Title: Stability of Vocal Variables Measured During the Early Communication Indicator for Children with Autism Spectrum Disorder

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Introduction: Reliable (i.e., stable) means for assessing vocal development in children with autism spectrum disorder (ASD) are needed to enable early evaluation of response to intervention for children with ASD who are not yet talking or are in the early stages of word learning. The short duration, simple standardized procedures, and play-based format make the Early Communication Indicator (ECI; Greenwood, Buzhardt, Walker, Jia, & Carta, 2019; Greenwood, Carta, & McConnell, 2011; Priest et al., 2001) provides an ecologically valid, cost-effective context for estimating individual differences in vocal development in young children with ASD. This study aims to determine how many 6-min ECI sessions are required to achieve adequate stability for five vocal variables that assess volubility and vocal complexity. The tested vocal variables are not included in the original ECI scoring protocol.

Method: Eighty-three children with ASD (62 male; 21 female) from a multi-site randomized controlled trial were included. Treatment group assignment did not affect this study's results; thus, treatments are not discussed further. At the study's start, participants had a mean chronological age of 23.33 months (*SD* = 4.02 months) and mean developmental quotient (Mullen Scales of Early Learning; Mullen, 1995) of 60.12 (*SD* = 18.09). Participants completed monthly 6-min ECI procedures with an examiner who was blind to the study's purpose. Three sessions were collected at Time 1 and three sessions were collected at Time 2, with a mean of 10 months between Time 1 and 2 administrations. As described in the ECI procedures, the examiner and child engaged in semi-structured play in a lab setting with a standard toy set.

We coded five vocal variables from the ECI samples: (a) number of total vocalizations (communicative and noncommunicative vocalizations), (b) number of communication acts with a canonical syllable, (c) proportion of vocalizations that are communicative, (d) diversity of key consonants used in communication acts, and (e) proportion of vocalizations with a canonical syllable. Vocalizations were defined as nonvegetative voiced sounds produced during exhalation. Using EduG software (Swiss Society for Research in Education Working Group, 2006), we conducted a generalizability (G) study followed by a corresponding decision (D) study for each of the vocal variables at each time point. The G study results are the intraclass correlation coefficient (ICC) values (an estimate of stability) and the variance estimates used in the D study. The D study uses the G study's results to estimate how many sessions' scores must be averaged to provide a stable estimate of individual differences on the variable of interest (Yoder, Lloyd, & Symons, 2018).

Results: ICCs for stability across sessions within time is the study focus. As predicted, the number of sessions required for adequate stability (ICC $\geq$ .70) was slightly fewer at Time 2 than at Time 1 and the across-session ICC increased as the number of ECI sessions increased for all variables (see Table 1). The number of sessions required for adequate stability varied slightly across vocal variables within both study time periods (see Figure 1).

Discussion: The results provided encouraging results for using the ECI as a sampling context to measure individual differences on various aspects of vocalizations in young children with ASD. Although volubility (i.e., number of total vocalizations) required the most sessions to achieve adequate stability within time period of the vocal variables, adequately stable estimates for the vocal variables were achieved in as little as one session at Time 2 and two sessions at Time 1. That is, when attempting to quantify individual differences on a generalized tendency to vocalize or do so in a certain way, investigators must average scores across more sessions for younger participants, who typically show more variability in performance, than for older children. This finding is consistent with other findings on measuring communication in preschool-aged children with intellectual disabilities (Sandbank & Yoder, 2014).

Future studies should (a) seek replication, (b) assess validity, (c) investigate the feasibility of coding the tested vocal variables reliably using real-time coding, and (d) estimate relative amount of resources required for each vocal variable.

Table 1
Extrapolated Intraclass Correlation Coefficients by Number of Early Communication Indicator (ECI) Sessions

		Number of sessions				
		1	2	3	4	5
Time 1	Number of total vocalizations	.50	.67	.75	.80	.83
	Number of communication acts with a canonical syllable	.48	.65	.74	.79	.82
	Proportion of vocalizations that are communicative	.51	.68	.76	.81	.84
	Diversity of key consonants used in communication acts	.66	.80	.85	.89	.91
	Proportion of vocalizations with a canonical syllable	.61	.76	.83	.86	.89
Time 2	Number of total vocalizations	.60	.75	.82	.86	.88
	Number of communication acts with a canonical syllable	.77	.87	.91	.93	.94
	Proportion of vocalizations that are communicative	.78	.88	.92	.93	.95
	Diversity of key consonants used in communication acts	.79	.88	.92	.94	.95
	Proportion of vocalizations with a canonical syllable	.73	.85	.89	.92	.93

Note. Shaded cells indicate values meeting or exceeding the stability criterion of ICC ≥ .70.

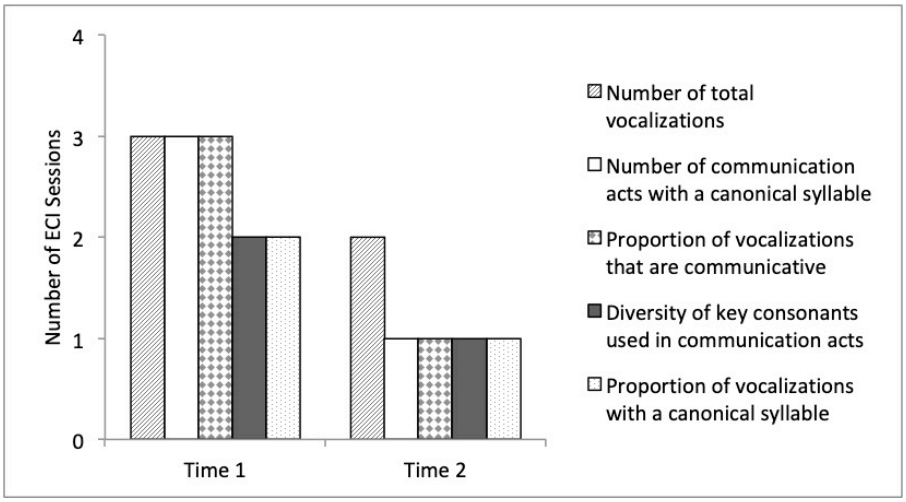

Figure 1. Number of Early Communication Indicator (ECI) sessions required to achieve adequate stability (ICC ≥ .70). Time 1 = study initiation; Time 2 = study endpoint / average of 10 months after Time 1.

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