The Concurrent and Predictive Validity of the IGDI-ECI for Toddlers with Communication Delays

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THE CONCURRENT AND PREDICTIVE VALIDITY OF THE IGDI-ECI
FOR TODDLERS WITH COMMUNICATION DELAYS

By

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This dissertation is dedicated to the children and families of the Kidtalk-Tactics Project.

Thank you for sharing the joy of watching your children grow.
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ABSTRACT

The purpose of this study was to examine the concurrent and predictive validity of the IGDI-ECI and to model communication growth on the key skill elements of the IGDI-ECI in toddlers with significant communication delays. Concurrent validity of the measure was evaluated by examining correlations at 24 and 36 months between the Total Communication Score of the IGDI-ECI and the CDI, CSBS:DP, PLS-4, and a caregiver child communication sample. The Total Communication score (a composite of gestures, vocalizations, word and multiple word use) did not significantly correlate with other measures at 24 months, but correlated with the PLS-4 at 36 months. Hierarchical linear models demonstrated growth curves for Total Communication and key skill elements that differ somewhat from other samples of children with IFSPs. HLMs also showed that the IGDI-ECI at entry predicts outcomes at 36 months on the measure itself but not on the caregiver-child communication sample. Implications and directions for future research were discussed.
CHAPTER ONE

INTRODUCTION

A focus on accountability in early childhood has catalyzed a renewed interest in assessing young children with disabilities to document growth resulting from intervention (Greenwood, Carta, & McConnell, 2011; Grisham-Brown & Pretti-Frontczak, 2011; Hebbeler, Barton, & Mallik, 2008; Neisworth & Bagnato, 2004; Snow & Van Hemel, 2008), particularly within a response to intervention (RTI) framework (Greenwood, Walker, & Buzhardt, 2010; Pfeiffer-Fiala, Pretti-Frontczak, Moore, & Lyons, 2011; Vanderheyden, Snyder, Broussard, & Ramsdell, 2008; Vanderheyden, Witt, & Barnett, 2005). Tiered intervention approaches to communication, literacy, and social-emotional development depend on universal screening and frequent progress-monitoring to ensure that children are receiving adequate levels of support and are responding to the intervention delivered (Bagnato, Neisworth, & Pretti-Frontczak, 2011; Greenwood, Carta, Walker, Hughes, & Weather, 2006; Vanderheyden et al., 2008; Vanderheyden et al., 2005). All providers are encouraged to gather data to document whether or not an intervention is resulting in child communication gains as a part of their evidence-based practice (American Speech-Language and Hearing Association [ASHA], 2008; Grisham-Brown & Pretti-Frontczak, 2011). Without effective progress monitoring tools, providers may continue to use intervention approaches without evaluating whether or not a child is gaining functional skills (Vanderheyden et al., 2008). While there is broad agreement that early childhood practitioners should gather information regarding growth following intervention, speech-language pathologists (SLPs), early childhood special educators (ECSEs), and other providers frequently rely on traditional, often cumbersome assessments of child communication to document progress (Crais, 1995; Huang, Hopkins, & Nippold, 1997). Because standardized assessments are intended to identify children with communication delays and are not necessarily suited to progress-monitoring (Bagnato et al., 2011; Crais, 2011; Grisham-Brown & Pretti-Frontczak, 2010), there is a critical need to examine the utility and appropriateness of measures of early communication for children with and at-risk for communication delays for the purposes of monitoring a child’s responsiveness to intervention (Bagnato et al., 2011; Grisham-Brown & Pretti-Frontczak; Heilmann, Nockerts & Miller, 2010; Greenwood et al., 2010; Vanderheyden et al., 2008).
The aim of this study was to examine the predictive and concurrent validity of the *Individual Growth and Development Indicator- Early Communication Index* ([IGDI-ECI]; Luze et al., 2001), a tool developed to monitor a child’s developing communication skills during the infant and toddler period. Results from standardized measures were used to predict the child’s communication growth on the IGDI-ECI and in an authentic communication sample to provide validity information about the use of this progress-monitoring tool for toddlers with communication delays. Growth curve analysis was used to help contribute to the evidence base concerning norms on the IGDI-ECI for toddlers with communication delays.

**Ecological Perspectives and Best Practices for Assessing Infants and Toddlers**

Guidelines from ASHA, the Division for Early Childhood (DEC), the National Association for the Education of Young Children (NAEYC) and the National Research Council (NRC) agree upon several important practices for assessing and monitoring communication development in infants and toddlers (ASHA, 2008, Neisworth & Bagnato, 2004, NAEYC & NAECS/SDE, 2003; Sandall, Hemmeter, Smith, & McLean, 2005; Snow & Van Hemel, 2008). These assessment practices are rooted in ecological theories that have influenced federal IDEA legislation (Grisham-Brown & Pretti-Frontczak, 2011; McLean & Crais, 2004). Ecological theories of child development posit that children grow and learn within a unique ecology comprised of the people, places, activities, and culture of the world around them (Bronfenbrenner, 1992). The child is influenced by his or her environment and, in turn, influences the environment; thus there is a bidirectional effect of adult and child on each other during interactions (Bronfenbrenner, 1992). In order to assess child communication skills in an ecologically valid manner, a provider should observe the child on multiple occasions, in multiple settings, and with multiple familiar communication partners to examine what the child is able to do. Likewise, ecologically valid assessments should include the caregiver as an active participant because the family system is a major feature of the child’s ecology. Without considering the child’s interactions with familiar people in familiar places and settings, assessments fail to yield meaningful, contextually relevant information about a child’s skills (Bagnato et al., 2011).

Consistent with ecological theory, professional organizations have encouraged early intervention providers to collaborate and partner with families at each stage of the assessment process. Families provide information about child strengths and needs, as well as their own priorities for the assessment (ASHA, 2008; Crais, 1995, 2011; Grisham-Brown & Pretti-
In order to establish an effective, family-centered partnership, the provider should secure caregiver involvement during the assessment process to set the stage for collaboration during intervention (Crais, 1995; 2011).

Guidelines from the major professional organizations agree that providers should use multiple types of measures in order to gain a more complete picture of child skills in multiple contexts (ASHA, 2008; Bagnato et al., 2011; Crais, 1995, 2011; Grisham-Brown & Pretti-Frontczak, 2011; NAEYC & NAECS/SDE, 2003; Snow & Van Hemel, 2008). Such an approach has been referred to as a convergent assessment model because information comes together from multiple sources to inform decision-making (Bagnato, Neisworth, & Munson, 1997). The use of standardized measures alone is typically insufficient for gaining an accurate assessment of child abilities and functioning in everyday contexts and should be combined with observational data, parent-reported measures, and curriculum-based measures. Assessments should also meet standards of equitability, ensuring that they are useful for all children. Assessment tools and activities should also provide information that guides intervention and the identification of functional child outcomes. Lastly, the assessment process should include plans to monitor the child’s progression toward the identified skills.

Early childhood professionals are challenged by the process for conducting assessments in a manner consistent with guidelines from professional organizations (Keilty, LaRocco, & Casell, 2009; Snow & Van Hemel, 2008) as well as by the strengths and limitations of the measures available for assessing early communication skills, particularly for the purposes of progress monitoring (Crais, 1995; Greenwood, Carta, & McConnell, 2011; Vanderheyden et al., 2008). In a recent study, providers reported a lack of resources and administrative support needed to engage in other assessment activities besides the use of standardized measures when a child enters the Part C system (Keilty et al., 2009). Providers stated that they were unable to perform functional assessments until after IFSP goals are written because the initial visits are only to be billed for the purposes of determining eligibility (Keilty et al., 2009). Even after intervention begins, the degree to which providers use multiple means of gathering information about child skills in natural contexts remains unclear. Survey research from two studies (Crais, 1995; Huang et al., 1997) indicates a reliance on individually-administered standardized tests for assessing early communication skills. While standardized tests may have a role to play in
identifying children with communication delays, providers would benefit from progress-monitoring tools designed to measure expressive communication in infants and toddlers to ensure that interventions are working to support the child’s development (Greenwood et al., 2011; Vanderheyden et al., 2008, Heilmann et al., 2010).

**Traits of Progress Monitoring Tools**

Tools for progress monitoring should meet the same core guidelines as other early childhood communication measures, but they should have several unique characteristics as well. First, progress monitoring tools should be repeatable for frequent use and they should be sensitive to incremental changes in child skills (Greenwood et al., 2011; Luze et al., 2001, Vanderheyden et al., 2008). They should also be easy to administer and score, particularly for use in tiered models in which progress monitoring tools are used to screen and track the development of all children (Greenwood et al., 2011; Vanderheyden et al, 2005; Vanderheyden et al., 2008). Early communication tools should include prelinguistic communication skills (i.e. gestures, vocalizations, and joint attentional skills) and they should allow adaptations for infants and toddlers with severe disabilities (Neisworth & Bagnato, 2004).

**Individual Growth and Development Indicator- Early Communication Index (IGDI-ECI)**

The IGDI-ECI is one of several IGDIIs developed as a general outcome measure documenting important skill benchmarks during the infant-toddler period (Luze et al., 2001). The IGDIIs were created with several purposes in mind: for intervention decision-making for children with and at-risk for communication delays, to follow child development in RTI frameworks, for program level accountability and evaluation, and for national data collection on child outcomes (Greenwood et al., 2011). Through social validation research, the IGDI’s developers identified expressive communication as an important domain to assess and pinpointed several early skill benchmarks to indicate whether a child was developing at an expected rate (Luze et al., 2001; Greenwood et al., 2011). After field testing and evaluating the psychometric properties of two alternate versions, researchers finalized the IGDI-ECI protocol as a naturalistic play sample between the assessor and child. The IGDI-ECI was designed to be inexpensive, quick to administer and score, and sensitive to small changes in child communication. The administration protocol offers suggestions for children with physical and sensory impairments as well as guidelines for speakers of languages other than English (www.igdi.ku.edu).
In further validation studies to determine norms for children birth to 42 months, the measure was found to have concurrent validity with the Preschool Language Scale-3 \((r=.63;\) Zimmerman, Steiner, & Pond, 1992) and with a caregiver reported tool developed by the research team \((r=.51;\) Luze et al., 2001). The original IGDI-ECI norming study reported a 90% overall reliability and a range of 70% to 81% on the communication skill elements (gestures, vocalizations, single words, and multiple words). Split-half reliability was conducted on even versus odd administrations and was reported to be \(r=.89\) for the Total Communication mean and \(r=.62\) for the Total Communication slope. The measure was found to differentiate between rates of communication across three time periods and between children without and without disabilities.

Normative growth rates for children with IFSPs were developed in two studies that included multiple program sites (Greenwood et al., 2008; Greenwood et al., 2010). The Greenwood et al. 2008 study included a cohort of children (EPIC sample; \(n=51\)) with communication delays who were receiving home-based Part C services in addition to a wider group across programs who had IFSPs. This data included a high proportion of children from low-SES backgrounds and children were described as having significant communication delays though no specific characteristics (i.e. means on other developmental measures) were reported. The 2008 study offered growth models for the Total Communication score but not the skill elements for children with IFSPs. The IFSP group in the 2010 study included 471 children with IFSPs who attended EHS programs in two states. Specific details on child communication status were not reported.

The Greenwood et al. (2008) and Greenwood et al. (2010) studies offered slightly different growth patterns for children with IFSPs. The 2010 study reported that children with IFSPs had a mean of 16.29 communication acts per minute at 36 months, whereas the 2008 study reported a mean of 13.9 acts per minute. Each cohort also had somewhat different reported rates of growth on the weighted communication score. In the 2008 aggregated sample, children with IFSPs grew at a rate of .47 acts per minute per month. The 2010 study indicated that children with IFSPs grew at a rate of .79 acts per minute per month in addition to a slight acceleration rate that led to a curvilinear trajectory for children with and without disabilities (Greenwood et al., 2010). It is unclear whether the differences in these two studies results from varying child characteristics because demographic data regarding the type and severity of child communication
impairments was not reported. Detailed descriptions of children in included in normative samples are important when evaluating the utility of progress monitoring tools. Children who have IFSPs are a diverse set of children, and providers need to know to whom they are comparing child progress.

These studies do illustrate that there are differences in growth patterns in children with and without IFSPs. Data from the Greenwood et al. (2010) study detailed these differences on the individual skill elements and the weighted rate of communication. First, several general trends were noted in typically developing children. The rate of vocalizations increased until about 15 months of age, at which point the rate of vocalizations began to decrease. The deceleration in the rate of vocalizations appeared to coincide with the increasing rate of single words after the first year. Gesture use remained relatively stable after they emerged in the latter half of the first year. Single and multiple word use accelerated rapidly after 18 months.

Children with IFSPs, however, continued to use vocalizations at a higher rate at 36 months (2.47 per minute) compared to those without IFSPs (1.35 per minute; *p* = .001) perhaps because they used fewer single and multiple words over time (Greenwood et al., 2010). At 36 months, children with IFSPs had lower rates of symbolic communication than their typically developing peers. While children without IFSPs used an average of 3.19 single words per minute at 36 months, children with IFSPs used 2.66 per minute (*p* = .015). The onset of single word use occurred 3-4 months later for the IFSP sample as well. Likewise, children without IFSPs used multiword phrases at a rate of 4.84 phrases per minute compared to 2.43 phrases per minute for the IFSP group (*p* = .0001). Slopes for single and multiple words were also significantly lower for children with IFSPs, resulting in lower intercepts at 36 months.

While these norms help illustrate differences in children with and without IFSPs who also meet the income eligibility criteria to participate in Early Head Start programs, we do not know much about the characteristics of the children in these samples regarding the severity of their communication delays. Data from the 2010 study were gathered from 27 EHS centers in two states. The sample included 471 children who had IFSPs for some kind of developmental delay. No other data on the communication skills of these children were reported. The 2008 study appears to include children with more significant delays but specific child characteristics are not known. While the Greenwood et al. (2008) and Greenwood et al. (2010) studies offered important information regarding norms for children with and without IFSPs, more information is
needed to describe the growth of children with significant communication delays. Analyzing the
communication trajectories of a sample of children with communication challenges can help
providers compare child progress to a cohort of children with similar communication profiles.
Replicating growth curve modeling for children with well-documented developmental profiles
will allow for comparisons across the studies and will offer more data regarding developmental
trajectories for toddlers with communication delays.

While the IGDI-ECI appears to possess many of the traits necessary for monitoring early
communication development, additional validity information for infants and toddlers with
communication delays is needed. In order to establish that the IGDI-ECI is an appropriate tool
for monitoring communication development in toddlers with communication delays, providers
need to know three things regarding the properties of the measure. First, they need to know that
data gathered from the IGDI-ECI generally agrees with data gathered from other common
methods of assessment, particularly from naturalistic assessment information gathered in daily
routines. While the IGDI-ECI may include the caregiver in the administration, it takes place
using a standardized set of toys that may not be a part of the child’s everyday play routines. In
order to establish the tool as being ecologically valid, providers need to know that the results
from this measure generally reflect the way that the child communicates with his or her
caregivers in everyday routines and activities. Second, providers need more data about patterns
of growth that they may expect from children with communication delays so that they may
compare child gains to gains from other children with delays who are receiving intervention.
Finally, providers need to know whether scores form the IGDI-ECI predict child growth in
everyday, functional routines.

As such, the current analysis will add to the evidence base regarding the concurrent
validity of the IGDI-ECI with other early communication measures at multiple time points in
toddlerhood as well as its concurrent validity with a transcribed caregiver-child interaction in an
authentic everyday routine. Data will also be used to document patterns of growth on key skill
elements in toddlers with communication delays allowing for a comparison with previously
reported normative data for children with communication delays (Greenwood et al., 2008; 2010).
This analysis will also investigate how well the IGDI-ECI and other measures of communication
at entry predict child communication growth in the caregiver-child play routine.

**Types of Test Validity**
When providers choose tools for progress monitoring or for other assessment purposes, they need to consider whether or not the measure is valid for a particular use. Broadly speaking, validity refers to the degree to which the test measures what it claims to measure for the population with whom it will be used (Bailey, 2004; Grisham-Brown & Pretti-Frontczak, 2011). There are several types of validity that should be considered when choosing assessment measures: content validity, which concerns how well the assessment examines the domain that it is testing (i.e. does a communication assessment measure all the components of communication that it should measure?), instructional utility, or how well the assessment informs intervention planning for the child, construct validity, which illustrates that the assessment measures the hypothetical construct it intends to, and criterion validity, or how well the assessment corresponds to other measures, presently or in future administrations (Bailey, 2004).

This paper will focus on two types of criterion validity, concurrent and predictive. Concurrent validity refers to the degree to which the assessment correlates to other measure that examines the same construct (Bailey, 2004). By comparing scores on one measure to scores on another, concurrent validity data helps providers know whether or not the chosen measure agrees with other commonly used tools, strengthening the findings of the assessment. This analysis will contribute to the evidence base surrounding the concurrent validity of the IGDI-ECI by comparing to several types of early communication measures detailed below. Predictive validity refers to the ability of the assessment to predict a measure of future performance (Bailey, 2004). Strong predictive validity is particularly important for eligibility determinations because without it, children who do not need services might receive them, and children who need intervention might not be identified (McCathren, Yoder, & Warren, 2000).

Types of Early Communication Measures

Providers have a number of choices in addition to the IGDI-ECI when selecting tools to monitor child communication development, and this analysis will examine how the IGDI-ECI relates to other well-established means of collecting data. Information may be gathered through norm-referenced (standardized) measures, parent-reported measures, curriculum-based measures, dynamic assessments, and language sampling (ASHA, 2008; Crais, 2011; Grisham-Brown & Pretti-Frontczak, 2011). Each method of gathering information has strengths and limitations when used for progress monitoring which are discussed in the following sections.
**Standardized measures.** Norm-referenced or standardized measures compare the child’s skills on a specific developmental domain to a larger sample of children, utilizing a specific protocol with a standardized set of materials. The resulting score reflects the child’s performance relative to the mean of the wider group (Bailey, 2004; NAEYC & NAECs/SDE, 2003; Nelson, 2010; Snow & Van Hemel, 2008). Commonly used early communication measures include the *Preschool Language Scale-4* (PLS-4; Zimmerman, Steiner, & Pond, 2002), the *Clinical Evaluation of Language Fundamentals-Preschool 2* (CELF-Preschool 2; Semel, Wiig, & Secord, 2004), the *Peabody Picture Vocabulary Test* (PPVT, Dunn & Dunn, 2007), and the *Expressive One Word Picture Vocabulary Test* (EOWPVT, Brownell, 2000). Standardized measures help determine a child’s eligibility for services and describe general change over time (Nelson, 2010), but they do not typically offer much information for intervention planning or for progress monitoring because they are not intended to detect incremental changes in child skills (Bagnato, 2005; Crais, 2011; McLean, 2005; Snow & Van Hemel, 2008).

It is unclear if standardized measures accurately represent a child’s functional communication in everyday contexts (Bagnato, 2005; Bagnato et al., 2011; Crais, 1995; Crais, 2011; McLean, 2005; Snow & Van Hemel, 2008) or whether scores on standardized measures accurately predict functional gains in communication in children with disabilities (Crais, 1995). Critics of using standardized measures also point to measures’ inability to track changes in child communication in young children with disabilities because the child’s response modality may not be accepted due to norming procedures (Bagnato, 2005; Neisworth & Bagnato, 2004; McLean, 2005; Snow & Van Hemel, 2008). In addition, standardized early communication measures are often limited by an emphasis on communication forms over function (Crais, 1995) and a cursory examination of prelinguistic communication skills (Wetherby & Prizant, 1992).

Further, many standardized assessments do not allow for an active caregiver role in the assessment process (Crais, 2011). Young children are particularly sensitive to the interaction style of adult communication partners, and the child’s performance on an assessment administered by an unfamiliar adult might not yield accurate information about the child’s skills (Wetherby & Prizant, 2002). Including the caregiver as a participant in the assessment process might help the child communicate as he or she typically would, increasing the likelihood that the assessment will yield accurate results. Unique among standardized tools is the *Communication and Symbolic Behavior Scales: Developmental Profile* ([CSBS:DP]; Wetherby & Prizant, 2002),
which offers caregivers an active role in the assessment. During the CSBS:DP, caregivers are asked to be active and responsive communication partners with their child to gain the best insight into his or her skills (Wetherby & Prizant, 2002). The CSBS:DP also offers caregivers the opportunity to validate the child’s performance during the assessment to indicate whether or not he communicated as he normally does. Measures like the PLS-4 (Zimmerman et al., 2002) and the Battelle Developmental Inventory-II (Newborg, 2004) permit the caregiver to report on child skills to give credit for items on the protocols.

While most standardized measures of early communication are intended to identify children with a significant communication delay (Nelson, 2010), providers also use them to monitor progress even though they require considerable time to administer and score (Crais, 1995; Huang et al., 1997; Snow & Van Hemel, 2008). Further, providers may also use tools expecting them to predict child communication growth, when, in fact, the measures have not been evaluated for children with disabilities, particularly for the purposes of progress-monitoring (Snow & Van Hemel, 2008). While psychometric data for some norm-referenced measures predicts communication growth on other standardized tools, a construct called predictive validity, few standardized common measures indicate if the measures predict communication development in more functional, meaningful contexts in young children with disabilities (Snow & Van Hemel, 2008). See Table 1 for a review of the concurrent and predictive validity of measures used in this study.

**Caregiver reported measures.** Caregivers are generally considered experts on their child’s communication skills, and research suggests that they are reliable informants who can offer accurate information about how a child communicates in daily routines and activities with familiar people (Crais, 2004; Fenson et al., 2007; Rescorla, Ratner, Jusczyk, & Jusczyk, 2005). A wide body of research indicates that caregiver-reported tools are reliable and valid measures of child communication (Fenson et al, 2007; Heilmann, Weismer, Evans, & Hollar, 2005; Miller, Seday, & Miolo, 1995; Rescorla et al., 2005; Thal, Desjardin, & Eisenberg, 2007) and they may predict child communication outcomes as well as other standardized measures (Fenson et al., 2007). Caregiver-completed observational tools and checklists are less frequently used than individually-administered standardized assessments (Crais, 1995; Huang et al., 1997), yet they are an important way include the caregiver in the assessment process while gaining important information about what and how a child communicates.
However, some researchers have expressed concern that the most commonly used standardized tools were not normed on a sufficiently diverse sample of families (Feldman, Dollaghan, Campbell, Kurs-Lasky, Janosky, & Paradise, 2000), and that these measures may not be equally valid across levels of SES. While ethnicity and SES might influence the validity of caregiver reported vocabulary measures, at a minimum they correlate moderately with observational communication samples and other standardized measures (Pan, Rowe, Spier & Tamis-LeMonda, 2004). Frequently used caregiver-reported measures include the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007) and the Language Development Survey (LDS; Rescorla, 1989). These caregiver-reported tools are also norm-referenced. For the purposes of progress-monitoring, caregiver reported measures are suitable for periodic use and are relatively easy to score. Comparing data gathered from the IGDI-ECI with caregiver reported data may also support the ecological validity of the IGDI-ECI.

**Curriculum-based assessments and curriculum-based measures.** Curriculum-based assessments (CBAs) and curriculum-based measures (CBMs) are often used as alternatives to traditional standardized assessments (Bagnato et al., 2010). CBAs are comprised of items that describe a developmental continuum of skills that a child should develop and use in functional everyday activities and in academic settings (McLean, 2005, Neisworth & Bagnato, 2004; Snow & Van Hemel, 2008). Many CBAs are considered to be criterion-referenced because they compare the child’s skills to a predetermined standard of mastery. Criterion-referenced measures do not produce standard scores; instead they offer scores that indicate how many skills the child has acquired in a particular domain. Measures such as the Assessment, Evaluation, and Programming System for Infants and Young Children ([AEPS]; Bricker, 2002) and The Carolina Curriculum for Infants and Toddlers with Special Needs (Johnson-Martin, Jens, Attermeier, & Hacker, 1991) rely on observations of child skills in routine settings and are linked to a curriculum which is designed to teach these skills. CBAs are useful for the purposes of progress monitoring because they include a list objectives that providers can use to track the development of child skills in the child’s everyday environments (Bagnato et al., 2011).

CBMs are used for progress-monitoring of skills relevant to a particular developmental domain, like communication, mathematics, and early literacy skills (Greenwood et al., 2011; Vanderheyden et al., 2008; Vanderheyden et al., 2005). CBMs, also referred to as “general outcome measures,” reflect common and necessary skill benchmarks that can be used to track
developmental progress and responsiveness to intervention (Greenwood et al., 2006; Luze et al., 2001). The IGDI-ECI is one general outcome measure that is used to monitor early child communication development in a play-based context (Greenwood et al., 2011).

**Dynamic assessments.** Some early childhood communication measures include components of dynamic assessment within their protocols. Dynamic assessments, based on the work of Feuerstein (1980) and Lidz (1991), allow the communication partner to provide models or cues to the child to illustrate what he or she can do with support (Losardo & Syverson, 2011). Dynamic assessment approaches typically involve a “test-teach-retest” pattern in order to identify which types of supports a child might need to succeed on a task (Bagnato et al., 2011) and they are frequently used to distinguish between children who have language differences and those who have language disorders (Losardo & Syverson, 2011). While there are no formal dynamic assessment measures, some early communication assessments allow the assessor to provide the child with models. For example, the CSBS:DP (Wetherby & Prizant, 2002) allows the administrator and caregiver to model, respond to and expand upon child communication. Dynamic assessments are well-suited to progress-monitoring because they can be individualized, they help identify effective supports and because they offer information about what the child can do in everyday activities.

**Language sampling.** Language sampling analysis (LSA) in everyday activities meets many but not all of the challenges inherent in progress monitoring. Samples gathered in everyday routines clearly reflect a child’s functional skills, can track presymbolic and symbolic developments, could include the child’s caregiver, and may be used frequently (Heilmann et al., 2010). Language samples offer detailed and nuanced information about how a child communicates. While LSAs offer precise information about a child’s communication in an ecologically valid manner, conventional guidelines for gathering samples might render LSAs too resource intensive for many providers. Transcription of samples can be time consuming, and SLPs and educators might not have a background in using transcription software. However, a recent study suggests that samples as short as one or three minutes might reliably assess a child’s mean length of utterance in preschool children (Heilmann et al., 2010).

The purpose of this paper is two fold. First, it will provide additional concurrent and predictive validity data on the use of the IGDI-ECI for toddlers with communication delays. Second, it will document the use of multiple types of assessment tools for infants and toddlers.
with identified communication delays to uncover relationships between measures and the ability of each tool to predict early communication on the IGDI-ECI and in a caregiver-child communication sample, offering information on the validity of the measures. Specific research questions are as follows:

a. What are the correlations between the IGDI-EC Total Communication Score and other types of commonly used measures (CSBS:DP, CDI:WU, PLS-4, and a communication sample) at 24 and 36 months?

b. What are the patterns of growth on the total communication score and the four key skill elements of the IGDI-ECI in toddlers with significant communication delays who are receiving intervention?

c. Are the patterns of growth demonstrated by children in this analysis similar to the patterns demonstrated by the IFSP cohorts in prior research?

d. Does the IGDI-ECI Total Communication Score, PLS-4, or CDI at entry into a program predict the child’s Total Communication Score at 36 months in children with significant communication delays?

e. Does the IGDI-ECI Total Communication Score, PLS-4, or CDI at entry into a program predict the child’s rate of number of different words use in a caregiver-child play sample at 36 months in children with significant communication delays?
CHAPTER TWO

METHOD

Participants

29 toddlers with communication delays between the ages of 24 and 48 months took part in the intervention study in which the assessment data were collected. Participant children were served by a model demonstration project aiming to help caregivers embed naturalistic communication strategies in daily routines and activities. Each child and their family participated in at least 24 intervention sessions in which they were taught to use Enhanced Milieu Teaching (EMT) strategies (Hancock & Kaiser, 2006) in family-identified routines and activities (Kashinath, Woods, & Goldstein, 2006; Woods, Kashinath, & Goldstein, 2004).

The mean age at entry was 23 months. Fifteen children were boys and 14 children were girls. Participant children had a range of disabilities that impacted their communication development. Thirteen children had Down syndrome, six had red flags for autism, six had developmental delays, and four had other syndromes and conditions that led to significant communication delays (stroke, Cri du Chat syndrome, etc.). While children had a range of communication abilities at the beginning of intervention, as a group, they demonstrated significant communication delays on several measures of early communication and global development. The group of children had a mean MSEL early learning composite of 74.5 (SD=21.1; range=49-119). The mean total language score on the PLS-4 was 73.9 (SD=15.9; range=52-114). Half the children (n=14) were presymbolic communicators at entry with less than 10 words used on the CDI. See Table 1.

Children in the intervention were excluded from this analysis if their primary mode of communication was something other than spoken communication or sign due to ambiguities in the testing and scoring procedures for children who use alternate modalities. Three children were excluded based on this criterion.

Measures

Communication measures chosen for this analysis were selected for two reasons. First, they were part of a larger battery of assessments administered to children participating in a longitudinal intervention study on naturalistic teaching strategies in family-identified routines
and activities. Second, they represent the major categories of assessments described above. Measures include two standardized and individually administered measures, one caregiver-reported measure, a general outcome measure intended for progress-monitoring, and one measure with characteristics of dynamic assessment.

**Mullen Scales of Early Learning (MSEL).** The MSEL (Mullen, 1995) is an individually-administered, norm-referenced measure that assesses child development across domains. It is normed for children from birth to 68 months and the normative sample included children with disabilities. The MSEL has a test-retest reliability of .76 to .96 and an inter-rater reliability of .91 to .99. The MSEL communication subscales correlate with the Preschool Language Scale (Zimmerman, Steiner, and Pond, 1979) with a range of .72 to .85. The MSEL was administered at entry into the project by the child’s interventionist in their home or childcare center. The Early Learning Composite will be used in this analysis.

**Preschool Language Scale-4 (PLS-4).** The PLS-4 (Zimmerman et al., 2002) is a norm-referenced, individually-administered measure of expressive and receptive communication for children age birth to six years. The assessment was normed on a sample reflective of the demographic information generated by the 2000 United States Census (Zimmerman et al., 2002) and children with disabilities were included in the normative sample. The administration manual reports data on test-retest correlations for three age groups (range = .95 to .97), internal consistency scores for the subscales and the total language score for age subgroups (range = .81 to .97) and inter-rater reliability scores ($r = .99$). Sensitivity and specificity values are also reported in the administration manual. Concurrent validity scores are reported in relation to the Denver II assessment, but not to other measures of early childhood communication. The PLS-4 was administered by the child’s interventionist at entry into the project and at 24 months and 36 months. The total language score, which is a sum of expressive and receptive communication subscales, will be used in this analysis.

**MacArthur-Bates Communicative Development Inventories (CDI).** The CDI is a norm-referenced, caregiver-reported measure of infant and toddler communication skills (Fenson et al., 2007). The Words and Gestures form is intended for infants eight to 16 months of age and includes items regarding expressive and receptive vocabulary in addition to gesture use. The Words and Sentences form is intended for toddlers from 16 to 30 months and includes an expressive vocabulary inventory as well as items concerning the child’s emerging grammar.
Test-retest correlations are provided for the Words and Gestures form (Gestures $r = .6$ to $.8$; Vocabulary Comprehension $r = .95$). Convergent validity data was reported on the Words and Sentences form between the CDI and the EOWPVT (Brownell, 2000) and ranged from $.73$ to $.85$. Predictive validity was illustrated by reporting correlations between scores from two time points during toddlerhood and ranged from $.53$ to $.74$. Other examinations of the CDI Words and Gestures form with the CDI Words and Sentences Form resulted in a moderate correlational coefficient for vocabulary production ($r = .39$; Feldman, 2000). The concurrent validity of the CDI has been widely examined with other measures of vocabulary as well as against data from spontaneous language samples in typical and clinical populations (Feldman et al., 2005; Miller et al., 1995; Pan et al., 2004, Thal et al., 2006, Rescorla et al., 2005). Data from the CDI were gathered at 24 and 36 months.

**Individual Growth and Development Indicator-Early Communication Index (IGDI-ECI).** The IGDI-ECI (Luze et al., 2001) is a curriculum-based measure used for monitoring growth in expressive communication in children birth to 42 months. This six-minute, play-based communication sample measures the child’s vocalizations, gestures, words and word combinations through direct observation and event recording. During the play sample, the administrator minimizes his or her use of questions and responds naturally to the child’s communication. The measure is intended to be repeatable in order to track the child’s communication development over time. To score the IGDI-ECI, the frequency of each communication skill is tallied across the six-minute sample in order to calculate a rate of communication. A weighted Total Communication score is generated by multiplying the number of single words by a factor of two and multiple words by a factor of three; gestures and vocalizations are counted individually. The IGDI-ECI has an overall reliability of 90% across communication skill elements (Luze et al., 2001). The IGDI-ECI weighted Total Communication score has concurrent validity of 0.62 with the PLS-3 (Zimmerman, Steiner, & Pond, 1992). The IGDI-ECI was administered every three months or quarterly after entry into the study.

**Communication and Symbolic Behavior Scales: Developmental Profile (CSBS:DP).** The CSBS:DP measures emerging communication and symbolic play skills in infants and toddlers between six and 24 months (Wetherby & Prizant, 2002). The assessment includes communication “temptations” or situations intended to elicit communication from the child that mimic commonly occurring daily routines like reading books, having snacks, and engaging in
pretend play. The assessor tracks the child’s joint attention, communicative functions, vocalizations, gestures, words, and play acts during the assessment to find a total measure of the child’s communication. The child’s caregiver is an active participant in the assessment and is asked to respond naturally to the child’s communication. The CSBS:DP is norm-referenced on a population that included children with disabilities in the sample and. The CSBS generates subscale scores of speech, social communication, and symbol use as well as an overall composite. The measure has a test-retest reliability of 0.80, interrater reliability that ranges from 0.70 to 0.95 and convergent validity with the MSEL expressive language subscale reported with a correlation of 0.89. The CSBS:DP has a sensitivity of 0.89 and a specificity of 0.85. The CSBS:DP was administered by the child’s interventionist with the caregiver present and participating at 24 months.

Caregiver-child communication sample (CCCS). Five-minute caregiver-child interactions were recorded at 24 and 36 months. Before each communication sample, the interventionist asked caregivers to indentify a naturally occurring, child-preferred play routine. The CCCS was chosen because it differs from the IGDI-ECI in its participants and in its context. While both tools measure spontaneous child communication, the CCCS occurs with the caregiver, not an assessor. Second, the CCCS was gathered in an unstructured, natural play routine not with a standardized set of materials. Before filming the CCS, interventionists asked caregivers to engage and respond to their child as they typically do. Some caregivers chose to engage in play with objects with their young children. Others engaged in pretend play, social games, and some used books during their interactions. All communication samples were transcribed according to the Systematic Analysis of Language Transcripts guidelines ([SALT]; Miller & Chapman, 2002) by trained graduate assistants. Transcripts were then analyzed to find the number of different words (NDW) used by children in each segment. Numbers of different words is a commonly used metric in validity studies that compare results of a measure to data from language samples (Feldman et al., 2005). The NDW data were then transformed into a rate of number of different word use by dividing by the length of the sample in order to account for different lengths of interactions.

Test Administrators and Procedures

With the exception of the CDI, the child’s primary interventionist administered each of the assessments. Interventionists had backgrounds in speech-language pathology (n=4), early
childhood special education (n= 3), and mental health counseling (n= 1). Most held at least a Master’s degree (n=5) and all had a minimum of two year’s experience in early intervention with young children with disabilities. The interventionist serving the child and family during the course of the communication intervention conducted all child communication assessments. Assessments occurred in the child’s home or childcare center, depending upon where intervention took place. The IGDI-ECI, MSEL, and PLS-4 were administered to the child directly by the interventionist according to each measure’s standardized protocol. The CSBS:DP was administered with the child and caregiver together, and the CDI was completed by the child’s primary caregiver. Graduate research assistants scored the MSEL and PLS-4. Each assessment was double scored for accuracy.

Graduate research assistants also completed an online training to become certified to score the IGDI-ECI. Reliability was conducted on 25% of all IGDI-ECI data and on 25 % of transcribed communication samples. Percent agreement on the measures ranged from (71 to 100) with a mean of 89.5 %. Graduate assistants learned to score the CSBS:DP by watching and practicing with the segments provided in the video supplement to the manual (Wetherby & Prizant, 2002).

**Statistical Approach**

In order to examine concurrent relationships between the IGDI-ECI and other measures of early communication (research question (a), Pearson product moment correlations were run using SPSS 19 between the following variables at 24 months: CDI Number of Words Used, CSBS:DP Total Communication Score, IGDI-ECI Weighted Total Score, IGDI-ECI rate of single words subscore, PLS-4 Expressive communication subscale, and the rate of number of different words used in the communication sample. At 36 months correlations were run between the IGDI-ECI Total Communication score, rate of single words score on the IGDI-ECI, PLS-4 Expressive Communication subscale score, CDI: Number of Words Used and the rate of number of different words used in the caregiver-child communication sample. Correlations indicate the strength and direction of relationships between variables and are appropriate for descriptive designs (Glass & Hopkins, 1996). Correlations between two continuous variables give a coefficient $r$.

Research questions (b),(c), and (d) were addressed with by using Hierarchical Linear Modeling ([HLM]; Raudenbush & Bryk, 2002). The IGDI-ECI was chosen as the
outcome/dependent variable to measure growth over time because it is intended to be a repeatable and sensitive tool to track changes in child communication (Greenwood et al., 2008). In order to compare data to prior studies, we used the weighted rate of Total Communication as the outcome variable. A separate set of models with the number of different words used in the caregiver-child play sample as an outcome were run to illustrate the predictive ability of the IGDI-ECI.

HLM is well suited to questions involving nested data. The growth curve analysis (GCA) used here is one type of hierarchical linear model characterized by multiple time points nested within an individual (Raudenbush & Bryk, 2002). Growth rates are expected to vary between individuals, and predictors may be used to account for between-subject variance as well as within subject variance (Davison, Hammer, & Lawrence, 2011). GCA is tolerant of missing data and it permits subject to have different numbers of observations. GCA also enables the researcher to choose where to center the intercept of the growth curve for ease of interpretation. In congruence with previous work on the IGDI-ECI, data will be centered at 36 months because it marks a child’s transition from Part C services to Part B services (Greenwood, 2010).
CHAPTER THREE

RESULTS

Results are organized by research questions identified to examine the concurrent and predictive validity of the IGDI-ECI. The research questions are supported by tables and figures located at the end of the manuscript.

(a) What are the correlations between the IGDI-EC Total Communication Score and other types of commonly used measures (CSBS:DP, CDI:WU, PLS-4, and a caregiver-child communication sample) at 24 and 36 months?

At 24 months, the IGDI-ECI Total Communication score did not significantly correlate with other standardized measures of early communication (CDI:WU $r=-.14$, CSBS:DP $r=.31$; PLS-4, $r=.23$) nor with the rate of number of different words on the CCCS ($r=.1$). However, at 24 months, the IGDI-ECI single words subscale score significantly correlated with the rate of number of different words used in the caregiver-child communication sample ($r=.45, p<.039$).

At 24 months, significant correlations were found between the PLS-4 EC subscale and the CDI ($r=.63, p<.003$), the PLS-4 EC subscale and the CSBS: DP ($r=.66, p<.001$), and the PLS-4 EC subscale and the rate of number of different words in the communication sample ($r=.54, p<.001$). The CDI significantly correlated with the CSBS:DP ($r=.58, p<.009$) and the rate of number of different words on the CCCS ($r=.65, p<.003$). In summary, several of other standardized measures and communication sample correlated significantly with each other, but not with the IGDI-ECI Total Communication score at 24 months. See Table 2 for the full correlation matrix.

At 36 months, the IGDI-ECI TC score significantly correlated with the PLS EC subscale ($r=.62, p<.001$). It did not significantly correlate with the CCCS ($r=.41$). The IGDI-ECI single words subscale did not significantly correlate with any other standardized measure or the CCCS. The single word subscale did significantly correlate with the Total Communication score ($r=.65, p<.000$). The PLS-4 EC subscale significantly correlated with the CCCS ($r=.71, p<.001$). See Table 3 for the correlation matrix. In sum, the IGDI-ECI TC score significantly correlated with
the PLS-4 at 36 months, but did not significantly correlate with the CDI, CSBS:DP, or CCCS at either time point.

(b) What are the patterns of growth on the Total Communication score and the four key skill elements of the IGDI-ECI in toddlers with significant communication delays?

(c) Are the patterns of growth demonstrated by children in this analysis similar to the patterns demonstrated by the IFSP cohort in the Greenwood et al. (2010) study?

**Growth in the Total Communication Score.** In order to describe trends in growth on the Total Communication score, we began by fitting an unconditional model with TIME as a Level 1 within-subject predictor. In this model and in all subsequent models, data were centered at 36 months so that the intercept may be interpreted as the predicted mean among children as they transition from Part C services to Part B services. No Level 2 predictors were included in the initial linear growth model. Table 4 compares parameters with the Greenwood et al. studies (2008; 2010), and Table 5 details the model for Total Communication development in the current study. Figure 1 depicts individual participant growth on the Total Communication score. The equation for linear growth on the Total Communication score is as follows:

\[
\text{Rate}_{TCij} = \beta_0i + \beta_1i(TIME)_{ij} + r_{ij}
\]

\[
\beta_0i = \gamma_{00} + u_{0j}
\]

\[
\beta_1i = \gamma_{10} + u_{1j}
\]

Data from the analysis indicate that \(\gamma_{00}\), or the mean rate of weighted communication acts per minute at 36 months for children in this sample was 11.89 \((p<.001)\). The variance component \(u_{0j}\) was significant \((p<.001)\), indicating that there is significant between child variation on the intercept at 36 months. The rate of change in the Total Communication score \((\gamma_{10})\) was 0.43 \((p<.001)\). On average, children gained 0.43 weighted communication acts per minute per month. \(u_{1j}\) had a variance component of 0.0339 and was significant, indicating between subjects variability on the rate of change \((p=0.006)\). Next, an acceleration term was added into the model as a Level 1 predictor, but unlike the findings from the Greenwood et al. (2010) study, it was not significant \((p=.91)\). As such, the model including a linear growth term was the most parsimonious model of growth on the Total Communication score.
The growth curve generated for the Total Communication score differs from the IFSP sample in the Greenwood studies. The IFSP group in the Greenwood et al. (2010) study had a mean intercept of 16.29 weighted communication acts per minute at 36 months compared to 11.89 in the current analysis. Children in the IFSP sample of the aggregated sample (Greenwood et al., 2008) had a mean intercept of 13.9. The slope for the Total Communication growth rate was lower in the current analysis ($\gamma_{10} = 0.43$) compared to 0.79 in the 2010 study and 0.47 in the aggregated 2008 sample. Additionally, children in this sample did not display an accelerating rate of change in Total Communication score growth. Their growth was linear, in agreement with the Greenwood et al. (2008) models for children with IFSPs. See Figure 2 for a graphical depiction of growth curves from the three groups and Table 4 for a comparison of coefficients from the studies.

**Gesture Development.** In order to predict gesture development over time, a model with TIME as a Level 1 within-subjects predictor was run. See Table 6 for a list of parameters and Figure 3 for a graph of individual participant trajectories. The equation for this model was:

$$\text{Rate}_{\text{GEST}}_{ij} = \beta_{0i} + \beta_{1i}(\text{TIME})_{ij} + r_{ij}$$

$$\beta_{0i} = \gamma_{00} + u_{0j}$$

$$\beta_{1i} = \gamma_{10} + u_{1j}$$

In this model, the mean rate of change, $\gamma_{10}$, was not significant ($\gamma_{10} = -0.003; p = .944$). As such, TIME was removed from the model. The best-fitting equation for gesture development in this sample was the unconditional model.

$$\text{Rate}_{\text{GEST}}_{ij} = \beta_{0i} + r_{ij}$$

$$\beta_{0i} = \gamma_{00} + u_{0j}$$

In this model, the intercept $\gamma_{00}$ represents mean gesture use at 36 months. The coefficient for $\gamma_{00}$ was 0.995 ($p < .001$) or 0.995 gestures per minute. Because the growth term was not significant, the plot for predicted gesture takes the form of a straight line. The random effects component, $u_{0i}$, was 0.33. Its chi-square test was significant ($\chi^2 = 147.52, df = 8, p < .001$), indicating that there was between-subjects variability on gesture use at 36 months.

The pattern of gesture use is similar to data from the Greenwood et al. (2010) findings with a few subtle differences. The $\gamma_{00}$ for the model including IFSP as a predictor was 1.21 gestures per minute ($p < .001$; Greenwood et al., 2010). In this sample, there were no group differences between children with and without IFSPs in the mean rate of gesture use at 36
months. Unlike the current analysis, the 2010 study found a small negative slope ($\gamma_{10} = -0.0421; p < .001$) and a slight deceleration rate ($\gamma_{20} = -0.00128; p < .001$) for gesture use over time in children with and without IFSPs. Figure 4 depicts predicted growth based on the current analysis and based upon the data from Greenwood et al. (2010).

**Vocalization Development.** To characterize vocalization development over time, we began by fitting a linear growth model with random error terms. See Table 8 for a list of parameters and Figure 5 for individual growth trajectories. The equation for the growth model is as follows:

$$\text{Rate}_{\text{VOC}ij} = \beta_0j + \beta_1j(TIME) + r_{ij}$$

$$\beta_0j = \gamma_{00} + u_{0j}$$
$$\beta_1j = \gamma_{10} + u_{1j}$$

Data indicated that children are predicted to use 3.5 vocalizations per minute at 36 months ($p < .001$). The linear growth term for TIME was not significant ($\gamma_{10} = 0.011; p = 0.7$) in this model. Next, an acceleration term ($\text{TIME}^2$) was added to determine whether or not there was a curvilinear growth pattern in vocalization development. Previous studies describe an increasing then decreasing rate of vocalizations after the onset of single words, so an acceleration term was added into the model (Greenwood et al., 2010).

$$\text{Rate}_{\text{VOC}ij} = \beta_0j + \beta_1j(TIME) + \beta_2j(TIME)^2 + r_{ij}$$

$$\beta_0j = \gamma_{00} + u_{0j}$$
$$\beta_1j = \gamma_{10} + u_{1j}$$
$$\beta_2j = \gamma_{20}$$

In this model, $\gamma_{00}$, or the mean rate of vocalizations per minute at 36 months was 3.39 ($p < .001$). There was significant between subjects variability on the rate of vocalizations at 36 months ($u_0 = 2.48; \chi^2 = 114.5; p < .001$). The coefficient for the acceleration term ($\gamma_{20}$) was significant ($p = .034$) and revealed a slightly negative decrease in rate vocalization use over time at a rate of -0.003 vocalizations per minute per month. There was significant between subject variability on the slope ($u_1 = .013; p < .001$), but not on the acceleration rate, so $\beta_2$ was left as a fixed effect.

Greenwood et al. (2010) also reported a decrease in vocalization rates a function of time. The mean intercept for rate of vocalizations for the IFSP cohort was 2.47 per minute at 36 months. The predicted slope for TIME in this sample was -0.13 vocalizations per minute per
month ($p<.001$) and the deceleration rate was -0.0064 ($p<.001$). Figure 6 depicts predicted growth in vocalizations based on the current analysis compared to Greenwood et al. (2010).

**Single Word Use.** We began to model single word use over time by running an unconditional model with TIME as a level 1 predictor. See Table 9 for a list of model parameters and Figure 7 for a graph displaying individual child growth trajectories. The equation is as follows:

$$\text{Rate\_SINGLEWORD}_{ij} = \beta_0 + \beta_1 \text{TIME} + r_{ij}$$

$$\beta_0 = \gamma_0 + u_{0j}$$

$$\beta_1 = \gamma_1 + u_{1j}$$

In this model, $\gamma_0$ represents the mean rate of single word use per minute at 36 months. Its coefficient was 2.08 ($p<.001$). The random effects component $u_{0j}$ was 4.46 ($\chi^2$=240.48; $df$= 28; $p<.001$), indicating significant between subjects variability in single word use at 36 months. $\gamma_1$ was 0.096 ($p<.001$), indicating that on average, children increase their rate of single word use by 0.096 single words per minute per month. The random effects term $u_{1j}$ was significant, indicating that there was between subjects variability in the rate of increase in single word use (0.009; $\chi^2$=75.96, $df$= 28, $p<.001$). Because prior research indicated a curvilinear pattern of growth in single word development, we ran a model with TIME$^2$ as a level 1 predictor, but it was non-significant ($\gamma_{20}=-0.002; p=.18$). It was removed from the model.

Greenwood et al. (2010) found that their IFSP group had a mean intercept ($\gamma_0$) of 2.66 single words per minute. On average the use of single words increased at a rate of 0.038 single words per minute per month. The rate of acceleration was 0.00202 ($p=.001$). Figure 8 depicts predicted growth in single words based on the current analysis compared to Greenwood et al. (2010).

**Multiple Word Use.** To model growth in multiword phrases over time, we began with an unconditional model with TIME as a level 1 predictor. See Table 10 for a list of parameters and Figure 9 for individual growth trajectories. The model is as follows.

$$\text{Rate\_MULTIWORD}_{ij} = \beta_0 + \beta_1 \text{TIME} + r_{ij}$$

$$\beta_0 = \gamma_0 + u_{0j}$$

$$\beta_1 = \gamma_1 + u_{1j}$$
\( \gamma_{00} \) has a coefficient of 1.91 (\( p=.006 \)). As such, children are predicted to use 1.91 multiword phrases per minute at 36 months. \( u_{ij} \) was significant (12.023; \( \chi^2 =1698.7, \text{ df}=28; p<.001 \)) indicating that there was between subjects variability in multiple word use at 36 months. \( \gamma_{10} \) was equal to 0.106 (\( p=.002 \)). On average, children gained .106 multiple word phrases per minute per month. The variance component \( u_{ij} \) was significant, meaning that children varied in their rates of growth in multiple word phrases (0.026; \( \chi^2=166.53; \text{ df}=28; p<.001 \)). Prior research illustrated significant acceleration terms, so \( \text{TIME}^2 \) was added to the linear growth model. The acceleration term was not significant (\( p=.389 \)) and was removed from the model.

Greenwood et al. (2010) reported that children with IFSPs used 2.43 multiple words per minute (\( p<.001 \)). The rate of growth was 0.0053 phrases per minute per month (\( p<.001 \)) and the rate of acceleration rate was 0.00525 phrases per minute per month (\( p=.001 \)). Figure 10 depicts predicted growth in multiple word phrases based on the current analysis compared to Greenwood et al. (2010).

\((d)\) Does the IGDI-ECI Total Communication Score, PLS-4, CDI, or MSEL at entry into a program predict the child’s Total Communication Score at 36 months in children with significant communication delays?

Next, we examined whether or not any standardized measures at entry predicted growth on the IGDI-ECI Total Communication score and the predicted mean at 36 months. The unconditional growth model had significant between child variance on the mean and on the intercept, so predictors at Level 2 were entered to help explain some of the variability between children. Further, if measures significantly predicted scores on the IGDI-ECI Total Communication score, there would be evidence for the predictive validity of the assessment tool used as the predictor. Table 5 describes the model parameters that follow. The variable \( \text{TIME} \) was centered at 36 months and the variables for the assessment measures were each grand mean centered.

First, we ran a model that included the IGDI-ECI Total Communication score at entry as a Level 2 predictor of the mean Total Communication score intercept at 36 months (\( \gamma_{00} \)) as well as the rate of growth (\( \gamma_{10} \)). Significant findings would support the predictive validity of the IGDI-ECI. The model is as follows:

\[
\text{Rate}_{\text{TC}}_{ij} = \beta_{0i} + \beta_{1i}(\text{TIME})_{ij} + r_{ij}
\]
\[ \beta_{0i} = \gamma_{00} + \gamma_{01} \text{(Rate\_TC\_EN)} + u_{0j} \]
\[ \beta_{1i} = \gamma_{10} + \gamma_{11} \text{(Rate\_TC\_EN)} + u_{1j} \]

In this model, the mean weighted rate of Total Communication at 36 months (\( \gamma_{00} \)) was 11.8 communication acts per minute (p<.001) when controlling for the Rate\_TC\_EN effect. There was significant between child variability on the intercept (\( u_0 = 22.10; \chi^2 = 176.12; df=27; p<.001 \)). \( \gamma_{01} \), or the Rate\_TC\_EN effect on the intercept was 0.1 (p=.006). For every increase in one weighted communication act per minute on the IGDI-ECI at entry, a child is predicted to have a 0.1 unit gain per minute beyond the mean on his or her Total Communication score at 36 months. The slope for TIME in this model (\( \gamma_{10} \)) was 0.4 (p<.001). On average, children gained 0.4 communication acts per minute per month, though there was significant between child variability on the mean slope (\( u_1 = 0.05; \chi^2 = 55.9; df=27; p<.001 \)). The IGDI-ECI total score at entry was not a significant predictor of the slope (\( \gamma_{10} = -0.00036; p=.873 \)).

Next, we ran a model with the PLS-4 Total Language scores at entry as a Level 2 predictor to examine the predictive ability of the standardized tool with IGDI-ECI. The PLS-4 was added to the model with the Rate\_TC\_EN.

\[ \text{Rate\_TC}_{ij} = \beta_{0i} + \beta_{1i}(\text{TIME})_{ij} + r_{ij} \]
\[ \beta_{0i} = \gamma_{00} + \gamma_{01} \text{(Rate\_TC\_EN)} + \gamma_{02}(\text{PLS}) + u_{0j} \]
\[ \beta_{1i} = \gamma_{10} + \gamma_{11} \text{(Rate\_TC\_EN)} \gamma_{21}(\text{PLS}) + u_{1j} \]

This growth model had a \( \gamma_{00} \) of 12.07 (p<.001). On average, children used 12.067 weighted communication acts per minute at 36 months. The variance component (\( u_0 \)) was 8.16 and was significant (\( \chi^2 = 87.9; df=26; p<.001 \)) indicating between child variability on the intercept at 36 months. The variance on the intercept decreased from 22.09 in the model with Rate\_TC\_EN entry alone. The PLS effect on the intercept (\( \gamma_{02} \)) was .23 and was significant (p<.001). For every unit increase in the PLS-4 total language score at entry, a child’s predicted weighted rate of communication at 36 months increased by .23 weighted communication acts per minute beyond the mean, controlling for the child’s weighted rate of communication score at entry. In this model, the Rate\_TC\_En effect (\( \gamma_{01} \)) was no longer significant (\( \gamma_{01} = 0.061; p=.082 \)). The mean TIME effect in this model (\( \gamma_{10} \)) was 0.44 (p<.001).

Controlling for the PLS effect and Rate\_TC\_En effect, children gained 0.44 weighted communication acts per minute per month. \( U_1 \), or between child variability on the slope, was
0.029 and was not significant ($\chi^2 = ; df=26; p=.065$). As such, TIME could be left as a fixed effect. The PLS-4 at entry significantly predicted a child’s rate of growth on the IGDI-ECI Total Communication score ($\gamma_{21}=0.01; p<.001$), controlling for the Rate_TC_EN effect. For every unit on the PLS-4 at entry, a child’s rate of increase on the IGDI-ECI Total Communication score increased by 0.01 units beyond the mean slope. In this model, the Rate_TC_EN did not predict the mean rate of change ($\gamma_{11}=-0.003; p=.257$).

A subsequent model examined whether or not the CDI, a measure that includes caregiver report of early communication skills, predicted the slope and mean intercept of the Total Communication score. The CDI Number of Words used at entry into the project did not predict the slope ($\gamma_{11}=0.0009; p=.204$) nor the mean intercept ($\gamma_{01}=0.009; p=.350$) when added to the model with Rate_TC_EN as a predictor. The MSEL ELC at entry significantly predicted both the intercept ($\gamma_{02}=0.15; p=.001$) and the rate of change ($\gamma_{12}=0.007; p<0.011$) in addition to the contributions from the IGDI-ECI scores at entry. In sum, the rate of Total Communication at entry, the PLS-4 at entry, and the MSEL ELC each predicted the rate of Total Communication at 36 months in toddlers with significant communication delays. Only the model with the PLS-4 as a predictor reduced between-child variability on the slope to a point of non-significance.

After exploring the predictive ability of standardized measures, we explored other Level 2 predictors that could contribute to our understanding of variables that predict growth in child communication development. GENDER as a Level 2 predictor did not predict the intercept or the rate of growth ($\gamma_{02}=13.9 p=.25; \gamma_{12}=0.71; p=.31$). SYMBOL, a dummy variable indicating or whether or not the child was a symbolic communicator with more than ten spoken words or sign at entry was nonsignificant on the intercept and the rate of growth ($\gamma_{02}=6.67 p=.621; \gamma_{12}=.56; p=.47$). While these predictors were nonsignificant, it is possible that there was not adequate power to detect effects.

To explore whether or not we could explain additional some of the variability in growth trajectories between children, we examined whether or type of disability predicted child rates of growth on the IGDI-ECI Total Communication score. Because our cohort of children included a significant subset of children with Down syndrome (DS; $n=13$), we entered a child’s DS status as a Level 2 predictor. Children with DS often experience significant communication delays (Roberts, Price, & Malkin, 2007). The DS dummy variable (DS=1, non-DS=0) was entered into a model that also included the PLS-4 and Rate_TC_EN as predictors to see if DS status
explained between child variability above and beyond the contributions from the child’s language status at entry. The model for the DS effect is as follows:

\[
\text{Rate}_\text{TC}_{ij} = \beta_0i + \beta_1i(\text{TIME})_{ij} + r_{ij}
\]

\[
\beta_0i = \gamma_{00} + \gamma_{01}(\text{Rate}_\text{TC}_\text{EN}) + \gamma_{02}(\text{PLS}) + \gamma_{03}(\text{DS}) + u_{0j}
\]

\[
\beta_1i = \gamma_{10} + \gamma_{11}(\text{Rate}_\text{TC}_\text{EN}) + \gamma_{12}(\text{PLS}) + \gamma_{13}(\text{DS}) + u_{1j}
\]

In this model, the \(\gamma_{00}\) predicted rate of weighted communication per minute is 13.3 \((p<.001)\). The variance component for the intercept \((u_0)\) was 5.63 \((\chi^2 = 66.38; df=25; p<.001)\) indicating significant between subjects variability. The IGDI-ECI Total Communication score at entry, the PLS-4 at entry and the child’s Down syndrome status were significant predictors of the mean intercept at 36 months. The Rate_TC_En effect on the intercept \((\gamma_{01})\) was -0.005 \((p=.01)\). For children with DS, controlling for the scores on the PLS at entry, each additional point on the weighted rate of Total Communication at entry yields at -0.005 point reduction in the rate of Total Communication scores at 36 months. For children who do not have Down syndrome, a unit increase on the PLS at entry increases the predicted Total Communication score at 36 month by a .239 weighted communication acts. The DS effect on the intercept \((\gamma_{02})\) was -3.01 \((p=.006)\). Controlling for the PLS effect on the intercept, children with Down syndrome are predicted to have -3.01 fewer communication acts per minute than their non-DS peers at 36 months. 

Accounting for the mean intercept at 36 months, the group with Down syndrome communicated, on average, at a rate of 10.2 weighted acts per minute.

The mean slope \((\gamma_{10})\) in this model was 0.486 \((p<.001)\). Controlling for the PLS effect and weighted rate of Total Communication at entry effect, children without DS gain 0.486 weighted communication acts per minute per month \((p<.001)\). The variance component \(u_{1j}\) was not significant \((0.00049; \chi^2=28.32, df=26; p=.342)\). This means that there is not significant between child variability on rates of change on the Total Communication score in this model. The PLS effect on the slope \((\gamma_{12})\) was 0.008 \((p<.001)\). For every unit on the PLS at entry, children without DS gained 0.008 weighted communication acts per minute per month. The DS effect on the slope \((\gamma_{12})\) was -.22 \((p<.001)\). Controlling for the PLS effect, children with DS grew at a rate of 0.260 acts per minute per month compared to 0.486 for children without DS.

\(e\) Does the IGDI-ECI Total Communication Score, PLS-4, or CDI at entry into a program predict the child’s rate of number of different words use in a caregiver-child
To examine the extent to which the IGDI-ECI and other standardized measures predicted growth in the number of different words (NDW) in an authentic caregiver-child interaction, we began by building a growth model representing change in the rate of NDW used per minute as a function of time. The degree to which measures predict child communication in an everyday routine helps to provide information regarding the ecological validity of the measure. We hypothesized that the IGDI-ECI at entry and the CDI at entry would predict the child’s rate of NDW use at 36 months. Variables for the standardized measures were each grand mean centered. See Table 11 for a list of parameters from each of the models. In order to answer these questions, we began by constructing an unconditional growth model:

\[
\text{Rate}_{-_\text{NDW}} = \beta_0 + \beta_1 \text{(TIME)} + r_j
\]

\[
\beta_0 = \gamma_0 + u_0
\]

\[
\beta_1 = \gamma_{10} + u_{1j}
\]

In this model \(\gamma_{00}\) represented the mean rate of number of different word used per minute at 36 months. \(\gamma_{00}\) was equal to 3.1 different words per minute (\(p<.001\)). The variance component \(u_0\) was 9.01 and was significant (\(\chi^2=137.95, df=27; p<.001\)) indicating that there was significant between subjects variability in the rate of NDW at 36 months. The mean slope \(\gamma_{10}\) represented the average rate of change in NDW as a function of time. \(\gamma_{10}\) was 0.2 (\(p=.002\)) On average, children increase their NDW at a rate of .2 different words per minute per month. The random effects term \(u_{1j}\) was .06 and was significant, indicating between subjects variability in the rate of change (\(\chi^2=66.99, df=27; p<.002\)).

Next, we included the IGDI-ECI Total Communication score (Rate_TC_EN) at entry as a Level 2 predictor along with the child’s rate of different word use at entry (Rate_NDW_EN). The analysis was intended to evaluate the degree to which the IGDI-ECI Total Communication score is able to predict child communication development in a functional, authentic routine with familiar caregivers. The model with the IGDI-ECI at entry as a predictor is as follows:

\[
\text{Rate}_{-_\text{NDW}} = \beta_0 + \beta_1 \text{(TIME)}_{ij} + r_j
\]

\[
\beta_0 = \gamma_0 + \gamma_{01} \text{(Rate}_{-_\text{NDW} _\text{EN}}) + \gamma_{02} \text{(Rate}_-_\text{TC} _\text{EN}) + u_0
\]

\[
\beta_1 = \gamma_{10} + \gamma_{11} \text{(Rate}_{-_\text{NDW} _\text{EN}}) + \gamma_{21} \text{(Rate}_-_\text{TC} _\text{EN}) + u_{1j}
\]
In this model $\gamma_{00}$ represents the mean intercept at 36 months. Children are predicted to use 3.00 different words per minute at 36 months in play interactions with their caregivers ($p<.001$). The variance component $u_{0j}$ was 7.23 and was significant, indicating between subjects variability on the rate of NDW use at 36 months ($\chi^2=118.9; df=25; p<.001$). Controlling for the child’s rate of different word use at entry, the rate of Total Communication on the IGDI-ECI at entry (Rate_TC_EN) was not a significant predictor of the intercept at 36 months ($\gamma_{02}=0.42; p=0.073$). Also controlling for the child’s rate of different word use at entry, Rate_TC_EN did not predict the mean rate of change ($\gamma_{10}$) in this model ($\gamma_{21}=0.003; p=.919$). As such, the IGDI-ECI Total Communication Score at entry predicted neither the mean rate of different words used at 36 months, nor the rate of growth in different words used in a caregiver-child communication sample.

We then tried a model with the PLS-4 at entry as a predictor of growth in NDW on the CCCS. The PLS-4 correlated moderately with the CCCS at 24 months ($r=.54; p<.05$) and strongly at 36 months ($r=.71; p<.01$) so we hypothesized that it would significantly predict the mean intercept in NDW use at 36 months controlling for a child’s rate of different word use at entry. The model was as follows:

$$\text{Rate}_\text{NDW ij} = \beta_0 i + \beta_1 i (\text{TIME})_{ij} + r_{ij}$$

$$\beta_0 i = \gamma_{00} + \gamma_{01} (\text{Rate}_\text{NDW EN}) + \gamma_{02} (\text{PLS}) + u_{0j}$$

$$\beta_1 i = \gamma_{10} + \gamma_{11} (\text{Rate}_\text{NDW EN}) + \gamma_{21} (\text{PLS}) + u_{1j}$$

The mean rate of NDW at 36 months ($\gamma_{00}$) in this model was 3.05 ($p<.001$). The random effects component ($u_{0j}$) was 7.77 and was significant ($\chi^2=130.56; df=25; p<.001$) indicating between subjects variability on the intercept. The PLS effect on the intercept ($\gamma_{02}$) was 0.07 and was significant ($p=.05$), controlling for the child’s rate of different word use at entry. For every unit increase on the PLS score at entry, a child is predicted to gain 0.07 different words per minute beyond the mean on the CCCS at 36 months. The PLS effect on the slope was nonsignificant ($\gamma_{12}=0.004; p=.245$).

We then ran a model with the CDI at entry as a Level 2 predictor. The CDI Words Used also correlated well with the CCCS at 24 months ($r$) so we hypothesized that it would predict the NDW used at 36 months. The model was as follows:

$$\text{Rate}_\text{NDW ij} = \beta_0 i + \beta_1 i (\text{TIME})_{ij} + r_{ij}$$

$$\beta_0 i = \gamma_{00} + \gamma_{01} (\text{Rate}_\text{NDW EN}) + \gamma_{02} (\text{CDI}) + u_{0j}$$
\[ \beta_{1i} = \gamma_{10} + \gamma_{11} (\text{Rate}_{\text{NDW}_{\text{en}}}) + \gamma_{21} (\text{CDI}) + u_{ij} \]

In this model the mean rate of NDW at 36 months (\( \gamma_{00} \)) was 3.02 (\( p<.001 \)). The variance component (\( u_{0j} \)) was 7.44 and was significant (\( \chi^2=118.39; df= 25; p<.001 \)) indicating between subjects variability in the rate of NDW at 36 months. The CDI at entry significantly predicted the child’s rate of NDW use at 36 months (\( \gamma_{02} = 0.013; p<.035 \)). For every additional word used on the CDI at entry into the project, a child gained 0.13 different words per minute in the CCCS at 36 months. The mean rate of growth in NDW used (\( \gamma_{10} \)) was 0.020 (\( p<.001 \)) or a predicted 0.02 different words per minute per month. The variance component \( u_{1j} \) was significant, indicating that children had significantly different rates of growth in their use of NDW through the toddler period (\( u_{1j}=0.05; \chi^2=54.2; df=25; p<.001 \)). The CDI was a significant predictor of the child’s rate of growth in NDW use (\( \gamma_{21} = 0.002; p<.001 \)). For every unit increase on the CDI at entry, a child gained an additional 0.002 different words per minute per month on the CCCS. The CDI was the only measure that predicted both the mean intercept and rate of change in different word use on the CCCS.
CHAPTER FOUR

DISCUSSION

This study contributes to our understanding of early communication development in children with significant delays and it offers valuable information regarding the validity of IGDI-ECI and other progress monitoring tools used with toddlers with significant communication challenges. Data from this study depict patterns of growth on the IGDI-ECI and from a caregiver child interaction, and in doing so, allows for comparisons with developmental trajectories from other cohorts of toddlers with IFSPs described in prior research. This analysis ultimately supports the concurrent and predictive validity of the IGDI-ECI with some limitations and it offers information about how well the measure relates to growth in an authentic caregiver-child interaction. Using this data, providers may be better able to evaluate which types of progress monitoring tools give them best information for specific children at a particular time.

Patterns of Communication Development in Toddlers with Significant Communication Delays

Total Communication. In general, patterns of communication development demonstrated by this sample of children with communication delays parallel those found in prior studies on the IGDI-ECI in children with IFSPs with a few notable differences (Greenwood et al., 2008; Greenwood et al., 2010). On the Total Communication score, children in our sample displayed a linear growth rate although the slope was smaller than children with IFSPs in the two other norming studies. Unlike the Greenwood et al. 2010 study, children in this sample did not show evidence of an accelerating rate of change on the Total Communication score, a finding that agrees with data from the Greenwood et al. (2008) sample. Instead, the growth rate was constant across the toddler period. Children in this sample also had lower mean rates of weighted communication at 36 months than the other two cohorts, which could be attributable to the significance of their disabilities. While we do not have much information about child characteristics from the other two studies, children in this sample had a range of delays, many of which were present from birth. Despite the significance of their impairments, though, these children made consistent gains in their weighted rates of communication as a function of time. As such, providers working with children with significant delays should expect, at a minimum,
linear growth over time. A lack of growth on the IGDI-ECI over time could signal to the provider that a change to the child’s intervention plan is warranted.

Data from this study also point to an important characteristic of child communication development in children with communication delays. In this sample and in prior research, children varied significantly in their rates of growth and in their mean weighted rates of communication at 36 months. Like children who are typically developing, children with significant delays vary considerably among themselves and are not homogenous. In this study, we used several child-level predictors to explain variability in child growth rates and in mean scores at 36 months. The child’s language level on the PLS-4 at entry into the project was a significant predictor of child communication at 36 months, but it did not explain variation in child growth rates. Likewise, the IGDI-ECI score at entry predicted a child’s score at 36 months, but not their rate of growth.

We wondered, then, whether other child characteristics might impact rates of growth. Knowing that genetic conditions like Down syndrome can cause persistent communication challenges, we examined whether or not child’s DS status predicted child rates of change and scores at 36 month. Results indicated that within a sample of children with significant delays, the presence of DS explains a child’s growth in Total Communication in addition to the variability already explained by initial language level. Children with DS had lower slopes (slower rates of change) and lower mean levels of weighted Total Communication at 36 months. This model explained enough between child variability on the slope to render the variance component non-significant. However, even after accounting for initial language level and DS status, children still varied in their weighted rates of communication at 36 months. Even children with the same type of disability display a wide range of communication outcomes. Indeed, Figure 11 reveals that even within a type of disability like DS, children develop communication skills at different rates.

Other factors then, might explain how fast children increase their weighted rates of communication. Traits external to the child like the caregiver’s level of responsiveness and the amount and type of intervention received could influence the child’s rate of communication at 36 months. Yet given the nature of the data in this study, both caregiver responsiveness and the amount and type of intervention were common, though not identical, across children. All caregivers participated in an intervention that taught responsiveness strategies and caregivers were coached until they implemented the model with acceptable fidelity. While children engaged
in the present intervention at similar intensity, each child may have received additional intervention through Part C services. That difference in intervention dosage could explain some between child variability in Total Communication scores at 36 months. No matter the reason for varying rates of growth in toddlers with significant communication delays, it is clear that children grow at different rates. Given the heterogeneous nature of communication development among young children with disabilities, using progress monitoring tools and other means of data collection help providers document skill development unique to a child to determine whether or not he or she is making gains subsequent to intervention.

**Gesture use.** Data from this analysis agreed with prior findings that, after their onset, gesture use remains relatively stable across toddlerhood in children with significant delays. While this analysis did not reveal the subtle increases and decreases indicated by Greenwood et al. (2010), both analyses found that children used about one gesture per minute after gestures emerge. While the mean of approximately one gesture per minute is a helpful rule of thumb, children varied significantly on this skill element as well. Figure 3 shows a fair amount of diversity in gesture use. Participant children in this study included toddlers with ASD who may have used gestures less frequently, and it included children with Down syndrome who may have used gestures more frequently across time.

It is helpful for providers to have an idea of how often toddlers with disabilities typically use gestures in order to assess whether or not children in intervention are spontaneously using prelinguistic means to communicate. For children who have goals targeting the use of gestures, analyzing this subscale could help providers track the child’s rate of gesture use across time. However, because the requirements of coding gestures on the IGDI-ECI involve a simple frequency tally, providers might consider recording additional information to the scoring protocol to document types and functions of gestures used (pointing, showing, clapping, to regulate behavior, share attention, comment, etc.). For children with ASD, in particular, interventionists often wanted to know what the types and functions of gestures the child used. To meet this need, coders abbreviated this information on the score form (i.e. p=point, g=give; R=request, PR=protest) to offer supplemental information to the interventionist regarding the child’s use of gestures.

**Vocalization use.** Like children in the IFSP cohorts in prior studies, children in this sample used vocalizations at a high rate throughout toddlerhood. Children who are typically
developing tend to rapidly decrease their use of vocalizations after the onset of symbolic communication (Greenwood et al., 2010), but children in this study began only a slight decrease in vocalizations after 30 months. It makes sense that children in this data set continued to vocalize at a high rate later into toddlerhood given their somewhat slower pace in acquiring symbolic forms of communication. By 36 months, they continued to use roughly three and a half vocalizations per minute. It is clear, then, that vocalizations continue to be an important communication form for children with significant delays throughout the toddler period.

There may be an alternate explanation for the elevated vocalization rate beyond simply the lack of symbolic communication forms, however. Children with significant communication delays, particularly those with Down syndrome, often have concerns with speech intelligibility (Roberts et al., 2007). If coders of the IGDI-ECI are unable to ascertain the meaning of a word, it should be coded as a vocalization. It unclear how many of the vocalizations used by children in this study were word approximations that did not meet the minimum standard for intelligibility.

**Single word use and multiple word use.** Compared to children from other IFSP cohorts, children with significant delays had a later onset of single and multiple word use and lower rates of change on both skill elements. As we discovered with the other skill elements, there was significant variability among children in symbol use. In this sample, first words appeared around 15 months and grew linearly compared to an onset of around 12-13 months in the Greenwood et al. (2010) study. As in the 2010 study, multiple words emerged around 18 months, but unlike other cohorts, the rate of change was constant and did not accelerate. A review of individual growth trajectories revealed that some children showed little growth while others did accelerate as a function of time. Because of the IGDI-ECI’s coding definitions, we also do not know how many single and multiple words were unique and how many were repetitions. Some children who seemed to be strong symbol users have repeated words multiple times. This same affect would apply to the other data sets as well, but could inflate raw numbers on the measure.

**Validity and Utility of the IGDI-ECI**

One of the primary aims of this study was to evaluate the concurrent, predictive, and ecological validity of the IGDI-ECI for toddlers with communication delays. While the major purpose of the IGDI-ECI are different than those of other measures, it is important that a progress-monitoring tool generally agree with findings from naturalistic communication samples, caregiver reported data, and other standardized assessments (Bagnato et al., 2010). Knowing how
well the IGDI-ECI agrees with other measures will help providers decide how, when, and where to gather progress monitoring information.

To do this, we first evaluated the concurrent validity of the IGDI-ECI by running correlations between the Total Communication score and several other commonly used measures at 24 and 36 months. At 24 months, the IGDI-ECI showed relative weakness compared to the CDI:WU, the CSBS:DP, the PLS-4 EC subscale, and the number of different words used in a caregiver-child interaction because it did not significant correlate with any of the above measures. We did find a significant relationship between the single word subscore and the CCCS. It is possible that the single word subscore and the NDW from the CCCS had a common construct, the rate of symbol use, and were more closely related to one another than the Total Communication score.

The sample size might have limited the power to detect relationships between measures at 24 months, though the other standardized measures correlated significantly with each other and with the CCCS. Further, correlations between other measures were generally consistent with previously reported validity data on those tools. For instance, the CDI had a correlational coefficient of 0.65 \( (p<.001) \) with NDW in the CCCS, an identical value reported for the CDI and spontaneous communication samples another study of a group of toddlers with Down syndrome \( (r=.65, p<.001; \text{Miller et al., 1995}) \). Significant relationships were found between the PLS-4 and the CSBS:DP and CDI as well.

Several factors could explain the non-significant correlation between the IGDI-ECI and other measures at 24 months. First, the IGDI-ECI was administered by the child’s interventionist in a familiar setting (either home or school). While the developers stress the importance of having a familiar play partner administer the measure (Luze et al., 2001), it is possible that the other measures either included more significant caregiver input on items (PLS-4; CDI), or involved the caregiver directly in the interactions (CSBS:DP; CCCS). While we hypothesized that measures like the PLS-4 would not correlate well with the authentic caregiver child interaction because it has some structured and decontextualized tasks, it actually correlated more strongly with the CCCS than the IGDI-ECI at 24 months, perhaps because the PLS-4 allows for caregiver input on early items. It is possible that very young children, especially those with delays, communicate more readily and more frequently with their caregivers. On the other hand, trained administrators might be more responsive to the child’s communication than some
caregivers. Future work could examine whether there is an administrator effect on IGDI-ECI scores.

It is also possible that measuring child communication earlier in toddlerhood is less stable and reliable than later administrations. Other early communication measures report challenges due to variability in child performance early in infancy when children are acquiring new skills (Wetherby & Prizant; 2002). It is also common for any particular standardized measure to have different relationships with other measures at different points in time (Fenson et al., 2007). The CDI for instance, appears to have a peak in its predictive validity around 20 months (Fenson et al., 2007), and the CSBS:DP reports stronger relationships to other measures later in toddlerhood (Wetherby & Prizant, 2002).

The IGDI-ECI did correlate more strongly with other communication measures at 36 months than it did at 24 months. The relationship between Total Communication scores at 36 months and the PLS-4 are very close to those reported by Luze et al. (2001). The current study reported that $r=.62$ and Luze et al. reported that $r=.63$. The Total Communication score’s relationship to the CCCS neared significance at 36 months, though it did not reach the 0.05 cutoff. In general, the IGDI-ECI seems to have stronger concurrent validity with standardized and spontaneous communication measures at 36 months.

Additionally, the lack of significant correlations between the IGDI-ECI and the CCCS may have resulted from scoring differences on each tool. In the present analysis, the IGDI-ECI and the CCCS differed in both the context (i.e. the way the sample was gathered) and the outcome measure (the metric used for the dependent variable). In order to assess whether or not child communication scores depended on the context, it is important that future studies hold the outcome measures constant. This type of analysis would offer even more information regarding the ecological validity of the IGDI-ECI, because ultimately, results from the IGDI-ECI should agree with child communication in everyday routines and activities. This could be achieved in two ways. First, video recorded samples of the IGDI-ECI could be transcribed in order to yield a rate of NDW. Alternatively, the CCCS could be scored using a weighting system used to score the IGDI-ECI in which gestures and vocalization receive one point, single words two points, and multiple words three points.
This analysis also examined the predictive ability validity of the IGDI-ECI. It is important that scores on a progress monitoring tool predict future performance because providers use those scores to determine whether or not a child needs more intensive intervention (McCathren et al., 2001). If a measure does not reliably predict future performance, intervention decision-making is made more difficult. The IGDI-ECI demonstrated an ability to predict scores at future time points. The Total Communication score at entry was a significant predictor of child scores at 36 months in the hierarchical model with Rate_TC_entry as a Level 2 variable. In other words, the child’s score on the IGDI-ECI at entry predicted his or her Total Communication score outcome at 36 months.

However, the rate of total communication at entry did not predict growth in the NDW used in the caregiver-child play sample while controlling for the NDW used at entry. To some extent, this finding undercuts the ecological and predictive validity of the measure. The IGDI-ECI is a naturalistic play sample, but as noted earlier, it does not represent child communication in an everyday routine because, for the purposes of standardization, the type of play routine was held constant. Yet in order for the IGDI-ECI to serve as a proxy for more authentic interactions, providers require evidence that findings from the measure would generally predict and agree with data collected via more intensive means like language sampling and transcription. It is possible, however, that the IGDI-ECI might have predicted communication in a caregiver child sample if the scoring had been similar. If, for instance, the transcripts were scored in the same way as the IGDI-ECI (gestures and vocalizations receive one point, words receive two, etc.), the relationship between the scores might be stronger.

Clinically, both the IGDI-ECI and the caregiver-child communication sample appear to be useful for the purposes of progress monitoring in early childhood. The IGDI-ECI is quick to administer and score and holds the context of the interaction constant for comparison across time. It provides general information about a child’s use of key early communication skills and offers technological support to store information on an online database and to generate graphs that demonstrate change over time. The IGDI-ECI also appears to be a useful tool for program-wide RTI models in which the growth of all children must be monitored (Greenwood et al., 2008; Greenwood et al., 2010). Use of the tool can aid providers in collecting regular information about the child’s progress and in general, gives some metric by which to compare a
child’s development to other children with and without delays. Patterns of growth from this study and others including toddlers with communication challenges help to support that effort.

**Use of Caregiver-child Communication Samples**

Caregiver-child play interactions also seem to have an important place for the purposes of progress monitoring. While more time consuming to transcribe, measuring the child communication in his or her daily routines and with the child’s caregivers offers unique advantages. Most obviously, it represents what the child can do in the contexts in which they need to communicate. It also allows providers to consider subtleties and nuances that are important for intervention decision-making. Reviewing a transcript allows a provider to assess how much of the child’s communication was generative, and how much was imitated. It allows the provider to consider the mean length of utterance and the number of different words used. Transcripts can also be reviewed individually to document types and functions of gestures used, the overall rate of communication and other outcomes identified by the family and provider. Current research suggests that samples as short as 3 minutes might be used to document changes in child communication (Heilmann et al., 2010). Additionally, interactions an also be used to analyze a caregiver’s use of strategies targeted in intervention because their communication turns are also transcribed. Yet unlike the IGDI-ECI, transcripts cannot be used to compare a child’s gains to norms from children with similar characteristics if the routine is not held constant. Particularly for use by caregivers in center-based settings, transcribed samples may also be too time consuming to analyze and use widely.

Standardized measures might also have their place in collecting data over time. While there are many reasons cited here and elsewhere about the limitations of standardized measures for the purposes of progress monitoring, tools such as the CDI, CSBS:DP, and PLS-4 offer information that helps characterize child communication in a way that communication samples alone do not. The CDI, for instance, offers information about the child’s whole lexicon as reported by the caregiver, the CSBS:DP offers an opportunity to evaluate prelinguistic skills and play behaviors, and the PLS-4 gives a thorough treatment of receptive communication. The CDI stood out among the other measures as the only tool that was able to predict both the mean intercept at 36 months as well as the rate of growth in number of different words used in the CCCS. This underscores the importance of caregiver input to document a child’s communication development. These findings agree with prior research that caregiver report not only correlates
to, but predicts, child communication development in functional everyday routines (Fenson et al., 2007).

Taken as a whole, data from this study highlights the importance and unique contributions of multiple methods of documenting child communication growth during intervention. As emphasized by the major professional organizations as well as researchers in assessment (ASHA, 2008; Bagnato et al., 2010; NAEYC/SDE, 2003), a multimethod, multi-informant approach to gathering data equips providers with the most information about child growth and development. The IGDI-ECI is one tool that providers can use to quickly to gain information about a child’s expressive communication. Providers should also take care to engage caregivers in the process of collecting data for progress monitoring, whether through direct observations, caregiver report, or both.

Limitations

While this study contributes to what we know about growth trajectories for toddlers with significant communication delays as well as traits of the IGDI-ECI, there are several limitations that should be considered when interpreting the findings of the current analysis. First, children in this study were participants in a routines-based, naturalistic communication intervention in addition to their usual Part C services. As such, this group of children may have had more time in intervention than other toddlers with significant communication delays, which could have influenced their growth trajectories. Also, comparisons to other groups of children with IFSPs were limited by a lack of demographic information currently available from other studies. Once that data becomes available, we will be able to determine whether or not the IFSP groups represented children with mild or significant delays, on average. The results from the growth curve analysis might have been influenced by a few children who appeared to be outliers in single and multiple word use. These cases will be analyzed more closely to see if they should be removed from the data set. While the sample size was sufficient for growth curve modeling, the findings from the correlations would be strengthened by having a greater sample size, particularly at the 24-month time point. Data collection is ongoing and the sample size will increase in the coming months.

Directions for Future Research

Findings from the study could be built upon to extend what we know about growth trajectories in toddlers with significant delays. First, while the models presented here explain
some variation between children, we do not know what might contribute to differential rates of growth in toddlers with delays beyond initial language level and DS status. Examining data within a disability type like DS reminds us that children vary considerably, and that communication development is a complex phenomenon. While we examined child-level factors here, other variables could influence child growth rates. Parent responsiveness, for instance, has been documented as a predictor of vocabulary growth in children who are typically developing and who are low-birthweight (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008; Landry, Smith, & Swank, 2006). Future analyses could examine whether caregiver factors like responsiveness predict a child’s growth rate on the IGDI-ECI. As noted previously, caregivers in this study were coached until they were able to implement the KTTP intervention with fidelity. In this sample, at least, caregivers demonstrated at least moderately responsive interactions with their toddlers. In wider samples, however, caregiver responsiveness could significantly impact the child’s communication development. Other variables like amount and intensity of intervention could influence rates of growth.

Additional research examining the predictive and concurrent validity of the IGDI-ECI could either replicate or challenge the findings from this study, adding more to what we know about how this measure relates to a child’s communication in functional, everyday routines. In particular, replications at earlier time points (at and before 24 months) would help uncover whether or not the IGDI-ECI Total Communication score agrees with other measures earlier in toddlerhood. This information is especially important for providers who plan to use the measure with younger infants and toddlers. Future studies could also examine whether or not there is an examiner effect on IGDI-ECI. Such a study could compare results from IGDI-ECI administrations enacted by caregivers and interventionists to see if there are significant differences in child communication attributable to either the administrator of the interaction style of the administrator. Also, additional comparative work between the IGDI-ECI and caregiver-child samples coded in the same manner as the IGDI-ECI could give more detail as to whether the measure reflects what children can do in their everyday routines and activities.
Table 1

Participant Demographics

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls (n=14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys (n=15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at entry (months)</td>
<td>23</td>
<td>11-30</td>
<td>5</td>
</tr>
<tr>
<td>MSEL ELC</td>
<td>74.5</td>
<td>49-119</td>
<td>21.1</td>
</tr>
<tr>
<td>PLS-4 TLS</td>
<td>73.9</td>
<td>52-114</td>
<td>15.9</td>
</tr>
<tr>
<td>CDI-WU</td>
<td>50.8</td>
<td>0-536</td>
<td>112.3</td>
</tr>
</tbody>
</table>

Note. MSEL ELC = Mullen Scales of Early Learning Early Learning Composite; PLS-4 TLS = Preschool Language Scale 4 Total Language Score; CDI-WU = MacArthur Bates Communicative Development Inventory Words Used.
Table 2

**Correlations Between Measures at 24 Months (n=20)**

<table>
<thead>
<tr>
<th></th>
<th>CDI:WU</th>
<th>CSBS:DP</th>
<th>IGDI SW</th>
<th>IGDI TW</th>
<th>PLS-4 EC</th>
<th>CCCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDI:WU</td>
<td>-</td>
<td>.581 **</td>
<td>0.13</td>
<td>-0.14</td>
<td>.63**</td>
<td>.65**</td>
</tr>
<tr>
<td>CSBS:DP</td>
<td>.58 **</td>
<td>-</td>
<td>.44 *</td>
<td>0.31</td>
<td>.66 **</td>
<td>0.32</td>
</tr>
<tr>
<td>IGDI SW</td>
<td>0.13</td>
<td>0.44</td>
<td>-</td>
<td>.73 **</td>
<td>0.33</td>
<td>.45*</td>
</tr>
<tr>
<td>IGDI TC</td>
<td>-0.14</td>
<td>0.31</td>
<td>0.73**</td>
<td>-</td>
<td>0.23</td>
<td>0.1</td>
</tr>
<tr>
<td>PLS-4 EC</td>
<td>.63**</td>
<td>.66**</td>
<td>0.33</td>
<td>0.23</td>
<td>-</td>
<td>.54*</td>
</tr>
<tr>
<td>CCCS</td>
<td>.65**</td>
<td>0.32</td>
<td>.45*</td>
<td>0.1</td>
<td>.54*</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. CDI-WU= MacArthur Bates Communicative Development Inventory Words Used. CSBS:DP= Communication and Symbolic Behavior Scales: Developmental Profile Weighted Raw Score; IGDI SW= Individual Growth and Development Indicator: Early Communication Index Single Words subskill; IGDI TC= Individual Growth and Development Indicator- Early Communication Index Total Communication score. Preschool Language Scale-4 Expressive Communication subscale; CCCS= Caregiver-child communication sample. *p<.05, **p<.01.*
Table 3

*Correlations Between Measures at 36 Months (n=29).*

<table>
<thead>
<tr>
<th></th>
<th>IGDI SW</th>
<th>IGDI TW</th>
<th>PLS-4 EC</th>
<th>CCCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGDI SW</td>
<td>-</td>
<td>.65**</td>
<td>0.19</td>
<td>-0.04</td>
</tr>
<tr>
<td>IGDI TC</td>
<td>.65**</td>
<td>-</td>
<td>.62**</td>
<td>0.41</td>
</tr>
<tr>
<td>PLS-4 EC</td>
<td>0.19</td>
<td>.62**</td>
<td>-</td>
<td>.71**</td>
</tr>
<tr>
<td>CCCS</td>
<td>-0.04</td>
<td>0.41</td>
<td>.71**</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. IGDI SW= Individual Growth and Development Indicator: Early Communication Index Single Words subskill; IGDI TC= Individual Growth and Development Indicator- Early Communication Index Total Communication score. Preschool Language Scale-4 Expressive Communication subscale; CCCS= Caregiver-child communication sample. *p<.05, **p<.01.*
Table 4

Comparison of Growth Modeling Studies on the IGDI-ECI for Toddlers with IFSPs.

<table>
<thead>
<tr>
<th>Study Results</th>
<th>Greenwood et al., 2008</th>
<th>Greenwood et al., 2010</th>
<th>Current sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>189</td>
<td>471</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total Communication</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 36 months</td>
<td>13.9 (.73)</td>
<td>16.29 (0.66)</td>
<td>11.89 (0.97)</td>
</tr>
<tr>
<td>Linear growth (slope)</td>
<td>0.47 (0.03)</td>
<td>0.79 (0.07)</td>
<td>0.43 (0.05)</td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.01 (0.00064)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gestures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 36 months</td>
<td>1.21 (0.03)</td>
<td>0.99 (0.12)</td>
<td></td>
</tr>
<tr>
<td>Linear growth (slope)</td>
<td>-0.042 (0.004)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>-0.0012 (0.00012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vocalizations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 36 months</td>
<td>2.47 (0.147)</td>
<td>3.39 (0.34)</td>
<td></td>
</tr>
<tr>
<td>Linear growth (slope)</td>
<td>-0.208 (0.0065)</td>
<td>-0.02 (0.03)</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>-0.0066 (0.0002)</td>
<td>-0.003 (0.001)</td>
<td></td>
</tr>
<tr>
<td><strong>Single Words</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 36 months</td>
<td>2.66</td>
<td>2.08 (0.42)</td>
<td></td>
</tr>
<tr>
<td>Linear growth (slope)</td>
<td>0.088</td>
<td>0.1 (0.02)</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>-0.0011</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Multiple Words</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 36 months</td>
<td>2.43</td>
<td>1.91 (0.65)</td>
<td></td>
</tr>
<tr>
<td>Linear growth (slope)</td>
<td>0.23</td>
<td>0.106 (0.032)</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values in parentheses are standard errors. All values listed are significant.
Table 5

*Two Level Growth Models for the Rate of Total Communication on the IGDI-ECI.*

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1 (Linear Growth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>11.89</td>
<td>0.967</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $\gamma_{10}$</td>
<td>0.43</td>
<td>0.0448</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Variance $\chi^2$</td>
<td>df</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Intercept, $u_0$</td>
<td>23.497</td>
<td>204.58</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.0339</td>
<td>50.7</td>
<td>28</td>
<td>0.006</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>12.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 2 (Growth with Rate_TC_EN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>11.8</td>
<td>0.97</td>
<td>27</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Time (Slope) $\gamma_{10}$</td>
<td>0.4</td>
<td>0.06</td>
<td>27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Intercept $\gamma_{01}$</td>
<td>0.1</td>
<td>0.03</td>
<td>27</td>
<td>0.006</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Slope $\gamma_{11}$</td>
<td>0</td>
<td>0.002</td>
<td>27</td>
<td>0.873</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Variance $\chi^2$</td>
<td>df</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Intercept, $u_0$</td>
<td>22.10</td>
<td>176.12</td>
<td>27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.05</td>
<td>55.9</td>
<td>27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>11.58</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 3 (Growth with PLS-4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>12.07</td>
<td>0.64</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $\gamma_{10}$</td>
<td>0.44</td>
<td>0.048</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Intercept $\gamma_{01}$</td>
<td>0.06</td>
<td>0.03</td>
<td>26</td>
<td>0.082</td>
</tr>
<tr>
<td>Rate_TC_En Effect on Slope $\gamma_{11}$</td>
<td>-0.003</td>
<td>0.002</td>
<td>26</td>
<td>0.122</td>
</tr>
<tr>
<td>PLS Effect on Intercept $\gamma_{02}$</td>
<td>0.23</td>
<td>0.05</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PLS Effect on Slope $\gamma_{12}$</td>
<td>0.009</td>
<td>0.003</td>
<td>26</td>
<td>0.005</td>
</tr>
<tr>
<td>Random Effects</td>
<td>Variance $\chi^2$</td>
<td>df</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Intercept, $u_0$</td>
<td>8.16</td>
<td>79.19</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
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<td>37.63</td>
<td>26</td>
<td>0.065</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>11.6</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Continued from Table 5

**Model 4 (Growth with CDI)**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>11.78</td>
<td>0.92</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.41</td>
<td>0.0005</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Intercept $Y_{01}$</td>
<td>0.09</td>
<td>0.036</td>
<td>26</td>
<td>0.015</td>
</tr>
<tr>
<td>Rate_TC_En Effect on Slope $Y_{11}$</td>
<td>-0.001</td>
<td>0.002</td>
<td>26</td>
<td>0.61</td>
</tr>
<tr>
<td>CDI Effect on Intercept $Y_{02}$</td>
<td>0.009</td>
<td>0.009</td>
<td>26</td>
<td>0.301</td>
</tr>
<tr>
<td>CDI Effect on Slope $Y_{12}$</td>
<td>0.0009</td>
<td>0.0005</td>
<td>26</td>
<td>0.053</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>22.72</td>
<td>175.72</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.05</td>
<td>55.51</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>11.55</td>
<td></td>
<td></td>
<td></td>
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</table>

**Model 5 (Growth with MSEL ELC)**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>11.9</td>
<td>0.075</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.41</td>
<td>0.04</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Intercept $Y_{01}$</td>
<td>0.04</td>
<td>0.04</td>
<td>26</td>
<td>0.245</td>
</tr>
<tr>
<td>Rate_TC_En Effect on Slope $Y_{11}$</td>
<td>-0.003</td>
<td>0.002</td>
<td>26</td>
<td>0.164</td>
</tr>
<tr>
<td>MSEL Effect on Intercept $Y_{02}$</td>
<td>0.15</td>
<td>0.05</td>
<td>26</td>
<td>0.001</td>
</tr>
<tr>
<td>MSEL Effect on Slope $Y_{12}$</td>
<td>0.007</td>
<td>0.003</td>
<td>26</td>
<td>0.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>13.47</td>
<td>117.61</td>
<td>26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.03</td>
<td>42.37</td>
<td>26</td>
<td>0.022</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>11.73</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Data are centered at 36 months.
Table 6

Two Level Growth Model for the Rate of Total Communication on the IGDI-ECI Predicted by Down Syndrome Status.

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\Upsilon_{00}$</td>
<td>13.3</td>
<td>0.75</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $\Upsilon_{10}$</td>
<td>0.58</td>
<td>0.06</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_TC Effect on Intercept $\Upsilon_{01}$</td>
<td>0.04</td>
<td>0.03</td>
<td>25</td>
<td>0.21</td>
</tr>
<tr>
<td>PLS Effect on Intercept $\Upsilon_{02}$</td>
<td>0.23</td>
<td>0.04</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>DS Effect on Intercept $\Upsilon_{03}$</td>
<td>-3.01</td>
<td>1.01</td>
<td>25</td>
<td>0.006</td>
</tr>
<tr>
<td>Rate_TC Effect on Slope $\Upsilon_{11}$</td>
<td>-0.005</td>
<td>0.002</td>
<td>25</td>
<td>0.01</td>
</tr>
<tr>
<td>PLS Effect on Slope $\Upsilon_{12}$</td>
<td>0.008</td>
<td>0.002</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>DS Effect on Slope $\Upsilon_{13}$</td>
<td>-0.28</td>
<td>0.07</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>5.63</td>
<td>66.38</td>
<td>25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.01</td>
<td>26.25</td>
<td>25</td>
<td>0.394</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>11.46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Data are centered at 36 months.
Table 7

Unconditional Model for Gesture Use on the IGDI-ECI.

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_0$</td>
<td>0.995</td>
<td>0.12</td>
<td>28</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>0.33</td>
<td>147.52</td>
<td>28</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Data are centered at 36 months.
Table 8

Unconditional Growth Model for Vocalizations on the IGDI-ECI.

Model 1 (Growth with Acceleration Term)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_{00}$</td>
<td>3.39</td>
<td>0.34</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $\gamma_{10}$</td>
<td>-0.02</td>
<td>0.03</td>
<td>28</td>
<td>0.54</td>
</tr>
<tr>
<td>Acceleration, $\gamma_{20}$</td>
<td>-0.003</td>
<td>0.001</td>
<td>115</td>
<td>0.034</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>2.48</td>
<td>114.53</td>
<td>28</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.013</td>
<td>85.94</td>
<td>28</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>2.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Data are centered at 36 months
Table 9

Unconditional Growth Model for Single Words on the IGDI-ECI.

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\Upsilon_{00}$</td>
<td>2.08</td>
<td>0.42</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $\Upsilon_{10}$</td>
<td>0.1</td>
<td>0.02</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random Effects</th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>4.46</td>
<td>240.5</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.01</td>
<td>75.96</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Data are centered at 36 months.
Table 10

Unconditional Growth Model for Multiple Words on the IGDI-ECI.

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $\gamma_0$</td>
<td>1.91</td>
<td>0.65</td>
<td>28</td>
<td>0.006</td>
</tr>
<tr>
<td>Time (Slope) $\gamma_{10}$</td>
<td>0.106</td>
<td>0.032</td>
<td>28</td>
<td>0.002</td>
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</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_0$</td>
<td>12.023</td>
<td>1698.7</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Slope, $u_1$</td>
<td>0.026</td>
<td>166.53</td>
<td>28</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>1.016</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Data are centered at 36 months.
Table 11

Two Level Growth Models for Number of Different Words on the Caregiver-child Communication Sample.

<table>
<thead>
<tr>
<th>Model 1 (Linear Growth)</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>3.10</td>
<td>0.64</td>
<td>29</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.20</td>
<td>0.06</td>
<td>29</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_{00}$</td>
<td>9.01</td>
<td>137.95</td>
<td>27</td>
</tr>
<tr>
<td>Slope, $u_{1}$</td>
<td>0.06</td>
<td>66.99</td>
<td>27</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>2.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model 2 (Growth with Rate TC EN)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>3.00</td>
<td>0.52</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.19</td>
<td>0.05</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Intercept $Y_{01}$</td>
<td>0.42</td>
<td>0.38</td>
<td>27</td>
<td>0.289</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Slope $Y_{11}$</td>
<td>0.002</td>
<td>0.026</td>
<td>27</td>
<td>0.919</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Intercept $Y_{02}$</td>
<td>0.07</td>
<td>0.038</td>
<td>27</td>
<td>0.073</td>
</tr>
<tr>
<td>Rate_TC_EN Effect on Slope $Y_{21}$</td>
<td>0.003</td>
<td>0.026</td>
<td>27</td>
<td>0.919</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
<tr>
<th>Variance</th>
<th>$\chi^2$</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_{00}$</td>
<td>7.23</td>
<td>118.9</td>
<td>25</td>
</tr>
<tr>
<td>Slope, $u_{1}$</td>
<td>0.04</td>
<td>57.09</td>
<td>25</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>2.10</td>
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<td></td>
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</table>

Model 3 (Growth with PLS-4)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>3.05</td>
<td>0.544</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.21</td>
<td>0.051</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Intercept $Y_{01}$</td>
<td>0.40</td>
<td>0.003</td>
<td>27</td>
<td>0.168</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Slope $Y_{11}$</td>
<td>0.01</td>
<td>0.018</td>
<td>27</td>
<td>0.58</td>
</tr>
<tr>
<td>PLS Effect on Intercept $Y_{02}$</td>
<td>0.07</td>
<td>0.036</td>
<td>27</td>
<td>0.05</td>
</tr>
<tr>
<td>PLS Effect on Slope $Y_{21}$</td>
<td>0.004</td>
<td>0.003</td>
<td>27</td>
<td>0.245</td>
</tr>
</tbody>
</table>

Random Effects

<table>
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<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_{00}$</td>
<td>7.77</td>
<td>130.56</td>
<td>25</td>
</tr>
<tr>
<td>Slope, $u_{1}$</td>
<td>0.06</td>
<td>72.96</td>
<td>25</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>2.04</td>
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<td></td>
</tr>
</tbody>
</table>

Model 4 (Growth with CDI)

<table>
<thead>
<tr>
<th>Fixed Effects</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Approx df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $Y_{00}$</td>
<td>3.02</td>
<td>0.54</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time (Slope) $Y_{10}$</td>
<td>0.20</td>
<td>0.05</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Intercept $Y_{01}$</td>
<td>0.51</td>
<td>0.29</td>
<td>27</td>
<td>0.095</td>
</tr>
<tr>
<td>Rate_NDW_EN Effect on Slope $Y_{11}$</td>
<td>0.01</td>
<td>0.02</td>
<td>27</td>
<td>0.635</td>
</tr>
<tr>
<td>CDI Effect on Intercept $Y_{02}$</td>
<td>0.01</td>
<td>0.006</td>
<td>27</td>
<td>0.026</td>
</tr>
<tr>
<td>CDI Effect on Slope $Y_{21}$</td>
<td>0.002</td>
<td>0.0003</td>
<td>27</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Random Effects

<table>
<thead>
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<th>Variance</th>
<th>$\chi^2$</th>
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<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept, $u_{00}$</td>
<td>7.44</td>
<td>118.39</td>
<td>25</td>
</tr>
<tr>
<td>Slope, $u_{1}$</td>
<td>0.05</td>
<td>54.2</td>
<td>25</td>
</tr>
<tr>
<td>Level 1, $r$</td>
<td>2.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Individual participant growth trajectories on the rate of Total Communication per minute on the IGDI-ECI.
Figure 2. Predicted growth rates on the Total Communication score on the IGDI-ECI as a function of time across three studies.
Figure 3. Individual participant gesture use trajectories on the IGDI-ECI as a function of time.
Figure 4. Predicted growth rates in gesture use on the IGDI-ECI as a function of time across two studies.
Figure 5. Individual participant vocalization growth trajectories on the IGDI-ECI as a function of time.
Figure 6. Predicted growth rates in vocalizations on the IGDI-ECI as a function of time across two studies.
Figure 7. Individual participant growth trajectories in single word use on the IGDI-ECI as a function of time.
Figure 8. Predicted growth rates in single word use on the IGDI-ECI as a function of time across two studies.
Figure 9. Individual participant growth trajectories in multiple word use on the IGDI-ECI as a function of time.
Figure 10. Predicted growth rates in multiple word use on the IGDI-ECI as a function of time across two studies.
Figure 11. Individual growth trajectories on the rate of Total Communication on the IGDI-ECI in children with and without Down syndrome as a function of time.
APPENDIX A

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM
Date: 4/10/2009
To: Juliann Woods [jwoods@fsu.edu]
Address: 1200
Dept.: COMMUNICATION DISORDERS

From: Thomas L. Jacobson, Chair
Re: Use of Human Subjects in Research
KidTalk Tactics

The application that you submitted to this office in regard to the use of human subjects in the research proposal referenced above has been reviewed by the Human Subjects Committee at its meeting on 04/08/2009. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 4/7/2010 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.
By copy of this memorandum, the Chair of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Juliann Woods, Chair [jwoods@fsu.edu]
HSC No. 2008.1902
APPENDIX B

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673, FAX (850) 644-4392

RE-APPROVAL MEMORANDUM

Date: 2/12/2010

To: Juliann Woods [jwoods@fsu.edu]

Address: 1200
Dept.: COMMUNICATION DISORDERS

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research
KidTalk Tactics

Your request to continue the research project listed above involving human subjects has been
approved by the Human Subjects Committee. If your project has not been completed by
2/9/2011, you are must request renewed approval by the Committee.

If you submitted a proposed consent form with your renewal request, the approved stamped
consent form is attached to this re-approval notice. Only the stamped version of the consent form
may be used in recruiting of research subjects. You are reminded that any change in protocol for
this project must be reviewed and approved by the Committee prior to implementation of the
proposed change in the protocol. A protocol change/amendment form is required to be submitted
for approval by the Committee. In addition, federal regulations require that the Principal
Investigator promptly report in writing, any unanticipated problems or adverse events involving
risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are
reminded of their responsibility for being informed concerning research projects involving
human subjects in their department. They are advised to review the protocols as often as
necessary to insure that the project is being conducted in compliance with our institution and
with DHHS regulations.

Cc: Juliann Woods, Chair [jwoods@fsu.edu]
HSC No. 2010.3880
REFERENCES


BIOGRAPHICAL SKETCH

Mollie Friedman received her B.A. in English Literature and International Affairs from Florida State University. Upon graduation, she served in the United States Peace Corps in Cameroon. Mollie earned an M. S. in Communication Science and Disorders from Florida State University. She has served as the coordinator of the Florida site of the Kidtalk-Tactics Project serving infants and toddlers with disabilities and their families. Her research interests include coaching caregivers to implement responsiveness interventions, collaboration approaches with caregivers in child care settings, and early communication development and measurement.