Expressive and receptive vocabulary learning in children with diverse disability typologies

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A combined storybook and play vocabulary intervention was implemented as a single-subject study of 23 children of diverse typologies, including 10 with autism spectrum disorder (ASD), three with developmental disability (DD), five with Down Syndrome, and five with specific language impairment (SLI), who were currently receiving speech-language services and had an individual education plan (IEP) goal targeting language. Participants' ages ranged from 3 years-1 month to 7 years-4 months. A parallel treatment design was used to identify changes at (a) word level, (b) child level, and (c) in children of similar typological and developmental profiles. All children learned vocabulary words to criterion in both expressive and receptive modalities. Children of different etiological origin did not vary in the trajectory of their receptive or expressive word learning. These results suggest that the trajectory of word learning may be remarkably consistent across disability typologies. The theoretical and clinical ramifications of these findings are discussed.

The Individuals with Disabilities Education Act (IDEA 1997) mandates that school-age and pre-school-age children are eligible for speech and language services based on either broad language deficits or vocabulary deficits regardless of disability typology. Therefore, children from number of disability subtypes, including autism spectrum disorder (ASD), developmental disability (DD), or intellectual disability (ID), as well as for primary language disabilities (language impaired) may receive speech and language services when needed. Regardless of under which eligibility typology these children qualify, special educators, resource specialists, and especially speech-language pathologists (SLPs), are required to provide appropriate services when a significant language disorder is present. Therefore, school-based special educators and SLPs are often providing services to a variety of children belonging to a number of diverse populations [e.g. children with specific language impairment (SLI), ASD, global DD, ID, and multiple disabilities]. The purpose of this report is to examine the procedures of a mixed storybook and play vocabulary intervention that was implemented as a single-subject study across 23 children with diverse eligibility.

Importance of vocabulary

Vocabulary is an overarching, fundamental language domain that requires children to learn words from multiple grammatical classes (e.g. nouns, verbs, and adjectives). In addition, word knowledge is a foundation for many other aspects of language and for achievement. Despite this, vocabulary development is often overlooked in children with disabilities who have reached the two- or three-word combinatorial level (cf. Gillum and Camarata 2004). For example, in our participant pool, a 6-year-old with a non-verbal IQ score of 110, an expressive vocabulary score of 90, and a *Preschool Language Scale* (PLS-3, Zimmerman *et al.* 1992) score of 76 (e.g. SLI-Participant 4) received speech/language services, but those services did not include goals specific to increasing vocabulary. In contrast, a 4-year-old with Down syndrome whose McArthur Communicative Development Inventory (M-CDI) reports 50–60 words and who is relatively unintelligible to unknown listeners (DS-Participant 1 in the current study) is likely to have individual education plan (IEP) goals relating to vocabulary. However, vocabulary is an important predictor of academic success, particularly in reading comprehension (Dickinson *et al.* 2003; Muter *et al.* 2004), and one in two children with SLI will struggle to learn to read (Catts *et al.* 2002). Thus, vocabulary should remain a high priority goal for many children, even those who are older and have more advanced grammar.

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In addition, there are often parallel developmental trajectories for receptive and expressive vocabulary acquisition in typically developing children, with receptive knowledge often preceding expressive knowledge (Henriksen 1999). In contrast, for populations with disabilities, these patterns may not match the general, typically developing population. For example, children with Down syndrome, on average, have receptive repertoires well above their expressive vocabulary (Chapman *et al.* 1990), children with ASD have been reported to sometimes learn expressive targets before they can identify them receptively (Wynn and Smith 2003), and children with SLI could be considered two subgroups, those with and without receptive language deficits (cf. Conti-Ramsden *et al.* 1997). Despite these varied patterns among populations with disabilities, there is a noted gap in the literature as it pertains to receptive vocabulary acquisition (Gillum and Camarata 2004). Therefore, studies of vocabulary across modalities (receptive versus expressive) within and across diverse typologies of developmental disabilities are warranted.

Intervention approaches for teaching vocabulary

Word learning has a venerable history in the language intervention history (cf. McCulloch *et al.* 1955). A number of intervention strategies have been successful at improving vocabulary in preschool-aged children with vocabulary deficits. Use of storybooks to improve vocabulary has been studied successfully across a wide range of populations (Collins 2010; Coyne *et al.* 2004; Dale *et al.* 1996; Hoffman 1997; Ewers and Brownson 1999; Lefebvre *et al.* 2011; Sénéchal *et al.* 1995; Walsh and Blewitt 2006). Naturalistic play-based interventions, such as Enhanced Milieu Training, have demonstrated positive outcomes in late-talking children (Girolametto *et al.* 1996; Kaiser and Hester 1994; Yoder *et al.* 1995), as well as children with intellectual disabilities (Kaiser and Roberts 2013; Kaiser *et al.* 2001), ASD (Åsberg and Sandberg 2010; Prelock *et al.* 2011; Yoder *et al.* 1995), and even cleft lip and palate (Scherer and Kaiser 2007). These approaches have the added benefit of allowing vocabulary to be targeted both expressively (e.g. 'what do you see?') and receptively (e.g. 'find the X') within a context familiar to both clinicians and parents.

Combining storybook and play-based approaches creates an intervention that draws upon elements of language therapy used regularly and successfully in preschool and school-aged populations (Staskowski and Rivera 2005). It also allows clinicians to target vocabulary across at least two learning contexts, which may be important to support generalization

(Kendall 1981; Scruggs and Mastropieri 1994). Individually, these intervention procedures have been implemented successfully across populations so a combined vocabulary intervention might be feasibly applied by clinicians across disability populations with books, toys, and vocabulary targets appropriate to the individual child regardless of eligibility typology.

Vocabulary learning across disability typologies

Variability between populations of differing etiologies is widely known and widely studied. It is further acknowledged that many populations with disabilities demonstrate high rates of variability (Evans 2002; Lahey *et al.* 1992; Perry et al. 2010; Wynn and Smith 2003). The variability between and within clinical populations requires the development of intervention approaches flexible enough to adjust treatment based on developmental level, individual needs, and in some cases, the disability typology. To accurately identify appropriate interventions for individual children, it is necessary to examine procedures at the child level, at the population level, and in relation to other populations with vocabulary deficits. On the other hand, if an approach could be developed to teach vocabulary to a variety of disability types, this would simplify intervention and potentially have wide applicability. In addition, vocabulary studies across disability typologies could serve as a foundation for further studies exploring multiple 'shared' inhibitory factors such as semantic factors, auditory working memory, processing speed, and attention (Storkel 2011; Woodward and Markman 1998) that could impact word learning in ASD, DD, Down Syndrome, and SLI.

The purpose of this report is to examine a mixed storybook and play vocabulary intervention that was implemented across 22 children who were currently receiving speech–language services within the public school system who had been identified as ASD, intellectually disabled secondary to Down syndrome, SLI, or unspecified developmental disability (DD). Single-subject designs are ideal for examining effects of intervention for individual children. By combining data across children of similar typology and developmental profiles when warranted, we are able to examine the cumulative frequency and trends of vocabulary learning.

For this report, we ask: (a) do individual children learn novel vocabulary words using a hybrid storybook/play design in both expressive and receptive modalities, and are there differences between modalities?; (b) do children with similar typological and developmental profiles demonstrate similar trends of vocabulary learning for expressive and receptive modalities?; and (c) do children of differing

typological and developmental profiles demonstrate similar or different trends of vocabulary learning for expressive and receptive modalities?

Method

A single-subject parallel treatments design (Gast 2010) was employed to compare words learned within receptive and expressive vocabulary intervention conditions. Children were taught vocabulary words that were absent in baseline expressive probes and at or below chance levels in receptive probes. Modality was randomly assigned so that half of the words were trained expressively and half of the words were trained receptively. Words were trained in only one modality.

Participants

Twenty-three children (range 3;1–7;4 years-old) were recruited to participate in a study for 6–8 months, depending on the length of time necessary to learn the word sets. Inclusionary criteria were: (a) qualifying for language intervention services within public schools in the metropolitan area, (b) ability to imitate an adult's vocal behavior, and (c) an expressive vocabulary of at least 10 words per parent report. In addition, diagnostic status was assigned using children's non-verbal intellectual abilities as measured using the *Revised Leiter International Performance Scale* (Leiter-R, Roid and Miller 1997). Children receiving services under the label of ASD in the schools were assigned to the ASD group. Our recruitment efforts yielded 19 males and four females in the participant pool. Even though a higher number of males than females are expected in many disability typologies (e.g. ASD; see Watkins *et al.* 2014), this ratio was much higher than predicted. We neither specifically recruited males nor excluded females; this simply was the distribution of our sample. There was one female in each typology.

Participants received baseline testing using the *Test of Auditory Language Comprehension-3* (TACL-3, Carrow-Woolfolk 1999), a receptive test that includes both grammar and vocabulary; the *Preschool Language Scale-3* (PLS-3, Zimmerman *et al.* 1992), an omnibus language test, the *Peabody Picture Vocabulary Test-4* (PPVT-4, Dunn and Dunn 2007), a receptive vocabulary test, and the *Expressive One-Word Picture Vocabulary Test-4* (EOWPVT-4, Martin and Brownell 2011), an expressive vocabulary test.

Information on standardized assessments for each subgroup of children is found in Table 1. Children with DS (*n*=5) scored well below average for non-verbal IQ, vocabulary, and language; and several children were not able to establish basal levels on standardized tests. Classification as ASD was based on eligibility for special education services within that

typology. It is noteworthy that eligibility for ASD in school settings is not the same as a medical/clinical diagnosis (see Camarata 2014). We accepted the school eligibility because the vocabulary intervention was designed to be applicable to these students (i.e. children eligible for ASD special education services in the US). Children with ASD (*n*=10) were subdivided into two groups: those with non-verbal IQs below 85 (ASD-LIQ range: 67–84) and those with non-verbal IQs above 85 (ASD-HIQ range: 86–109) in keeping with separating 'high-functioning' ASD. A NVIQ boundary of 85 was used for SLI and for ASD-HIQ because (a) this is a commonly employed cut-off in children with SLI (see Leonard 2014; Stark and Tallal 1981) and (b) it has been identified as a separation point for identifying high function in children with ASD on the Leiter International Performance Scale, the NVIQ employed in this study (Szatmari *et al.* 2003). Children with SLI (*n*=5) also scored within normal limits for non-verbal IQ (above 85) and below average for vocabulary and language, which is not unusual in this population (Leonard 2014). The three children with unspecified DD scored below average but above the cut-off for ID on non-verbal IQ (range=74–84) and below average on vocabulary, and language.

Vocabulary target selection

Sixteen vocabulary words were identified for each child. The pool of words included low-incidence vocabulary words, all of which were nouns, selected from the upper levels of the M-CDI. Issues of phonological difficulty and lexical density were considered primarily at the individual child level. This process created a set of words that the child could produce but did not demonstrate knowledge of either expressively or receptively.

After 16 words were identified, these words were randomly assigned to four sets for each child. Randomization included (a) assignment to set and (b) assignment to modality (expressive or receptive). Three sets were targeted during intervention, while a fourth set served as an untreated control. Control words were not taught in either modality but were included during each probe condition. Control words are not included in cumulative frequency graphs. Baseline procedures included at least three sessions of probes on all 16 words (targeted and control) to establish a stable data pattern before the first intervention condition was implemented.

Study design

A multiple-probe, parallel treatment design (Figure 1) was implemented for each child (Wolery *et al.* 2010). This design was developed to compare treatment conditions in behaviors that are not

Table 1 Descriptive Information Across Participant Subtypes

	DS	Autism spectrum disorder (ASD)	Specific language impairment (SLI)	DD
N	5	10	5	3
Age	4;6 (3;1–4;10)	4;2 (3;3–7;4)	4;7 (3;9–6;0)	4;3 (3;9–4;10)
Gender	4 boys; 1 girl	9 boys; 1 girl	4 boys; 1 girl	2 boys; 1 girl
Leiter	68.6 (16.02)	90.9 (13.54)	97.4 (7.92)	78.33 (5.86)
	40–77*	67–109	91–111	74–84
PLS-3	50.6 (0.89)	63 (11.95)	67.4 (13.07)	68 (26.89)
	50–52*	50–85*	52–82	74–84
PPVT-4	60 (13.75)	63 (11.95)	85.9 (15.71)	74 (14)
	36–77	50–85	49–103	60–88
TACL-3	60.4 (11.28)	70.82 (16.04)	82 (5.38)	79.33 (15.28)
	44–72	51–102	74–84	60–88
EOWPVT-4	61.6 (9.09)	70.63 (19.11)	77.4 (13.67)	72 (2)
	<55–73*	<55–108*	63–91	72–76

Mean (standard deviation), range presented below. PLS-3: Preschool Language Scales third (Zimmerman *et al.* 1992); PPVT-4: Peabody Picture Vocabulary Test fourth (Dunn and Dunn 2007); TACL-3: Test of Auditory Comprehension third (Carrow-Woolfolk 1999); EOWPVT-4: Expressive One-Word Picture Vocabulary Test fourth (Martin and Brownell 2011). *Participants with scores below floor were entered as floor for the calculation of means and standard deviations.

reversible wherein learning does not diminish under extinction. Conceptually, two current multiple-probe studies are implemented simultaneously, with one intervention (expressive vocabulary herein) implemented in one multiple-probe design whereas the second intervention condition (receptive vocabulary) in the other (see Wolery *et al.* 2010, p. 367). This design allowed expressive and receptive vocabulary to be treated simultaneously yet separately. During baseline, each child was asked to identify all vocabulary items in the modality in which the vocabulary items would be taught. During the intervention condition, children were asked to identify only those vocabulary items currently being targeted prior to the intervention session. When children reached criterion (80% correct across three sessions), they moved to a follow-up probe condition identical to the baseline probe condition.

Probe procedures
Baseline
At baseline, the child was asked to point to pictures representing the targeted vocabulary words (receptive condition) and to name the targeted vocabulary (expressive condition) for all four sets of words. Baseline probes were administered in the modality in which words were 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'. To maintain motivation, 'success words' were interspersed with the targeted vocabulary. These were words unrelated to the intervention (i.e. 'Elmo') that had been identified by the parent as words the child knew and would say or point to readily. These success words functioned to maintain a high level of response during the probe task and as a brief measure of ongoing effort. The order of trials was delivered randomly. At least two trials of

each word were included at each data collection point. Three data points were collected at baseline.

Intervention
'Daily' or intervention probes occurred during the intervention condition, antecedent to intervention, and were used to track children's word knowledge throughout intervention. Criterion to move to the next condition was 80% correct across three intervention probes. Only those words currently being targeted were included in the intervention probes. Before each intervention session, the child was asked to point to pictures of the targeted vocabulary words (receptive condition) and to name the targeted vocabulary (expressive condition). Except for the number of words in the intervention probe set (the active words only), the implementation of intervention probes was identical to the baseline probes. Positive corrective (e.g. 'you found it') and non-corrective feedback (e.g. 'thank you for talking') were given throughout the intervention probes. After the child reached 80% correct responses on intervention probes for three consecutive sessions, the next probe condition was initiated.

Follow-up
Follow-up probes were identical to baseline probes and were administered in the modality in which targets were taught. Feedback was non-corrective only and success items were used throughout the general probe condition.

Intervention procedures
Intervention sessions were conducted in 1 : 1 (clinician : child) therapy by licensed SLPs. 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. The combined time for
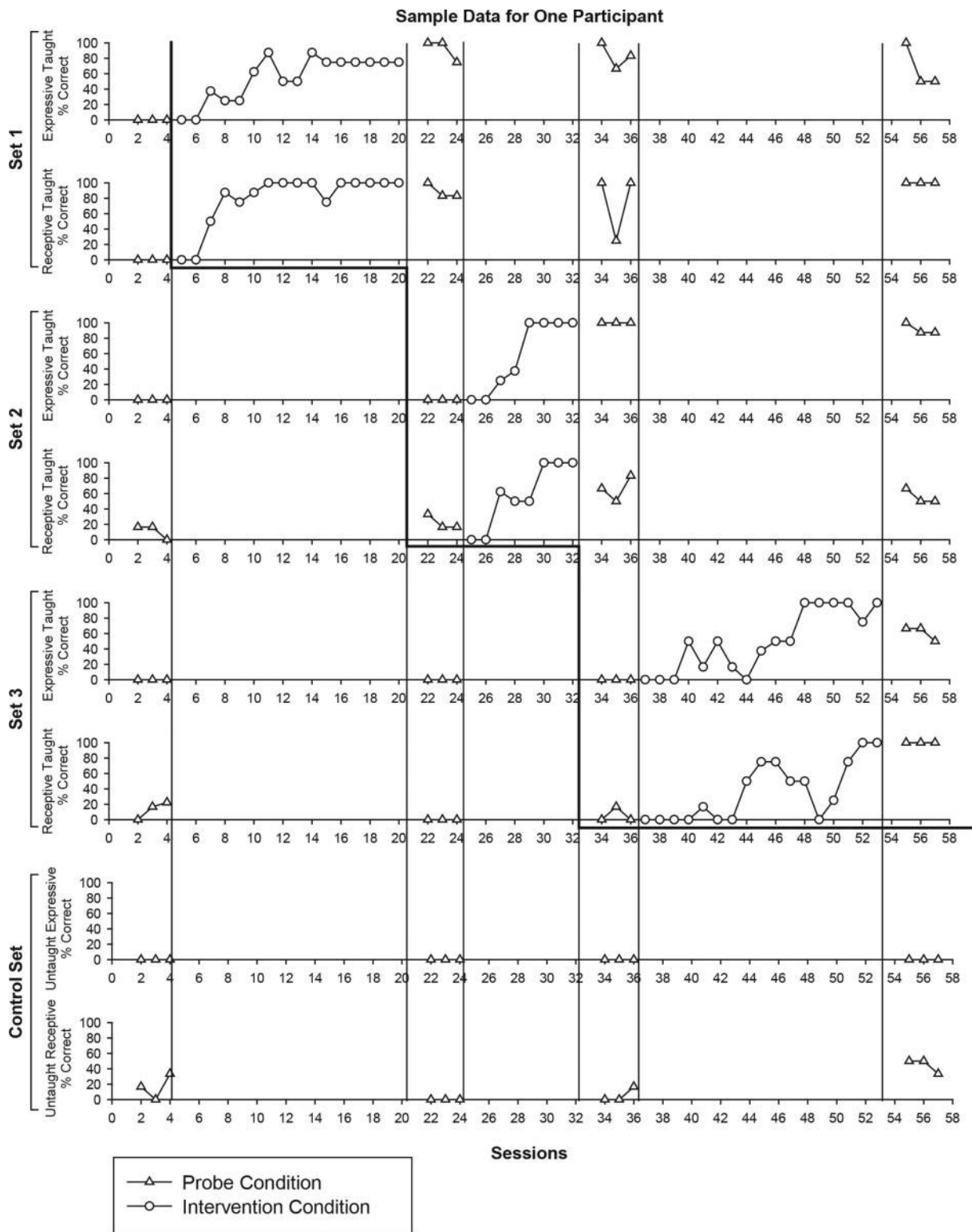
Figure 1 Sample learning data for one individual in the study. Sets of receptive and expressive words treated in separate but same-day sessions and were independent of one another.

storybook and structured play was 12 minutes for each modality (24 minutes total per session).

Storybook

During the storybook session, the child and the clinician viewed a picture book of at least 10 pages together while the clinician told a story about the pictures. Vocabulary words were verbally presented by

the clinician at least 10 times per session. Immediately after the clinician produced each vocabulary word, the clinician prompted the child to either name the vocabulary word when shown a picture that matched the word (expressive condition) or to identify the vocabulary word by pointing to the picture that matched the word (receptive condition). The play context followed the storybook context.

Play

During the play context, the clinician and child interacted with a set of toys that matched the storybook theme and included the target vocabulary items. For the first 10 children in the study, the clinician prompted the child to name or point to the items at least 10 times per condition, depending on whether the target vocabulary was assigned to the expressive or receptive conditions. For the remaining children, the clinician commented on the play, using the targeted vocabulary words, at least 10 times per session. This change in procedures occurred due to high levels of child noncompliance in the prompted condition and the desire to maintain a positive teaching environment. The clinician, play context, and reinforcers were identical across expressive and receptive conditions.

Feedback

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 items). 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 for a minimum of 2 seconds and then delivered the correct expressive or receptive exemplar.

Inter-observer agreement

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

Procedural fidelity

Procedural fidelity was determined across at least 30% of probe sessions and 30% of intervention sessions for each participant. Procedural fidelity was conducted by an independent observer either during the session or via videotape. The observer recorded the extent to which the probe and intervention trials were implemented as planned, including: *securing attention*, *delivery of task directive*, *response interval*, *praise testing behavior*, *appropriate corrective feedback*, and *inter-trial interval*. A dichotomous system (implemented or not implemented) was applied to each word trial and averaged to determine fidelity. Procedural fidelity ranged from 90 to 100% across sessions for all participants. Instances of low procedural fidelity were monitored throughout the project and were rectified as needed, usually through behavioral management to maintain the participant's attention during sessions.

Cumulative frequency analysis

Cumulative frequencies were established to analyze expressive and receptive trends within typology and to examine trends across typologies. The number of sessions required to reach criterion was established for each word set for each child. These were then graphed (Figs. 2 and 3) by typology. If a child needed 10 sessions to reach criterion on word set 1, the graph would show an increase in 'words learned' at session 10. Session 11 would then begin word set 2. The probe conditions have not been graphed on the cumulative frequency figures because children are not receiving instruction during this time.

Results

Data from individual participants were graphed and examined at the participant level (Research Question 1). Figure 1 is an example of a graph for one participant. Learning data across individual children from the same diagnostic category were then collapsed to address Research Questions 2 and 3.

Expressive and receptive word learning

Do individual children learn novel vocabulary words using a hybrid storybook/play design in both expressive and receptive modalities, and are there differences between modalities? All children ($n=23$) were successful in learning vocabulary words to criterion in both expressive and receptive modalities, indicating that the intervention was effective in terms of introducing new vocabulary into the repertoires of these children regardless of disability typology. However, there was variation with regard to the intervention length depending on group membership, with total length of intervention ranging from 35 to 74 sessions (children with DS), 21 to 73 sessions (children with ASD), 18 to 54 sessions (children with SLI), and 20 to 31 sessions (children with DD without Down syndrome or ASD). Individual children demonstrated a great deal of variability in (a) time to criterion and (b) patterns of word learning. See Table 2 for a summary of the average and ranges for each subset.

Seven children (three children with DS and four children with ASD) took at least five more sessions to learn the first set of words than they took to learn the second or third set of words. This quicker learning pattern on the later sets of words is hypothesized to be the result of 'learning to learn' for vocabulary. In contrast, eight children (two children
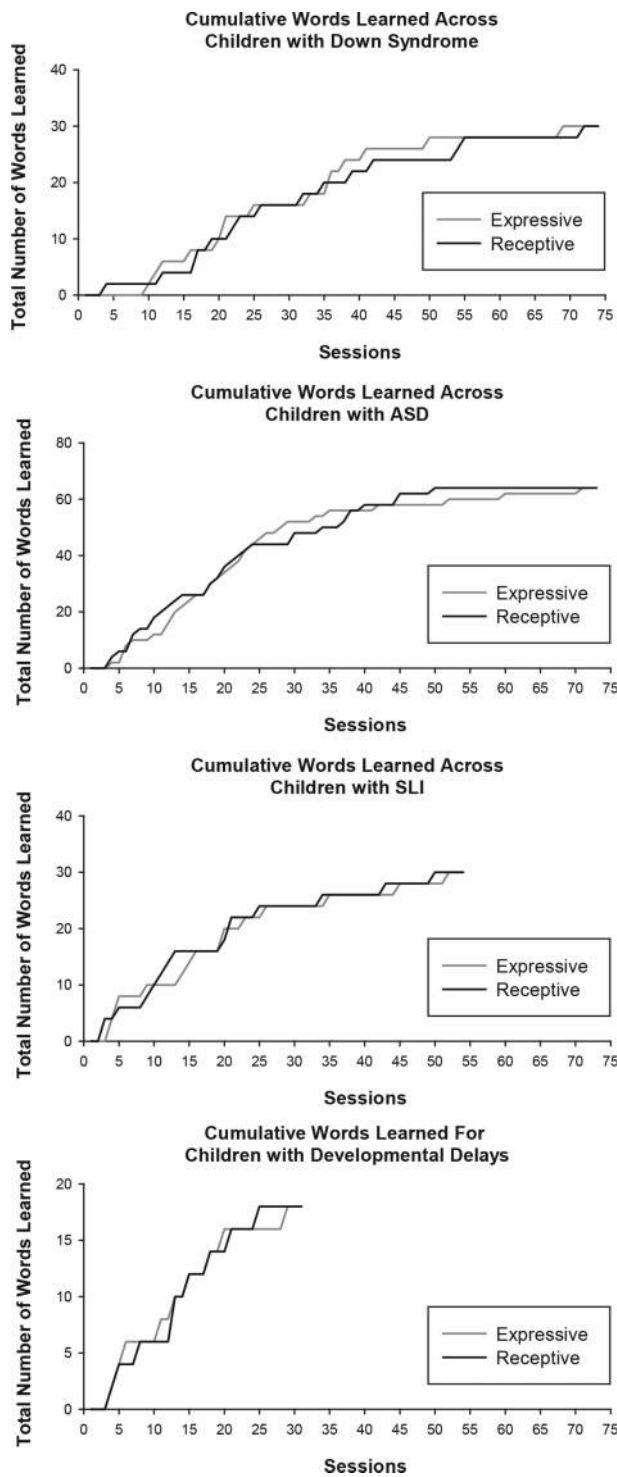
Figure 2 Cumulative frequencies of expressive and receptive vocabulary words by number of sessions to criterion across children of varied etiologies. Cumulative frequency was calculated by removing probe sessions and marking criterion sessions for each participant, then compiling them across sets. NOTE: *Y* axis relative to sample size for each set of children.

with DS, four children with ASD, and two children with SLI) appeared to have difficulty on either the second or third set of words. Item-level analysis revealed difficulty in one word in the set for these children. It is likely that some words were more difficult for individual children to learn than other

words. Issues of word-level discrepancies are discussed in the Limitations Section.

Finally, no individual child showed a consistent effect of preference for expressive or receptive learning (3/3 replications of reaching criterion in one modality before the other modality). Because words were taught and probed in only one modality, this finding does not support the theory that receptive learning is faster or 'easier' (pointing vs. talking) for these children (cf. Petursdottir and Carr 2011, for a review).

Trends within typological profiles
Do children with similar typological and developmental profiles demonstrate similar trends of vocabulary learning for expressive and receptive modalities? Within each typological profile, children showed a wide range of time necessary to finish the intervention. Each etiological group included some children that took two to three times as long to finish the intervention as other children within the same group. Children within each typological profile learned words both expressively and receptively. Children with DS, ASD (regardless of whether children were split by IQ), and DD learned expressive words and receptive words with roughly equivalent trend patterns. Children with SLI demonstrated a faster pattern of receptive learning, where receptive words were consistently learned to criterion one to two sessions faster than expressive words. However, this effect is seen only in the cumulative frequencies, as individual children did not demonstrate consistent (3/3 replications) preference for receptive sets.

Trends across typological profiles
Do children of differing typological and developmental profiles demonstrate similar trends of vocabulary learning for expressive and receptive modalities? The trajectory of both expressive and receptive vocabulary learning is highly similar when compared across children of different typological profiles (Figure 2). Expressive and receptive word sets demonstrated parallel learning curves. This is a striking finding because of the diverse typologies included in the study. Although the length of time varied within and across participants, the overall learning patterns for receptive and expressive vocabulary was generally similar regardless of disability typology. It should be noted that many of the children, regardless of disability typology, required a relatively high number of sessions to learn words, so the similarity is that many were relatively inefficient word learners. In addition, there was considerable variability in the number of sessions required for word learning to criterion (18–74 sessions), so that one could say that this variability was also a shared feature across typologies. On one hand, it was striking that
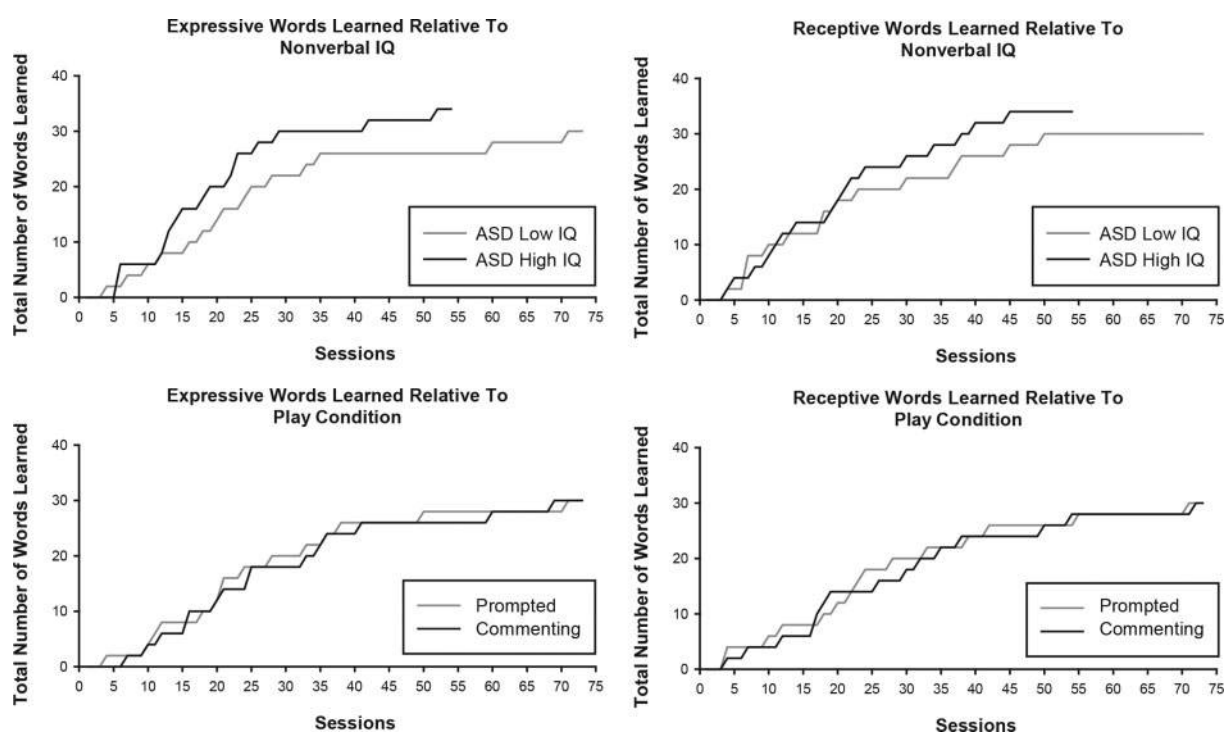
Figure 3 Cumulative frequency of expressive and receptive words learned, relative to (a) non-verbal IQ and (b) play condition for subsets of children.

Table 2 Number of Sessions to Criterion by Subset (Collapsed Across Expressive and Receptive Modalities)

	Per tier		Total	
	Average sessions	Range	Average sessions	Range
DS	17.4	7–25	49.2	35–74
SLI	11.0	4–22	29.6	18–54
DD	9.4	4–16	23.7	20–31
ASD	14.8	6–34	37.8	21–73
HIQ	13.5	6–23	31.0	21–54
LIQ	15.5	8–34	44.6	25–73

DS: Down syndrome (*n*=5); SLI: Specific language impairment (*n*=5); DD: Developmental disability (*n*=3); ASD: Autism spectrum (*n*=10); HIQ: High intelligence; LIQ: Low intelligence (ASD-HIQ *n*=5; ASD-LIQ *n*=5).

nearly all the words were learned, but also striking was the duration of training needed for some words. This finding was seen for SLI (18–54 sessions), ASD (21–73 sessions), and DS (35–74 sessions) participants.

Additional analyses

Additional analyses were completed *post hoc* based on questions that arose during data collection and primary analysis. Specifically, the importance of non-verbal IQ and the effect of a condition alteration during data collection are addressed.

Non-verbal IQ

Does nonverbal IQ level relate to the (a) length of time required to learn novel vocabulary items or (b) the pattern of learning? The question of whether non-verbal IQ is related to word learning can only be asked within the ASD subset, because only this typology included high (ASD-HIQ) and low (ASD-LIQ) subgroups. The children considered ASD-HIQ (Leiter score >85) ranged from 19 to 54 sessions while the children with ASD-LIQ (Leiter score <85) ranged from 24 to 73 sessions. Not surprisingly, on average, the ASD-HIQ group learned the full set of words in 31.0 sessions, whereas the ASD-LIQ group learned the full set of words in 44.6 sessions (Table 2). Except for length of time needed to reach criterion, learning patterns were similar for ASD-HIQ and ASD-LIQ.

Condition alteration

Did discontinuing the use of prompts within the play condition after the first ten participants alter the pattern of word learning? The first wave of 10 children who participated in the intervention study received either a prompted play intervention or a commenting play intervention. All subsequent children received the commenting play intervention due to some children's refusal to respond to the prompted play condition in the first set of participants. The 10 initial children had Leiter-R (Roid and Miller 1997) scores below 85 and similar language profiles (floor effects on PLS-3 and EOWVT-4). In the prompted play intervention, there were two children with DS and three children with ASD. In the commenting play intervention, there were three children with DS and two children with ASD. There were no

differences noted in the word-learning trajectory in either the expressive or receptive condition (Figure 3).

Discussion

Results indicate that the vocabulary intervention reported herein is effective at increasing both expressive and receptive vocabulary for all children studied: every child demonstrated learning in both expressive and receptive domains. Although duration of time needed to reach mastery varied across children, duration was similar for both modalities within individual children and in cumulative frequency analysis. Strikingly, the pattern of learning had high concordance across children despite substantial differences in language and/or cognition and across disability typology. This study provides a high number of replications (69) for this combination of vocabulary intervention procedures commonly used in schools and clinics (storybook reading, guided play), which was tested in 23 children of varying typologies: DS, ASD, SLI, and DD. The impact of this report is that the intervention presented within has high effectiveness at improving targeted real-world word knowledge.

Clinical implications
Population-specific patterns
The impetus for this study was based on the paucity of previous research on clinical vocabulary intervention across clinical groups. There is a general lack of vocabulary intervention studies generally and cross modal studies specifically despite evidence of the key role of vocabulary in development and the extensive evidence of reduced vocabularies in many clinical populations (Gillum and Camarata 2004). Although there are solid theoretical reasons for why different populations have word-learning deficits, and different factors contributing to these deficits, most children across these populations do evidence a need for vocabulary intervention (e.g. Hick *et al.* 2005). For example, children with DS demonstrate deficits in vocabulary knowledge (Chapman and Hesketh 2001), fast mapping of novel words, and learned vocabulary retention (Chapman *et al.* 1990). These deficits have been theorized to be linked to short-term memory and cognitive impairment (Jarrold *et al.* 1999). In contrast, children with ASD often demonstrate over-selectivity (attending to only part of the information; Lovaas *et al.* 1979) and under-generalization and may show deficits in vocabulary learning related to these characteristics (Brown and Bebko 2012). Notably, not all children with ASD have deficits in vocabulary learning (cf. Luyster 2009; Preissler and Carey 2005), nor do all children with SLI (Goffman and Leonard 2000; Leonard 2014; Steele and Mills 2011).

However, the children in this study demonstrated similar patterns of vocabulary learning, regardless of the theoretical basis underlying their deficits.

Receptive learning precedes expressive learning
In very young children who are developing typically, receptive vocabulary growth tends to exceed expressive vocabulary, and these children often quickly learn to say words they already know receptively (Heilmann *et al.* 2005). In addition, children with SLI sometimes show minimal deficits on receptive language measures, while showing large deficits on expressive language measures (Craig and Evans 1993; Goffman and Leonard 2000; Rescorla and Roberts 2002), and children with DS typically demonstrate greater impairment in expressive versus receptive vocabulary (Chapman and Hesketh 2001), possibly due to motor difficulties associated with speech disorders (Martin *et al.* 2009; Miller and Leddy 1999). By contrast, children with ASD sometimes have relatively significant receptive language deficits, even when their expressive language appears relatively intact (Hudry *et al.* 2010; Lord *et al.* 2004).

It might therefore be posited that children would have learned the receptive set of words (which they identify out of a set) prior to having learned the expressive set of words (which they must identify by saying the name of a picture). However, we found few differences in receptive versus expressive word learning among any of the 23 children in the data set. While some word sets were learned before others, no children in the DS, ASD, or DD sets demonstrated an overall preference for the receptive modality (or for the expressive modality). Several children within the SLI set did consistently reach criterion in the receptive modality prior to the expressive modality. However, these children demonstrated a consistent difference of less than one session overall, with an average of 11 sessions needed to reach criterion within an individual word set. Stated simply, receptive and expressive vocabulary developed in parallel and in close proximity to one another on a session-by-session basis regardless of disability typology.

Limitations
A single-subject study cannot directly compare across clinical groups and there are well-known pitfalls and attempting to establish 'similarities' using statistical analyses (see Dunnett and Gent 1977). However, this study has nearly 70 replications of findings that indicate children with vocabulary deficits (a) can and do learn new words, (b) show parallel growth trajectories in expressive and receptive modalities, and (c) within the ASD subset analysis, have no change in general developmental trajectory due

to IQ, although IQ seems to affect time in intervention (number of exemplars needed). Specifically, this study includes 15 replications of word learning in children with DS, 30 replications in children with ASD, 15 replications in children with SLI, and nine replications in children with unspecified DD. Thus, these data do appear to be compelling in terms of similar patterns across participants.

The single-subject approach also allows us to look at item-level responses. In doing so, we discovered that eight out of 23 children (35%) appeared to have difficulty on a single item that led to a dramatic increase in the length of time necessary to reach criterion. Half of these items were taught in the expressive modality, and half were taught in the receptive modality; there were also no overlapping words across children. In other words, it appears that the problem was not the words themselves or the modality in which they were taught, but the combination of the specific word and the particular child.

Item-level analysis gives us some indication of the idiosyncratic nature of the problem for specific words. For example, one child had an expressive target word 'cabin'. Although the child had not done so at baseline, during the intervention session, she identified the target as 'house'. This child persisted in using 'house' for 23 sessions, increasing the length of intervention. It is likely that this child was learning a second label for the target, which was not the goal of the intervention project. Second label learning is difficult for children with and without language-learning disabilities (cf. Markman 1994). However, because the child did not produce a first label at baseline, the word was not identified and removed from the set.

Future directions

The current study allows examination of vocabulary learning at (a) item level, (b) child level, and (c) etiological level. To compare the effects of an intervention across etiologies, a group comparison approach would be appropriate. In addition, although all children learned using the hybrid storybook/play approach described herein, a comparison of this intervention to other vocabulary interventions would be necessary to sufficiently test the effectiveness of the intervention against other strategies. An intriguing avenue of future study would be to examine the various factors that potentially inhibit word learning in a comparative study. For example, Stoel-Gammon (2011) discussed phonological factors that could relate to lexical learning. It would be interesting to explore whether this factor is differentially inhibitory in groups such as DS that often display disruptions in phonological development in addition to generally slower vocabulary learning. Additional

factors to be studied across groups could include auditory working memory, morphosyntactic factors, processing speed, and semantic features.

Another future direction would be to examine the broader generalization of the words learned within this intervention approach. Additional generalization conditions could include across settings, interaction partners, and material. The word leaning training and probes did parallel contexts that children with disabilities often encounter in word production and comprehension tasks, but addition research could yield important data on the degree to which broader generalization occurs and whether there are differences in generalization across disability typologies.

Clinically, the current study offers several pieces of information. First, a hybrid storybook and play strategy is effective in teaching vocabulary. Second, expressive and receptive vocabulary words take equal amounts of time to learn. Third, there is great individual variation at the item and child level. Fourth, at the population level, there appear to be striking similarities across typological and developmental profiles as they relate to response to vocabulary intervention.

Disclaimer statements

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