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Research Note

Vocal Communication With Canonical Syllables Predicts Later Expressive Language Skills in Preschool-Aged Children With Autism Spectrum Disorder

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Purpose: We examined associations between vocal communication with canonical syllables and expressive language and then examined 2 potential alternative explanations for such associations.
Method: Specifically, we tested whether the associations remained when excluding canonical syllables in identifiable words and controlling for the number of communication acts. Participants included 68 preverbal or low verbal children with autism spectrum disorder (M_{age} = 35.26 months).
Results: Vocal communication with canonical syllables and expressive language were concurrently and longitudinally associated with moderate to strong (R^2s = .13–.70) and significant (ps < .001) effect sizes. Even when excluding spoken words from the vocal predictor and controlling for the number of communication acts, vocal communication with canonical syllables predicted expressive language.
Conclusions: The findings provide increased support for measuring vocal communication with canonical syllables and for examining a causal relation between vocal communication with canonical syllables and expressive language in children with ASD who are preverbal or low verbal. In future studies, it may be unnecessary to eliminate identifiable words when measuring vocal communication in this population. Following replication, vocal communication with canonical syllables may be considered when making intervention-planning decisions.

Compared with children with typical developmental histories, children with autism spectrum disorder (ASD), as a group, exhibit reduced use of vocalizations with canonical syllables (i.e., combinations of consonant-like and vowel-like sounds produced with rapid, adultlike transitions; Oller, 2000; Paul, Augustyn, Klin, & Volkmar, 2005; Patten et al., 2014; Wetherby et al., 2004). In the course of typical development, canonical syllables are expected to emerge at 5–10 months of age (Cobo-Lewis, Oller, Lynch, & Levine, 1996; Eilers et al., 1993; Koopmans-van Beinum & van der Stelt, 1986; Oller, 2000). The production of canonical syllables represents a pivotal stage in vocal development that has been theoretically and empirically associated with spoken language development in children with ASD (e.g., McDaniel, D'Ambrose Slaboch, & Yoder, 2018; Oller, 2000). Furthermore, spoken language (i.e., "useful speech") achieved during the preschool years predicts social, adaptive, and vocational outcomes in children with ASD (e.g., Billstedt, Gillberg, & Gillberg, 2005; Howlin, 2000). The reduced use of canonical syllables in vocal communication may thus have far-reaching implications for language development and long-term outcomes of preschool-aged children with ASD.

Previously Reported Associations Between Vocal Communication With Canonical Syllables and Expressive Language in Children With ASD

A recent meta-analysis revealed a large mean effect size (i.e., r = .62) for the association between consonant-centric vocalization metrics (i.e., metrics that required vocalizations to include consonants such as indices of canonical

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syllable use or consonant inventory) and expressive language for young children with ASD (McDaniel et al., 2018). This mean effect size includes 49 effect sizes of this association (Pearson *r* or partial *r*) and provides an estimate of the strength of the relation between consonant-centric vocalizations and expressive language in this population. Of the 49 effect sizes included in the aforementioned quantitative synthesis, 24 specifically examined the use of canonical syllables in young children with ASD (Woynaroski et al., 2016; Yoder, Woynaroski, Keceli-Kaysili, & Watson, 2016). For example, Woynaroski et al. (2016) found that an aggregate variable of the proportion of communication acts including canonical syllables and the number of different consonants used communicatively predicted future expressive language scores for initially preverbal children with ASD ($r = .64$). Using the same sample, Yoder et al. (2016) found significant concurrent and longitudinal associations between communication acts with canonical syllables and expressive language skills. There is a need, however, to further explore the large positive effect sizes indexing the magnitude of the association between consonant-centric vocalizations and expressive language that have been reported in prior work involving preschool-aged children with ASD.

Evaluating Alternative Explanations for the Association Between Vocal Communication With Canoncial Syllables and Expressive Language

There are two possible explanations for the previously observed associations between vocal communication with canonical syllables and expressive language that warrant further investigation. First, it is possible that some or even many of a child's instances of intentional communication acts with canonical syllables are spoken words. If so, associations with expressive language might merely reflect the association of two indices of expressive language. This alternative explanation can be tested empirically by excluding spoken words when identifying communication acts with canonical syllables.

Second, the association between vocal communication with canonical syllables and expressive language could be explained by a third variable covarying with vocal communication with canonical syllables and expressive language: children's generalized tendency to communicate. Children who communicate more frequently might produce both vocal communication with canonical syllables and spoken words more frequently. If so, associations between vocal communication with canonical syllables and expressive language might merely reflect the tendency to communicate regardless of whether the child is using vocalizations, words, or another form of communication. This alternative explanation can be tested empirically by statistically controlling for the child's number of communication acts at Time 1. This measure of the frequency of communication acts provides a measure of the child's generalized tendency to communicate, regardless of form (e.g., gesture, vocalization, or word).

Neither of these two possible alternative explanations for the association between vocal communication with canonical syllables and expressive language in children with ASD has been examined. The current study was conducted to address this gap in the literature.

Purpose and Research Questions

We addressed two research questions: (a) Is vocal communication with canonical syllables associated with expressive language concurrently and longitudinally in preschool-aged children with ASD? We hypothesized that vocal communication with canonical syllables would be associated with expressive language, and that the magnitude of these associations would decrease with increased time between the measurements of vocal communication with canonical syllables and expressive language. (b) Do identified associations between vocal communication with canonical syllables and expressive language remain significant when excluding canonical syllables in identifiable words and controlling for the number of communication acts? We hypothesized that the associations between vocal communication with canonical syllables and expressive language would remain significant when excluding canonical syllables in identifiable words and controlling for the number of communication acts. If positive associations are observed even when controlling for the aforementioned possibilities, results would support future efforts designed to test a causal relation between early vocal communication with canonical syllables and later expressive language.

Method

The University of North Carolina at Chapel Hill and Vanderbilt University institutional review boards approved all study procedures. Caregivers provided written consent for participants included in the study.

Design

We drew upon extant data from a larger longitudinal correlational study of language development in preschool-aged children with ASD (Yoder, Watson, & Lambert, 2015). The current study includes four time points that span 12 months. For the current study, Time 1 is 4 months after the initiation of the larger study. Times 2, 3, and 4 follow at 4-month intervals. Thus, Time 2 is 4 months after initiation of the current study, Time 3 is 8 months after initiation, and Time 4 is 12 months after initiation. All further references to time refer to the current study, not the larger study from which the present data were drawn.

Participants

Participants in the current study included 68 preschool-aged children with ASD (57 boys, 11 girls) from the larger longitudinal correlational study conducted by Yoder et al. (2015). We included all participants from the larger study

who used at least five communication acts during the Communication and Symbolic Behavior Scales–Developmental Profile Behavior Sample (CSBS-DP; Wetherby & Prizant, 2002) at Time 1 to use our limited coding resources wisely and increase the likelihood of the participants using spoken words. Based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (American Psychiatric Association, 2000), 94% of participants were diagnosed with autism, and the remainder were diagnosed with pervasive developmental disorder–not otherwise specified. Participants had a mean chronological age of 35.26 months (SD = 7.16) and a mean mental age on the Mullen Scales of Early Learning of 12.59 months (SD = 5.11) at the start of this larger study (Mullen, 1995). They used 20 or fewer spoken words per parent report and no more than five spoken words during a 15-min language sample with an examiner at entry into the larger study. At Time 1 of the current study, which was 4 months after initiation of the larger study, participants understood a mean of 113 words (SD = 108; range: 0–396) and used a mean of 19 words (SD = 27; range: 0–117) per parent report on the MacArthur–Bates Communicative Development Inventories (MB-CDI)–Words and Gestures form (Fenson et al., 2007).

Variables

Vocal Communication With Canonical Syllables

Vocal communication with canonical syllables was measured during the CSBS-DP at Time 1 and Time 3 of the current study (8 months later). The CSBS-DP is a norm-referenced assessment of communicative competence that includes communication temptations, book-sharing activities, symbolic and constructive play probes, and a language comprehension probe designed to elicit communication acts from the child. We used 5-s partial interval behavior sampling to quantify vocal communication with canonical syllables. First, we identified intentional communication acts, which were defined as (a) a nonimitative symbol (i.e., sign or word), (b) a conventional gesture with attention shown to the adult, or (c) a nonconventional gesture or nonword vocalization with coordinated attention to object and person. Intervals with communication acts were then coded for the presence of a canonical syllable. For example, a child saying "Duh" while reaching toward the bubbles container and looking back and forth between the examiner and the bubbles container would be coded as vocal communication with a canonical syllable because the child produced a canonical syllable within an intentional communication act. If the child had said "Bubble" or another word rather than "Duh" (e.g., "more"), it would also be coded as vocal communication with a canonical syllable. The metric used to quantify vocal communication with a canonical syllable was the number of 5-s intervals with a communication act that included a canonical syllable. This approach to coding vocal communication with canonical syllables is consistent with prior work in our laboratories linking this aspect of vocal development with expressive language (e.g., Woynaroski et al., 2016; Yoder et al., 2016).

Vocal Communication With Canonical Syllables Without Identifiable Words

Then, we determined whether each interval with an instance of vocal communication with a canonical syllable included an identifiable spoken word. Identifiable words were defined as vocalizations that met criteria for pronunciation (i.e., sufficiently similar to the adult production), referential use (i.e., used in a semantically appropriate manner and not an immediate imitation), and analyzable content (e.g., not singing, filler words, or nonword sound effects). Word approximations (if they met the above criteria) could be coded as identifiable words. The intervals with identifiable words, including word approximations, were excluded from the vocal communication with canonical syllables without identifiable words variable. Thus, this process "purified" the vocal communication with canonical syllables variable to only include nonword vocalizations. For example, a child saying "Duh" while reaching toward the bubbles container and looking back and forth between the examiner and the bubbles container would be coded as vocal communication with a canonical syllable without an identifiable word. However, if the child had said "Bubble" or "Buh-buh" (word approximation) rather than "Duh," it would not be coded as vocal communication with a canonical syllable without an identifiable word.

Expressive Language

To increase stability of the expressive language variable, we sought to aggregate data from three sources, assuming sufficient intercorrelation: (a) the MB-CDI Expressive Vocabulary subscale (i.e., the raw number of words children were reported to say by their caregivers), (b) the number of different root words produced during a 15-min unstructured communication sample (UCS) with an unfamiliar examiner, and (c) the CSBS-DP Word subscale scaled score (Yoder, Lloyd, & Symons, 2018). We calculated this aggregate by averaging the z scores for the relevant component variables from each measure. All of the expressive language measures were collected at Times 1 through 4, each 4 months apart.

Number of Communication Acts

We measured the number of communication acts that the child produced to control for a generalized tendency to communicate when addressing our second research question. To quantify the number of communication acts, we identified the number of 5-s intervals with a communication act during the Early Social Communication Scales (Mundy et al., 2003) and UCS at Time 1. Had we measured and controlled the number of communication acts in the CSBS-DP, we would have removed the communicative nature of the predictor variable of interest, which would not have served our research question. Table 1 provides a summary of constructs, measures, metrics, and time periods relevant to analyses.

Interrater Reliability

A second coder independently coded 20% of the samples; the primary coder was blinded to which samples would be coded for interrater reliability. The intraclass

Table 1. Study constructs, measures, metrics, and time periods.

Construct	Measure	Metric	Time periods
Vocal communication with canonical syllables	CSBS-DP	Number of 5-s intervals with a communication act with a canonical syllable	1 & 3
Vocal communication with canonical syllables without identifiable words	CSBS-DP	Number of 5-s intervals with a communication act with a canonical syllable without identifiable words	1 & 3
Expressive language	MB-CDI	Expressive vocabulary subscale raw score	1–4
	Unstructured communication sample	Number of different root words produced during sample	
	CSBS-DP	Word subscale scaled score	
Number of communication acts	ESCS	Number of 5-second intervals with a communication act across samples	1
	Unstructured communication sample		

Note. CSBS-DP = Communication and Symbolic Behavior Scales–Developmental Profile Behavior Sample (Wetherby & Prizant, 2002); MB-CDI = MacArthur–Bates Communicative Development Inventories–Words and Gestures form (Fenson et al., 2007); ESCS = Early Social Communication Scales (Mundy et al., 2003).

correlation coefficient using a two-way random model for absolute agreement for each coded variable exceeded .90.

Results

Preliminary Analyses

Bivariate correlations between the three expressive language metrics (i.e., MB-CDI expressive subscale, number of different word roots produced during the UCS, and CSBS-DP Word subscale scaled score) were strong (i.e., r values = .70–.82). Thus, an aggregate of the three component variables was created as planned.

Associations Between Vocal Communication With Canonical Syllables and Expressive Language

A series of regression analyses was run to examine associations between the number of vocal communication acts with canonical syllables in communication acts and expressive language concurrently and 4, 8, and 12 months later. Due to noted heteroscedasticity in the data, all calculations were completed with heteroscedastic-consistent standard errors via the HCREG macros for SPSS (Hayes & Cai, 2007). There was no evidence of undue influence.

The regression results, as indicated by R^2 values (see Table 2), showed moderate to strong and significant (p values < .001) associations. R^2 values indicate the proportion of variance in expressive language that is accounted for by the vocal communication with canonical syllables predictor variable, when including identifiable words and not controlling for children's generalized tendency to communicate. As a reference, the mean effect size for the meta-analysis of the association between vocalizations and expressive language was R^2 = .25 (r = .50; McDaniel et al., 2018). The strongest association was observed for vocal communication with canonical syllables and expressive language, both measured at Time 3 (R^2 = .70). The weakest association was observed for Time 1 vocal communication with canonical syllables predicting expressive language 12 months later (i.e., Time 4; R^2 = .13). Nonetheless, a moderate association across 12 months is noteworthy.

Excluding Canonical Syllables in Identifiable Words and Controlling for the Number of Communication Acts

We excluded canonical syllables in identifiable words by using the "vocal communication with canonical syllables without identifiable words" variable. That is, the primary predictor of interest differs from that of previous analyses, which included words with canonical syllables and communication with canonical syllables that were not part of words. To control for the number of communication acts, we tested whether vocal communication with canonical syllables without identifiable words was significantly associated with expressive language after controlling for the number of communication acts. When using vocal communication with canonical syllables without identifiable words as the predictor, even after controlling for communication acts, the associations of interest remained significant at all

Table 2. Associations between vocal communication with canonical syllables and expressive language concurrently and longitudinally.

Expressive language	Vocal communication with canonical syllables					
	Time 1			Time 3		
	n	*F*	R^2	*n*	*F*	R^2
Time 1	65	33.72*	.47	N/A	N/A	N/A
Time 2	59	14.05*	.21	N/A	N/A	N/A
Time 3	65	17.16*	.23	65	59.38*	.70
Time 4	64	7.30*	.13	64	45.79*	.54

Note. Time 1 = study initiation; Time 2 = 4 months after study initiation; Time 3 = 8 months after study initiation; Time 4 = 12 months after study initiation; N/A = not applicable.

*p < .001.

tested time points, as shown in Tables 3 and 4 (ΔR^2 values indexing the unique variance in expressive language accounted for by vocal communication with canonical syllables without identifiable words, after controlling for child communication acts = .06–.32, p values < .05).

Discussion

This study explored possible explanations for previously observed associations between vocal communication with canonical syllables and expressive language in preschool-aged children with ASD. As expected, for preschool-aged children with ASD, vocal communication with canonical syllables was associated with concurrent and future expressive language skills. These associations held even when excluding identifiable words from the metric of vocal communication with canonical syllables and when controlling for the number of child communication acts. Overall, the current findings provide increased support for measuring vocal communication with canonical syllables in children with ASD who are not yet speaking or in the early stages of word learning. It is notable that vocal communication with canonical syllables predicts expressive language in children with ASD even though children with ASD as a group vocalize less often than children with typical developmental histories (Ozonoff et al., 2010; Patten et al., 2014; Warren et al., 2010). Thus, the lower rate of vocalizations in children with ASD does not preclude vocal communication with canonical syllables from being a useful predictor, assuming the sampling procedure is long enough or that one uses multiple sampling procedures and aggregates scores across procedures.

In the current study, the strength of the association between vocal communication with canonical syllables and expressive language skills was large in magnitude (i.e., R^2 values = .47–.70) for concurrent associations and moderate–large in magnitude (i.e., R^2 values = .13–.54) for predictive associations. These findings are consistent overall with results from prior studies that tested associations between vocal communication with canonical syllables and current or future expressive language without controlling for the alternative explanations presented here (e.g., Woynaroski et al., 2016; Yoder et al., 2016).

The positive and significant association with expressive language when excluding identifiable words from the predictor and statistically controlling for the number of child communication acts at entry to the study indicates that the associations between vocal communication with canonical syllables and expressive language are not solely attributable to a child's use of spoken words within utterances or generalized tendency to communicate. Thus, there must be other explanations for the relation between vocal communication with canonical syllables and expressive language concurrently and predictively.

Multiple theories could explain why vocal communication with canonical syllables may be important for expressive language development. These theories incorporate child factors, caregiver factors, and the interaction between these factors to varying degrees. From a child-focused perspective, vocal communication with canonical syllables may be associated with improved motoric accuracy (e.g., Iverson, 2010; Stoel-Gammon, 2011) and increased attempts to talk (e.g., a child attempting to say words he or she understands; Woynaroski et al., 2016). When used repeatedly over time, the child may learn to produce their vocal targets more accurately as they receive feedback from others and consequently refine their speech production skills. Also, the child's communicative use of canonical syllables may elicit more frequent or more complex linguistic input from caregivers, which may scaffold later expressive language development (e.g., Nelson, Carskaddon, & Bonvillian, 1973; Woynaroski et al., 2017; Woynaroski, Yoder, Fey, & Warren, 2014). This perspective, which focuses on bidirectional interactions between children and adults, would be consistent with multiple theories (e.g., social feedback theory [Goldstein, King, & West, 2003; Goldstein & Schwade, 2008] and the transactional theory of spoken language development [Camarata & Yoder, 2002; McLean & Snyder-McLean, 1978; Sameroff & Chandler, 1975]).

Limitations

Two primary limitations should be acknowledged. First, the sample is restricted to preschool-aged children

Table 3. Unstandardized coefficients, standard error (*SE*), and variance in current or later expressive language accounted for by Time 1 vocal communication with canonical syllables when excluding identifiable words and controlling for Time 1 communication acts.

Expressive language	*n*	*B* Time 1 CA (*SE*)	Time 1 CA ΔR^2	*B* Time 1 CSWIW (*SE*)	Time 1 CSWIW ΔR^2
Time 1	65	0.007* (0.003)	.004	0.052*** (0.008)	.233
Time 2	59	0.009 (0.006)	.038	0.036** (0.013)	.098
Time 3	65	0.011* (0.004)	.091	0.042** (0.014)	.162
Time 4	64	0.018* (0.007)	.124	0.029* (0.014)	.063

Note. CA = number of 5-s intervals with a communication act during the Early Social Communication Scales (Mundy et al., 2003) and unstructured communication sample; CSWIW = vocal communication with canonical syllables without identifiable words produced during the Communication and Symbolic Behavior Scales–Developmental Profile Behavior Sample (Wetherby & Prizant, 2002); Time 1 = study initiation; Time 2 = 4 months after study initiation; Time 3 = 8 months after study initiation; Time 4 = 12 months after study initiation.

*p < .05. **p < .01. ***p < .001.

Table 4. Unstandardized coefficients, standard error (*SE*), and variance in current or later expressive language accounted for by Time 3 vocal communication with canonical syllables when excluding identifiable words and controlling for Time 1 communication acts.

Expressive language	*n*	*B* Time 1 CA (*SE*)	Time 1 CA ΔR^2	*B* Time 3 CSWIW (*SE*)	Time 3 CSWIW ΔR^2
Time 3	65	0.012* (0.005)	.151	0.037*** (0.006)	.320
Time 4	64	0.016** (0.005)	.161	0.036*** (0.007)	.243

Note. CA = number of 5-s intervals with a communication act during the Early Social Communication Scales (Mundy et al., 2003) and unstructured communication sample; CSWIW = vocal communication with canonical syllables without identifiable words produced during the Communication and Symbolic Behavior Scales–Developmental Profile Behavior Sample (Wetherby & Prizant, 2002); Time 1 = study initiation; Time 3 = 8 months after study initiation; Time 4 = 12 months after study initiation.

*$p < .05$. **$p < .01$. ***$p < .001$.

with ASD who were preverbal or low verbal; however, this population is arguably one of the most appropriate populations for measuring the prelinguistic skills, such as vocal communication with canonical syllables. Second, we used concurrent and longitudinal correlational study designs. Although these two designs can be useful for accumulating evidence of associations (relevant to both designs) and establishing temporal precedence (relevant to the longitudinal correlational elements), neither can account for all possible third variable explanations. We accounted for two of the most likely alternative explanations (i.e., that the production of canonical syllables, at least, in part, reflects the use of identifiable words or word approximations and/or is highly intercorrelated with a generalized tendency to communicate), but numerous other potential third variable explanations remain. Therefore, causal conclusions cannot be drawn from these findings.

Strengths

Four strengths should be acknowledged. First, this study represents an additional step in testing potential alternative explanations for the previously observed associations between vocal communication with canonical syllables and expressive language in children with ASD. Prior studies have rarely addressed a generalized tendency to communicate as a third variable explanation, and none have addressed the potential influence of vocal communication containing spoken words. Second, we used an aggregate measure of expressive language to provide a more stable estimate of this construct than single measures afford. Third, the sample was relatively large, boosting power for analyses and increasing the likelihood that our sample was representative of the population of children with ASD who are in the early stages of language development (thereby increasing the likelihood of the findings replicating). Fourth, this longitudinal study spanned a relatively long time period (i.e., 12 months), allowing us to examine the magnitude of associations of interest over varied intervals.

Future Directions

Given the novel nature of these findings, replication is required. Given that the study sample here was somewhat homogenous, future studies should evaluate the extent to which the present findings generalize to the broader population of children with ASD (e.g., by including samples of children who are at different chronological and/or language ages and children who speak languages other than English). In addition, studies investigating why vocal communication with canonical syllables is associated with expressive language skills in children with ASD are needed. The findings from this study do not provide evidence to support one theoretical perspective over another. Thus, further investigation is needed to address competing theoretical explanations for the findings. For example, a path model could be used to evaluate whether the association is mediated by receptive language and/or caregiver linguistic input (e.g., linguistic mapping). Receptive language mediating the association would support the hypothesis that, as vocal communication with canonical syllables increases, the child is attempting to say words that he or she understands but does not yet produce clearly. Caregiver linguistic input mediating the association would provide evidence that the child's vocal communication elicits input from the caregiver that the child is able to use for producing more adultlike word forms. Additionally, intervention studies are needed to test whether targeting prelinguistic vocalizations (e.g., vocal communication with canonical syllables) in children with ASD who are in the early stages of word learning facilitates expressive language growth. These intervention studies would permit drawing causal conclusions for some research questions.

Implications

These findings have implications for research and clinical practice. Related to future research studies, the findings indicate that it may be unnecessary to identify and eliminate identifiable words when measuring vocal communication in children with ASD in the preverbal and early verbal stages of language development. Eliminating the need to determine whether vocalizations are identifiable words greatly simplifies the coding task. Simplifying the coding tasks increases feasibility and reduces cost due to the required time for training and coding.

If future research supports the causal link between vocal communication with canonical syllables and expressive

language, three clinical implications are apparent. First, vocal communication with canonical syllables may provide a positive prognostic indicator that the child is ready to learn expressive language. Second, clinicians can point caregivers to the changes in their children's vocal communication with canonical syllables as evidence of important advances prior to the onset of expressive language. Such information may encourage caregivers to continue to do what they are doing that might be contributing to expressive development. Third, clinicians can draw caregivers' attention to children's vocal communication with canonical syllables to encourage consistent linguistic mapping of children's attempts to produce vocal communication with canonical syllables.

Conclusion

Canonical syllables in communication acts predicted expressive language skills in initially preverbal or low verbal children with ASD concurrently and up to 12 months later. These associations remained significant even when excluding spoken words from vocal communication with canonical syllables and controlling for the number of communication acts. Findings support further investigations exploring why vocal communication with canonical syllables predicts expressive language and testing interventions targeting vocal communication with canonical syllables in preschool-aged children with ASD who are preverbal or in the early stages of language acquisition.

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