## Appendix 1 Developmental milestones in motor and language development (adapted from Lenneberg 1967, 128–130)

<table>
<thead>
<tr>
<th>Year</th>
<th>Motor Development</th>
<th>Vocalization and Language</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1</strong>&lt;br&gt;0–6 months</td>
<td></td>
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<tr>
<td>3 months</td>
<td>Supports head when prone</td>
<td>Less crying than at 8 weeks; smiles when talked to; <em>cooing</em></td>
</tr>
<tr>
<td>4 months</td>
<td>Plays with rattle; head self-supported</td>
<td>Responds to human sounds more definitely</td>
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<tr>
<td>5 months</td>
<td>Sits with props</td>
<td>Cooing begins to be interspersed with more consonantal sounds; all vocalizations are very different from the sounds of the mature language of the environment</td>
</tr>
<tr>
<td><strong>6–12 months</strong></td>
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<tr>
<td>6 months</td>
<td>Sitting; bends forward and uses hands for support; cannot yet stand without help; no thumb apposition</td>
<td>Cooing changing into babbling resembling monosyllabic utterances; neither vowels nor consonants have very fixed recurrences</td>
</tr>
<tr>
<td>8 months</td>
<td>Stands holding on; grasps with thumb apposition</td>
<td>Reduplication frequent; intonation patterns distinct; utterances can signal emphasis and emotions</td>
</tr>
<tr>
<td>10 months</td>
<td>Takes side steps, holding on; pulls to standing position</td>
<td>Vocalizations are mixed with sound-play such as gurgling or bubble-blowing; tries unsuccessfully to imitate sounds</td>
</tr>
<tr>
<td>12 months</td>
<td>Walks when held by hand; walks on feet and hands, knees in air; seats self on floor</td>
<td>Identical sound sequences replicated with higher relative frequency of occurrence and words are emerging; definite signs of understanding some words and simple commands</td>
</tr>
<tr>
<td><strong>Year 2</strong>&lt;br&gt;18–24 months</td>
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<tr>
<td>18 months</td>
<td>Grasp, prehension, and release fully developed; gait stiff, propulsive, and precipitated; creeps downstairs backwards</td>
<td>Has a repertoire of three to fifty words; babbling now of several syllables with intricate intonation pattern; little ability to join any of the lexical items into spontaneous two-item phrases; understanding is progressing rapidly</td>
</tr>
</tbody>
</table>
Appendix 1

<table>
<thead>
<tr>
<th>Age</th>
<th>Motor Development</th>
<th>Language Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 months</td>
<td>Runs, but falls in sudden turns; can quickly alternate between sitting and stance; walks stairs up or down, one foot forward only</td>
<td>Vocabulary of more than fifty items; begins to join items into two-word phrases; all phrases appear to be own creations; increase in communicative behavior and interest in language</td>
</tr>
<tr>
<td>30 months</td>
<td>Jumps into air with both feet; stands on one foot for about two seconds; takes few steps on tiptoe; can move digits independently; manipulation of objects much improved</td>
<td>Fastest increase in vocabulary; no babbling; utterances have communicative intent; frustrated if not understood by adults; sentences and phrases have characteristic child grammar; intelligibility not very good; understands what is said</td>
</tr>
<tr>
<td>Year 3</td>
<td>Tiptoes well; runs smoothly with acceleration</td>
<td>Vocabulary of some 1,000 words; about 80 percent of utterances are intelligible even to strangers; grammatical complexity of utterances is roughly that of colloquial adult language</td>
</tr>
<tr>
<td>Beyond 3</td>
<td>Jumps over rope; hops on dominant foot; catches ball in arms; walks line</td>
<td>Language is well-established; deviations from adult norm tend to be more in style than in grammar</td>
</tr>
</tbody>
</table>

Note: We now know there are wide variations in precise ages at which a normal child reaches a “milestone.” However, the sequence of milestones and their correlations remains Lenneberg’s major point. Within a single child, there do not seem to be necessary causal links between motor development and language development (Bates et al. 1979; Menyuk 1995; Bloom 1993).
Appendix 2a  Developmental milestones in infant speech perception

Year 1

0–2 months  Distinguishes maternal voice, speech and non-speech
Perceives wide set of sound distinctions corresponding to possible phonetic contrasts along many major dimensions of phonetic variation (appendix 2b)
Discriminates between different numbers of syllables (Bijeljac-Babic, Bertoncini and Mehler 1993/1992)
Discriminates canonical and non-canonical syllables (Moon et al. 1992)
Discriminates certain prosodic differences in stress and accent (Christophe et al. 1994)

2–3 months  Discriminates certain allophonic variations between sounds, e.g., the allophones of [t] and [r] in “night” vs. “nitrate” (Hohne and Jusczyk 1994)
Discriminates bisyllables with initial stress from those with final stress, e.g., “bada” from “bada” (Jusczyk and Thompson 1978; Spring and Dale 1977; Jusczyk, Cutler and Redanz 1993)
Compensates for changes in speaking rates (Eimas and Miller 1980)

4 months  Prefers to listen to words over other sounds (Colombo and Bundy 1983)
“Duplex Perception” is evident (Eimas and Miller 1992)

5 months  Capable of linking auditory and articulatory information (Kuhl and Meltzoff 1982, 1984)

6–7 months  Pair of syllables recognized as unit when “supported by rhythmic familiarity” regardless of syllable ordering (Morgan and Saffran 1995)
When acquiring English, distinguishes English words compared to Norwegian words, but not compared to Dutch (Jusczyk, Friederici et al. 1993); infant appears to know some aspects of possible patterns of words in specific language
First evidence that early perception of sound distinctions is being narrowed to more closely reflect the Specific Language Grammar being acquired; certain distinctions weaken or disappear when not in the specific language being acquired (Werker and Lalonde 1988; Polka and Werker 1994)
“Magnet Effect”: recognition of specific language “prototype” vowel sounds (Kuhl et al. 1992)

Word segmentation skills apparent: infant recognizes words in sentences which were heard in isolation (monosyllabic words like “dog” or bisyllabic words like “doctor”) and recognizes words in isolation which were heard in sentences (Jusczyk and Aslin 1995)

Recognizes recurrence of a three-sound sequence of continuous synthesized speech (Saffran, Aslin and Newport 1996)

8 months
Recognizes words from stories read two weeks earlier (Jusczyk and Hohne 1997)
Recognizes phonotactic patterns of specific language, e.g., strong–weak patterns in English, and listens longer to these (Jusczyk, Cutler and Redanz 1993)

9 months
Distinguishes English from Dutch words (Jusczyk, Luce and Luce 1994)
Uses phonotactic information to segment speech into words (Mattys and Jusczyk 2001)
Prefers language-specific phonotactically well-formed strings (Friederici and Wessels 1993; Jusczyk et al. 1993; Jusczyk, Luce and Charles-Luce 1994)
Integration of segmental and suprasegmental information in recognition of units (Morgan and Saffran 1995)
Distinguishes passages with pauses between words from those with pauses within words (Myers et al. 1996)
Integrates multiple sources of information to locate word boundaries in fluent speech, phonotactic and prosodic (Aslin et al. 1998; Jusczyk 1997)

10–11 months
Uses context-sensitive allophones in segmenting words (Jusczyk, Hohne and Bauman 1998)
Loses response to distinctions of some allophonic sound variations (Pegg 1995)

12 months
Retains discrimination of phonetic contrasts which are phonemic in the infant’s native Specific Language Grammar; but has ceased to demonstrate discrimination of many, if not most, others (Werker 1994; Werker and Tees 1984a, b; Best 1994)
Onset of first words in production (appendix 3)

Year 2

14 months
Does not use phonetic detail in a task requiring the pairing of words and objects, suggesting “functional reorganization” (e.g., /bih/ vs. /dih/) (Stager and Werker 1997; Schvachkin, 1973; Garnica 1973)
### Appendix 2b  Examples of sound distinctions perceived by infants

<table>
<thead>
<tr>
<th>Distinction</th>
<th>Examples</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. VOT (−V/+V)</td>
<td>pa/ba</td>
<td>Eimas et al. 1971</td>
</tr>
<tr>
<td></td>
<td>Guatemalan infants</td>
<td>Lasky et al. 1975; Aslin and Pisoni 1975</td>
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<tr>
<td></td>
<td>acquiring Spanish</td>
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<tr>
<td></td>
<td>show English type</td>
<td></td>
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<tr>
<td></td>
<td>contrast, not Spanish</td>
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</tr>
<tr>
<td></td>
<td>African Kikuyu infants</td>
<td>Streeter 1976</td>
</tr>
<tr>
<td></td>
<td>2 months old</td>
<td>Aslin et al. 1981</td>
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<tr>
<td></td>
<td>show (+/−V); (Kikuyu has</td>
<td></td>
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<tr>
<td></td>
<td>no V/−V; only pre-V/V</td>
<td></td>
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<tr>
<td></td>
<td>Infants from English-</td>
<td>Werker et al. 1981</td>
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<tr>
<td></td>
<td>speaking environments</td>
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<tr>
<td></td>
<td>also distinguish −V vs.</td>
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<tr>
<td></td>
<td>+V as well as pre-V</td>
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<tr>
<td></td>
<td>tha/dha</td>
<td>Werker 1994</td>
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<tr>
<td></td>
<td>(breathy voiced vs. voiceless aspirated dental stops e.g. Hindi)</td>
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<tr>
<td>2. Place features</td>
<td>ba/ga</td>
<td>Moffitt 1971; Morse 1972; Eimas 1974; Bertoncini et al. 1987</td>
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<tr>
<td></td>
<td>bæ/dæ</td>
<td>Eimas and Miller 1980; Holmberg et al. 1977; Levitt et al. 1988</td>
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<tr>
<td></td>
<td>dæ/gæ</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ma/na</td>
<td>Werker 1994</td>
</tr>
<tr>
<td></td>
<td>fa/θa</td>
<td>Werker and Tees 1984</td>
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<tr>
<td></td>
<td>va/ða</td>
<td>Kuhl 1980, Holmberg et al. 1977</td>
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<tr>
<td></td>
<td>ta/t (Hindi dental vs. retroflex)</td>
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<td></td>
<td>glottalized velar vs.</td>
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<td></td>
<td>uvular: /kˈi/ vs. /qˈi/</td>
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<td></td>
<td>Salish/Nthlakampx</td>
<td></td>
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<td></td>
<td>/s/ vs. /ʃ/</td>
<td></td>
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<tr>
<td>3. Manner features</td>
<td>oral/nasal consonants</td>
<td>Eimas and Miller 1980; Miller and Eimas 1983</td>
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<tr>
<td></td>
<td>ba/ma</td>
<td>Trehub 1976; Morse 1972</td>
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<td></td>
<td>Stridency with the</td>
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<td></td>
<td>consonant /r/ (Czech);</td>
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<tr>
<td></td>
<td>falling and rising</td>
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<td></td>
<td>intonation (ba+) (ba−)</td>
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<tr>
<td>Liquids</td>
<td>/r/ and /l/</td>
<td>Eimas 1975</td>
</tr>
<tr>
<td></td>
<td>(2–3 month old American; 6–8 month old Japanese)</td>
<td>Tsushima et al. 1994</td>
</tr>
<tr>
<td>4. Vowels</td>
<td>/a/ vs. /i/, /i/ vs. /u/</td>
<td>Kuhl and Hillenbrand 1979; Polka and Werker 1994; Trehub 1973; Swoboda et al. 1976</td>
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<tr>
<td>---</td>
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<tr>
<td>/Y/ Vs. /u/ (lax high front rounded vs. lax high back rounded)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral/nasal vowel distinction (as in Polish, French)</td>
<td>/p̥a/, /p̥a/</td>
<td>Trehub 1976</td>
</tr>
</tbody>
</table>
Appendix 3 Developmental milestones in infant speech production

**Year 1**

0–1.5 months  Reflexive and vegetative sounds (Stark, Rose and McLagen 1974)
— cry
— vegetative sounds (coughing, burping, swallowing, glottal catches, grunts, sighs)
— discomfort sounds (fussing)
Vocal tract not developed; high larynx. Primitive reflexes: e.g., tongue in apposition with soft palate. Child unable to control tongue, lips, jaw muscles.
“Vocal contagion” (Piaget 1962/1945)

1.5–3 months  “Cooing” and laughter
Maturation of vocal tract
Comfort sounds: produced in pleasurable interaction
“The new combination of the features of voicing, egressive breath direction and consonant like results from the overlap of a period of acquisition of control over the larynx with the reflexive activity of the vocal tract which has not yet been suppressed” (Stark et al. 1978)
Beginning babbling periods: vocalization containing “articulated and identifiable sounds and syllables”

4 months  Vocal play

5 months  Expansion, exploratory mapping of sounds
Playful use of behaviors like squealing, yelling, nasal murmurs
Terminates in “marginal babbling”: consonantal and vocalic elements are combined in novel ways; consonantal and vocalic elements both occur, but may not resemble syllables of adult speech in their durational aspects or other articulatory features
Produce sounds after short-term exposure (Kuhl and Meltzoff 1996); elaborate reproductions possible (Uzgiris 1993; de Boysson-Bardies 1999)

6–12 months
6–10 months  Canonical babbling, including Reduplicated babbling. Canonical syllables found for first time. Two or more syllables with two or more articulatory movements combined (Koopmans-van Beinum and Van der Stelt 1998); adult-like timing develops (Vihman 1996)
Properties of babbling distinguishable in terms of infant’s language vs. other language (e.g., French first vs. Arabic) by phoneticians, at 6 months (de Boysson-Bardies et al. 1984)

10–14 months
Variegated babbling: variation in C and V within a series; V, VC, and CVC syllables in addition to CV
Greater variety of intonation and stress pattern
Babbling shows evidence of specific properties of infant’s language which are continuous with first words and detectable by untrained adults (e.g., de Boysson-Bardies, Vihman and Vihman, 1991, Oller et al. 1976; Vihman et al. 1985)
Some evidence of sound-meaning correspondences in babbling (Blake and Fink 1987; Blake and de Boysson-Bardies 1992)
Onset of first words

Year 2 +
Multisyllabic vocabulary may be pronounced as one or two syllables, reduced in length (Johnson, Lewis and Hogan 1997) and structure
Common “deformations” of the adult target reflect universal structures and organizing principles
Mastery of language-specific phonologies through integration of segmental and suprasegmental units may develop for years
Appendix 4  Developmental milestones in infant syntax: perception

Year 1

0–2 months  Infants know a few days after birth “which language is going to be their maternal language” (Mehler and Christophe 1995, 948): they distinguish their own language from others; e.g., French newborns distinguish French from Russian and prefer French; infants in Spanish-speaking environments distinguish Spanish from English and prefer Spanish (Mehler et al. 1988; Moon et al. 1993).

“Infants are able to tell apart two different languages, even when neither of them is present in their environment” (Mehler and Christophe 1995, 947). They distinguish foreign languages from each other – French infants distinguish Italian and English (Mehler and Christophe 1995; Mehler et al. 1988), or English and Japanese (Nazzi et al. 1995, 1998). They respond more to a change in language than to a change in speaker (Nazzi et al. 1998).

Newborns discriminate lists of lexical and functional (“grammatical”) words (e.g., “chew, chair, find” from “it’s, the, in, your”) (Shi, Werker and Morgan 1999).

2 months  Infants continue to discriminate their native language from other languages, but may no longer respond to distinction between two foreign languages. Infants may have already “set the first values to individuate the structure of the maternal language,” beginning to tune out other variations (Mehler and Christophe 1995, 947; Mehler et al. 1988).

“. . . [A]ble to remember the order of spoken words when they are embedded within the coherent prosodic structure of a single well formed sentence” (Mandel, Kemler Nelson and Jusczyk 1996)

4 months  Continue to respond to a change in language (native language vs. foreign language), but not to a change in sentences uttered within a language (Bahrick and Pickens 1988).

Show evidence of ability for clausal segmentation in their native language and in some foreign languages as well. However, English learning infants do not do so in Japanese (Mandel, Jusczyk and Mazuka 1992; Jusczyk, Mazuka et al. 1993).

5 months  Still discriminate languages from different rhythmic classes; e.g., American infants distinguish English and Japanese or Italian and Japanese, but not within two foreign languages which share “rhythmic class” (e.g., Italian versus Spanish).
Distinguish two “similar” (stress-timed) languages if one is the native language, e.g., American infants distinguish English and Dutch (Nazzi and Jusczyk 1999).

**6–12 months**

**6 months**

Clausal segmentation becomes more language specific. For example, infants acquiring English continue to prefer well-formed clausal segmentation in English, but no longer distinguish well-formed from non-well-formed segmentation of clauses in Polish (Jusczyk 1989).

Detect clauses in fluent speech (Nazzi et al. 2000).

Infants do not distinguish phrasal segmentation as well formed or not (Jusczyk et al. 1992).

**7 months**

Detect abstract “algebraic” patterns in sound sequences generated by artificial grammar (Marcus et al. 1999).

**9 months**

Distinguish phrasal segmentation as well formed or not in their native language (Jusczyk et al. 1992).

In speech processing, phonological packaging into “major prosodic units” overrides syntactic units in phrasal units (for example, subject–predicate sentences with pronoun subjects do not show the same preference effects as those with non-pronoun subjects) (Gerken, Jusczyk and Mandel 1994).

**10 months**

Sensitive to grammatical function morphemes versus phonologically dissimilar nonsense morphemes (Shady 1996).

**11 months**

Notice violations of grammatical morphemes in novel sentences (Shady 1996; Shafer et al. 1998; Gomez et al. 1999, 133)

**12 months**

Infants detect abstract patterns generated by a finite state grammar and generalize to change of vocabulary (Gomez and Gerken 1999). Parameter setting may be accomplished before the first words (Mazuka 1996).

**Year 2**

**18 months +**

Language-specific syntax becomes increasingly evident.

Infants learning English are shown to be sensitive to discontinuous elements involving agreement, e.g., “is–ing” (Santelmann and Jusczyk 1998).

**Year 3**

Comprehension of basic operations of complex syntax and knowledge of ambiguity becomes evident, e.g., as in VP ellipsis (Foley et al. 2003).

Comprehension of basic grammatical operations becomes evident by start of third year: simple sentences, as well as coordinate and adjoined or embedded sentences.

**Year 3+**

Development of semantic scope operations in syntax is gradual, as well as some language-specific syntax.

Development continues for operations involving integration of language-specific lexicon and syntactic computation, e.g., “promise/tell” alterations in control structures in English (e.g., Cohen, Sherman and Lust 1993; Chomsky 1969), or Spanish lexical control variations (Padilla Rivera 1990; Cromer 1987).

Language-specific pragmatic principles continue to develop.

Lexical, semantic and pragmatic knowledge continue to develop in language-specific interaction with the syntax of the language.
Appendix 5  Developmental milestones in infant syntax: production

**Year 1**

12 months  First words.

**Year 2**

14 months  Average about ten words in production (Benedict 1979), often single word utterances.

15 months  Combinations appear, e.g., “Dada widā” (Bloom 1973).

17–19 months  Successive single word utterances (Bloom 1973). Beginning of sentence construction. Early language-specific constraints on word order and structure are evident, although utterance length is constrained. Gradual release on length constraint as words begin to be combined into sentences. Early word combinations, “wiping baby chin” (Bloom 1973; 1970). Often missing overt inflection, with cross-language differences in how much, and which, inflection is missing.

**2 Years**

Complex syntax, with various forms of embedding and transformations, becomes evident as early sentences grow in length. Morphosyntax continues to grow.

**Years 3+**

The essential syntax of a grammar for the language is evident. Certain language-specific properties of grammar, syntax/semantics interactions, and lexicon/syntax interactions continue to develop.
Appendix 6  Developmental milestones in infant semantics

Year 1

0–6 months

Beginnings of word recognition, e.g., “mommy” and “daddy” or infant’s own name (Tincoff and Jusczyk 1999; Huttenlocher 1974; Nelson et al. 1993; Mandel, Jusczyk and Pisoni 1995).

6–12 months

7.5–8 months

Remembers and detects words in fluent speech (Jusczyk and Aslin 1995). Remembers words from stories heard two weeks earlier (Jusczyk and Hohne 1997).

9 months

Labeling facilitates categorization (Balaban and Waxman 1997).

10.5 months


11 months

Developing receptive lexicon (Halle and de Boysson-Bardies 1994); ability to actively seek a named object for frequent words.

12 months

Kind concepts like a “cup” or “ball” are acquired. Uses property or kind properties (e.g., “dog” versus “ball”) to differentiate and quantify objects (Xu and Carey 1995; Xu et al. 1999; Xu 2002; Wilcox and Baillargeon 1998; Spelke et al. 1995); linkages between words and categories are made (Waxman and Markow 1995).

Year 2

12–24 months

12–13 months

Distinguishes novel words categorically (count nouns versus adjectives; link nouns and object categories) (Waxman 1999). Rapid increase in receptive lexicon (Benedict 1979).

14 months

“[C]an rapidly learn associations between words and objects” with only a few minutes of exposure (Werker et al. 1998, 1289). Understands as many as fifty words (Benedict, 1979; Snyder, Bates and Bretherton, 1981).

Discriminates between two different words for a single action (e.g., “push” and “pull”), and between two different actions, but shows “a difficulty in processing language labels and actions simultaneously,” thus not linking specific words to specific actions (Casasola and Cohen, 2000).

15–16 months

“word spurt” in comprehension (Casasola and Cohen, in press).

18 months

One trial learning is sufficient for initiation of new words (Nelson and Bonvilian 1973).
Able to form an association between a nonsense language label and a causal action within minutes (e.g., “push” and “pull”) (Casasola and Cohen, 2000). Symbolic competencies are fully developed for: object permanence, deferred imitation, symbolic play (Piaget 1983).
New words proliferate; estimated vocabulary 10–220 (Fenson et al. 1994).

**2 Years+**
May understand and produce 50–1,000 words (Fenson et al. 1994).

**3 Years+**
Estimated vocabulary of 5,000–10,000 words by 5 years (Anglin 1993). By 6 years the child may control 14,000 word meanings; by adult, 50,000–300,000.
Development of theory of mind and communicative intentions relevant to language (Mitchell 1996; Sabbagh and Callanan 1998).
Higher order semantics (e.g., logical connectives and quantifiers) continue to develop.
Integration of pragmatic, semantic and syntactic factors continues to develop.