

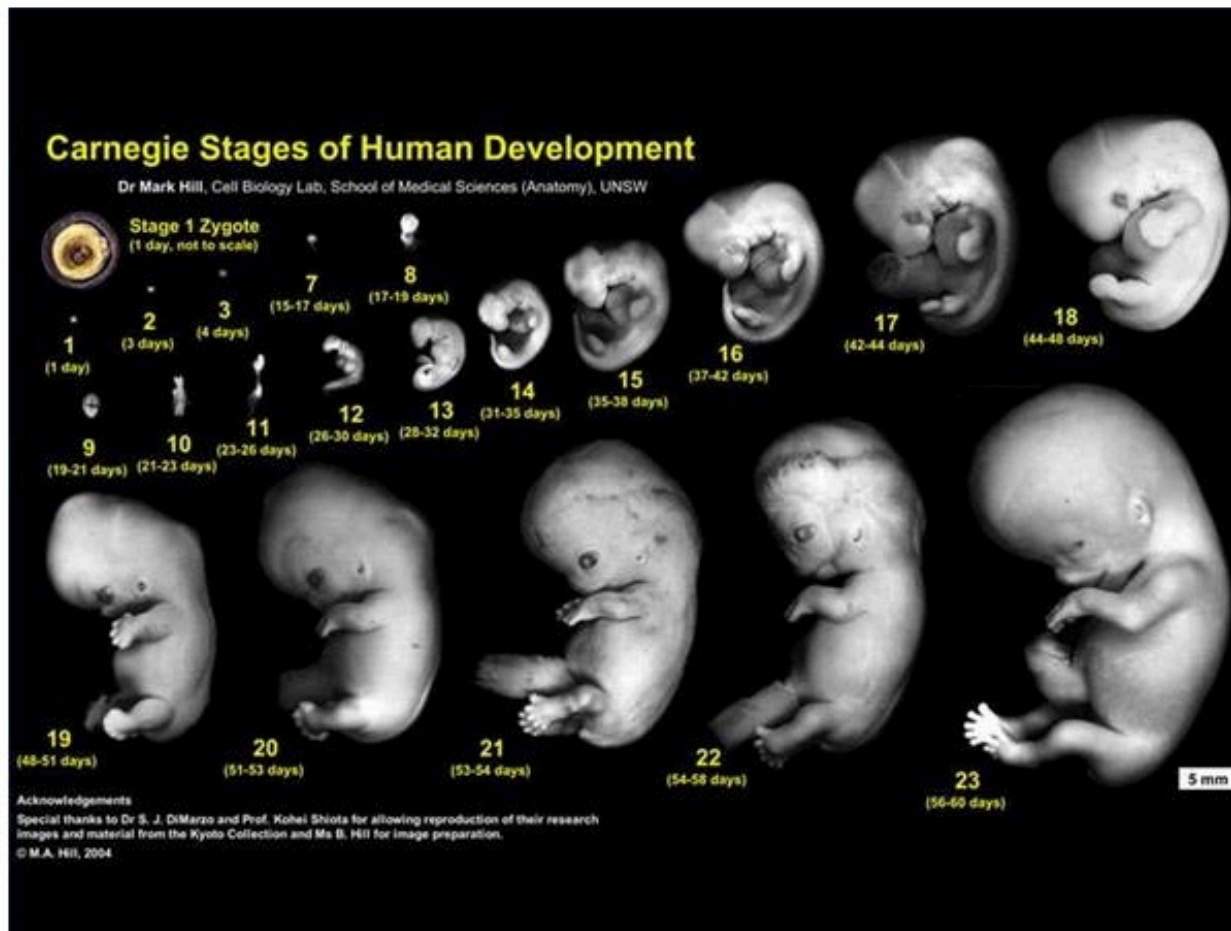
Human Development



Cogs 184 * UCSD

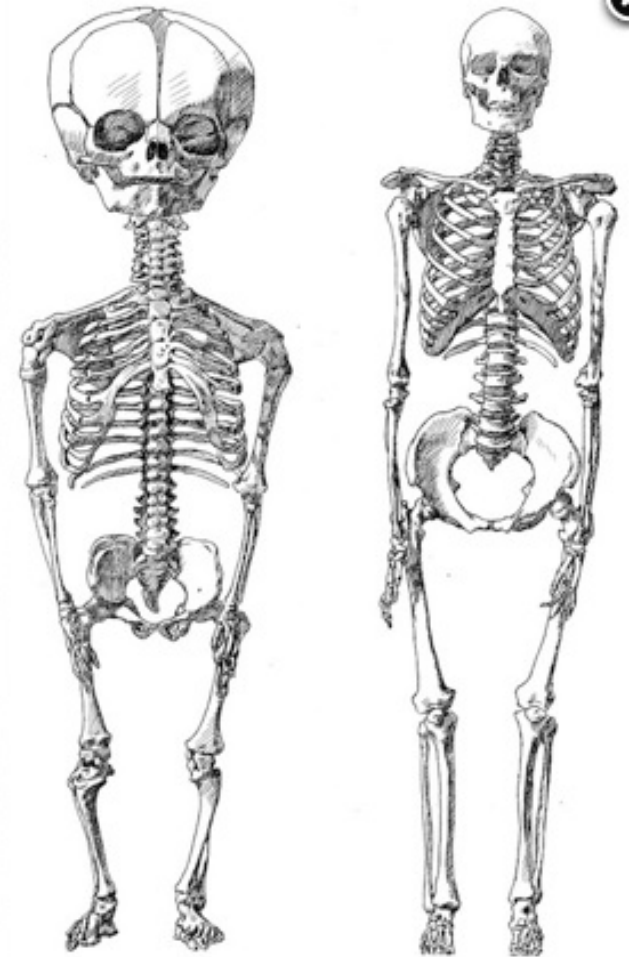
Ontogeny Recapitulates Phylogeny

- Does development duplicate the stages of evolution?
 - Some changes fit
 - e.g. Human fetus has, loses tail



Ontogeny Recapitulates Phylogeny

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 - Some changes fit
 - e.g. Human fetus has, loses tail
 - Some don't
 - e.g. Brain-body ratio decreases w/age, but increased over our phylo-history



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Infant and Adult Skeletons 2001-3, ink on paper, 14"x11"

Ontogeny Recapitulates Phylogeny

- Does development duplicate the stages of evolution?
 - Some changes fit
 - e.g. Human fetus has, loses tail
 - Some don't
 - e.g. Brain-body ratio decreases w/age, but increased over our phylo-history
- Still, ontogeny and phylogeny are related in important ways
 - e.g. Cross-species homologies are often defined per common embryology
 - e.g. Behaviors that appear *earlier* in devel are often of special significance
 - e.g. Some behaviors are necessary prerequisites for later ones

Hand & Mouth



The Babkin Reflex

Grasp and deliver



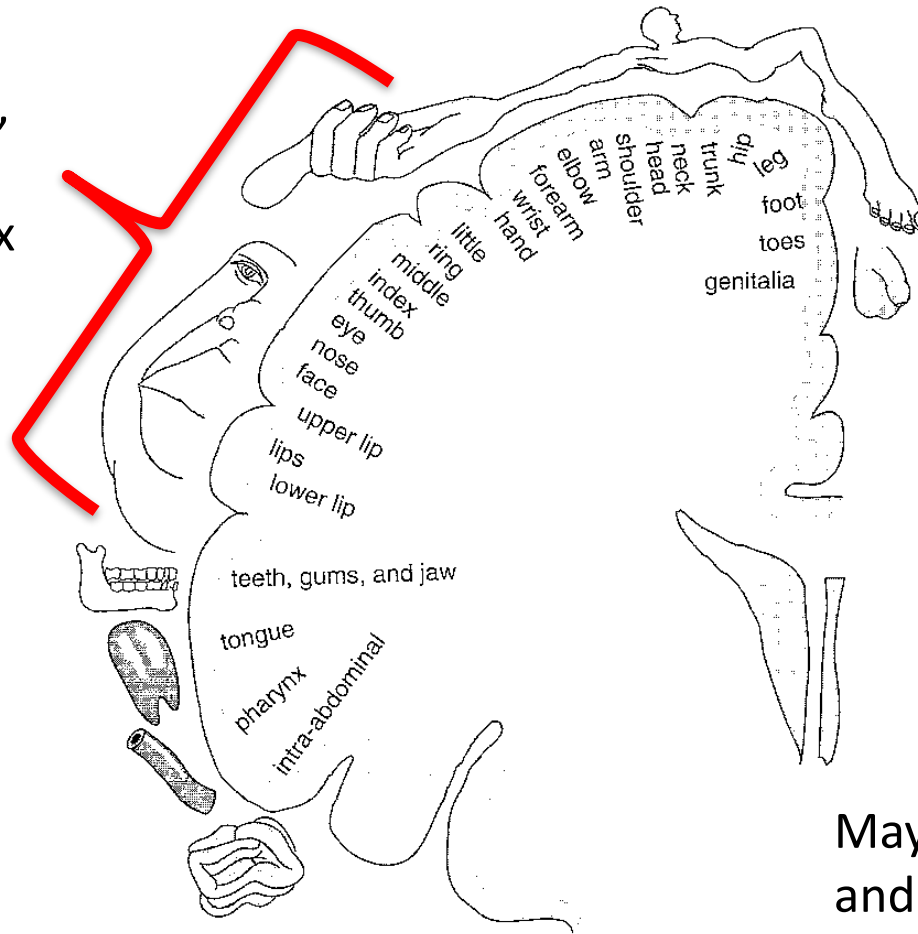
Tool Use

Initially coupled.
Increasingly, but never fully, separate.



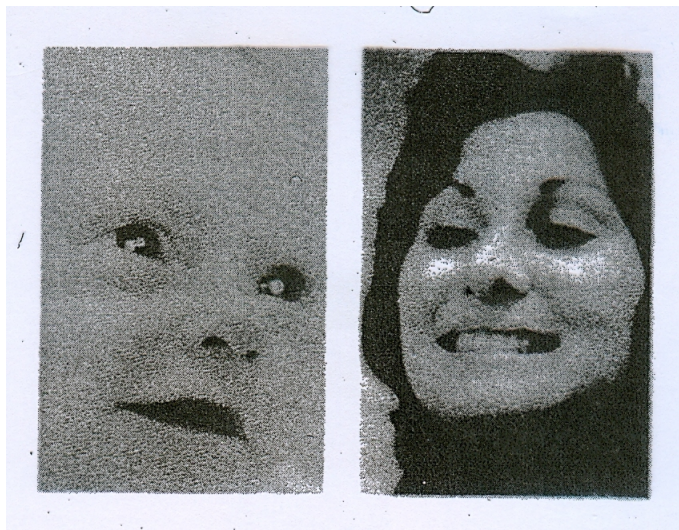
Hand & Mouth

Hand & Mouth
are adjacent in
Somatosensory,
Motor and
Premotor cortex

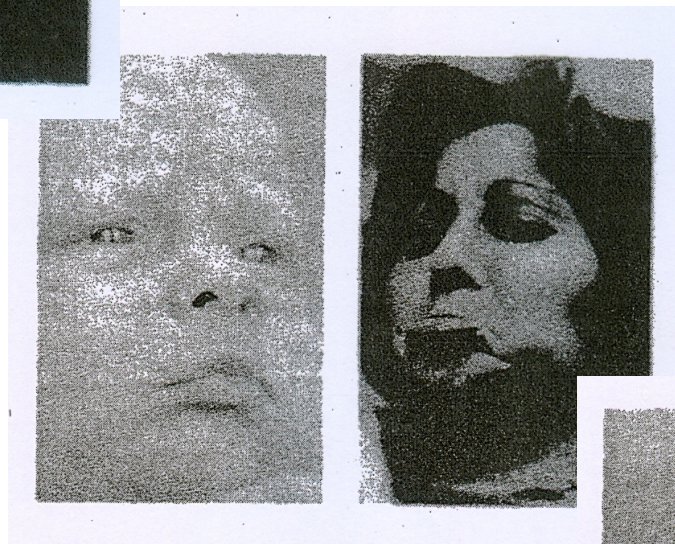


May develop in concert
and co-influence

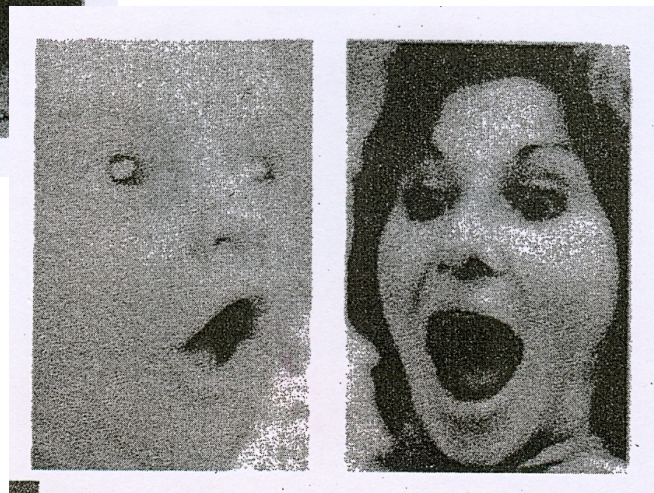
Neo-Natal Imitation



From just days after birth



Eyes & Mouth:
Critical components of
emotional expression



Neo-Natal Imitation

Also seen in some nonhuman primates



Pointing

Even newborn hands will form “pointing” shape



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Of course, this is not really “pointing”, but does indicate early independent finger control

Pointing

But by as early as three months, finger *is* used for pointing

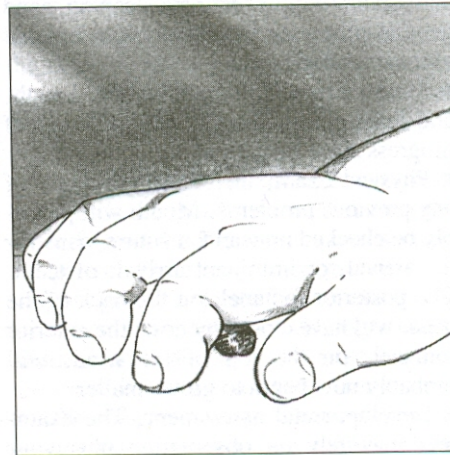


Early pointing
is often accompanied by
Vocalizations

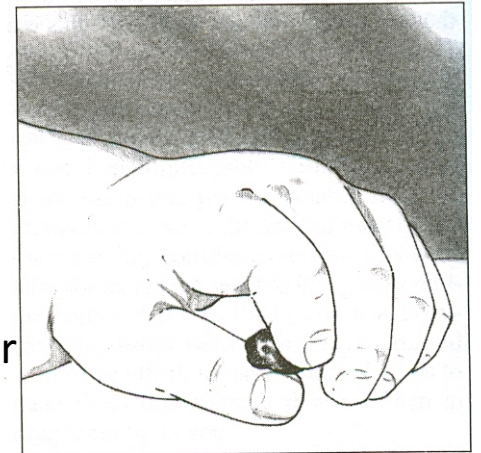
Hand Control



3 months
Begin
visually-mediated
grasp



6 months
Improved, but still
whole hand grasp



9 months
Individual finger
control

Using fewer fingers requires
MORE premotor activity
than whole hand

Hand Control

By 1 year, more refined control than other primates,
involving additional active inhibition,
and differential timing



Bimanual Coordination

~ 9 months, hands begin to differentiate in roles

Right hand –
Fine motor
control



Left hand –
Support

Prehistoric tools appear to have involved a similar division of labor for left and right hand



Infants use their heads - to reach!

Shen et al. (2010)



Infants use their heads - to reach!

Shen et al. (2010)

i.e. Hand-eye coordination essential



METHODS:

- Motion sensors on Head & Hands
- Bird's Eye view and Face-on cameras
- Subjects presented with pairs of objects
 - Free to reach

Infants use their heads - to reach!

Shen et al. (2010)

i.e. Hand-eye coordination essential



RESULTS:

- All showed Head-stabilization before reach
- Also co-orientation of Head and reaching Hand
- Older looked longer before reach, younger just at reach

IMPLICATIONS:

- Reaching is not just about the hands!
- Instead, about cross-modal sensory-motor coordination

The Development of Combinatorics

e.g. Nested Cups



The Development of Combinatorics

PAIRING

Simple, repetitive
object pairings

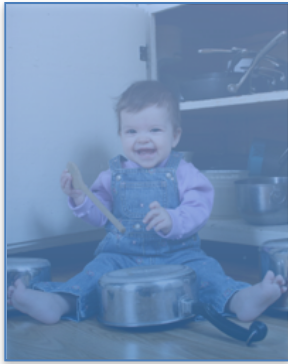


“Bang, bang, bang”

The Development of Combinatorics

PAIRING

Simple, repetitive
object pairings



POT

Putting multiple objects
into same “pot”



i.e. Whatever new action you develop,
do same to any object

The Development of Combinatorics

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Simple, repetitive object pairings



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SUBASSEMBLY

Put A in B, then put AB in C



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Simple, repetitive object pairings



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Put A in B, then put AB in C



The Development of Combinatorics

PAIRING

Simple phonemic pairings

b + a

“ba”

“ba”

“ba”

“ba”

POT

Same phoneme paired with multiple others
(First words)

b + a

m + a

p + a

d + a

SUBASSEMBLY

“ba”

“ma”

“pa”

“da”

i.e. Whatever new action you develop

- e.g. “* a” -

do same to with any phoneme.

The Development of Combinatorics

PAIRING

Simple phonemic pairings

b + a

“ba”
“ba”
“ba”
“ba”

POT

Same phoneme paired with multiple others
(First words)

b + a

b + ai

b + ee

m + a

m + ai

m + ee

“ba”
“ma”

“bye”
“my”

“bee”
“me”

SUBASSEMBLY

Multiple phonemes combined
(More complex words)

b + a + l

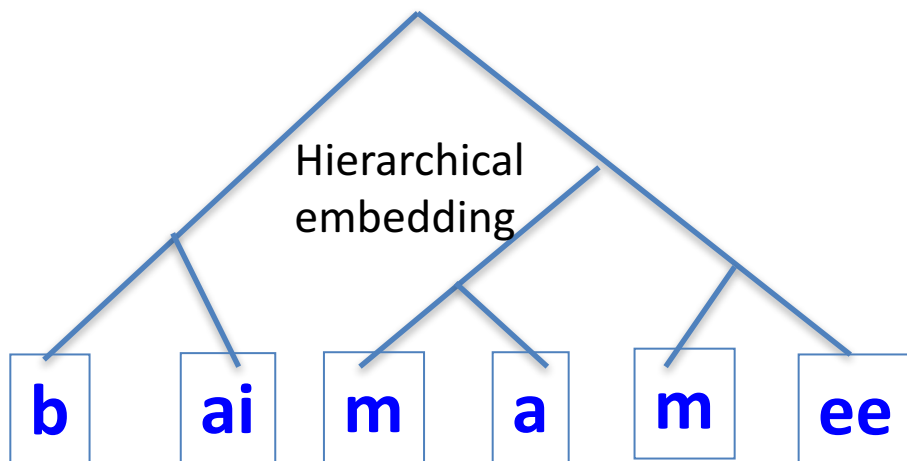
m + a + m + ee

“ball”
“mommy”

Two word sentences

b + ai + m + a + m + ee

“bye mommy”



The Development of Combinatorics

PAIRING

Simple object pairings



POT

Putting multiple objects
Into same pot



SUBASSEMBLY

Put A in B, then
put AB in C



Simple phonemic pairings

b + a

Same phoneme paired with
multiple others
(First words)

b + a	b + ai	b + ee
m + a	m + ai	m + ee

Multiple phonemes
combined
(More complex words)

b + a + l

Two word sentences

b + ai + m + a + m + ee

Vocal control lags behind Hand control

Babbling



Babbling

Action routines that "tool up" the vocal system

- 6 months
 - Preceded by increase of rhythmic, repetitious hand movements
 - Thereafter, repeat syllable (Ba, Ba, Ba, Ba)
 - At this stage, produce all phonemes of all languages
- 9 months
 - Shaped by heard language (use more heard sounds)
 - Shows influenced of affect (intonation)
 - First embedded combinatorics
- 1 year
 - Use words in appropriate contexts
 - Only babble sounds of own language

Human infants are motorically retarded



i.e. We are
ALTRICIAL
- helpless –
(vs. Precocial)
at birth

Human infants are motorically retarded



i.e. We are
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Probably an adaptation
for fitting increasingly large head
out of
increasingly small pelvic opening

Human infants are motorically retarded



Compared to nonhuman primates



Humans require up to a year to become independently mobile



Compensate for motoric retardation with SOCIAL precociality

e.g. We can vocally communicate before we walk

e.g. Before we can walk or use objects as tools,
we can use SOCIAL TOOLS



Attentional Interactions



White
(high contrast)
Sclera

Infants have
(relatively)
BIG eyes

Adult size at birth
in little face.

Very attractive to
us primates

Attentional Interactions

Gaze Games - Universal



e.g. Peek-a-boo,
Loom & recede,
etc.

Usually accompanied by
POSITIVE affect
from both parties

Helps “tool up”
social attention system.



Humans develop gaze-following



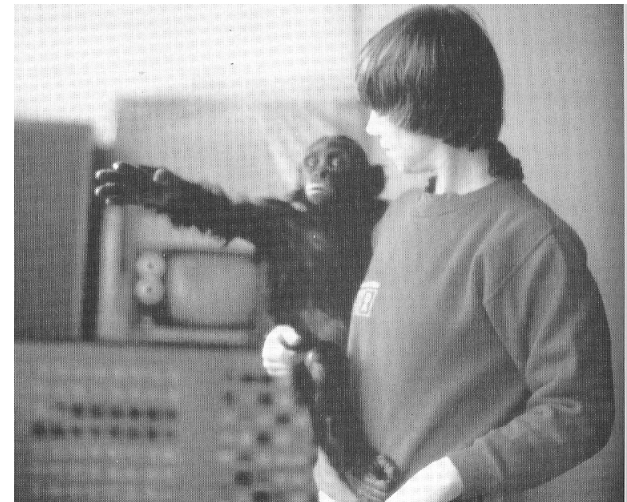
This will be an essential prerequisite for
LANGUAGE DEVELOPMENT
and other cultural learning.



Nonhuman Primates also show Gaze Following



But they do not point or show
unless
human-enculturated



All (and only) Humans Point and Show



Human infants are “enculturated” to point and show



Different cultures “point” in different ways
(e.g. with whole hand, finger, eyes, chin, etc.)

Point & Show Coordination with others = **“You, Me, It”**
required for language development



Coordinating Word Learning
Yu, Smith & Pereira (2008)

Vocalizations contingent with sustained hand/eye engagement
>> Learning names of objects

Coordinating Word Learning

Yu, Smith & Pereira (2008)



METHODS:

- Subjects 17-20 months with Mom
- Head camera & Head Motion tracker on Infant & Mom
- Plus Bird's Eye camera & Computer Vision analysis of video

- Free play with sets of 3 toys,
- Mom teach names (nonsense words) for novel toys
- Tested later by requesting Infant to give toy

Coordinating Word Learning

Yu, Smith & Pereira (2008)



RESULTS:

- Names learned were NOT those most frequently heard!
- Instead, they were names for toys that were grasped &/or loomed, w/head-stabilized look at time named
- Attentive mom directs and/or awaits child's attention to object
- So language learning depends on the social coordination of multiple modalities of attention