

Cross-modal Generalization of Vocabulary in Children with Specific Language Impairment

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Specific language impairment is a language disorder diagnosed in childhood characterized by nonverbal intelligence within normal limits but language skills below normal levels (Leonard, 2000; Stark & Tallal, 1981). The diagnosis requires a test of nonverbal cognitive abilities (Camarata & Nelson, 2002; Camarata & Swisher, 1990), in addition to language testing. The measures used to assess cognitive abilities must be nonverbal in order to prevent language from being a confounding variable on verbal IQ measures. A large epidemiological study has indicated that SLI has a prevalence of 7.4% for boys and 6% for girls (Tomblin et al., 1997).

Children with SLI tend to have deficits in word-learning (Leonard, 2000). Word-learning is the ability to encode a visual and phonological representation of an object, link the two representations, and retrieve a representation by labeling or pointing to the object. Children with SLI show, on average, a 12 month discrepancy in their production of their first words, in comparison to typically developing children (Leonard, 2000). For this population, first words emerge at the average age of 23 months instead of at 11 months (Leonard, 2000). This late acquisition of words is predictive of language impairment at seven years of age (Taylor, Zubrick, & Rice, 2013). Although research has suggested that children with SLI use fewer verbs than typical language peers, contrasting findings by Thordardottir and Ellis Weismer (2001) demonstrate that the usage of high-frequency verbs between the two groups does not reveal such a discrepancy.

The current body of literature addressing vocabulary learning in children with SLI has addressed both fast mapping and learning. The process called “fast mapping” was described by

Carey and Barlett (1978), and refers to the ability to quickly retrieve linguistic features of a novel word from working memory, after minimal exposure to that word. Children with SLI perform similarly to typically developing age-matched peers on fast mapping tasks; however, they have more difficulty encoding these words into their long-term memory, or learning them more permanently (Gray, 2003). That is, short term recall appears to be similar to typically developing children, but those with SLI show deficits in long term retrieval of these forms even when they can employ fast mapping for rapid learning. Research by Horst and Samuelson (2008) further suggests that fast mapping does not necessarily entail retention in typically developing 24-month-olds.

Research on vocabulary acquisition in children with SLI suggests that this population requires more support than their typical language peers in word-learning tasks. Kieran and colleagues (1998) employed a supported learning context, which used modeling, imitation, comprehension, and production prompts to teach new vocabulary. The results of this study demonstrated that children with SLI learned to produce fewer words than children with typical language. Additionally, Rice and colleagues (1994) found that, after viewing a recorded story presentation, children with SLI required more repetitions of a new word in order to comprehend it, in comparison to their typically developing peers. Although typically developing children could learn three words after hearing each three times, children with SLI required ten repetitions on average, or more than 300% more exposure. Also, after these ten repetitions, the children failed to retain their comprehension gains one to three days afterwards, unlike children with typical language, who had significantly longer retention. Although fast mapping performance is consistent with that of typical language peers, children with SLI evidently require more support

for word-learning and maintenance, making them candidates for language therapy focusing on vocabulary learning.

Previous research has also investigated how to enhance word-learning in various populations with disabilities, and some techniques may be particularly beneficial to children with SLI. Word-learning studies of children with SLI, as mentioned previously, have already incorporated high input, supported learning, and story contexts. Additionally, the literature has indicated that activities such as shared book reading can increase both receptive and expressive vocabulary in typically developing preschoolers (Robbins & Ehri, 1994; Senechal, 1997; Waskik & Bond, 2001). Senechal's findings suggest that "wh-" questions, in particular, may promote the development of expressive vocabulary. In children with autism, an important principle of language intervention is the child's high motivation to participate (Koegel et al., 2003). Such motivation can be provided by varying the task, allowing the child to choose or direct aspects of intervention, and using motivating reinforcers. Extensive research has also demonstrated that naturalistic milieu training principles are an evidenced-based strategy for improving communication in preschool children with language needs in a variety of populations with disabilities (Hancock & Kaiser, 2006). The combination of interactive book reading, child motivation, naturalistic approach, and high input frequency of target vocabulary will likely provide maximal opportunity for word-learning success.

After a word has been learned, a question relevant to efficient therapy practice is whether the learned word can be generalized from expressive to receptive forms, or from receptive to expressive forms. These forms are often considered to be "modalities." If the speech-language pathologist can instruct in one modality (e.g. the expressive), while having learning occur in the other (e.g. receptive), the result is "cross-modal generalization". Among other benefits, an

intervention resulting in cross modal generalization is more efficient than one that does not transfer from receptive to expressive forms and vice versa (Jacobs and Thompson, 2000).

Children with SLI may have deficits in receptive, expressive, or both modalities. Deficits can be evident at the lexical (vocabulary), grammatical, syntactic, pragmatic, phonological, and morphosyntactic level (Leonard, 2000). If an intervention in the expressive modality generalizes to learning in the receptive modality, or vice versa, the one treatment is appropriate for children with vocabulary needs in the receptive, expressive, and both modalities. Findings in the literature on cross-modal generalization of language demonstrate that generalization patterns are different for typically developing children, children with language deficits, and children with pragmatic or cognitive deficits.

Prior research in typically developing children suggests that cross-modal generalization occurs from the receptive to the expressive modality. Typically developing three-year-old children have productive language that is less advanced than their receptive language, as demonstrated by lower mean scores on productive tasks (Fraser, Bellugi, & Brown, 1963). Dollagan (1985) also found that more preschool children were able to comprehend a label for a fast-mapped word than were able to produce it. The children were only able to produce the initial phonemes of the label.

It has long been known that some populations with disabilities may display only partial knowledge of a learned language form, failing to generalize across settings and modalities (Guess, 1969). This research suggests that cross-modal generalization for vocabulary occurs in some populations, but not others. For example, Guess and Baer (1973) and Guess (1969) demonstrated that there was not reliable generalization between receptive and expressive knowledge of plural morphemes in children with intellectual disabilities. In a study of boys with

autism, Wynn and Smith (2003) found that, although these children could learn the receptive and expressive forms of words, there was neither consistent generalization from expressive to receptive, nor vice versa. Expressive to receptive generalization was the most common form of generalization, though, with two of six children demonstrating this consistently across two word-learning instances. They also reported that receptive to expressive generalization occurred only in children with comparatively higher language scores.

Although successful cross-modal generalization has not been demonstrated in children with autism and intellectual disabilities, this does not directly suggest that children with SLI will demonstrate similar performance. Previous research has focused primarily on populations of children with more severe disabilities, including cognitive and pragmatic deficits as well as language impairments. Children with SLI do not have global intellectual and pragmatic deficits, so they may show higher levels of cross-modal generalization than seen in the current literature on word-learning in children with other disabilities. In a study of grammatical learning, Camarata and colleagues (2009) reported that children with SLI presenting with receptive language deficits and undergoing an expressive treatment for age-appropriate morphemes significantly increased their receptive language skills. This increase in receptive skills associated with treatment on expressive forms is an instance of successful cross-modal generalization in SLI, albeit for grammatical structures rather than lexemes. The intervention consisted of direct imitation, imitation plus modeling, conversational recast, and naturalistic methods. The results from Camarata and colleagues indicate that cross modal generalization is possible across receptive and expressive domains for children with SLI; however, the generalization required significant support and the authors did not examine vocabulary.

The purpose of the proposed study is to address the issue of cross modal generalization of lexical items in children with SLI by examining two research questions: 1) Is there expressive to receptive cross-modal generalization in children with SLI? And, 2) is there receptive to expressive cross-modal generalization in children with SLI? We will also examine whether there is maintenance of learned words after treatment is terminated, a question motivated by the previous reports of difficulty with long term maintenance of word-learning in SLI.

### **Method**

The data for this project were derived from a larger study of word-learning in children with disabilities, which included participants with SLI (Camarata and Wolery, Principal Investigators). A multiple baseline, multiple probe, single-subject design methodology was implemented to teach vocabulary so that generalization and maintenance could be examined. The design allows the investigation of individual learning and cross-modal generalization in real time with appropriate, individualized vocabulary for each participant.

Three children with SLI were taught nouns that, at baseline, were at or below chance response levels for receptive forms and absent expressively. By random assignment, half of these words were taught receptively, and half were taught expressively. Intervention included supported learning, shared book reading, and a naturalistic approach, all of which have been previously reported to promote word-learning in children with disabilities. During the intervention sessions, children were asked to identify target words in either the receptive or expressive modality, when prompted by the clinician in a discreet trial. These probe sessions occurred both before and during each phase of intervention. The study compared target words learned in the receptive and expressive modality and probed cross-modal generalization. The design included three sets of receptive intra-subject subject replication and three sets of

expressive intra-subject replication, resulting in six total replications. Note that the goal of the intervention was also to ensure word-learning in a specific modality (expressive or receptive) so that cross modal generalization to the contrasting modality could be probed after learning.

### **Participants**

Participants in this study were three preschool-aged children recruited to participate through Nashville Metro Schools and The Vanderbilt Bill Wilkerson Center. Inclusionary criteria were (a) non-verbal intellectual ability within normal limits (e.g., 85 to 115 on the Leiter-R, Roid & Miller, 1997), (b) language scores below normal limits on one or more standardized language tests, and (c) receptive or expressive vocabulary scores below normal limits, as indicated by standardized testing.

### **Standardized Testing**

As part of the study participation, children were administered standardized tests in order to assess nonverbal intellectual ability, expressive and receptive language, and vocabulary. Nonverbal intellectual ability was assessed using the *Revised Leiter International Language Performance Scale* (Leiter-R, Roid & Miller, 1997). All three children scored within normal limits. Expressive and receptive language was assessed using the *Preschool Language Scale – 3* (PLS-3, Zimmerman et al., 1992). All three children scored below normal limits on receptive or expressive, and combined measures. Children also were administered the *Test of Auditory Language Comprehension* (TALC-3, Carrow-Woolfolk, 2001), the *Peabody Picture Vocabulary Test-4* (PPVT-4, Dunn & Dunn, 2007), which assessed receptive vocabulary, and the *Expressive One-Word Picture Vocabulary Test-4* (EOWPVT-4, Martin & Brownell, 2010), which tested expressive vocabulary. These measures are summarized in Table 1.



Table 1.

*Description of participants and standardized test results.*

Child	Age	Gender	Leiter-R	PLS-3	TACL	PPVT	EOWPVT
JB (13)	37	M	90	80	87	93	63
AB (18)	64	M	94	60	87	92	81
NS (25)	65	M	108	63	81	58	63

### **Vocabulary Selection**

At least 16 noun targets for each child were selected in a five step process. First, parents indicated words missing from the child's vocabulary through parent report. Second, target words that the child could not imitate intelligibly due to phonological limitations were eliminated from the target vocabulary set. This was done to ensure that expressive word attempts were intelligible to the coders. Third, to ensure that the child could match, the clinician asked the child to match two different images of the same object. If the child could not match the objects, the labels for the objects were excluded from the vocabulary set. Fourth, to determine the child's baseline expressive knowledge of words, the child was asked to name each image representing a target word. Lastly, to assess baseline receptive knowledge, the child was required to identify each picture from a set of four by pointing. Words that were identified correctly at or above 25% (chance level) were eliminated from the intervention targets. Before intervention, all words were probed three times in order to obtain a stable baseline. Two expressive targets and two receptive targets were selected as controls and were monitored, but not treated. In total, each child had four pairs of two receptive targets, and four pairs of two expressive targets. The fourth receptive and

expressive pairs were controls and were not treated during the study, but these forms were monitored to evaluate incidental, untreated learning.

### **Language Intervention**

During each intervention set, two receptive and two expressive vocabulary words were targeted in a one-on-one session with the clinician and child. Intervention sessions occurred at an average of four times per week. After the child demonstrated mastery of the words by having three stable data points at an average of 80% or higher accuracy, the clinician began instruction of the next vocabulary set. The clinician, play context, and reinforcement were consistent across receptive and expressive conditions. This procedure was replicated three times for each participant, for a total of twelve words (six expressive and six receptive) for each participant.

All words were taught in a storybook context, followed by a structured play context. During the storybook procedure, the words were presented at least 10 times by the clinician. For words targeted receptively, the clinician prompted the child to identify the word by pointing to it by asking “Where’s [target]?” For words targeted expressively, the clinician prompted the child to label the word by pointing to it and asking “What’s that?”

During the play portion, the clinician and child interacted with toys that corresponded to objects seen in the storybook, including both target and non-target vocabulary. The clinician named the object by commenting on the play, at least 10 times throughout the play session. The clinician provided scaffolding of joint attention during the labeling of the words. The total duration of each intervention session was 24 minutes. 12 minutes were dedicated to the receptive targets, and 12 to the expressive targets.

### **Reinforcement**

During intervention, correct responses of pointing or labeling were positively reinforced by using social rewards such as verbal praise, high-fives, or smiles. Incorrect responses were corrected by the clinician. In the receptive condition, responses were corrected by saying “Uh-oh! Here it is.” and pointing to the correct picture. In the expressive condition, responses were corrected by saying “Uh-oh! It’s a [target]” while touching or holding the object referent. Subsequent correct responses were positively reinforced as described above. If the child did not respond, the clinician waited a few seconds and provided the correct response by pointing or labeling.

**Probe Conditions**

Probes were used to assess the receptive and expressive knowledge of the target vocabulary set before, after, and during the intervention. These probes were divided into daily, within modality, and cross-modal probes. To probe a word receptively, the child was told: “Point to [target].” To probe a word expressively, the child was asked “What’s that?” Accuracy was averaged across each word pair in the set. A sample graph of probe data collected is shown below in Figure 1.

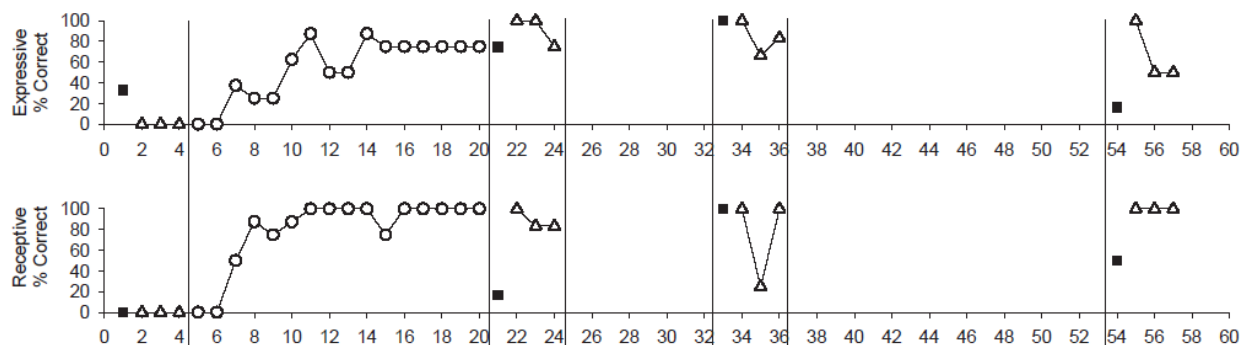


Figure 1: Sample graph of data obtained during probe sessions.

**Daily intervention probes** (See the circles in Figure 1) assessed the child's knowledge of the target vocabulary set, or the words that were being taught during an intervention session. These probes took place before each intervention session and each word was probed at least two times. The child was asked to point to images of words being targeted receptively, and label images of words that were being targeted expressively. The order of the trials was randomized. In the receptive probes, children selected one out of four pictures following the clinician prompt to identify the target. In the expressive probe, the child was presented one picture and provided a name for it. All responses received non-corrective feedback, such as "nice pointing!", in order to separate assessment from instruction. "Success words," or words which the child's caretaker identified as those that the child knew, were interspersed throughout the probes in order to ensure that the child could be successful in the task. When the children demonstrated an average of 80% correct unprompted responses averaged across three trials, the words were considered to be "learned". The experimenter began teaching the next set of target words after both words had reached learning criterion. If "seagull" and "cruise ship" were the two receptive targets and "crab" and "kayak" were the two expressive targets, the daily intervention probes would consist of these four words probed in the modality in which they were being taught.

**Within modality probes** (See the triangles in Figure 1) assessed the child's knowledge of all eight expressive and eight receptive target words, inclusive of the four control words. Each word was probed two times. These served as baseline for each intervention set. Data collection occurred at least three times, including before the initiation of a new vocabulary set. Unlike the daily intervention probes, these probes were not collected during each intervention session. Assessment occurred in the modality in which the word was taught, or was scheduled to be taught. As with the daily intervention probes, "success words" and non-corrective feedback were

incorporated into the procedure. If “seagull” and “cruise ship” were the two receptive targets and “crab” and “kayak” were the two expressive targets, the within modality probe would consist of these four words and the 12 other targets probed in the modality of teaching.

**Cross-modal probes** (See the squares in Figure 1) were the same as within modality probes, except that target words were assessed in the modality opposite training. That is, receptive probes were given for expressive intervention targets and expressive probes for receptive targets. Each word was probed three times. These probes assessed whether the child generalized between the receptive and expressive modalities for a learned word. The probes were collected at baseline, and once at the conclusion of each target word set. Due to the structure of the intervention, vocabulary targeted in the first set was probed on two subsequent occasions, after the completion of the second and third intervention set. Vocabulary targeted in the second set was probed on one subsequent occasion, after the completion of the third intervention set. If “seagull” and “cruise ship” were the two receptive targets and “crab” and “kayak” were the two expressive targets, the cross-modal probe would probe “seagull” and “cruise ship” expressively and “crab” and “kayak” receptively. There would also be probes for the 12 other target words, assessed in the opposite modality of teaching.

### **Data Analysis**

Inter-observer agreement (IOA) data was collected in order to ensure reliability of the dependent variable, or probes. Procedural fidelity was collected in order to ensure reliability of administration of the independent variable, or intervention.

### **Inter-Observer Agreement (IOA)**

According to Gast (2010), IOA should ideally be collected for 20 to 33% of sessions with a suggested minimum of 80% agreement. To calculate IOA, the clinician and an independent

observer marked whether the child's response on each probe was correct, incorrect, or if there was no response given. The independent observer conducted IOA either during the session, or by watching a recording of the session. IOA was collected for a minimum of 33% percent of the sessions in each probe condition. Average agreement was 98% (SD=2.8). The discrete nature of the targets supported high IOA as correct and incorrect responses were readily identifiable.

### **Procedural Fidelity**

According to Gast (2010), procedural fidelity should be calculated for at least 20% of sessions. To collect procedural fidelity, an independent observer recorded data either during the intervention session or while watching a recorded version. Scoring included whether the child's attention was secured and whether he or she responded within the correct interval of time. It also included whether the clinician delivered instruction correctly, praised appropriately, provided appropriate feedback, and maintained an appropriate interval between trials. In the present study, procedural fidelity was calculated for at least 36% of the sessions in each probe condition. Average agreement was 98% (SD=5.1) Again, the discrete nature of the training and clear procedural descriptions supported high fidelity.

### **Learning**

The dependent variables were graphed as they are collected during the probes. Analysis was first conducted visually, observing the stability, trend, levels, immediacy, consistency, and overlap of the data (Gast, 2010). Separate visual analysis was completed for the two independent variables, or the expressive and receptive interventions.

In order to investigate whether or not participants have successfully cross-modal generalized between the receptive and expressive conditions, it must be ensured that the children

have learned, or reached criterion on the target vocabulary words. A child was considered to have reached criterion on a word if his or her accuracy across three trials was 80%.

### **Cross-Modal Generalization**

Cross-modal generalization was tested after learning of the target words. Each of the two target words was probed three times in the opposite modality of teaching. Criteria for generalization differed based on whether generalization was being tested in the receptive or expressive modality. Criterion also differed based on whether partial or complete knowledge of the probes was accepting as learning. “Partial” knowledge of a word was defined as the child having 50% or higher accuracy for receptive to expressive cross-modal generalization and 66.7% or greater for expressive to receptive generalization. “Complete” knowledge of a word was defined as at least 80% accuracy, consistent with the study’s learning criterion, prior single-subject research (Wynn & Smith, 2003), and criterion used by speech-language pathologists when setting short-term goals.

**Partial knowledge** for expressive to receptive generalization was demonstrated by the child identifying target words accurately in the majority of trials and above chance, or greater than 3/6, or 50% of the trials. This means that the child should accurately identify the target in at least 4/6 of the trials, or with 66.7% accuracy.

Partial knowledge for receptive to expressive generalization had lower criterion. While children identified a word in the receptive condition out of four possible pictures, expressive probes required the child to choose a target vocabulary word out of an arbitrarily large lexicon. We defined generalization as the child achieving a minimum of 50% accuracy. This would imply the child either achieved at least 100% generalization (3/3) for one word and 0% generalization

(0/3) for the other, or generalized each word with 50% accuracy. Each of these situations would result in accuracy of 50%, or 3/6.

**Complete knowledge** was a minimum of 80% for both directions of generalization.

Using this percentage allows criterion to be consistent across the daily and cross-modal probes. It also is consistent with criterion used for learning when a speech-language pathologist sets goals for clients.

### **Results**

Plots of each child's probe data appear in figures 2 through 4. All children demonstrated learning of all target vocabulary words and expressive to receptive cross-modal generalization.



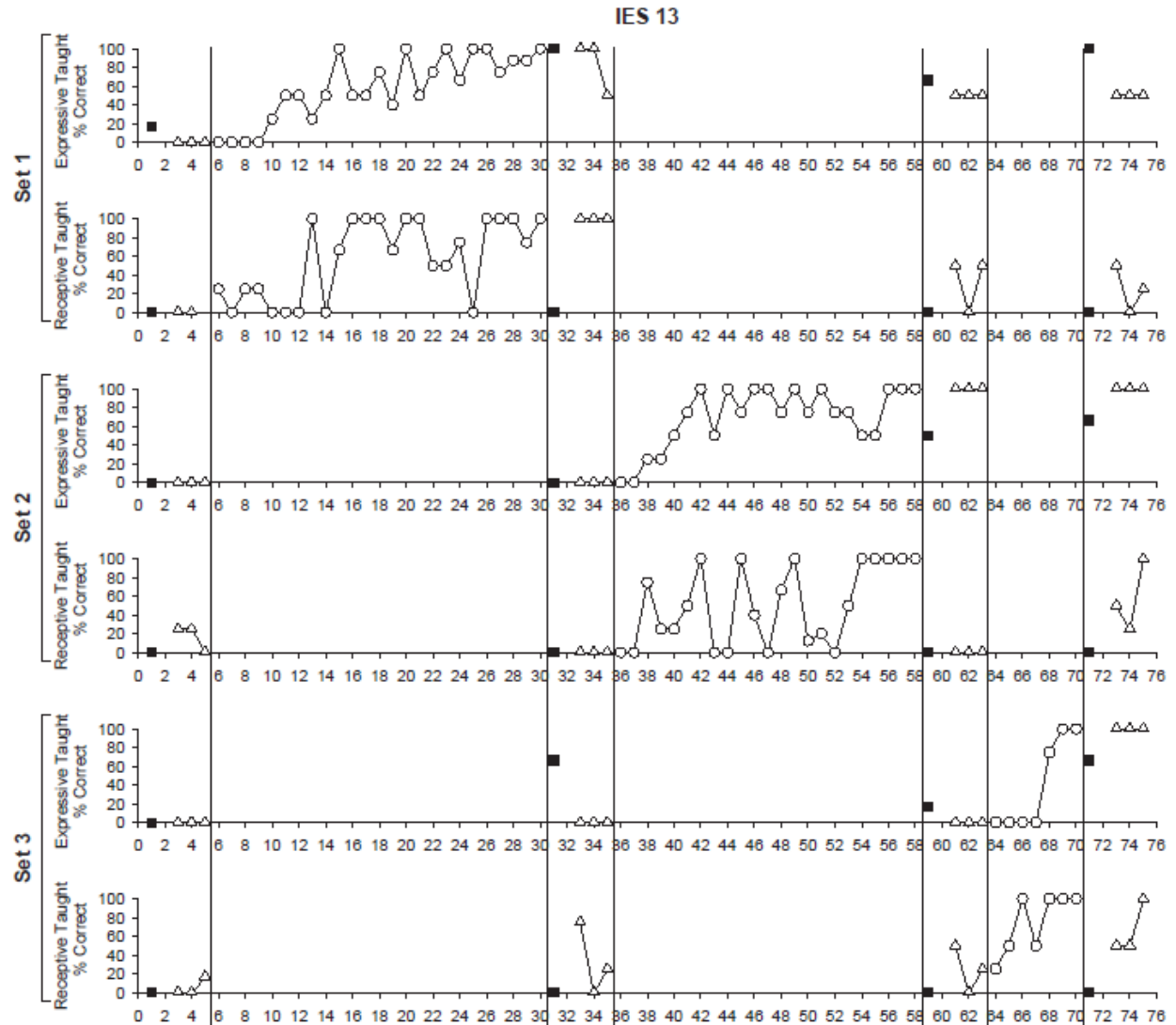


Figure 2: Participant 13’s daily (triangles), within modality (circles), and cross-modal (squares) probes.

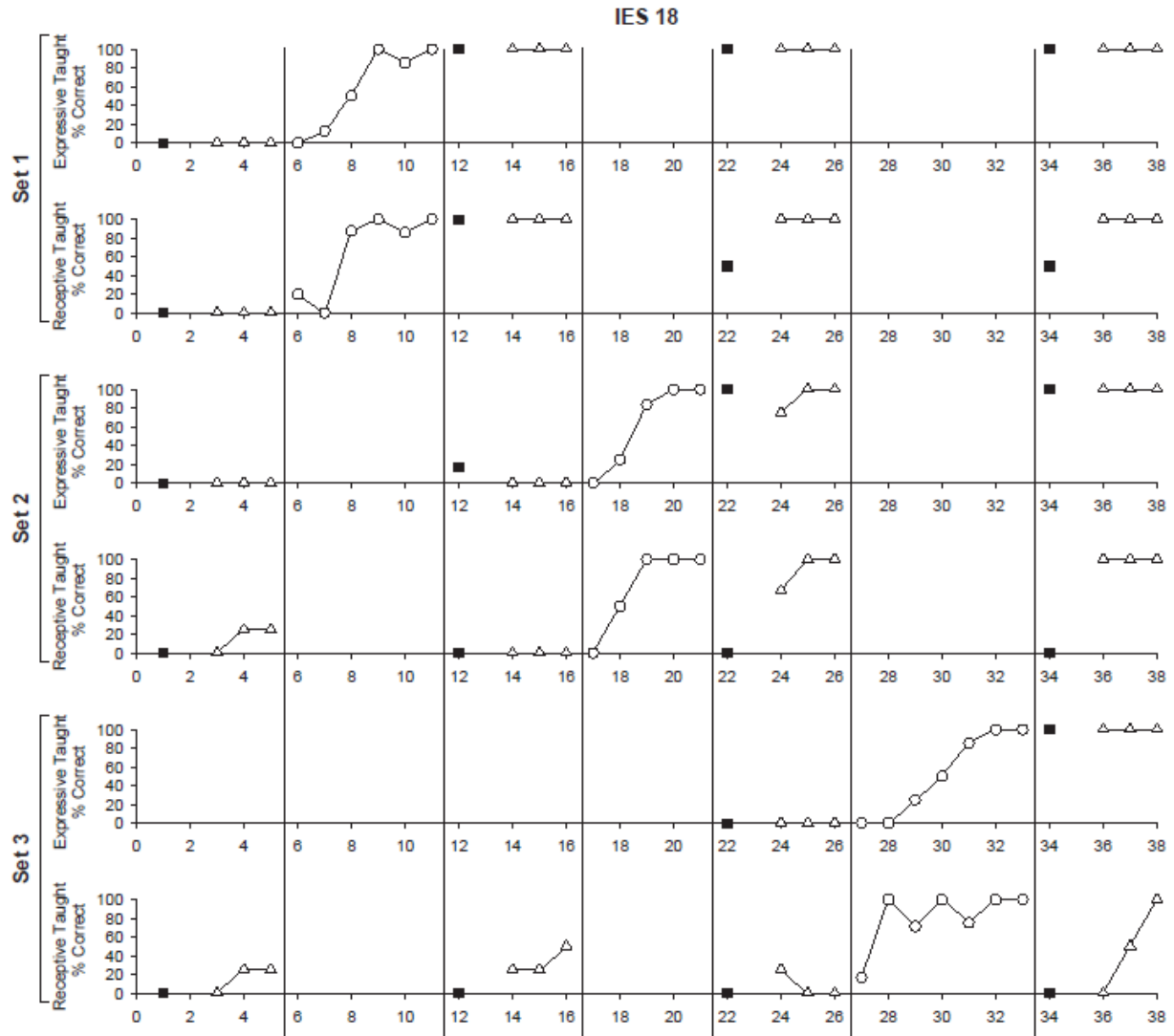


Figure 3: Participant 18’s daily (triangles), within modality (circles), and cross-modal (squares) probes.

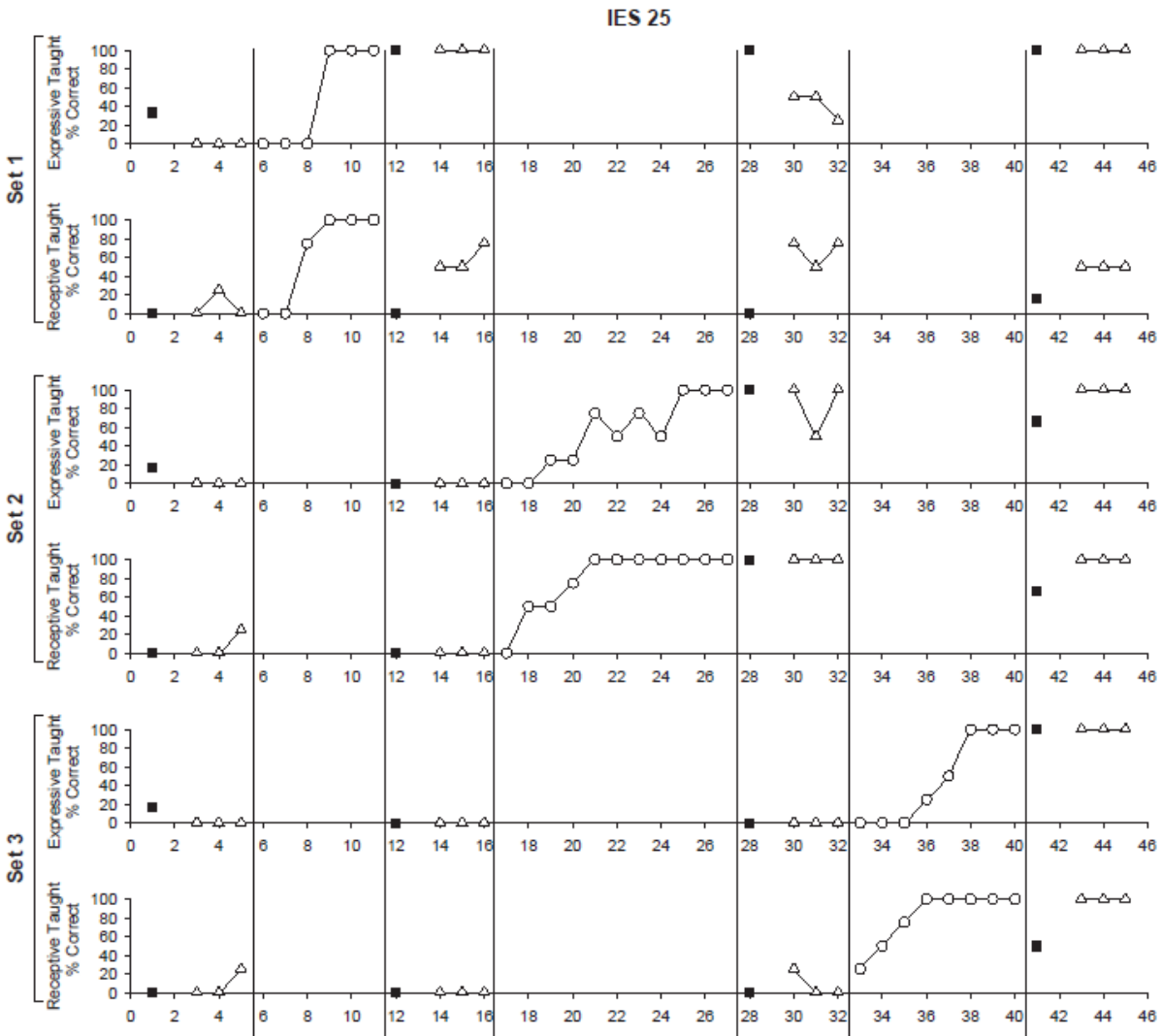


Figure 4: Participant 25’s daily (triangles), within modality (circles), and cross-modal (squares) probes.

**Learning**

The participants demonstrated learning of all 12 expressive and receptive target vocabulary words, as evidenced by an average of 80% accuracy across three trials at the end of each intervention. There was some incidental learning of control words, although this data was not relevant to the analysis. Learning can be visualized by increased in level of accuracy, upward trend of accuracy, and stability of learning data for most intervention sessions. The number of

sessions to criterion within each intervention set ranged from seven to 25 sessions, as participant 13 required the most number of sessions to reach criterion. The number of sessions to criterion for each child is summarized below in Table 2.

Table 2.

*Number of sessions to learning criterion*

Participant	Probe Condition 1	Probe Condition 2	Probe Condition 3
13	25	23	7
18	6	5	7
25	6	11	8

Average accuracy and variability for the expressive and receptive learning interventions were compared by calculating mean accuracy and standard deviation of daily probes. There was no significant difference in mean accuracy between the expressive and receptive conditions. Hartley's Homogeneity of Variance Test revealed that there was no significant difference between estimates of variation for the two types of interventions. Means and standard deviations of daily probes appear below in Table 3.

Table 3.

*Mean and standard deviation of daily probe values.*

	Mean	Standard Deviation
Expressive Intervention	57.4	39.5
Receptive Intervention	64.8	39.7

### **Cross-Modal Generalization**

**Partial knowledge** criterion revealed that participants 18 and 25 demonstrated three replications of expressive to receptive cross-modal generalization by achieving 66.7% or greater

accuracy in the cross modal probes (Table 4). Participant 13 achieved two replications of expressive to receptive generalization. Participant 13 did not demonstrate any replications of receptive to expressive generalization; however, participant 18 demonstrated one replication and participant 25 demonstrated two replications. Probes occurring one intervention phase later revealed that expressive to receptive generalization was maintained (Table 5). Receptive to expressive generalization was not maintained consistently. A summary of cross modal probes appears in tables 4 and 5.

**Complete knowledge** criterion revealed that participants 18 and 25 demonstrated three replications of expressive to receptive cross-modal generalization by achieving 80% or higher accuracy in the cross-modal probes (Table 4). Participant 13 achieved one replication of expressive to receptive generalization. Participant 13 did not demonstrate any replications of receptive to expressive generalization; however, participants 18 and 25 each demonstrated one replication. Probes occurring one intervention phase later revealed that expressive to receptive generalization was inconsistently maintained (Table 5). Receptive to expressive generalization was not maintained.

Table 4.

*Success in the probe condition immediately following intervention phase (out of three possible legs).*

Participant	Cross Modal Probe Values	Expressive Taught Receptive Probed		Probe Values	Receptive Taught Expressive Probed	
		Proportion of Probes $\geq$ 80% Correct	Proportion of Probes $\geq$ 66.7% Correct		Proportion of Probes $\geq$ 80% Correct	Proportion of Probes $\geq$ 50% Correct
13	100, 50, 66.7	0.3	0.7	0, 0, 0	0.0	0.0
18	100, 100, 100	1.0	1.0	100, 0, 0	0.3	0.3
25	100, 100, 100	1.0	1.0	0, 100, 50	0.3	0.7
Proportion of Children Successful At or Above Criterion (averaged across 3 probes)		2/3	3/3		0/3	1/3

Table 5.

*Success in the probe condition one intervention phase later (out of two possible legs).*

Participant	Cross Modal Probe Values	Expressive Taught Receptive Probed		Probe Values	Receptive Taught Expressive Probed	
		Proportion of Probes $\geq$ 80% Correct	Proportion of Probes $\geq$ 66.7% Correct		Proportion of Probes $\geq$ 80% Correct	Proportion of Probes $\geq$ 50% Correct
13	66.67, 66.67	0.0	1.0	0, 0	0.0	0.0
18	100, 100	1.0	1.0	50, 0	0.0	0.5
25	100, 66.67	0.5	1.0	0, 66.67	0.0	0.5
Proportion of Children Successful At or Above Criterion (averaged across 2 probes)		2/3	3/3		0/3	0/3

## Discussion

Typically developing children are thought to generalize language knowledge from the receptive to the expressive modality at high levels, but the children with language impairments in this study did not demonstrate the same pattern. To be sure, there was cross modal generalization

in these children with SLI, but the results suggests that they were more likely to cross-modal generalize from the expressive to the receptive modality than from the receptive to expressive modality.

Children with SLI differ from children with intellectual disabilities in that their cognition is within normal limits. This suggests that the SLI population may be able to apply higher levels of reasoning skills to generalize vocabulary from one modality to the other. Guess and Baer (1973) and Guess (1969) found that children with intellectual disabilities were neither able to generalize plural morphemes from the receptive to the expressive modality nor the expressive to receptive modality. Because the children in the present study were able to generalize from the expressive to receptive modality, the findings support the expectation that children with SLI show stronger generalization than children with intellectual disabilities.

Children with SLI differ from children with autism in that they are motivated and reinforced by social interaction, while children with autism are not. We would expect that children with SLI would demonstrate stronger cross modal generalization than children with autism because of receptiveness to scaffolding by social interaction. Wynn and Smith (2003) found that, in children with autism, although the most common direction of generalization was from the expressive to the receptive modality, generalization was not consistent in either direction. The findings from the present study confirm expectations that children with SLI demonstrate stronger cross modal generalization than children with autism.

Although children with SLI differ from typically developing children in that their performance on language assessments is below normal limits (Leonard, 2000; Stark & Tallal, 1981) there are no gross deficits in nonverbal cognition. Additionally, children with SLI demonstrate slower phonological retrieval, have poorer performance on comprehension and

productions tasks after fast-mapping, learn fewer words, and require more than three times as many repetitions to learn words (Kieran et al., 1998; Leonard, 2000; Rice et al., 1994; Watkins et al., 1993). Thus, while typically developing children demonstrate the ability to generalize from the receptive to expressive condition (Fraser, Bellugi, & Brown, 1963; Dollagan, 1985), it is expected that children with SLI may have more difficulty doing so because of increased support needed for word learning. Conforming to these expectations, children with SLI showed weak receptive to expressive cross modal generalization in comparison to their expressive to receptive generalization. The performance of children in the present study is also consistent with findings by Camarata and colleagues (2009) demonstrating that children with SLI can generalize grammatical morphemes from the expressive to the receptive modality.

### **Participant Characteristics and Learning**

Individual participant differences may have encouraged different performance on the word-learning task. Participant 13 was the youngest at 37 months of age (see Table 1). This participant achieved the fewest replications of expressive to receptive cross-modal generalization and was the only one of the three that did not demonstrate any receptive to expressive generalization. His receptive vocabulary was within normal limits, but his expressive vocabulary was below. His younger age, and thus less mature reasoning skills may have lowered his performance in comparison to the two older participants. Cognitive development theories such as those developed by Jean Piaget (Piaget, 1959; Piaget, J. & Inhelder, B., 1958) suggest that primitive reasoning does not begin to develop until at least four years of age.

The older participants, who were close in age, consistently generalized from the expressive to the receptive modality, despite having different vocabulary profiles. Participant 18 was 64 months, had receptive vocabulary within normal limits, and expressive vocabulary below



normal limits. Participant 25 was 65 months and had both receptive and expressive vocabulary below normal limits. Participant 18 demonstrated complete maintenance of receptive knowledge of generalized words while participant 25 showed complete maintenance in one opportunity and partial maintenance in the other. Neither of these participants demonstrated consistent generalization from the receptive to the expressive modality. Both showed complete generalization of receptive vocabulary in one opportunity and participant 25 showed partial expressive to receptive generalization in another opportunity.

### **Intervention Characteristics and Learning**

In addition to participant characteristics, differences between the present intervention and prior interventions may have contributed to differences in generalization. The present study emphasized naturalistic intervention through storybook reading and interactive play. Discreet trial training, or teaching in which the clinician provides a prompt (e.g. “what’s this?”) that the child is rewarded for responding to, was incorporated into the intervention. In contrast, the interventions conducted by Wynn and Smith (2003), Guess and Baer (1973), and Guess (1969) used operant conditioning in the form of discreet trial training, in absence of a more naturalistic context. The present study’s intervention may have promoted more generalization because it was conducted using familiar, child-centered activities. Proponents for naturalistic intervention argue that the approach better facilitates generalization to the child’s environment (Spradlin & Siegel, 1982).

Intervention targets may have also contributed to study outcomes. While the present study targeted nouns, Guess and Baer (1973) and Guess (1969) targeted generalization of plural morphemes. In an article discussing why children with SLI have difficulty acquiring tense marking morphemes, Leonard and colleagues (1997) proposed that this difficulty could arise

from difficulty forming implicit rules, lack of knowledge that tense marking is required, or difficulty perceiving the morpheme's brief duration. Leonard and colleagues suggested that some of the same reasoning can be used to explain why some children have difficulty acquiring the plural morpheme. Acquiring bound morphemes may be more difficult than nouns because of the low perceptual salience and necessity of knowing and applying rules for use. Additionally, typically developing children tend to produce labels for people, food, objects, and routines as their first single-word utterances (Clark, 2009). Although it is difficult to distinguish whether the word class as used by the child is a noun or a verb, the adult forms of the utterance "ball", for example, can be categorized as a noun. The earlier acquisition of nouns suggests that they are more easily acquired than bound morphemes. The present study therefore may have demonstrated more generalization than the interventions reported by Guess and Baer (1973) and Guess (1969) due to the less complex nature of the target nouns.

### **Social Validity**

The present study has procedures, goals, and effects that are socially valid. The procedures of the intervention are socially valid because they can be feasibly implemented by speech-language pathologists in schools. The duration of the intervention was 24 minutes when the expressive and receptive vocabulary interventions were combined; however, if only the expressive intervention is used, the total time is 12 minutes per session. The goal of vocabulary learning has high validity because a subgroup of children with SLI is known to have delayed vocabulary development, in comparison to their typically developing peers (Leonard, 2000). The effects of the intervention were strong for the two older participants, who demonstrated consistent cross-modal generalization with some maintenance.

### **Implications**

In typically developing children, there is an assumption that learning in the receptive modality will generalize to the expressive modality, as demonstrated through previous research (Dollaghan, 1985; Fraser, Bellugi, & Brown, 1963); however, the findings from the present study suggest that children with SLI require vocabulary intervention focusing explicitly on expressive vocabulary in order to demonstrate learning in this modality because those forms taught receptively did not reliably generalize. Additionally, given that children with SLI can have deficits in the receptive, expressive, or both modalities (Leonard, 2000), the findings from this study propose that an intervention focusing primarily on expressive vocabulary will result in growth in both the expressive and receptive modalities.

### **Limitations and Future Directions**

Future research should investigate the relationship between age, cognitive skill level, and cross-modal generalization. It is hypothesized that the youngest participant demonstrated inconsistent cross-modal generalization due to younger age and less developed reasoning skills. Cognitive development theorists such as Piaget argue that the most basic forms of reasoning do not emerge in children until at least four years of age. There is partial support for this hypothesis in the findings of Guess and Baer (1973) and Guess (1969), which revealed that children with cognitive deficits were unsuccessful in cross-modal generalization. If reasoning skills are directly related to cross-modal generalization, we would also expect to see a positive correlation between cognition and cross-modal generalization.

Future research should also use similar procedures to examine cross-modal generalization in typically developing children, in addition to other populations with language needs. It is more valid to compare performance across different pediatric populations when the conditions of the intervention are held relatively constant.

**Conclusion**

The findings from the study suggest that children with SLI can cross-modal generalize from the expressive to the receptive modality. The study reveals that a structured, supported vocabulary expressive vocabulary intervention can be used in children with SLI who have receptive, expressive, or combined vocabulary deficits. Future directions include investigating cognitive development level as it relates to generalization.

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