterion levels for learning (50% and 67% versus 80% criterion during the active intervention probes). Therefore, it is clear that clinicians should not assume that expressive learning will generalize for

any particular vocabulary target or target set in children with DS. The results of this study indicate that receptive vocabulary should always be probed when words are initially taught expressively to determine whether cross modal generalization actually occurs in children with DS. Additionally, receptive vocabulary did not generalize to expressive in any of the children. The individual variability even within a fairly homogenous group of children with DS was considerable, as has been reported previously in typically developing children as well (cf. Bates, Dale, & Thal, 1995). Clinicians should assess cross-modal learning and provide additional instruction in the untrained modality as necessary to ensure full lexical acquisition.

Encouragingly, the current study also shows evidence of maintenance over several months, which has not always been reported in the previous literature (Pettursdottir & Carr, 2011). All five children showed relatively moderate levels of maintenance within the trained modality for vocabulary targets, even several months later. Children also demonstrated moderate levels of maintenance in untaught modalities for which generalization had occurred. This information can be used both for targeted language therapy and also for academic support in classroom settings.

**Limitations & Future Directions**

One limitation of the current study is the extensive probing required for comprehensive assessment of generalization in each probe session. During the intervention period, daily intervention probes were short, straightforward, and included only the vocabulary in which the child was being trained. During the cross modal and within-modality probe sessions, however, the inclusion of additional vocabulary (sixteen words as opposed to four words) and additional modalities (probed in both receptive and expressive modalities rather than one modality) may have resulted in some confusion and/or decreased motivation. Differences in the length and

intensity of the probe conditions relative to the daily intervention probes may account for some of the variability in individual child responses.

Future research is needed on the relative independence of expressive and receptive modalities as these relate to vocabulary and language learning. The current study isolated receptive and expressive modalities. Although clinicians frequently target receptive language goals independently in activities such as following directions, there is an ongoing need for empirical data on receptive language intervention (Camarata et al., 2009; Gillum & Camarata, 2004). In addition, many clinicians may target expressive and receptive language concurrently, such as in storybook reading. Further research is needed to consider the relationship of language modalities when they are taught simultaneously and when they are taught in isolation. On the one hand, this may improve efficiency in terms of target delivery and cross modal generalization (but see Wynn & Smith 2003 for children with ASD); on the other hand, isolating modality may serve to highlight the target forms and result in at least some degree of incidental cross modal generalization. The current study suggests that an efficient approach of intervention may be to target expressive forms first, followed by additional receptive training for those words with little or no cross modal generalization. However, order of presentation should be studied systematically to determine whether there is indeed any advantage to simultaneous or sequential instruction of vocabulary across modality.

## REFERENCES


Abbeduto, L., Murphy, M.M., Cawthon, S.W., Richmond, E.K., et al. (2003). Receptive language skills of adolescents and young adults with Down of Fragile X syndrome. *American Journal on Mental Retardation, 108,* 149-160.

Anderson, S.R. & Spradlin, J.E. (1980). The generalized effects of productive labeling training involving common object classes. *Journal of the Association of the Severely Handicapped, 5,* 143-167.

Baer, D.M. & Guess, D. (1971). Receptive training of adjectival inflections in mental retardates. *Journal of Applied Behavior Analysis, 4,* 129-139.

Bates, E., Dale, P.S., & Thal, T. (1995). Individual differences and their implications for theories of language development. In Fletcher, P. & MacWhinney, B. (Eds.), *Handbook of Child Language* (pp. 96-151). Oxford: Basil Blackwell.

Bird, E.K.R., Chapman. R.S., & Schwartz, S.E. (2004). Fast mapping of words and story recall by individuals with Down syndrome . *Journal of Speech, Language, and Hearing Research, 47,* 1286-1300.

Bucher, B., & Keller, M.F. (1981). Transfer to productive labeling after training in comprehension: Effects of three training variables. *Analysis and Intervention in Developmental Disabilities, 1,* 315-331.

Burgoyne, K., Duff, F.J., Clarke, P.J., Buckley, S., Snowling, M.J, & Hulme, C. (2012). Efficacy of a reading and language intervention for children with Down syndrome: a randomized controlled trial. *Journal of Child Psychology and Psychiatry, 53,* 1044-1053.

Camarata, S., Nelson K.E., Gillum H., and Camarata, M. (2009). Incidental reception language growth associated with expressive grammar intervention in SLI. *First Language, 29,* 51-63.

Chapman, R.S. (2006). Language learning in Down syndrome: The speech and language profile compared to adolescents with cognitive impairment of unknown origin. *Down Syndrome Research and Practice, 10,* 61-66.

Chapman, R.S. & Hesketh, L.J. (2001). Language, cognition, and short-term memory in individuals with Down syndrome. *Down Syndrome Research and Practice, 7,* 1-7.

Chapman, R.S., Schwartz, S.E., & Kay-Raining Bird, E. (1991). Language skills of children and adolescents with Down syndrome: I. Comprehension. *Journal of Speech and Hearing Research, 34,* 1106-1120.

Carrow-Woolfolk, E. (2001). *Test of Auditory Comprehension of Language, 3rd edition*. Circle Pines, MN: American Guidance Service.

Dollaghan, C. (1985). Child meets word: "Fast Mapping" in preschool children. *Journal of Speech and Hearing Research, 28,* 449-454.

Dunn, L. M, & Dunn, L. M. (2007). *Peabody Picture Vocabulary Test—4th edition.* Circle Pines, MN: American Guidance Service.

Eadie, P.A., Fey, M.E., Douglas, J.M., Parsons, C.L. (2002). Profiles of grammatical morphology and sentence imitation in children with specific language impairment and Down syndrome. *Journal of Speech, Language, and Hearing Research, 45,* 720-732.

Fidler, D.J., Hepburn, S., & Rogers, S. (2006). Early learning and adaptive behavior in toddlers with Down syndrome: Evidence for an emerging behavioral phenotype? *Down Syndrome Research and Practice,* 9, 37-44.

Gast, D.L. (2010). Single Subject Research Methodology in Behavioral Sciences. New York: Routledge, Taylor & Francis Group.

Gillum, H. & Camarata, S. (2004). Importance of treatment efficacy research on language comprehension in MR/DD research. *Journal of Mental Retardation and Developmental Disabilities Research Reviews, 10,* 201–207.

Gray, S. (2003). Word learning by preschoolers with specific language impairment: What predicts success? *Journal of Speech, Language, and Hearing Research, 46,* 56-67.

Guess, D. (1969). A functional analysis of receptive language and productive speech: Acquisition of the plural morpheme. *Journal of Applied Behavioral Analysis*, 2, 55-64.

Hojem, M. A., & Ottenbacher, K. J. (1988). Empirical investigation of visual-inspection versus trend-line analysis of single-subject data. *Physical Therapy*, *68*, 983-988.

Horner, R., & Baer, D. M. (1978). Multiple probe technique: A variation of the multiple baseline design. *Journal of Applied Behavior Analysis, 11,* 189-196.

Keller, M.F. & Bucher, B. (1979). Transfer between receptive and expressive language in developmentally disabled children [Abstract]. *Journal of Applied Behavior Analysis, 12,* 311.

Ledford, J.R., & Wolery, M. (2010). Teaching imitation to young children with disabilities: A review of the literature. *Topics in Early Childhood Special Education, 30,* 245-255.

Lieberman, R.G., Yoder, P.J., Reichow, B., & Wolery, M. (2010). Visual analysis of multiple baseline across participants graphs when change is delayed. *School Psychology Quarterly*, *25*, 28-44.

Marion, C., Martin, G., Yu, C.T., Buhler, C., Kerr, D., & Claeys, A. (2012). Teaching children with autism spectrum disorders to mand for information using "which?" *Journal of Applied Behavior Analysis, 45,* 865-870.

Martin, G.E., Klusek, J., Estigarribia, B., & Roberts, J.E. (2009). Language characteristics of individuals with Down syndrome. *Topics in Language Disorders, 29,* 112-132.

Martin, N. & Brownell, R., (2010). *Expressive One-Word Picture Vocabulary Test – 4th edition.* Novato, CA: Academic Therapy Publications.

Parsonson, B. S., & Baer, D. M. (1992). The visual analysis of data, and current research into the stimuli controlling it. In T.R. Kratochwill & J.R. Levin (Eds.), *Single-case research design and analysis: New directions for psychology and education* (pp. 15-40). Hillsdale, NJ: Lawrence Erlbaum.

Petursdottir, A., & Carr, J. (2011). A review of recommendations for sequencing expressive and receptive language instruction. *Journal of Applied Behavior Analysis, 44,* 859-876.

Roberts, J., Price, J., Barnes, E., Nelson, L., et al. (2007). Receptive vocabulary, expressive vocabulary, and speech production of boys with Fragile X syndrome in comparison to boys with Down syndrome. *American Journal on Mental Retardation, 112,* 177-193.

Roid, G. & Miller, L. (1997). *Leiter International Performance Scale - Revised.* Wood Dale, IL: Stoelting, Co.

Schumaker, J. & Sherman, J.A. (1970). Training generative usage by imitation and reinforcement procedures. *Journal of Applied Behavior Analysis, 3,* 273-287.

Siegel, G.M. & Spradlin, J.E. (1985). Therapy and research. *Journal of Speech and Hearing Disorders, 50,* 226-230.

Thal, D. J. & Tobias, S. (1992). Communicative gestures in children with delayed onset of oral

expressive vocabulary. *Journal of Speech and Hearing Research*, *35*, 1281–1289.

Wolf, J.M., & McAlonie, M.L. (1977). A multimodality language program for retarded preschoolers. *Education and Training of the Mentally Retarded,* 12, 197-202.

Wynn, J.W. & Smith, T. (2003). Generalization between receptive and expressive language in young children with autism. *Behavioral Interventions, 18*, 245-266.

Zar, J.H. (1984). *Biostatistical analysis.* Prentice Hall: New Jersey.

Zimmerman, I. L., Steiner, V. G., & Pond, R. E. (1992). *Preschool Language Scales*, Third Edition. San Antonio, TX: The Psychological Corporation.

**Table 1.** Description of participants and standard test results

| Child | Age | Gender | Leiter-R | PLS-3 | PLS AE | TACL-3 | PPVT-4 | EOWPVT-4 |
|---|---|---|---|---|---|---|---|---|
| George | 5;1 | M | 40 | <50 | 1;5 | 44 | <36 | <55 |
| Nick | 4;10 | M | 77 | <50 | 2;6 | 59 | 71 | 70 |
| Sam | 3;6 | M | 76 | 51 | 2;0 | 72 | 65 | <55 |
| Joy | 4;6 | F | 74 | <50 | 1;8 | 57 | 65 | <55 |
| Tony | 4;10 | M | 76 | 52 | 2;7 | 70 | 63 | 73 |

*Note*. Floor effects are seen on the PLS (floor = 50), PPVT (floor = 36) and EOWPVT (floor = 55). PLS Age Equivalencies (AE) are provided based on children's raw scores on the PLS.

**Table 2.** Children's success in probe condition immediately following intervention

| | Expressive Taught | | Receptive Taught | |
|---|---|---|---|---|
| Participant | Proportion of Targets at 50% Correct – Same Modality | Proportion of Targets at 67% Correct – Opposite Modality | Proportion of Targets at 67% Correct – Same Modality | Proportion of Targets at 50% Correct – Opposite Modality |
| George | 1.00 | 1.00 | 0.00 | 0.00 |
| Nick | .67 | 1.00 | 1.00 | .33 |
| Sam | .67 | .67 | .67 | 0.00 |
| Joy | .67 | .67 | 1.00 | 0.00 |
| Tony | .67 | .67 | .33 | 0.00 |
| Proportion of children successful across majority of tiers (2/3) | 1.00 | 1.00 | .600 | 0.00 |
| Total number of successful replications (of 15) | 11 | 12 | 9 | 1 |

**Table 3.** Children's success in the probe condition during first maintenance probes

| | Expressive Taught | | Receptive Taught | |
|---|---|---|---|---|
| Participant | Proportion of Targets 50% Correct – Same Modality | Proportion of Targets at 67% Correct – Opposite Modality | Proportion of Targets at 67% Correct – Same Modality | Proportion of Targets at 50% Correct – Opposite Modality |
| George | 1.0 | 1.0 | 0.0 | 0.0 |
| Nick | 1.0 | 1.0 | 1.0 | .50 |
| Sam | 0.0 | 0.0 | 0.0 | .50 |
| Joy | .50 | .50 | 1.0 | .50 |
| Tony | .50 | 1.0 | .50 | .50 |
| Proportion of children successful at criterion across both tiers | .40 | .60 | .40 | 0.0 |
| Total number of successful replications (of 10) | 6 | 7 | 5 | 4 |

**Figure 1.** George.

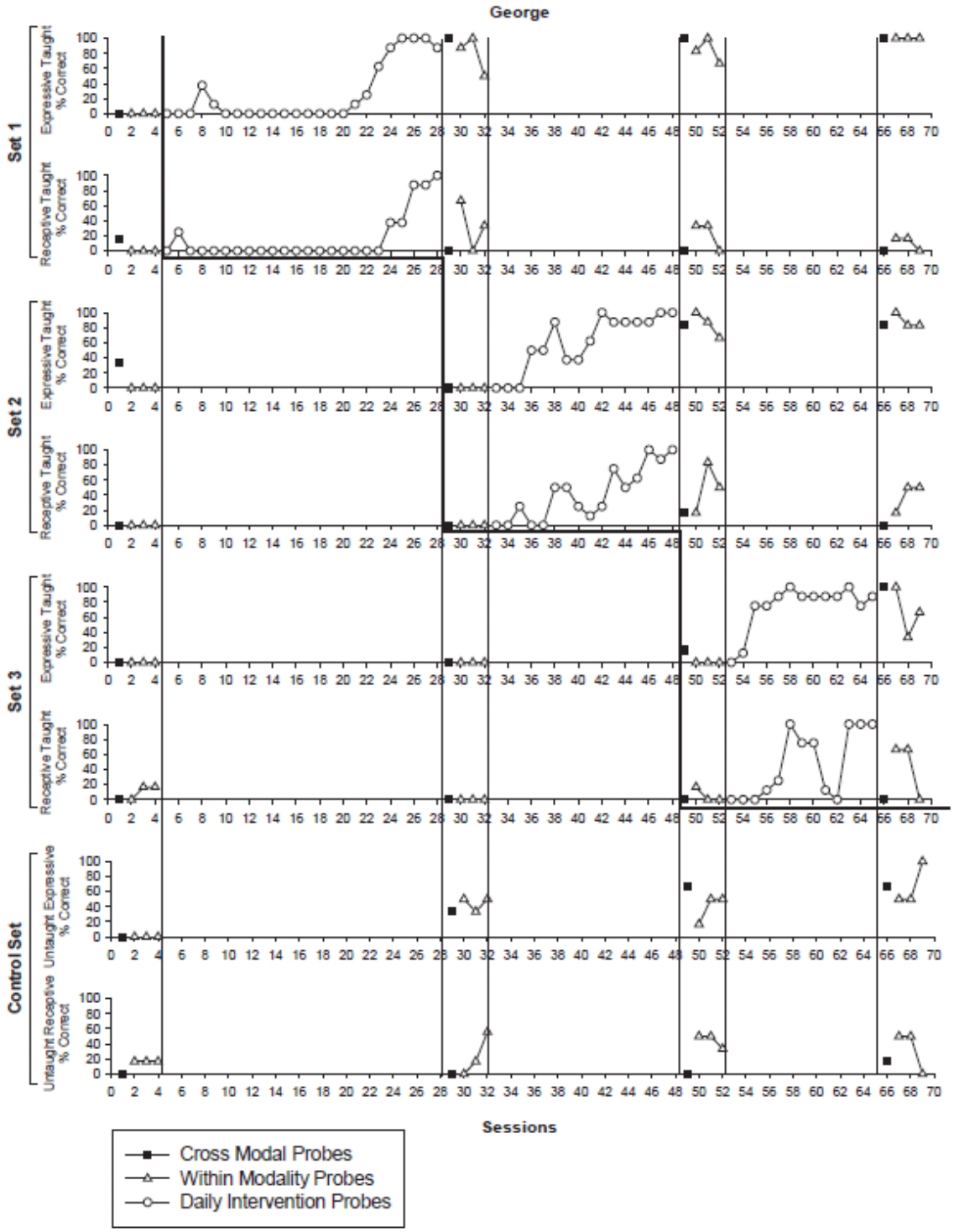


**Figure 2.** Nick.

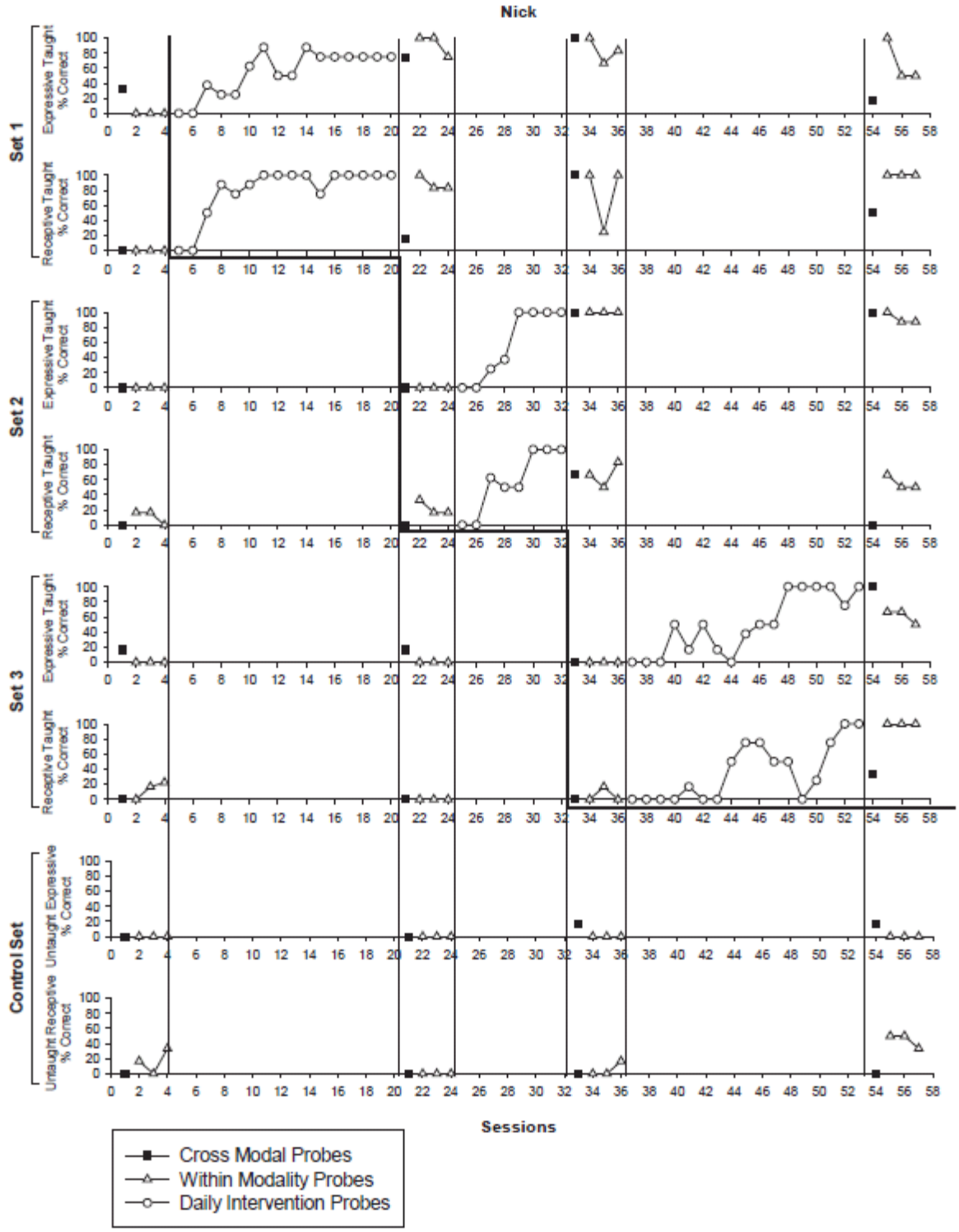


**Figure 3.** Sam.

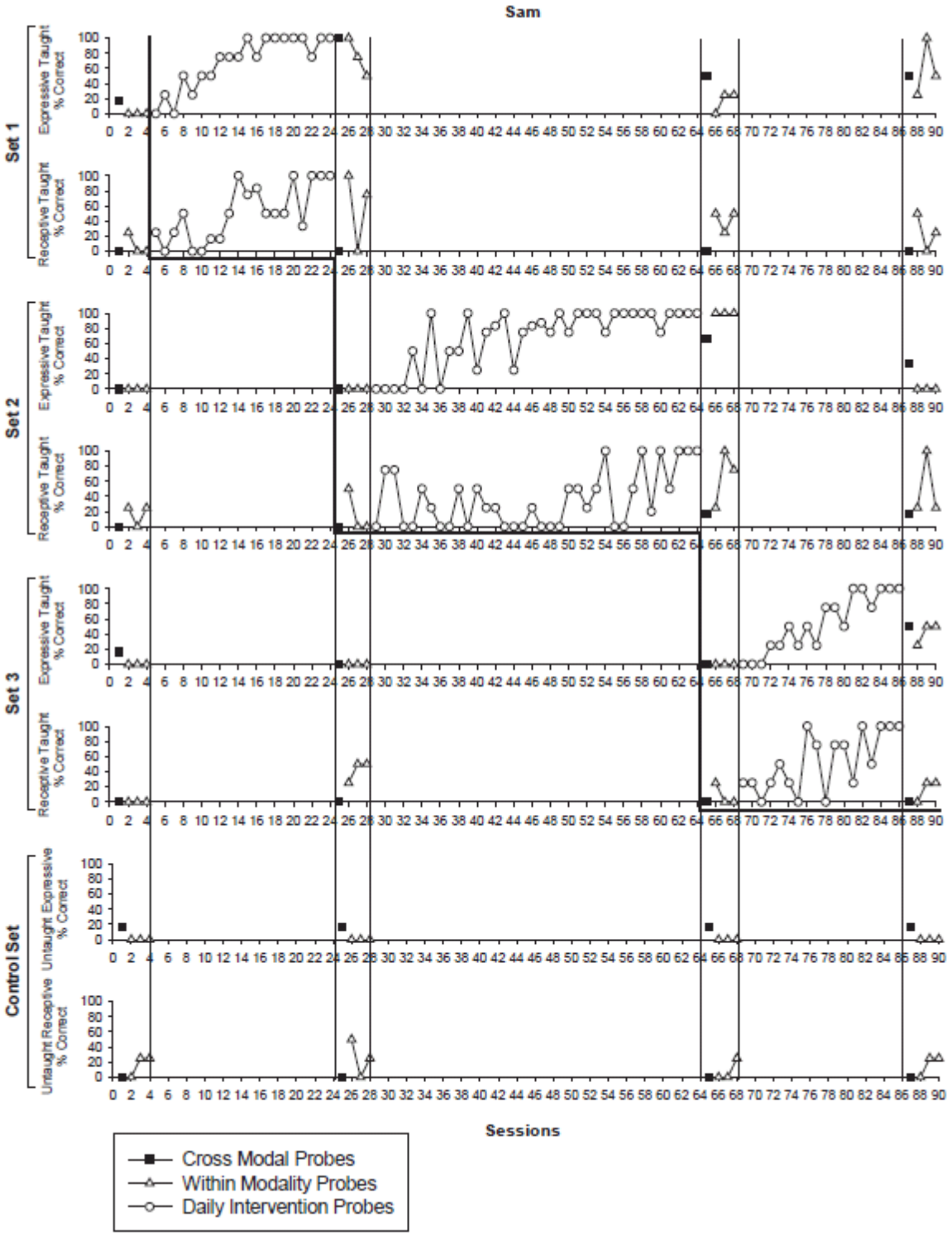

Sam
Set 1
Set 2
Set 3
Control Set
Expressive Taught % Correct
Receptive Taught % Correct
Untaught Expressive % Correct
Untaught Receptive % Correct
Sessions
Cross Modal Probes
Within Modality Probes
Daily Intervention Probes

**Figure 4.** Joy.

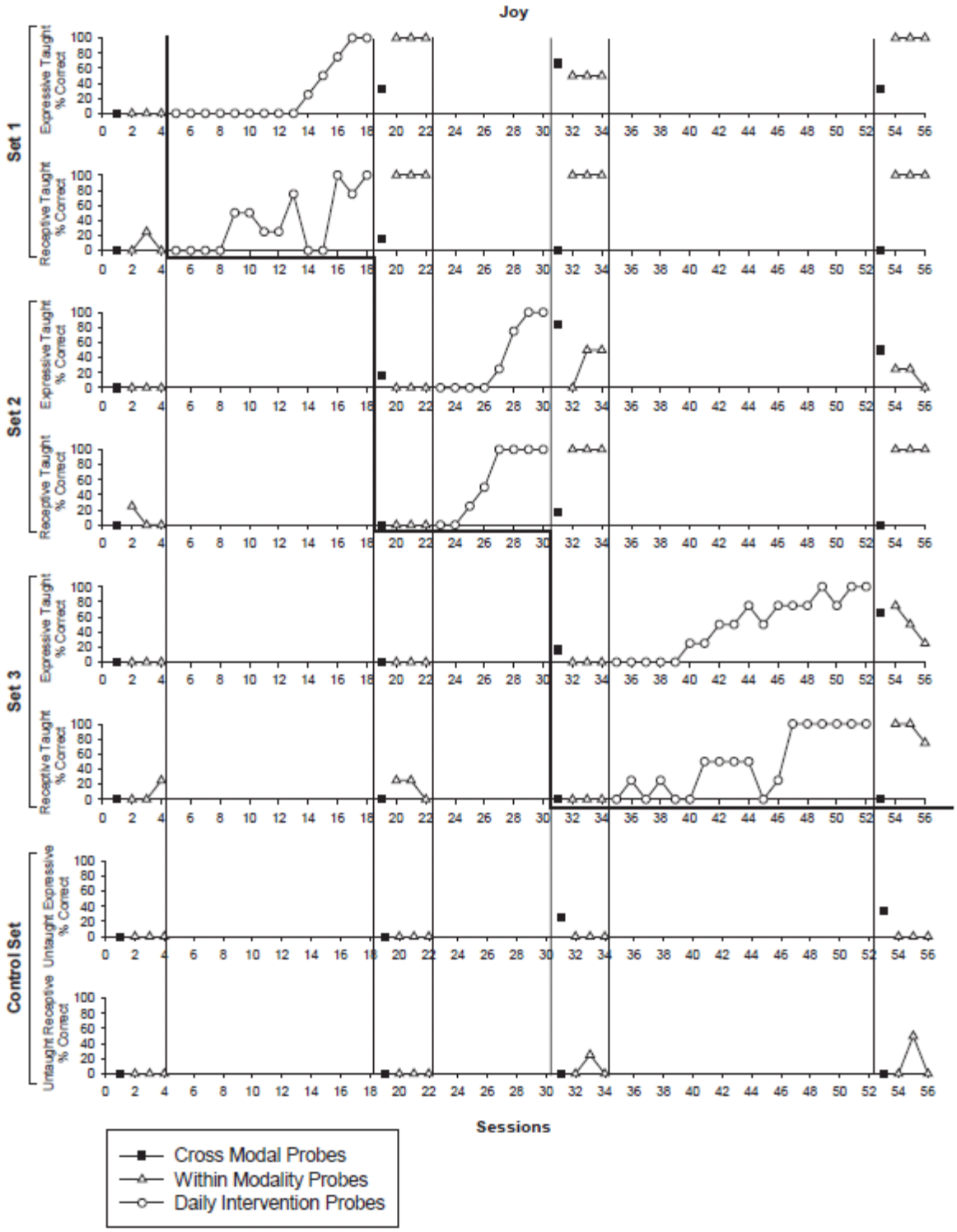
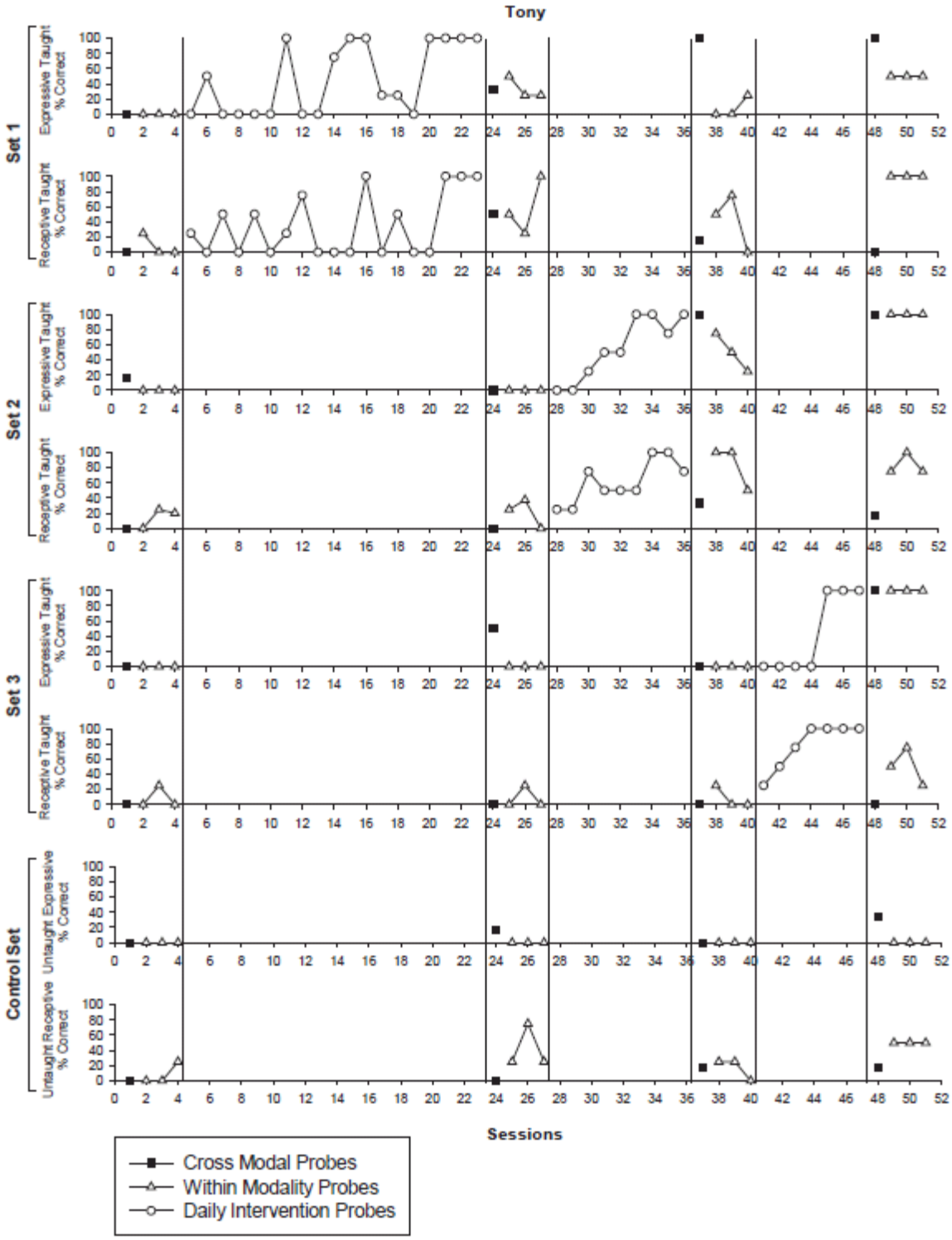

Joy
Set 1
Set 2
Set 3
Control Set
Expressive Taught % Correct
Receptive Taught % Correct
Untaught Expressive % Correct
Untaught Receptive % Correct
Sessions
Cross Modal Probes
Within Modality Probes
Daily Intervention Probes

**Figure 5.** Tony.



## APPENDIX A

**Illustration of vocabulary selection for "Tony."**

Step 1: Parents review noun list to select unknown words: Tony's parents reviewed a list of approximately 50 concrete nouns and selected those nouns they believed to be absent from the child's expressive and receptive repertoire. Tony's parents selected 20 words.

Step 2: Child imitation of unknown nouns: The child was asked to repeat each target word after the examiner. Pictures were not present. Tony was unable to produce one of the 20 s words intelligible and thus, this word was excluded from the XX. (20 words reduced to 19).

Step 3: Child picture matching: Tony was asked to match one picture for each of the 19 nouns to an identical picture from a small array. The clinician did not name the vocabulary word; the child was asked simply to match the pictures. Only those stimuli that the child could correctly match were included (no reduction; number of words remained at 19).

Step 4: Child word identification: The child was asked to identify each word expressively and receptively. Words identified at either >0% accuracy (expressive) or >25% accuracy (receptive) were excluded (19 words reduced to 17).

Step 5: Examiner selection of words: From this reduced pool (17 words), 16 words were randomly selected and then randomly assigned to (a) expressive or receptive condition and (b) target sets 1, 2, 3, or control. Tony's final list of words (alphabetized): astronaut, boomerang, cabin, carousel, gorilla, gazebo, helicopter, jester, lighthouse, lizard, oyster, pelican, pliers, sailor, silo, rhino

## APPENDIX B

Sample story and play scripts from *Storytime Language Program for Speech-Language Pathologists.*

**Sample Story Script.**

| RECEPTIVE CONDITION | EXPRESSIVE CONDITION |
|---|---|
| *Targets:* Pliers and Silo.<br>*Say:* This story has two special words. One is pliers and the other one is silo.<br>*Say*: There once was farmer. He had many tools. See his pliers.<br>Model: Point to the pliers | |
| Receptive Prompt: Where are the pliers? Or Touch pliers.<br><br>Feedback:<br>Correct: Yes, there are the pliers or yes, you found the pliers.<br>Error: Oops, here it is (Point to pliers).<br>No response: Thank you for looking. Here it is (Point to pliers). | Expressive Prompt: What are these? (Point to pliers).<br><br>Feedback:<br>Correct: Yes, these are pliers or you are right these are pliers.<br>Error: Oops, these are pliers.<br>No response: Thank you for looking. These are pliers (point to pliers). |

**Commenting Play.**

*Determining the Child's Attention*

Examples of when the child is attending to the object within play with the clinician include: the child looks at the object; the child has touched the object within 3 seconds; the child touches, manipulates, or reaches for the object; the child verbally or nonverbally indicates the object; the child verbally or nonverbally requests the object. It is not required to get the child to look to the clinician, prior to presenting a target comment.

*Presentation of Targets Comments*

Each word in the target set must be presented a minimum of 6 times, each. This will result is a minimum cumulative Target Commenting total of 12. The clinician can comment beyond the minimum of 12 at his or her own discretion. Target comments: occur when the child is attending the object; should be spaced throughout commenting play; may never be a *recast* of a target word but may follow production or attempted production of a target word if the clinician provides intervening language and waits 2 seconds; can never require that the child demonstrate receptive (e.g. "get the pliers") or expressive (e.g. "what's that?") knowledge of a target word. Choice questions are permissible (e.g. "do you want the pliers or the hammer?").

*Spacing Target Comments*

Target Comments should be spaced throughout the Commenting Play. At least 1 Target Comment of each word in the set should occur within each 2-minute segment of play. For example, if the Commenting play last 8 minutes, there should be at least 1 comment of each word from 0-2minutes, 2-4 minutes, 4-6 minutes, and 6-8 minutes.

*Duration*

The intervention portion of a session is 12 minutes in length, and is made up of the Target Story Book and Commenting play. The duration of the Commenting play will be the number of minutes that remain (of the 12) after presentation of the Target Story Book. For example, if the Target Story Book presentation lasts 6 minute, then the Commenting Play will last 6. Or, likewise, if the Target Story Book presentation lasts 3 minute, then the Commenting Play will last 9, and so forth.