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INVITED SEMINAR PRESENTATION

Neurological and developmental foundations of speech acquisition

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A SUMMARY: BRAIN DEVELOPMENT AND THE ENVIRONMENT*

A legacy of humanity's evolutionary past is that extensive brain development occurs as a child acquires speech during childhood. Brain development during childhood allows the brain to be shaped by the environment in which a child lives. Rather than possessing a genetic inheritance that includes a specialized body and mind fitted to a specific environmental niche, a human brain grows while exposed to the environment into which it is born. A child brings an ability to grasp complex patterns and a brain that grows through interacting with the environment. The environment shapes a child's brain, narrowing the potential to learn from a wide number of possible environments to fit the actual one in which a child lives. The following major aspects of brain development occur as the child interacts with the environment:

BRAIN WEIGHT

Function: Brain size gives humans the capacity to grasp complex patterns, including those that underlie speech.
Growth: The human brain at birth is about 25% of its adult weight, grows maximally to 80% of its adult weight during the first few years of life, and reaches its mature size at adulthood.

SELECTIVE ELIMINATION

Function: In areas of the brain responsible for speech learning as in other domains, a brain begins with "extra" cell connections. Those that are used are strengthened and retained, while those that are unused are eliminated.
Growth: Approximately one-third of cells are lost between birth and adulthood. Selective elimination occurs early in sensory areas and later in areas involved in higher cortical functions. The number of cell connections remains stable throughout much of adulthood.

GROWTH AND ELABORATION

Function: The environment stimulates growth and elaboration of cell connections, including those needed for speech learning.
Growth: An enriched environment promotes increased numbers of synapses per neuron in both children and adults, and environmental deprivation decreases numbers of cell connections. In humans, numbers of cell connections increase in old age, indicating a capacity for life long learning and, perhaps, compensating for neuronal deaths that occur during middle and old age.

MYELIN SHEATHS

Function: A white fatty substance on axons that acts as an insulator and speeds electrical transmission of signals between cells. Myelin is critical for gross and fine motor movements, including speech.
Growth: Myelination of the brain begins near three months before birth, achieves it peak growth between birth and the end of the first year, and continues to grow until adulthood.

WERNICKE'S AREA

Function: A functional region in left temporal lobe critical for language comprehension.
Growth: Peak in number of cell connections during the first half of the first year and achieve mature number of cell connections during the second half of the first year. Girls young as nine have more dendritic connections in Wernicke's area than do males. On average, persons with a university education have more dendritic connections in Wernicke's area than do those with a high school diploma, who in turn have more than those with less than a high school education.

BROCA'S AREA

Function: A functional region in the left frontal hemisphere that controls speech.
Growth: Density of cell connections in Broca's Area does not peak until 15 months, and does not reach a mature number of connections until 6 to 8 years old.

HIPPOCAMPUS

Function: The hippocampus is critical to working memory and such important speech activities as memory retention and word retrieval.
Growth: The hippocampus develops after the child is born, especially during the second year of life.

PREFRONTAL CORTEX

Function: The prefrontal cortex is critically important to many cognitive activities that underlie speech, including reasoning, planning, judgment, and attention.
Growth: Cell connections in the prefrontal lobes develop slowly throughout childhood and do not reach maturity until after adolescence.
* Adapted from: Bleile, K. (forthcoming). *Manual of articulation and phonological disorders (Second Edition)*. New York: Delmar.

ACQUISITION OF SPEECH

This compilation of data on typical speech development for English speaking children is designed to be used by speech-language pathologists. It is organised according to children's ages to reflect the typical developmental sequence. However, rates of development vary among typically developing children. Where possible, data from more than one study is presented for each category at each age to allow for comparison and to encourage consideration of diversity and individuality. Some of the limitations of the data collection procedures used in these studies are explored in James (2002) and caution should be taken when applying these data to children's speech production. A bibliography is provided at the end of this document regarding the development of speech in languages other than English.

Details of studies cited within this document

Authors	Year	Country	No. of children	Age of children	Sample type*	Data collection
Chirlian & Sharpley	1982	Australia	1357	2;6-9;0	Single word (SW)	Cross-section
Dodd	1995	UK & Australia	5	1;8 – 3;0	Connected Speech	Longitudinal
Donegan	2002	UK & USA	-	-	-	Compilation
Dyson	1988	USA	20	2;0-3;3	CS	Cross-section & longitudinal
Grunwell	1987	UK	-	-	-	Compilation
Haelsig & Madison	1986	USA	50	2;10-5;2	SW	Cross- section
James, McCormack & Butcher	1999	Australia	240	5;0-7;11	SW	Cross-section
James	2001	Australia	354	3;0-7;11	SW	Cross-section
James, van Doorn, McLeod	2001	Australia	354	3;0-7;11	SW	Cross-section
James, van Doorn, McLeod	2002	Australia	354	3;0-7;11	SW	Cross-section
Kehoe	1997	USA	18	1;10 - 2;10	SW	Cross-section
Kehoe	2001	USA	-	1;6 – 2;10	-	Compilation
Kilminster & Laird	1978	Australia	1756	3;0-9;0	SW	Cross-section
Lowe, Knutson & Monson	1985	USA	1048	2;7 – 4;6	SW	Cross-section
McGlaughlin & Grayson	2003	UK	297	0;1-1;0	Crying	Cross-section
McLeod, van Doorn & Reed	2001a	Australia	-	-	-	Compilation
McLeod, van Doorn & Reed	2001b	Australia	16	2;0 – 3;4	CS	Longitudinal
McLeod, van Doorn & Reed	2002	Australia	16	2;0 – 3;4	CS	Longitudinal
Oller, Eilers, Neal, Schwartz	1999	USA	3400	;10-1;0	CS; Parent report	Cross-section & longitudinal
Otomo & Stoel-Gammon	1992	USA	6	1;10 – 2;6	SW	Longitudinal
Pollock	2002	USA (Memphis)	162	1;6 – 6;10	SW & CS	Cross-section
Pollock & Berni	2003	USA (Memphis)	165	1;6 – 6;10	SW & CS	Cross-section
Porter & Hodson	2001	USA	520	2;6-8;0	SW	Cross-section
Preisser, Hodson & Paden	1988	USA	60	1;6-2;5	SW	Cross-section
Robb & Bleile	1994	USA	7	0;8-2;1	CS	Longitudinal
Robbins & Klee	1987	USA	90	2;6-6;11	SW	Cross-section
Roberts, Burchinal & Footoo	1990	USA	145	2;6-8;0	SW	Cross-section & longitudinal
Selby, Robb & Gilbert	2000	USA	4	1;3-3;0	CS	Longitudinal
Shriberg	1993	USA	-	-	-	Compilation
Smit	1993b	USA	997	3;0-9;0	SW	Cross-section
Smit	1993a	USA	997	3;0-9;0	SW	Cross-section
Smit, Hand, Frelinger, Bernthal & Bird	1990	USA	997	3;0-9;0	SW	Cross-section
Snow	1994	USA	9	1;0-1;8	CS	Longitudinal
Stoel-Gammon	1985	USA	34	1;3-2;0	CS	Longitudinal
Stoel-Gammon	1987	USA	33	2;0	CS	Cross-section
Templin	1957	USA	480	3;0-8;0	SW	Cross-section
Waring, Fisher & Aitken	2001	Australia	299	3;5 – 7;11	SW	Cross-section
Watson & Scukanec	1997a, b	USA	12	2;0-3;0	CS	Longitudinal

GLOSSARY. Acquired sounds: The age at which a certain percentage (often 75%) of children have acquired a phoneme in initial, medial and final position in single words. (This definition varies with different studies). **Phonetic inventory**: The repertoire of sounds a child can produce, regardless of the adult target. **Syllable shape**: The structure of a syllable within a word. C = consonant; V = vowel

0;0 – 1;0 year

"The interaction between infants and their caregivers lays so many foundations for later learning" (McLaughlin, 1998, p. 192)

NEUROLOGY

Brain weight: at birth is about 25% of its adult weight, grows maximally to 80% of its adult weight during the first few years.
Myelination of the brain begins near six months in utero, achieves it peak growth between birth and the end of the first year, and continues to grow until adulthood.
Wernicke's area: Peak in number of cell connections during the first half of the first year and mature number of connections during the second half of the first year.
Broca's area: Density of cell connections does not peak until 15 months, and does not reach a mature number of connections until 6 to 8 years old.
Hippocampus develops after the child is born, especially during second year of life.
Prefrontal cortex: Cell connections in the prefrontal lobes develop slowly throughout childhood and do not reach maturity until after adolescence (Bleile, forthcoming)

ORAL MECHANISM

Infant cf. adults
Oral space is smaller. Lower jaw smaller and retracted. Sucking pads are present, teeth emerge. Tongue large compared to size of oral cavity and therefore has more restricted movement. (Moves with jaw) Nose breather. Epiglottis and soft palate are in approximation as a protective mechanism .Newborns breathe/swallow at same time. Larynx is higher in newborn Eustachian tube lies in horizontal position. (More vertical in adults)

PERCEPTION

"By at least 2 days of age, the neonate has an ability to discriminate language specific acoustic distinctions…The 12 month old human has developed the capacity to categorise only those phonemes which are in its native language" (Ruben, 1997, p. 203)

VOCALISATION

0-6 weeks = reflexive vocalisations: cry, fuss
6-16 weeks = coo and laughter: vowel-like
16-30 weeks = syllable-like vocalisations
(Stark, Bernstein, & Demorest, 1983)
0-0;2 = phonation, quasivowels & glottals
0;2-0;3 = primitive articulation stage: gooing
0;4-0;5= expansion stage: full vowels, raspberries, marginal babbling
(Oller, Eilers, Neal & Schwartz, 1999)

BABBLING

"Late onset of canonical babbling may be a predictor of disorders… [ie.] smaller production vocabularies at 18, 24 & 36 mths" (Oller, Eilers, Neal & Schwartz, 1999, p. 223)

31-50 weeks = reduplicated babbling: series of consonant and vowel-like elements (Mitchell, 1997; Stark, 1979)
0;6+ = canonical stage: well-formed canonical syllables, reduplicated sequences (e.g., [babababa]) (Oller et al., 1999)

"The sounds babbled most frequently are produced more accurately by English-learning 2-year-olds, and appear more often in the languages of the world, than other sounds." (Locke, 2002, p. 249).

CRYING

Mean amount of crying /24 hours
1-3 months = 90 mins, mostly in the evening
4-6 months = 64.7 mins, mostly afternoon
7-9 months = 60.5 mins, afternoon/evening
10-12 months = 86.4 mins, mostly evening
Other studies show decrease at 10+ months
(McGlaughlin & Grayson, 2003)

PHONETIC INVENTORY

Consonants

Age	Position	No.	Typical consonants
0;8	initial	5	d, t, k, m, h
	final	3	t, m, h
0;9	initial	5	d, m, n, h, w
	final	2	m, h
0;10	initial	6	b, d, t, m, n, h
	final	4	t, m, h, s
0;11	initial	4	d, m, n, h
	final	2	m, h
1;0	initial	5	b, d, g, n, m, h
	final	2	m, h

Table data from Robb & Bleile (1994)
Nasal, plosive, fricative, approximant, labial, lingual (Grunwell, 1981)

Vowels
"Low, non-rounded vowels are favoured in the first year. Front-back vowel differences appear later than height differences" (Donegan, 2002)

PHONOLOGICAL PROCESSES

Present
All phonological processes (Grunwell, 1987)

SYLLABLE STRUCTURE

Primarily mono-syllabic utterances (Bauman-Waengler, 2000, p. 99)

PROSODY

0;10 – 1;0 = Begin with falling contour only. Flat or level contour, usually accompanied by variations such as falsettos or variations in duration of loudness (Marcos, 1987 adapted by Bauman-Waengler, 2000)

LANGUAGE

Perlocutionary stage (0 – 0;6+)
Listeners infer intentions: imposing communicative significance on children's verbal and nonverbal behaviours (e.g., cry, gaze, social smiles). Turn-taking dialogues (protoconversations). Motherese important.
Illocutionary stage (0;6-1;0+)
Intentionality: behaviour consciously directed towards influencing others to act on an object. Joint reference and joint action with others. Protodeclaratives (shared attention – often achieved by pointing or showing) and protoimperatives (requests for action) Primitive speech acts include: calling, greeting, requesting an action, protesting an action, repeating or practicing (Dore, 1974) (summarized in McLaughlin, 1998)

ACTIVITY

0;2 = achieves visual focus, lifts head (prone) 0;3 = reaches and grasps 0;4 = establishes head control 0;5 = sits with support, mouths objects 0;6 = improved jaw control for chewing 0;7 = crawls & pulls to standing 0;8 = manipulates objects 0;9 = stands briefly, claps 0;10 = drinks from cup 0;11 takes first steps (McLaughlin, 1998)

1;0 – 2;0 years

"…from 18 to 24 months…the largest growth within the phonological system takes place…also…the child's expressive vocabulary has at least tripled" (Bauman-Waengler, 2000, p. 107)

ORAL MECHANISM

Deciduous teeth continue to emerge

ACQUIRED SOUNDS

Consonants (females)
2;0 = /m, n, h, g/ (Chirlian & Sharpley, 1982)
Consonants (males)
2;0 = /m, n/ (Chirlian & Sharpley, 1982)
Consonant clusters
?
Vowels
?

PERCENT CORRECT

Consonants
2;0 = 69.2 (range 53-91)
(Watson & Scukanec, 1997b)
Consonant clusters
?
Vowels (American -nonrhotic)
1;6-1;11 = 82% (range = 69-96)
(Pollock & Berni, 2003)

INTELLIGIBILITY

2;0 = 26-50% intelligible (Weiss, 1982)

PHONETIC INVENTORY

"First words show individual variation in consonants used; phonetic variability in pronunciations" (Grunwell, 1987)
Consonants
/m, p, b, w, n, t, d/ (Grunwell, 1987)
Robb & Bleile (1994) – (see table) (additional age data in journal article,
range = 12 initial, 6 final phones)

Age	Position	No.	Typical consonants
1;0	initial	5	b, d, g, m, h
	final	2	m, h
1;6	initial	6	b, d, m, n, h, w
	final	3	t, h, s
2;0	initial	10	b, d, p, t, k, m, n, h, s, w
	final	4	t, k, n, s

Vowels (American)
1;3 = /ɪ, ʊ, ʌ, ɑ/
1;6 = /i, u, ʊ, ʌ, ɔ, ɑ, æ/
1;9 = /i,ɪ , u, ɛ, o, ʌ, ɔ, ɑ/
2;0 = /i, ɪ, u, ɛ, e, o, ɔ, ɑ, æ/
(Selby, Robb & Gilbert, 2000)

COMMON MISMATCHES

Consonants
?
Consonant clusters
?

PHONOLOGICAL PROCESSES

Present
Final consonant deletion, cluster reduction, fronting of velars, stopping, gliding, context sensitive voicing (Grunwell, 1987)

Declining
Reduplication, consonant harmony (Grunwell, 1987)

SYLLABLE STRUCTURE

?

PROSODY

Young children acquire skills that control intonation earlier than final syllable timing skills (Snow, 1994).
1;1 – 1;3 = Rising contour. High falling contour that begins with a high pitch and drops to a lower one
prior to 1;6 = high rising and high rising-falling contour
around 1;6 = falling-rising contour. Rising-falling contour (Marcos, 1987 adapted by Bauman-Waengler, 2000)

METALINGUISTIC SKILLS

1;6-2;0 = monitor own utterances: repair spontaneously, adjust speech to different listeners, practice sounds, words, sentences (Clark, adapted by Owens, 1996, p. 386)

LANGUAGE

Invented words
Children frequently use invented words in a phonetically consistent manner without a recognisable adult model. Called "proto-words" (Menn, 1978) or "phonetically consistent forms" (Dore et al., 1976).
Brown's Stage 1 (1;0 – 2;2)
MLU 1.0 = 2.0
First words; Semantic roles expressed in simple sentences. Single word utterances. Semantic roles (e.g. agent + action)
(Brown, adapted by McLaughlin, 1998)

ACTIVITY & PARTICIPATION

Social and emotional
12-18 months = refine emotions
18+ months = development of self-concept
(Bridges & Sroufe, adapted by Slee, 2002)
Cognitive: Sensorimotor period
1;0- 1;6 = Tertiary circular reactions: experimentation, actively seeking novelty
1;6-2;0 = Representational thought: mental reasoning about a problem before acting
(Piaget, adapted by Slee, 2002)
Motor
0;11 takes first steps
1;1 uses common objects appropriately
1;2 picks up small objects with thumb/finger
1;3 builds tower of 3-4 blocks
1;4 scribbles lines on paper
1;5 walk and run unassisted
1;6 walks up stairs
1;7 catches ball crudely
1;8 scribbles in circles
1;9 jump lifting both feet off the floor
1;10 climb, squat, kick a ball
1;11 put shoes on part way
2;0 turn book pages 2 or 3 at a time
(McLaughlin, 1998)

2;0 – 3;0 years

"Unlike toddlers, preschoolers develop more freedom of movement and therefore, soon become trailblazers in every sense of the word" (McLaughlin, 1998, p. 271

ORAL MECHANISM

During first 3 years of life:

Oral space enlarges. Growth of lower jaw + other bony structures. Disappearance of sucking pads. Increased muscle tone and "skilled" tongue movement. (Tongue movement become dissociated from jaw movement. Important for feeding & speech) Lowering & more sophisticated movement of larynx. Separation of epiglottis & soft palate.

DDK (2;6 – 2;11)

/pʌ/= 3.7 per second; /tʌ/ = 3.7 per second

/kʌ/ = 3.65 per second; patticake = 1.26/sec

(Robbins & Klee, 1987)

Maximum phonation time

2;6 – 2;11 = 5.55sec (Robbins & Klee, 1987)

ACQUIRED SOUNDS

Consonants (females)

≤3;0 = /m, n, h, w, p, b, t, d, k, g, f/

3;0 = + / s/ (Smit, et al., 1990)

2;0 = /m, n, h, g/

2;6 = + / p, ŋ, w, t, d, k/

3;0 = + / j, f/ (Chirlian & Sharpley, 1982)

3;0 = /h, ŋ, p, m, w, b, n, d, t, k, ʒ, f/

(Kilminster & Laird, 1978)

Consonants (males)

≤3;0 & 3;0 = /m, n, h, w, p, b, t, d, k, g/ (Smit, et al., 1990)

2;0 = /m, n/

2;6 = + / ŋ, d/

3;0 = + / p, b, h, w, k, g/ (Chirlian & Sharpley, 1982)

3;0 = /h, ŋ, p, m, w, b, n, d, j, g, ʒ/

(Kilminster & Laird, 1978)

Consonant clusters

"Two-year-old children can produce consonant clusters, but these may not be of the same form as the ambient language" (McLeod, van Doorn & Reed, 2001a).

Vowels

"The literature on vowel development suggests that vowels are acquired early, both in production and perception. There is considerable variability in their production, but most studies suggest that vowel production is reasonably accurate by age 3, although some studies call this into question." (Donegan, 2002, p. 2)

1;10-2;6= /i, ɑ/ mastered early. /e, æ/ next. /ɪ, ɛ/ least accurate

(Otomo & Stoel-Gammon, 1992)

PERCENT CORRECT

Consonants

2;0 = 69.2% (range 53-91)
2;3 = 69.9% (range 51-91)
2;6 = 75.1% (range 61-94)
2;9 = 82.1% (range 63-96)
3;0 = 86.2% (range 73-99)
(Watson & Scukanec, 1997b)
PCC = 70% (Stoel-Gammon, 1987)

Consonant clusters

2;0-3;4 = 29.5% (mean); 0.0 - 79.1% (range) in conversational speech
(McLeod, van Doorn & Reed, 2001b)

Vowels (American - nonrhotic)

2;0-2;5 = 92.4% (range = 78-100)
2;6-2;11 = 93.9% (range = 78-100)
(Pollock, 2002; Pollock & Berni, 2003)

Vowels (American - rhotic)

2;0-2;5 = 37.5% (range = 0-87)
2;6-2;11 = 62.5% (range = 0-100)
(Pollock, 2002)

INTELLIGIBILITY

2;0 = 26-50% intelligible (Weiss, 1982)
2;6 = 51-70% intelligible (Weiss, 1982)
3;0 = 71-80% intelligible (Weiss, 1982)
3;0 = 73% (50-80%) intelligible judged by three unfamiliar listeners. The children who used more complex sentences were more difficult to understand (Vihman, 1988)

PHONETIC INVENTORY

Consonants (word-initial)

9-10 consonants (Stoel-Gammon, 1987)
2;0 = /p, b, t, d, k, m, n, s, f, h, w, j/
2;3 = /p, b, t, d, k, g, m, n, s, f, h, w, j, l/
2;6 = /p, b, t, d, k, g, m, n, s, f, h, tʃ, w, j, l/
2;9 = /p, b, t, d, k, g, m, n, s, f, h, tʃ, w, j, l/
3;0 = /p, b, t, d, k, g, m, n, s, f, h, tʃ, ð, w, j, l/ (Watson & Scukanec, 1997b)

/m, p, b, w, n, t, d, (ŋ), (k), (g), h/

(Grunwell, 1987)

2;0, 2;5, 2;9 = /p, b, t, d, k, g, f, s, h, m, n, w, j, l/ (Dyson, 1988)

Consonants (word-final)

5-6 final consonants (Stoel-Gammon, 1987)
2;0 = /p, t, k, m, n, s, z/
2;3 = /p, t, d, m, n, s, z/
2;6, 2;9, 3;0 = /p, t, d, k, m, n, s, z, l, r/ (Watson & Scukanec, 1997b)

2;0 = /p, t, d, k, tʃ, ʔ, f, s, ʃ, m, n/

2;5 = /p, t, d, k, tʃ, ʔ, f, s, ʃ, m, n, ŋ, ɚ/

2;9 = /p, t, k, ʔ, f, s, ʃ, m, n, ɚ/(Dyson, 1988)

Consonant clusters

"A few clusters" (Stoel-Gammon, 1987)

2;6 = /pw, bw, -nd, -ts/
2;9 = /pw, bw, bl, -nd, -ts, -nt, -nz/
3;0 = /st, sp, pl, -nd, -ts, -nt, -nz, -st, -ŋk/ (Watson & Scukanec, 1997b)

2;0 = /fw, -ts (-ŋk)/

2;5 = /(fw), (bw), -ts, (-ps), (ntʃ), (ŋk)//

2;9 = /(fw), (kw), (-ps), (-ts), (-nts), (-ŋk)/

(Dyson, 1988)

2;0 = predominantly word-initial consonant clusters containing /w/ (e.g., [bw, kw])
3;0 = range of word-initial clusters predominantly containing /l/, /w/ or /s/. Common word-final clusters contained nasals (e.g., [-nd, -nt, -ŋk]).

(McLeod, van Doorn & Reed, 2001b)

Vowels

2;0 = /i, ɪ, u, ɛ, e, o, ɔ, ɑ, æ/

3;0 = /i, ɪ, u, ʊ, ɛ, e, o, ʌ, ɔ, ɜ, ɑ, æ/

(Selby, Robb & Gilbert, 2000)

COMMON MISMATCHES

Consonants (>15%)

n→ ŋ; j→ ø; l→ w; r→ w; v→b; θ→f; ð→ d; s→ dentalised; z→d; ʃ→ s; tʃ→ t/d; ʒ→d (Smit, 1993a)

Consonant clusters (>15%)

pr→p, pw; br→b, bw; tr→t, tw; dr→d, dw; kr→k, kw; gr→g, gw; fr→f, fw; θr→f, θw; sw→w; sm→m; sn→n; sp→p, b; st→t, d;

sk→k, skw→k, t, kw, gw; spl→p, b, pl, pw; spr→p, pw, pr, sp; str→t, d, st, tw, sw; skr→k, w, kw, gw, fw (Smit, 1993b)

PHONOLOGICAL PROCESSES

Present

Cluster reduction, fronting of velars, fronting /ʃ/, stopping /v, θ, ð, tʃ, dʒ/, gliding, context sensitive voicing (Grunwell, 1987)

Most prevalent = cluster reduction & liquid deviations (gliding) (Preisser et al., 1988)

2;0 = final consonant deletion, liquid simplification, later stopping, cluster reduction, vowelisation
3;0 = later stopping, cluster simplification (Watson & Scukanec, 1997b)

2;7-3;0 = 23% fronting (Lowe, Knutson & Monson, 1985)

Declining

Final consonant deletion (Grunwell, 1987)
Affrication, depalatisation, gliding, meathesis, prevocalic voicing, , vowel changes (James, 2001)

SYLLABLE STRUCTURE

Syllable shapes

CV, CVC, CVCV, CVCVC (Stoel-Gammon, 1987)
CV, VC, CVC, 2-syllable (Shriberg, 1993)
Monosyllabic words - V, CV, VC, CVC, CCVC, CVCC, CCVCC, CCVCCC, CCCCVC
Polysyllabic words - V, CV, VC, CVC, CCVC (Dodd, 1995; Watson & Skucanec, 1997)

PROSODY

"Significantly greater number of stress errors in SWS words (S = strong; W = weak). Tendency for greater number of stress errors in SWSW words. Stress errors were more frequent in imitated than spontaneous productions." (Kehoe, 1997).
"An analysis of children's truncation error syllable deletion patterns revealed the following robust findings:
(a) Stressed and word-final unstressed syllables are preserved more frequently than nonfinal unstressed syllables,
(b) word-internal unstressed syllables with obstruent onsets are preserved more frequently than word-internal syllables with sonorant onsets,
(c) unstressed syllables with non-reduced vowels are preserved more frequently than unstressed syllables with reduced vowels,
(d) right-sided stressed syllables are preserved more frequently than left-sided stressed syllables.
An analysis of children's stress patterns revealed that children made greater numbers of stress errors in target words with irregular stress." (Kehoe, 2001, p. 284)

METALINGUISTIC SKILLS

1;6-2;0 = monitor own utterances: repair spontaneously, adjust speech to different listeners, practice sounds, words, sentences (Clark, adapted by Owens, 1996, p. 386)

LANGUAGE

MLU

2;0 = 2.1 (range 1.2-3.2)
2;3 = 2.4 (range 1.7-3.8)
2;6 = 2.8 (range 2.1-3.6)
2;9 = 3.5 (range 2.1-5.2)
3;0 = 3.8 (range 3.3-4.7)
(Watson & Scukanec, 1997b)

Brown's Stage II (2;3 – 2;6)

MLU = 2.0 – 2.5
Modulation of meaning. Emergence of grammatical morphemes (e.g. plurals)

Brown's Stage III (2;7 – 2;10)

MLU = 2.5 – 3.0
Development of sentence form. Noun phrase elaboration and auxiliary development (questions and negatives) (Brown, adapted by McLaughlin, 1998)

PREDICTORS

Trends of typical consonant cluster development (McLeod et al., 2001a)

1. Two-year-old children can produce consonant clusters, but these clusters may not be of the same form as the ambient language.
2. Word-final consonant clusters generally appear in inventories earlier than word-initial clusters.
3. Two-element consonant clusters are generally produced and mastered earlier than three-element clusters.
4. Consonant clusters containing stops (e.g., /pl/, /kw/) are acquired generally before consonant clusters containing fricatives (e.g., /st/, /θr/).
5. Young children typically delete one element of a consonant cluster (cluster reduction).
6. Homonymy occurs in young children's attempts to produce consonant clusters. Homonymy frequently occurs as a result of cluster reduction; however, homonyms can also occur as a result of cluster creation.
7. There are a number of other non-adult realisations of consonant clusters; the most common is cluster simplification, with others including epenthesis and coalescence. Metathesis is rare.
8. The acquisition of consonant clusters is gradual and there is a typical developmental sequence. It is not an all-or-nothing process. For word-initial clusters, children may initially delete a member of a consonant cluster (one element realisation), then preserve the members but one may be produced in a non-adult manner (two element realisation), and finally they will produce the consonant cluster correctly (correct realisation). Other developmental sequences are possible, particularly for word-final consonant clusters.
9. There is an interrelationship between cluster reduction, cluster simplification and correct productions of consonant clusters. Initially, most children reduce consonant clusters. Over time, the occurrence of cluster reduction diminishes, while the occurrence of cluster simplification increases. Simultaneously, the occurrence of correct productions increases, until eventual mastery of production.
10. Despite there being a typical developmental sequence, the acquisition of consonant clusters is marked by reversals and revisions with considerable individual variation.

Warning signs of impairment at 2 years: Numerous vowel errors, frequent deletion of initial consonants, frequent use of glottal stop or [h] for a variety of consonants, backing (eg: [ku] for "two"), and, final consonant deletion particularly as the child approaches 3 years. (Stoel-Gammon, 1987)

Predictors of late talkers' phonological skills at 2;9: smaller phonetic inventories, less diverse and complex syllable structures, lower PCC scores, sound variability, atypical error patterns, little change in development across time (Williams & Elbert, 2003, p. 150)

3 years "Children with SLI and LD showed a delay in the acquisition of segments, syllabic structures and word structures, and in the simplification processes, compared with their age control group. However, SLI children also displayed significant differences vis-a-vis their language level controls, mainly in early acquisitions: vowels, nasals and stops at the segmental level, and in CV structures at the syllabic level. There is also a simplification process that seems to be more prevalent in these children than in their language level controls, namely, the deletion of unstressed syllables, mainly initial ones." (Aguilar-Mediavilla, Sanz-Torrent, & Serra-Raventos, 2002, p. 573)

3;0 – 4;0 years

"A client 3 years of age or older who is unintelligible is a candidate for treatment" (Bernthal & Bankson, 1998, p. 272)

ORAL MECHANISM

3 yrs = adult-like swallow

DDK (3;0 – 3;5/ 3;6 – 3;11)

/pʌ/= 4.66/ 4.81 per second

/tʌ/ = 4.56/ 4.78 per second

/kʌ/ = 3.82/ 4.83 per second

patticake = 1.36/ 1.75 per second
(Robbins & Klee, 1987)

Maximum phonation time

/a/ = 5.51/ 7.79sec (Robbins & Klee, 1987)

ACQUIRED SOUNDS

"3-year-olds had acquired all major phoneme classes, except liquids…sibilant lisps were still common until the age of 7 years"
(Porter & Hodson, 2001, p.165)

Consonants (females)

3;0 = /m, n, h, w, p, b, t, d, k, g, f, s/
3;6 = + / j /
4;0 = +/ v, ð, ʃ, tʃ/ (Smit, et al., 1990)

3;0 = / m, n, h, g, p, ŋ, w, t, d, k, j, f/
3;6 = + / b, ʃ, tʃ, s/
4;0 = + /l, ʒ, dʒ/ (Chirlian & Sharpley, 1982)

3;0 = /h, ŋ, p, m, w, b, n, d, t, k, ʒ, f/
3;6 = +/ j, g, l /
4;0 = + / ʃ, tʃ, dʒ / (Kilminster & Laird, 1978)

Consonants (males)

3;0 = /m, n, h, w, p, b, t, d, k, g/
3;6 = + / j, f /
4;0 = +/ dʒ / (Smit, et al., 1990)

3;0 = / m, n, ŋ, d, p, b, h, w, k, g/
3;6 = + /j, t, f, l, ʃ, tʃ, dʒ/
4;0 = + /s/ (Chirlian & Sharpley, 1982)

3;0 = /h, ŋ, p, m, w, b, n, d, j, g, ʒ/
3;6 = + / k, f /
4;0 = as above (Kilminster & Laird, 1978)

Consonant clusters

3;6 (males & females)= /tw, kw/
4;0 (females) = /tw, kw, pl, bl, kl/
4;0 (males) = /tw, kw/ (Smit, et al., 1990)

4;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, pr, br, tr, dr, kr, gr/ (Templin, 1957)

Vowels

Paradigmatic production (ie production of individual vowels) is generally mastered by 3 years. However, syntagmatic production (production of vowels in context such as polysyllabic words) takes up to at least 6 years (James, van Doorn & McLeod, 2001)

PERCENT CORRECT

Consonants

3;0-3;11 = 76.77% in monosyllabic words
3;0-3;11 = 76.41% in polysyllabic words
(James, van Doorn & McLeod, 2002)
3;5-3;11 = 85.2% (Waring, Fisher, Atkin, 2001)

Consonant clusters

3;5-3;11 = 86.4% (Waring, Fisher, Atkin, 2001)

Vowels (Australian)

3;0-3;11 = 94.9% in monosyllabic words
3;0-3;11 = 88.28% in polysyllabic words
(James, van Doorn & McLeod, 2001)

Vowels (American - nonrhotic)

3;0-3;5 = 97.3% (range = 89-100)
3;6-3;11 = 97.2% (range = 91-100)
(Pollock, 2002; Pollock & Berni, 2003)

Vowels (American - rhotic)

3;0-3;5 = 79.2% (range = 4-100)
3;6-3;11 = 76.5% (range = 4-100)
(Pollock, 2002)

INTELLIGIBILITY

3;0 = 71-80% intelligible (Weiss, 1982)
3;0 = 73% (50-80%) intelligible judged by three unfamiliar listeners (Vihman, 1988)

"A client 3 years of age or older who is unintelligible is a candidate for treatment"
(Bernthal & Bankson, 1998, p. 272)

PHONETIC INVENTORY

Consonants

/m, p, b, w, n, t, d, ŋ, k, g, h, f, w, s, (l), j, h/
(Grunwell, 1987)

initial = /p, b, t, d, k, g, f, s, h, m, n, w, j, l, r/;
final = /p, t, d, k, ʔ, f, v, s, z, ʃ, m, n, ŋ, r, ɚ/
(Dyson, 1988)

Consonant clusters

3;3 = /-ts, (fw), (kw), (tr), (sp), (st), (sn), (sl), (bw), (-ps), (-ns), (-ntʃ), (-ŋk)/ (Dyson, 1988)

Obstruent + approximant used, /s/ clusters may occur (Grunwell, 1987)

3;0 = range of word-initial clusters predominantly containing /l/, /w/ or /s/. Common word-final clusters contained nasals (e.g., [-nd, -nt, -ŋk]).
(McLeod, van Doorn & Reed, 2001b)

COMMON MISMATCHES

Consonants (>15%)

n→ ŋ; r→ w; v→b; θ→f; ð→ d; s→ dentalised (Smit, 1993a)

Consonant clusters (>15%)

pr→pw; br→bw; tr→tw; dr→dw; kr→kw; gr→gw; fr→fw; θr→fr; st→θt; skw→θkw; spl→ θpl, spw; spr→ θpr, spw; str→ θtr, stw; skr→ θkr, skw (Smit, 1993b)

PHONOLOGICAL PROCESSES

Present

Stopping /v, θ, ð/, fronting /ʃ, tʃ, dʒ/, gliding, (Grunwell, 1987)
3;0-3;6 Gliding of liquids, weak syllable deletion, glottal replacement, alveolar & labial assimilation, cluster reduction, stopping, vocalization, final consonant deletion (Haelsig & Madison, 1986)

Declining

Cluster reduction (Grunwell, 1987)
Backing, cluster reduction, deaffrication, final consonant deletion, final devoicing, initial consonant deletion, labial assimilation, palatalisation, stopping, unstressed syllable deletion, fricative simplification (James, 2001)

SYLLABLE STRUCTURE

CV, VC, CVC, Cn_ or _Cn, 2-syllable (Shriberg, 1993)

PROSODY

"…after 2 years of age, deletion of stressed syllables is relatively infrequent, and after 3 years of age, deletion of unstressed syllables is less frequent" (Kehoe, 2001,291)

PHONOLOGICAL AWARENESS

Emerging skills (Dodd & Gillon, 2001)

LANGUAGE

Brown's Stage IV (2;11 – 3;4)

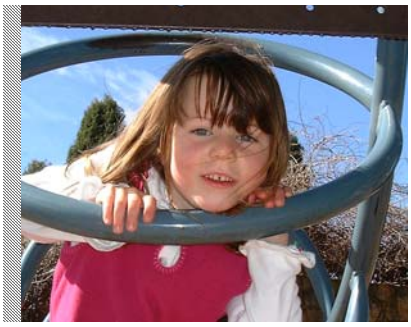
MLU = 3.0 – 3.75 Emergence of complex sentences. Embedding sentence elements.

Brown's Stage V

MLU = 3.75 – 4.50 Compound & conjoining sentences (McLaughlin, 1998)

4;0 – 5;0 years

"Two-year-olds' conversational skills are limited…five-year-old children are producing long, complex sentences…and maintaining a topic for several turns. In a few short years, children move much closer to the adult level of linguistic and communicative competence." (James, 1990, p. 74)



ORAL MECHANISM

DDK (4;0 – 4;5/ 4;6 – 4;11)

/pʌ/= 4.89/ 4.64 per second

/tʌ/ = 4.77/ 4.46 per second

/kʌ/ = 4.58/ 4.29 per second

patticake = 1.56/ 1.33 per second
(Robbins & Klee, 1987)

Maximum phonation time

/a/ = 8.01/ 9.22sec (Robbins & Klee, 1987)

ACQUIRED SOUNDS

Consonants (females)

4;0 = /m, n, h, w, p, b, t, d, k, g, f, s, j, v, ð, ʃ, tʃ/

4;6 = + /dʒ, l/ 5;0 = + /z/ (Smit, et al., 1990)

4;0 = / m, n, h, g, p, ŋ, w, t, d, k, j, f, b, ʃ, tʃ, s, l, ʒ, dʒ/

5;0 = + /r, v / (Chirlian & Sharpley, 1982)

4;0 = /h, ŋ, p, m, w, b, n, d, t, k, ʒ, f, j, g, l, ʃ, tʃ, dʒ/

4;6 = + /s, z/ 5;0 = + /r/ (Kilminster & Laird, 1978)

Consonants (males)

4;0 = /m, n, h, w, p, b, t, d, k, g, j, f , dʒ/

4;6 = + v, z/ 5;0 =+ /s, ʃ, tʃ/(Smit, et al., 1990)

4;0 = / m, n, ŋ, d, p, b, h, w, k, g, j, t, f, l, ʃ, tʃ, dʒ, s/

4;6 = + /ʒ/ 5;0 = + /r/ (Chirlian & Sharpley, 1982)

4;0 = /h, ŋ, p, m, w, b, n, d, j, g, ʒ, k, f /

4;6 = /t, l, ʃ, tʃ, dʒ/

5;0 = /r/ (Kilminster & Laird, 1978)

Consonant clusters (all children)

4;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, pr, br, tr, dr, kr/

4;6 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, pr, br, tr, dr, kr, gr, fr/

5;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, str/ (Templin, 1957)

Consonant clusters (females)

4;0 = /tw, kw, pl, bl, kl/

4;6 = /tw, kw, sp, st, sk, sw, pl, bl, kl, gl, fl, kr, skw/

5;0 = same as for 4;6 (Smit, et al., 1990)

Consonant clusters (males)

4;0 = /tw, kw/

4;6 = /tw, kw, gl/

5;0 = /tw, kw, sp, st, sn, bl, gl, dr/
(Smit, et al., 1990)

Vowels

Paradigmatic production (ie production of individual vowels) is generally mastered by 3 years. However syntagmatic production (production of vowels in context such as polysyllabic words) takes up to at least 6 years of age.
(James, van Doorn & McLeod, 2001)

PERCENT CORRECT

Consonants

4;0-4;11 = 83.97% in monosyllabic words
4;0-4;11 = 82.45% in polysyllabic words
(James van Doorn & McLeod, 2002)
4;0-4;11 = 88.5% (Waring, Fisher, Atkin, 2001)

Consonant clusters

4;0-4;11 = 88.1% (Waring, Fisher, Atkin, 2001)

Vowels (Australian)

4;0-4;11 = 95.2% in monosyllabic words
4;0-4;11 = 92.08% in polysyllabic words
(James van Doorn & McLeod, 2001)

Vowels (American - nonrhotic)

4;0-4;5 = 98% (range = 91-100)
4;6-4;11 = 99% (range = 94-100)
(Pollock, 2002; Pollock & Berni, 2003)

Vowels (American - rhotic)

4;0-4;5 = 90.1% (range = 37-100)
4;6-4;11 = 86.8% (range = 0-100)
(Pollock, 2002)

INTELLIGIBILITY

"A client 3 years of age or older who is unintelligible is a candidate for treatment" (Bernthal & Bankson, 1998, p. 272)

4;0 = 93% (73-100%) intelligible in conversational speech with unfamiliar listeners (Gordon-Brannan, 1993 cited in Gordon-Brannan, 1994).

PHONETIC INVENTORY

Consonants

/m, p, b, w, n, t, d, ŋ, k, g, h, f, v, w, s, z, ʃ, tʃ, dʒ, l, r, j, h/ (Grunwell, 1987)

Consonant clusters

obstruent + approximant; /s/ clusters (may be "immature") (Grunwell, 1987)

COMMON MISMATCHES

Consonants (>15%)

θ→f; s→ dentalised (Smit, 1993a)

Consonant clusters (>15%)

pr→pw; br→bw; tr→tw; dr→dw; kr→kw; gr→gw; fr→fw; θr→fr; st→θt; skw→θkw; spl→ θpl, spw; spr→ θpr, spw; str→ θtr, stw; skr→ θkr, skw (Smit, 1993b)

PHONOLOGICAL PROCESSES

Present

/θ/ -> [ŋ], /ð/ -> [d, v], palatisation of /ʃ, tʃ, dʒ/, gliding (Grunwell, 1987)

4;0-4;6 Weak syllable deletion, vocalization, gliding of liquids (20% criterion)
(Haelsig & Madison, 1986)

Declining

Cluster reduction (Grunwell, 1987)
Depalatalisation, gliding, glottal replacement (James, 2001)

SYLLABLE STRUCTURE

CV, VC, CVC, Cn_, _Cn, Cn_Cn, 2-syllable, 3-syllable (Shriberg, 1993)

PHONOLOGICAL AWARENESS

"The majority of 4-year-old children… will not exhibit phonological awareness other than syllable segmentation and the emergence of rhyme awareness" (Dodd & Gillon 2001,142)

LANGUAGE

"Preschool children show significant growth in their ability to understand and use words, including a variety of relational terms. Their ability to produce and understand various types of sentences, including questions and complex sentences, also develops tremendously…These remarkable developments …are accompanied by equally remarkable developments in the child's pragmatic abilities." (James, 1990, p. 106)

5;0 – 6;0 years

"By the time children enter school, their phonological development has progressed considerably" (Bauman-Waengler, 2000, p. 118)

ORAL MECHANISM

Teeth

May lose front incisors

DDK (5;0 – 5;5/ 5;6 – 5;11)

/pʌ/= 4.76/ 5.09 per second

/tʌ/ = 4.82/ 5.22 per second

/kʌ/ = 4.56/ 4.91 per second

patticake = 1.58/ 1.65 per second

(Robbins & Klee, 1987)

Maximum phonation time

/a/ = 8.06/ 9.42sec (Robbins & Klee, 1987)

ACQUIRED SOUNDS

Consonants

"By age 5, /l/ was acquired (93.4%) and /r/ was almost at criterion (84.8%). By age 6, all of the phonological deviation means, including liquids, were less than 5%." (Porter & Hodson, 2001, p. 169)

Consonants (females)

5;0 = /m, n, h, w, p, b, t, d, k, g, f, s, j, v, ð, ʃ, tʃ, dʒ, l , z/

5;6 = + /ŋ, θ/

6;0 = + /r/ (Smit, et al., 1990)

5;0 = / m, n, h, g, p, ŋ, w, t, d, k, j, f, b, ʃ, tʃ, s, l, ʒ, dʒ r, v/

No more at 5;6 or 6;0 (Chirlian & Sharpley, 1982)

5;0 = /h, ŋ, p, m, w, b, n, d, t, k, ʒ, f, j, g, l, ʃ, tʃ, dʒ, s, z, r/

5;6 = + / v/ (Kilminster & Laird, 1978)

Consonants (males)

5;0 = /m, n, h, w, p, b, t, d, k, g, j, f , dʒ, v, z, s, ʃ, tʃ/

5;6 = /ð, r/

6;0 = /ŋ, θ, z, l/ (Smit, et al., 1990)

5;0 = / m, n, ŋ, d, p, b, h, w, k, g, j, t, f, l, ʃ, tʃ, dʒ, s, ʒ , r/

No more at 5;6 or 6;0 (Chirlian & Sharpley, 1982)

5;0 = /h, ŋ, p, m, w, b, n, d, j, g, ʒ, k, f, t, l, ʃ, tʃ, dʒ, r/

No more 5;6 or 6;0 (Kilminster & Laird, 1978)

Consonant clusters (all children)

5;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, str/

6;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, skw, str/ (Templin, 1957)

Consonant clusters (females)

5;0 = /tw, kw, sp, st, sk, sw, pl, bl, kl, gl, fl, kr, skw/

5;6 = /tw, kw, sp, st, sk, sm, sn, sw, pl, bl, kl, gl, fl, kr, skw/

6;0 = /tw, kw, sp, st, sk, sm, sn, sw, sl, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, skw, spl/ (Smit, et al., 1990)

Consonant clusters (males)

5;0 = /tw, kw, sp, st, sn, bl, gl, dr/

5;6 = /tw, kw, sp, st, sn, pl, bl, kl, gl, fl, pr, tr, kr, gr, fr, dr/

6;0 = /tw, kw, sp, st, sk, sn, sw, pl, bl, kl, gl, fl, pr, br, tr, kr, gr, fr, dr/ (Smit, et al., 1990)

Vowels

Paradigmatic production (ie production of individual vowels) is generally mastered by 3 years. However syntagmatic production (production of vowels in context such as polysyllabic words) takes up to at least 6 years of age. (James et al., 2001)

PERCENT CORRECT

Consonants

5;0-5;11 = 89.54% in monosyllabic words

5;0-5;11 = 88.36% in polysyllabic words

(James van Doorn & McLeod, 2002)

5;0-5;11 = 93.4% (Waring, Fisher, Atkin, 2001)

Consonant clusters

5;0-5;11 = 94.9% (Waring, Fisher, Atkin, 2001)

Vowels (Australian)

5;0-5;11 = 94.8% in monosyllabic words

5;0-5;11 = 94.3% in polysyllabic words

(James van Doorn & McLeod, 2001)

Vowels (American -nonrhotic)

5;0-5;5 = 99% (range = 98-100)

5;6-5;11 = 99% (range = 98-100)

(Pollock, 2002; Pollock & Berni, 2003)

Vowels (American - rhotic)

5;0-5;5 = 88.2% (range = 0-100)

5;6-5;11 = 80.31% (range = 0-100)

(Pollock, 2002)

INTELLIGIBILITY

Intelligible (Gordon-Brannan, 1994)

PHONETIC INVENTORY

Consonants

/m, p, b, w, n, t, d, ŋ, k, g, h, f, v, θ, ð, w, s, z, ʃ, ʒ, tʃ, dʒ, l, r, j, h/ (Grunwell, 1987)

COMMON MISMATCHES

Consonants (>15%)

Nil (Smit, 1993a)

Consonant clusters (>15%)

> 5;6 = pr→pw; br→bw; tr→tw; dr→dw; kr→kw; gr→gw; skw→θkw; spl→ θpl, spw; spr→ θpr, spw; str→ θtr, stw; skr→ θkr, skw (Smit, 1993b)

PHONOLOGICAL PROCESSES

Declining

Deaffrication, epenthesis, metathesis, fricative simplification (v/ð) (James, 2001)

SYLLABLE STRUCTURE

CV, VC, CVC, Cn_, _Cn, Cv_Cn, 2 syllable, 3+ syllable (Shriberg, 1993)

PROSODY

Significant differences were found between children with language impairment and normally developing peers on: form (chunking input, chunking output) and function (focus input, interaction input, interaction output) (Wells & Peppé, 2003)

PHONOLOGICAL AWARENESS

Established skills (Australia + UK)

5;0 – 5;5 = syllable segmentation, rhyme awareness, alliteration awareness, phoneme isolation (+ letter knowledge, UK)

5;6 – 5;11 = phoneme segmentation (Dodd & Gillon, 2001)

LANGUAGE

"By the time children start school… they have a fairly large vocabulary and can talk about relationships among objects and events; and they are able to produce and understand a variety of simple as well as complex sentences; and they are able to express various communicative intents, carry on conversations, and adapt their speech style to their listeners. However, language development is not complete…" (James, 1990, p. 134)

6;0+ years

"As time goes on, it becomes more difficult to clearly number the individual developments. Major changes may be less specific…" (McLaughlin, 1998, p. 353)

ORAL MECHANISM

6 yrs = skull reaches adult size
6 yrs = permanent teeth emerge
7-10yrs = lower face "growth spurt"
9-13 = tongue and lips "growth spurt"
Mandible + tongue + lips continue to grow until 16 yrs (girls) and 18 yrs (boys)
(Bauman-Waengler, 2000)

DDK (6;0 – 6;5/ 6;6 – 6;11)
/pʌ/= 5.36/ 5.51 / sec /tʌ/ = 5.32/ 5.37 /sec
/kʌ/ = 4.94/ 4.85 /sec patticake = 1.61/ 1.64
(Robbins & Klee, 1987)

Maximum phonation time
/a/ = 10.99/11.47sec (Robbins & Klee, 1987)

ACQUIRED SOUNDS

Consonants (females)
6;0 = ALL = /m, n, h, w, p, b, t, d, k, g, f, s, j, v, ð, ʃ, tʃ, dʒ, l , z, ŋ, θ, r/ (Smit, et al., 1990)

6;0 = / m, n, h, g, p, ŋ, w, t, d, k, j, f, b, ʃ, tʃ, s, l, ʒ, dʒ r, v/
7;6 = + /θ, ð/ (Chirlian & Sharpley, 1982)

6;0 = /h, ŋ, p, m, w, b, n, d, t, k, ʒ, f, j, g, l, ʃ, tʃ, dʒ, s, z, r, v/
7;6 = + /θ, ð/ (Kilminster & Laird, 1978)

Consonants (males)
6;0 = / m, n, ŋ, d, p, b, h, w, k, g, j, t, f, l, ʃ, tʃ, dʒ, s, ʒ , r/
7;6 = +/ð/ 8;0 = + /θ/
9;0 = + /v/ (/z/ not achieved) (Chirlian & Sharpley, 1982)

6;0 = ALL = /m, n, h, w, p, b, t, d, k, g, j, f , dʒ, v, z, s, ʃ, tʃ, ð, r, ŋ, θ, z, l/
(Smit, et al., 1990)

6;0 = /h, ŋ, p, m, w, b, n, d, j, g, ʒ, k, f, t, l, ʃ, tʃ, dʒ, r/
6;6 = + /s, z, v/ (/θ, ð/ not achieved by 9;0)
(Kilminster & Laird, 1978)

Consonant clusters (all children)
6;0 = /tw, kw, sp, st, sk, sm, sn, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, skw, str/
7;0 = /tw, kw, sp, st, sk, sm, sn, sw, sl, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, θr, skw, spl, spr, str, skr/ (Templin, 1957)

Consonant clusters (females)
6;0 = /tw, kw, sp, st, sk, sm, sn, sw, sl, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, skw, spl/
7;0 = /tw, kw, sp, st, sk, sm, sn, sw, sl, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, θr, skw, spl/
8;0 = /tw, kw, sp, st, sk, sm, sn, sw, sl, pl, bl, kl, gl, fl, pr, br, tr, dr, kr, gr, fr, θr, skw, spl, spr, str, skr/ (Smit, et al., 1990)

Consonant clusters (males)
6;0 = /tw, kw, sp, st, sk, sn, sw, pl, bl, kl, gl, fl, pr, br, tr, kr, gr, fr, dr/ (Smit, et al., 1990)
7;0 = + / sm, sl, θr, skw, spl/
8;0 = + / spr, str, skr/ (Smit, et al., 1990)

Vowels
Paradigmatic production (ie production of individual vowels) is generally mastered by 3 years. However syntagmatic production (production of vowels in context such as polysyllabic words) takes up to at least 6 years of age.
(James, van Doorn & McLeod, 2001)

PERCENT CORRECT

Consonants
6;0-6;11 = 93.74% in monosyllabic words
6;0-6;11 = 90.76% in polysyllabic words
7;0-7;11 = 93.93% in monosyllabic words
7;0-7;11 = 90.99% in polysyllabic words
(James van Doorn & McLeod, 2002)
6;0-6;11 = 95.1%
7;0-7;11 = 98.4% (Waring, Fisher, Atkin, 2001)

Consonant clusters
6;0-6;11 = 96.6%
7;0-7;11 = 98.3% (Waring, Fisher, Atkin, 2001)

Vowels (Australian)
6;0-6;11 = 95.39% in monosyllabic words
6;0-6;11 = 94.86% in polysyllabic words
7;0-7;11 = 95.10% in monosyllabic words
7;0-7;11 = 95.44% in polysyllabic words
(James van Doorn & McLeod, 2001)

Vowels (American - nonrhotic)
6;0-6;5 = 98.5% (range = 94-100)
6;6-6;10 = 99.2% (range = n/a)
(Pollock, 2002; Pollock & Berni, 2003)

Vowels (American - rhotic)
6;0-6;5 = 80.3% (range = 0-100)
6;6-6;10 = 77.2% (range = 2-100)
(Pollock, 2002)

INTELLIGIBILITY

Intelligible (Gordon-Brannan, 1994).

PHONETIC INVENTORY

Consonants
ALL - /m, p, b, w, n, t, d, ŋ, k, g, h, f, v, θ, ð, w, s, z, ʃ, ʒ, tʃ, dʒ, l, r, j, h/
(Grunwell, 1987)

COMMON MISMATCHES

Consonants (>15%)
Nil (Smit, 1993a)

Consonant clusters (>15%)
tr→tw; skw→θkw; spl→θpl; spr→θpr, spw; str→θtr, stw; skr→θkr, skw
(Smit, 1993b)

SYLLABLE STRUCTURE

All (Shriberg, 1993)

PROSODY

(Wells & Peppé, 2003)

PHONOLOGICAL AWARENESS

Established skills (Australia)
6;0 – 6;5 = syllable segmentation, rhyme awareness, alliteration awareness, phoneme isolation
6;6 – 6;11 = phoneme segmentation
(Dodd & Gillon, 2001)

Established skills (UK)
6;0 – 6;11 = syllable segmentation, rhyme awareness, alliteration awareness, phoneme isolation, letter knowledge, phoneme segmentation (Dodd & Gillon, 2001)

LANGUAGE

"During the school-age years, children are developing more sophisticated syntactics and semantic forms. They are becoming more effective communicators and conversationalists. They are developing the ability to reflect on the nature of the language system itself. And, they are learning about the written language system." (James, 1990, p. 134)

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