

# **The LENA™ Developmental Snapshot**

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## **The LENA™ System**

The LENA language environment analysis system is a language monitoring and feedback system designed to provide information about the language environment of infants and toddlers to parents, clinicians, and researchers. The LENA System includes the LENA digital language processor (DLP) that children ages 2 through 36 months wear in the pocket of custom-made clothing. It records everything the child says and hears over a continuous 16-hour day. The audio data is transferred to a computer and analyzed by the LENA language environment analysis software. Parents can access automatically generated feedback reports to view objective information about their child's language environment. The Adult Word Count (AWC) report provides estimates of the total number of adult words the child hears, and the Conversational Turns (CT) report provides estimates of the total number of conversational interactions the child engages in with an adult. These reports permit AWC and CT estimates to be viewed as hourly, daily, or monthly totals. Daily AWC and CT percentile ranking estimates based on a normative database are reported in the LENA software.

The LENA System is intended: 1) to provide a measurement tool to help researchers gain insight into the natural language environment of children; 2) to aid professionals in the early detection of language delay; 3) to support home intervention programs directed at improving the language environment of language-delayed or disadvantaged children; and 4) to educate and provide feedback to parents regarding how much they talk to and interact with their children in order to aid them in maintaining and improving their children's language environments.

## **Abstract**

As part of the development of the LENA™ System, the research and development team at Infoture, consisting of speech language pathologists, linguists, statisticians and other researchers, created the LENA Developmental Snapshot (LDS). This 52-item Yes/No survey was designed to assess expressive and receptive language skills in children 2-36 months of age, and to estimate developmental age as a function of chronological age. Here we describe the development of the LDS. Initial respondents were drawn largely from the Infoture Natural Language Study participant pool, and their LDS scores were validated based on correlations with pre-existing standardized language and cognitive assessments. Participants in a longitudinal phase of the Infoture Natural Language Study completed the LDS at approximately monthly intervals to evaluate LDS test-retest reliability.

## **Keywords**

LENA Developmental Snapshot, item-by-item analysis, normative sample, test-retest reliability, validation.

## 1. Introduction

A child's receptive and expressive language skills provide information about overall language and cognitive development. Receptive language skills refer to what a child understands; these skills represent the child's language comprehension. Expressive language skills refer to language output; these skills are a representation of the child's productive language ability. The LENA™ Developmental Snapshot (LDS) is a 52-item Yes/No questionnaire that provides parents with an estimate of their child's developmental age with respect to receptive and expressive language skills. Results from parental responses on this validated survey may be visualized as a comparison of the child's developmental age to his or her chronological age.

## 2. Creation of the LENA Developmental Snapshot

Question items on the LDS were selected based on experimenter expertise and review of other standardized language and cognitive assessments, including: the *Preschool Language Scale, 4<sup>th</sup> Ed* (PLS-4) (Zimmerman, Lee, Steiner, & Pond, 2002); *Receptive-Expressive Emergent Language Test, 3<sup>rd</sup> Ed* (REEL-3) (Bzoch, League, & Brown, 2003); *Mullen Scales of Early Learning* (Mullen, 1995); *Bayley Scales of Infant and Toddler Development* (Bayley, 2006); *Ages and Stages Questionnaires* (ASQ) (Bricker, Squires, & Mounts, 1995); *MacArthur Communicative Development Inventories* (MCDI) (Fenson, et.al., 2007); the *Child Development Inventory* (CDI) (Ireton and Thwing, n.d.); and the *Rossetti Infant Toddler Language Scale* (Rosetti, 1995). A professional linguist and a certified Speech Language Pathologist formulated and preliminarily ordered the questions according to their age appropriateness.

The current LDS is a product of multiple developmental phases. Initially, a 54-item survey was developed to pilot test with fifteen families. These families were recruited from the Boulder, Colorado community and through

internet advertisements. Pilot participants were mailed the 54-item LDS survey (Version 1), an agreement to participate, a consent form and a postage-paid self-addressed return envelope. In addition, the pilot participants were asked to complete either the MCDI or ASQ, as appropriate to their child's age. Detailed analyses of the pilot phase responses and feedback resulted in 9 items being added to the LDS survey for a total of 63 items (Version 2).

### **3. Normative data collection**

The collection of normative data for LDS development proceeded in two phases. Participants from the Infoture Natural Language Study (INLS) were solicited for participation for the first phase (N=314); of these, 308 agreed to participate. See Technical Report ITR-02-1 for further information on the INLS. These participants completed the 63-item Version 2 of the LDS, a background information form, consent form, and select standardized child language questionnaires for validation purposes (e.g. ASQ, MCDI, and/or CDI, depending on the child's age). The forms were organized in a single packet and mailed to participants along with a postage-paid self-addressed return envelope. Participants received monetary reimbursement if responses were returned to Infoture within one week.

Normative data contributing to the LDS survey were collected several months after the last INLS participant was enrolled, and at that time most of the children from the INLS were older than 8 months of age. Thus, a second phase of LDS normative data collection added families with children between 2–7 months of age who had not participated in the INLS and had no previous experience with the LENA System. Thirty-nine new participants were recruited through internet advertisements. Selection was based on child's age as well as mother's education level, with the goal of obtaining a demographic distribution similar to that of the US population. As during the

first phase, participants received monetary reimbursement if responses were returned to Infoture within one week. These new recruits were mailed the same package as described above for the INLS participants; there was a 100% response rate.

#### **4. Final version of the LENA Developmental Snapshot**

To determine the final version of the LDS, responses from the normative data collection phase were subjected to an item characteristic analysis. Here, we determined how to optimize the survey validity through appropriate ordering of questions. Survey items were ordered empirically based on chronological age. In addition to reordering items, we eliminated 11 questions that did not provide consistent information about developmental age. The final version of the LDS (Version 3) contains 52 age-ordered items.

#### **5. Validated Samples**

Developmental age estimates and LDS total scores from the two phases of LDS normative data collection were validated against other contemporaneous measures including those completed in the initial packet, along with results from standardized assessments administered by a certified Speech Language Pathologist during the INLS (but within 6 weeks of completion of the LDS). Thus, LDS validation relied on both parental self-report and professional clinical examination using standardized language development assessments, including the PLS-4, REEL-3, CDI, the *Cognitive Adaptive Test (CAT)*, and the *Clinical Linguistic and Auditory Milestone Scale (CLAMS)* (Accardo & Caput, 2005). Table 1 demonstrates the convergent validity of the LDS; standardized language and cognitive assessment developmental age estimates were highly correlated with the LDS developmental age estimates.

Table 1: Correlation of LDS Data with Standardized Language Assessments

Assessment	N	Correlation
PLS-4 Receptive	51	.93
PLS-4 Expressive	51	.92
REEL-3 Receptive	75	.96
REEL-3 Expressive	75	.96
CDI Receptive Language	143	.84
CDI Expressive Language	142	.81
CLAMS	52	.97
CAT	52	.95
Overall Average		.93

All correlations were significant at the  $p < 0.01$  level (two-tailed)

In addition to correlating highly, LDS developmental age estimates agreed well with developmental age estimates from standardized assessments. For example, on average LDS age estimates did not differ significantly from PLS-4 or REEL-3 age equivalency estimates for either receptive or expressive language. LDS developmental age estimates also correlated highly with chronological age,  $r(306) = 0.92$ ,  $p < .01$ , and on average did not differ from chronological age, indicating that parental responses were consistently age specific.

## 6. Reliability

Three months after completing the LDS, a subset of INLS longitudinal-phase participants completed it again; these participants have continued to do so on a monthly basis, permitting an evaluation of test-retest reliability.<sup>1</sup> Scores from the first to the second completion (3 month interval) increased

<sup>1</sup> Some participants (N=7) stopped completing the LDS once they attained the maximum total (i.e., answered 'Yes' to all 52 items) for two months in a row.

an average of 3.9 points ( $SD = 3.4$ ); the average month-to-month increase for subsequent completions was 0.9 points ( $SD = 0.7$ ). Test-retest reliability for the LDS, as indicated in Table 2, was excellent.

Table 2. Test-retest Reliability of the LDS

Completion Month	N	Correlation with Subsequent LDS
10/06	308	.97
1/07	74	.98
2/07	73	.96
3/07	72	.97
4/07	72	.97
5/07	66	.96
6/07	61	.96
7/07	59	.95

## 7. Conclusion

The Lena Developmental Snapshot (LDS) was developed to provide parents an estimate of their child's developmental age with respect to expressive and receptive language skills. LDS total scores and age estimates are highly correlated with standardized observation-based and parent report language and cognitive assessments, an indication of instrument validity. Repeated monthly administrations show that the LDS has excellent test-retest reliability.

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