Language Development in Pediatric CI Users: Is the Glass Half Full or Half Empty?

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Outcomes in Pediatric Cochlear Implantation

- **Speech perception-**
  primary goal

- **Speech production-**
  critical for successful oral communication

- **Language development-**
  recognized as a crucial outcome measure by both proponents and opponents of pediatric implantation

From the reviews of one of our latest papers (in press, Audiol.& Neuro-Otol.)

Rev. A suggests adding:

"Results suggest that cochlear implantation before the age of 2 may be beneficial, but excellent results can be achieved at later ages as well".

Rev. B :

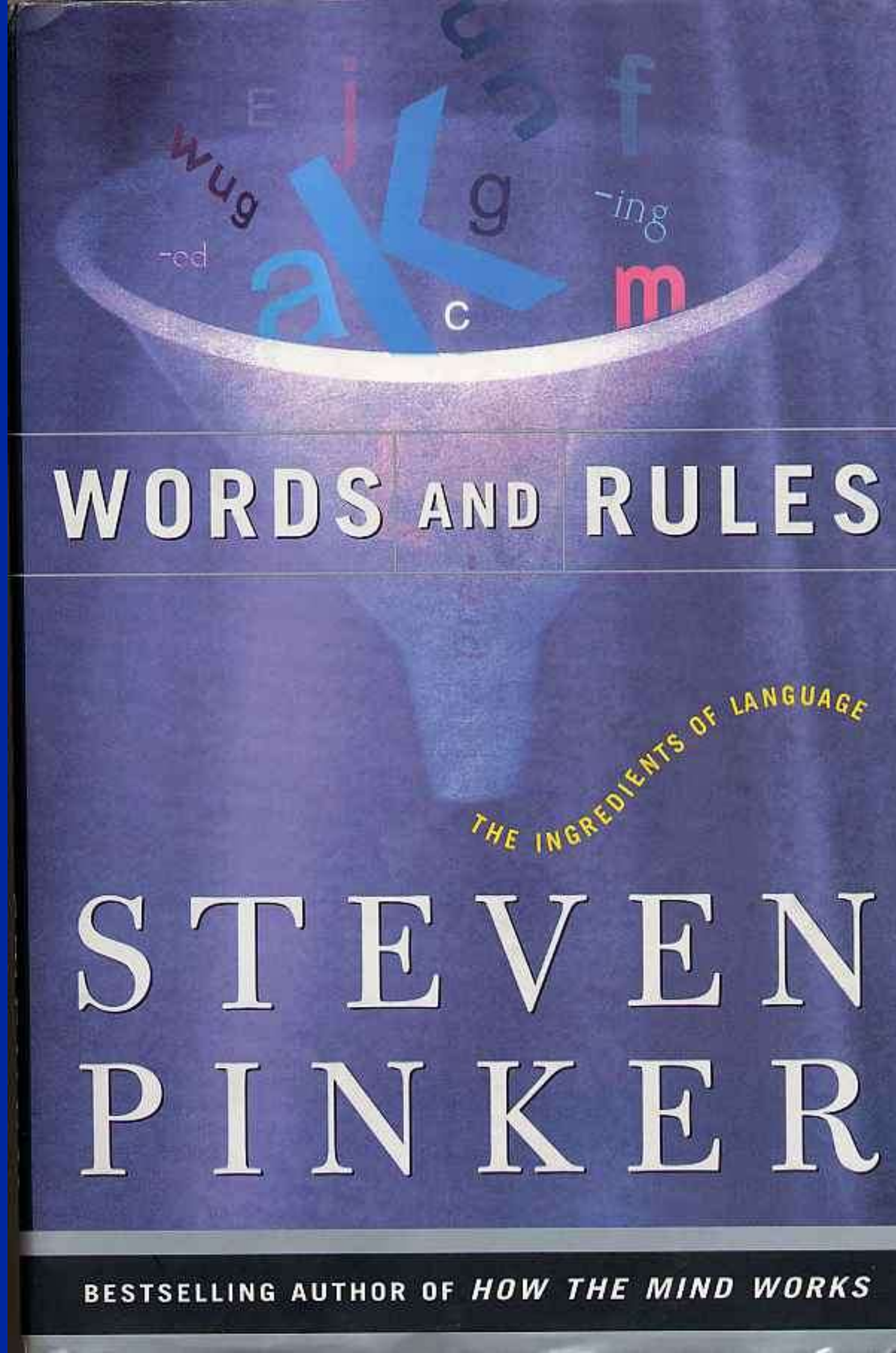
"Unfortunately, most research on 'language and speech outcomes' in cochlear-implanted children is characterised by a lack of theory, global language measures, and a bias towards excellency in outcome. I don't think it's necessary to add to this body of research".

Goals of this presentation

- Review potential risks of early implantation
- Describe some methods of language development assessment.
- Examine communicative outcomes as a function of age at implant for congenitally, profoundly deaf children: language development, speech perception and speech production.

Potential risks of early implantation

- Early implantation may carry significant additional risks related to anesthetic complications.
- Incidence of bradycardia for noncardiac surgery: 1.3%, 0.98%, 0.65% and 0.16% in years 1, 2, 3 and 4.
- Bradycardia was associated death in 8% of the cases (Young, 2002; Keenan et al., 1994).


WORDS AND RULES
THE INGREDIENTS OF LANGUAGE
STEVEN
PINKER
BESTSELLING AUTHOR OF HOW THE MIND WORKS

Reynell Developmental Language Scales - Expressive

- 62 items in six main sections, A-F
- Answers accepted in oral form or in Signed Exact English
- The first two sections use toys in support of verbal stimuli; later sections use pictures in addition to objects.
- **Section A: Words** (10 items)

  Example: “What’s this?” (It’s a doll)

Section B: verbs and phrases (6 items)

- **Bi- Verbs:** (show teddy bear jumping) “Look, teddy’s jumping on the bed. What’s teddy doing? Teddy’s…” (<u>jump/ing</u>).
- **Bii- Phrases:** (show first picture) “Here is a plate and here is a cup.” (Show second picture) “This time there is a big key in the picture. You tell me where the key is.”

  (<u>on the plate</u>).

Section C: inflections (12 items)
Section D: 3 and 4 clausal elements (10 items)

- **Ci- Plurals:** "Here is one cat. Here is another cat; so now there are two (cats)".
- **Cii- 3rd person:** "Every day this lady dances. What does she do every day? She (dances)".
- **Ciii- Past tense:** "This baby cries a lot. Yesterday he (cried)"
- **Section D:** Some spontaneous, some modelled.

"Teddy is hiding under the table. Tell me what's happening".

Section E: Complex structures (14 items)

- Ei- Imitation: “I want you to say exactly as I say.” Example: “I like days when the sun shines”.
- Eii- Correction of errors: “Horsie can’t say things properly. You listen and tell me what he should say.” Example: “The man drives car”.
- Eiii- Utterance completion: “Look at the pictures first. You can see a clown. He’s fallen over and he’s crying. I’ll begin the story and you finish it. The clown who…”

“ …fell over is crying”. (or other appropriate response)

Section F: Auxiliaries (10 items)

- Negatives: "Horsie says, 'My brother goes to school.' Panda says, 'My brother doesn't go to school.' Let's try one. You have Panda. Horsie says, 'My auntie watches television.' Panda says…" (<u>My auntie doesn't watch television</u>).
- Questions: "Horsie says, 'I saw the postman.'" (<u>Did I see the postman?).</u>
- Tags: "Horsie says, 'We wouldn't make a noise.'" (<u>We wouldn't make a noise, would we?).</u>

Table of age equivalent scores

Table A.2 RDLS III Expressive: age equivalent scores

Score	*Age equivalence*	*Score*	*Age equivalence*
0–6	under 1;09	30	3;10
7	1;09	31	3;11
8	1;10–2;00	32	4;00
9	2;01	33	4;01
10	2;02	34	4;02–4;03
11–12	2;03	35	4;04
13	2;04	36	4;05
14–15	2;05	37	4;06–4;08
16	2;05–2;6	38	4;09–4;11
17	2;07–2;08	39	5;00
18	2:09	40	5;01–5;02
19	2;10	41	5;03
20–21	2;11	42	5;04–5;06
22	3;00	43	5;07
23–24	3;01	44	5;08
25	3;02	45	5;09
26	3;03–3;04	46	5;10–6;02
27	3;05–3;06	47	6;03–6;04
28	3;07–3;08	48	6;05–6;07
29	3;09	49–	over 6;07

MacArthur Communicative Development Inventories (MCDI)

- Structured tests, language samples, and parent reports.
- MCDI Words and Gestures (8-16 months)
- MCDI Words and Sentences (16-30 months)
- RDLS Expressive as a function of MCDI subtests

  REXPae = 1.20+0.28*age + 0.02*words prod. +0.01*words und. + 1.23*momdad

  - **Multiple R = +0.872 R^2 =0.76 Adj R^2 =0.75**

Other tests

- Speech perception (sound alone): Potatohead sentences.
  - Examples: “Where are the glasses?”; “Give him some teeth”; “Put a hat on Mr. Potato Head”.
- Speech intelligibility:
  BIT (Beginner’s Intelligibility Test)
  - Examples: “The baby falls”; “Mommy walks”; “The baby cries”; “That is a big bed”.

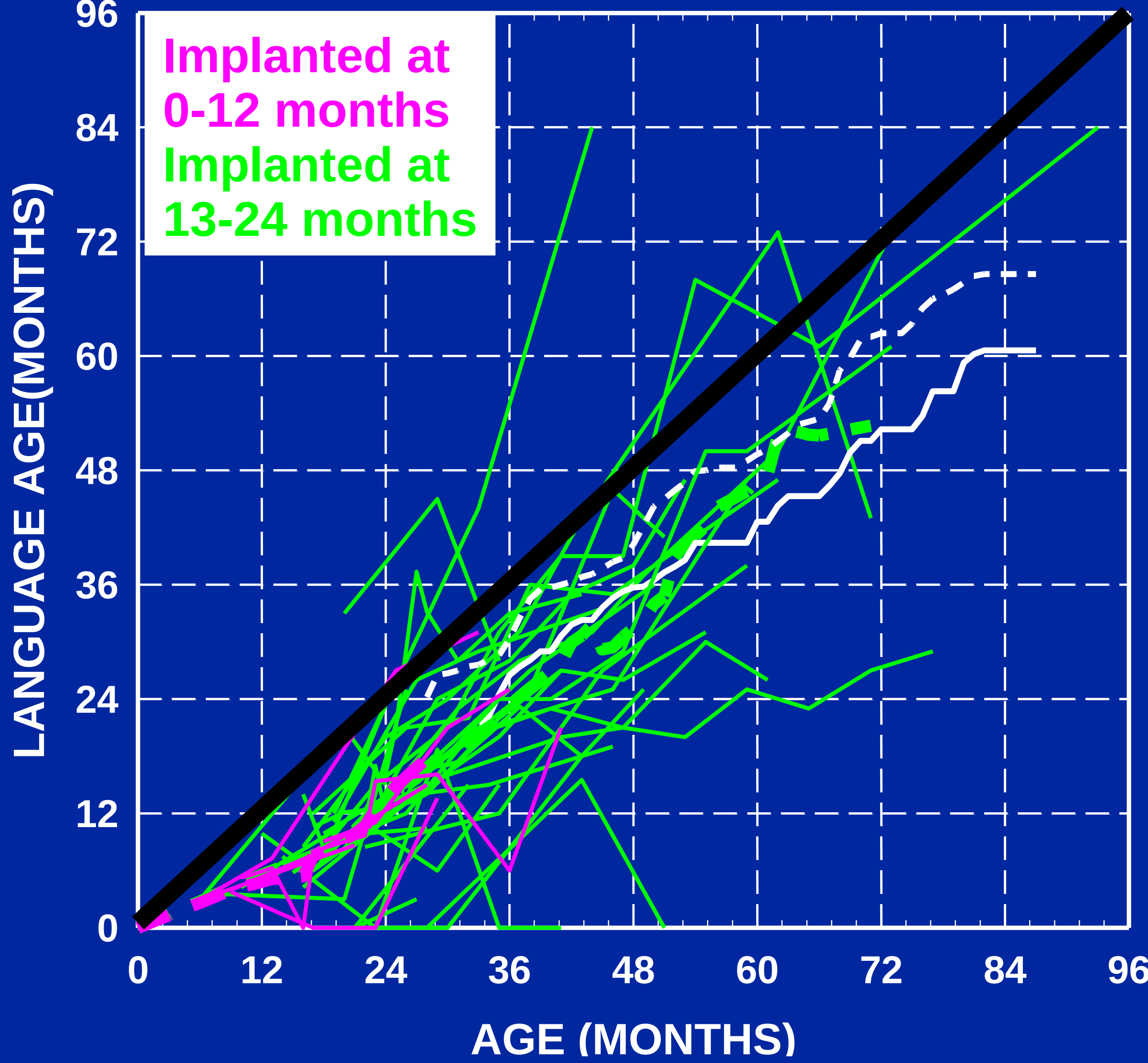
Subject Characteristics

Age at Implant Group	Mean Age at Implant (months)	N	Unaided PTA (best ear)	Percent Using Oral Mode of Communication
0-12	9.9	7	117.0 dB HL	76%
13-24	18.9	35	111.7 dB HL	71%
25-36	29.9	42	110.2 dB HL	57%
37-48	40.5	25	107.3 dB HL	46%

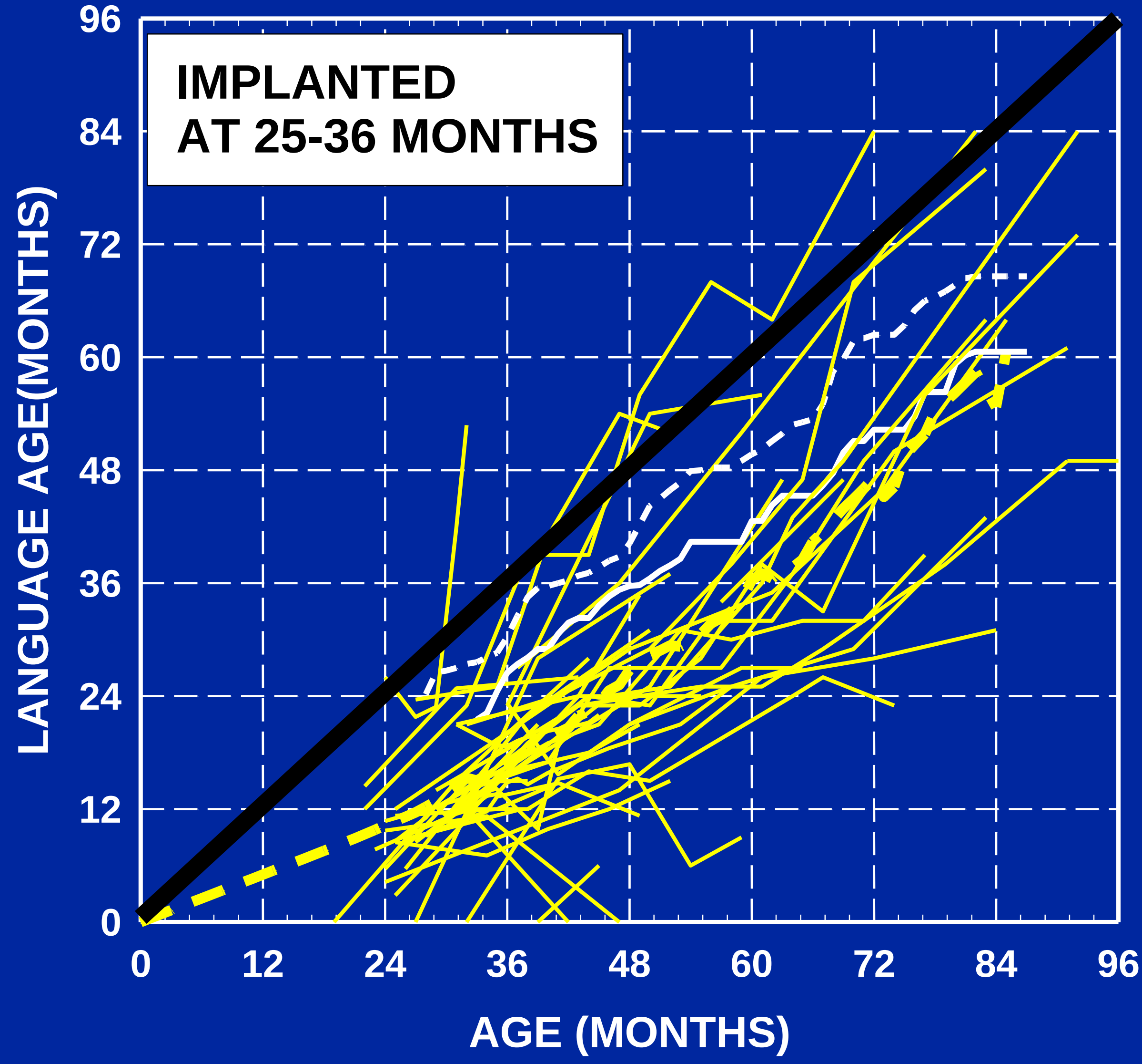
All subjects were congenitally, profoundly deaf, and used the CIS or SPEAK strategies since initial stimulation.

EXPRESSIVE LANGUAGE

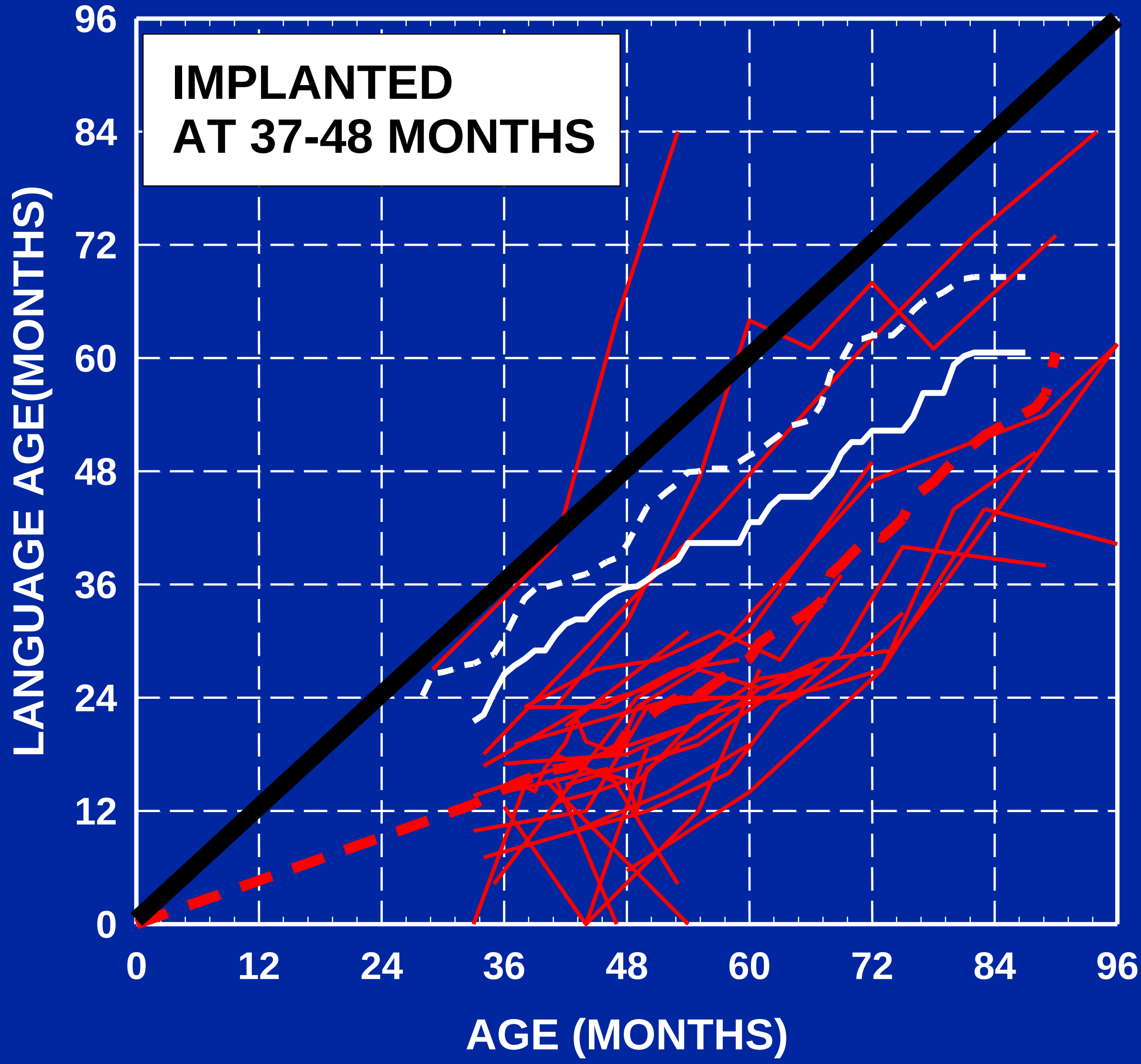
children implanted 0-12 and 13-24 months



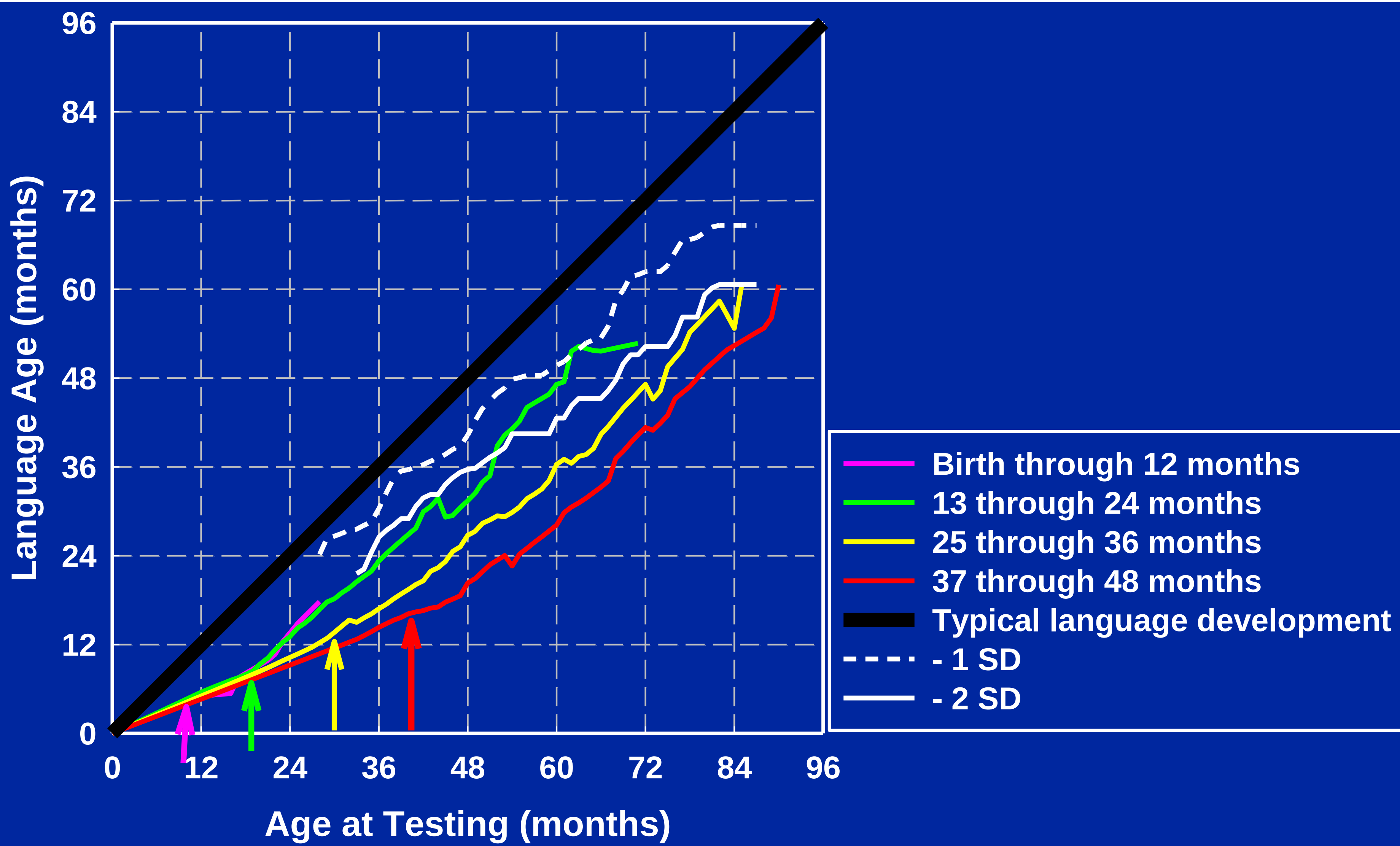
EXPRESSIVE LANGUAGE
children implanted 25 - 36 months



EXPRESSIVE LANGUAGE
children implanted 37 - 48 months



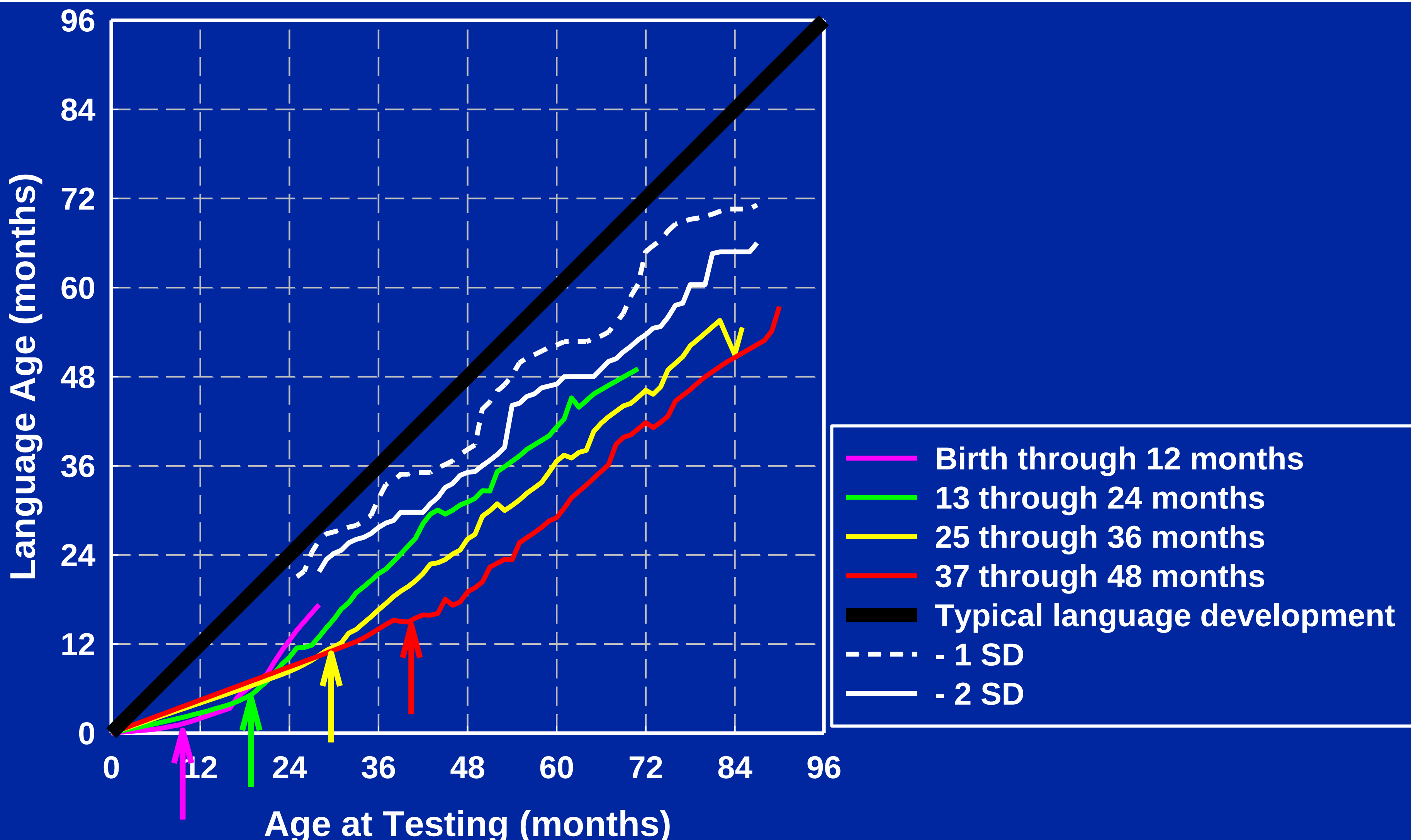
EXPRESSIVE LANGUAGE
average curve by age-at-implant



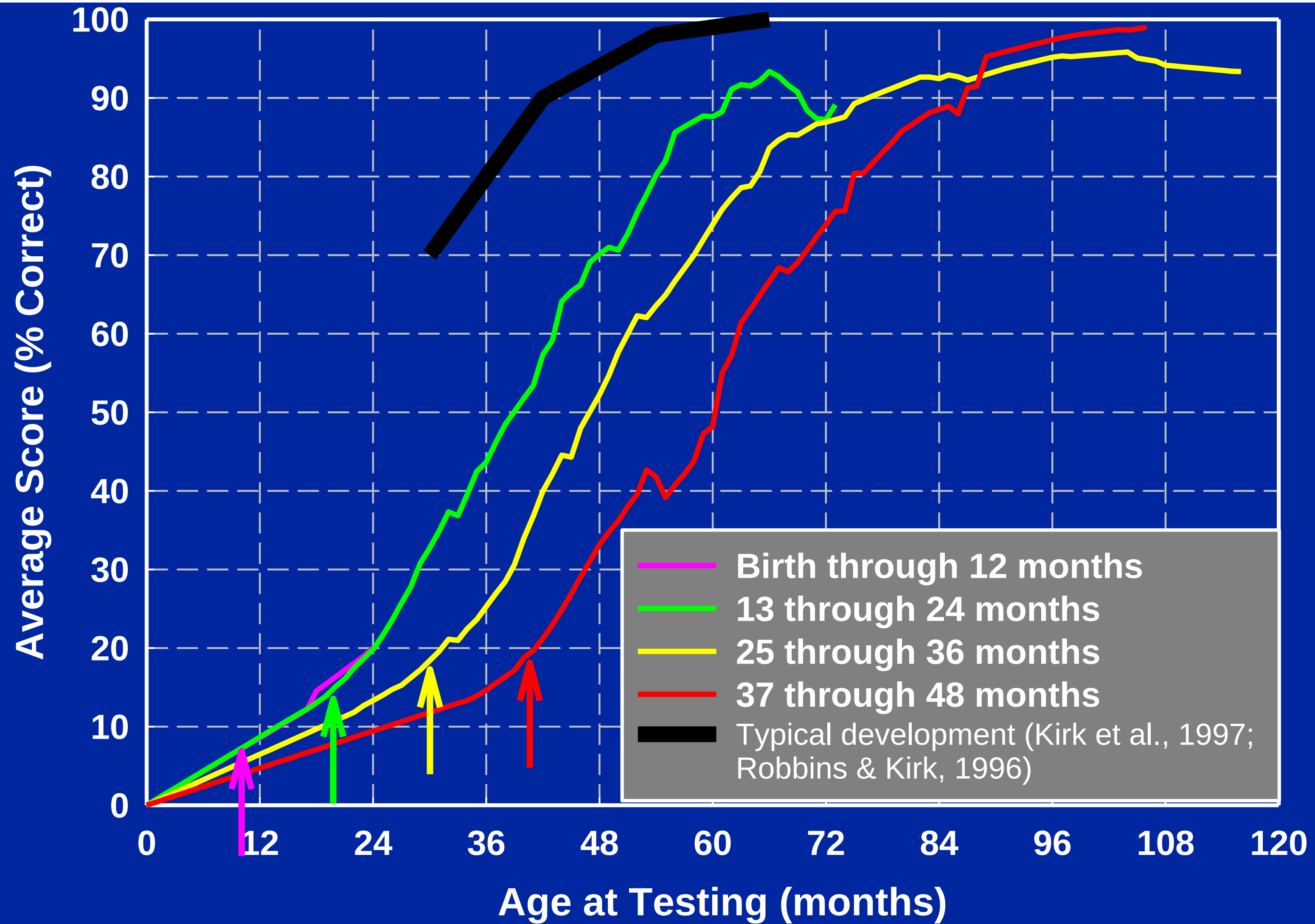
DTA Results-ExpressiveLanguage

- Imp. at 25-36 > imp. at 37-48
  Advantage: 3.0 months, $p<0.05$
- Imp. at 13-24 > imp. at 25-36
  Advantage: 5.2 months, $p<0.01$
- Imp. at 0-12 vs. imp. at 13-24
  Difference: <0.3 months, NS

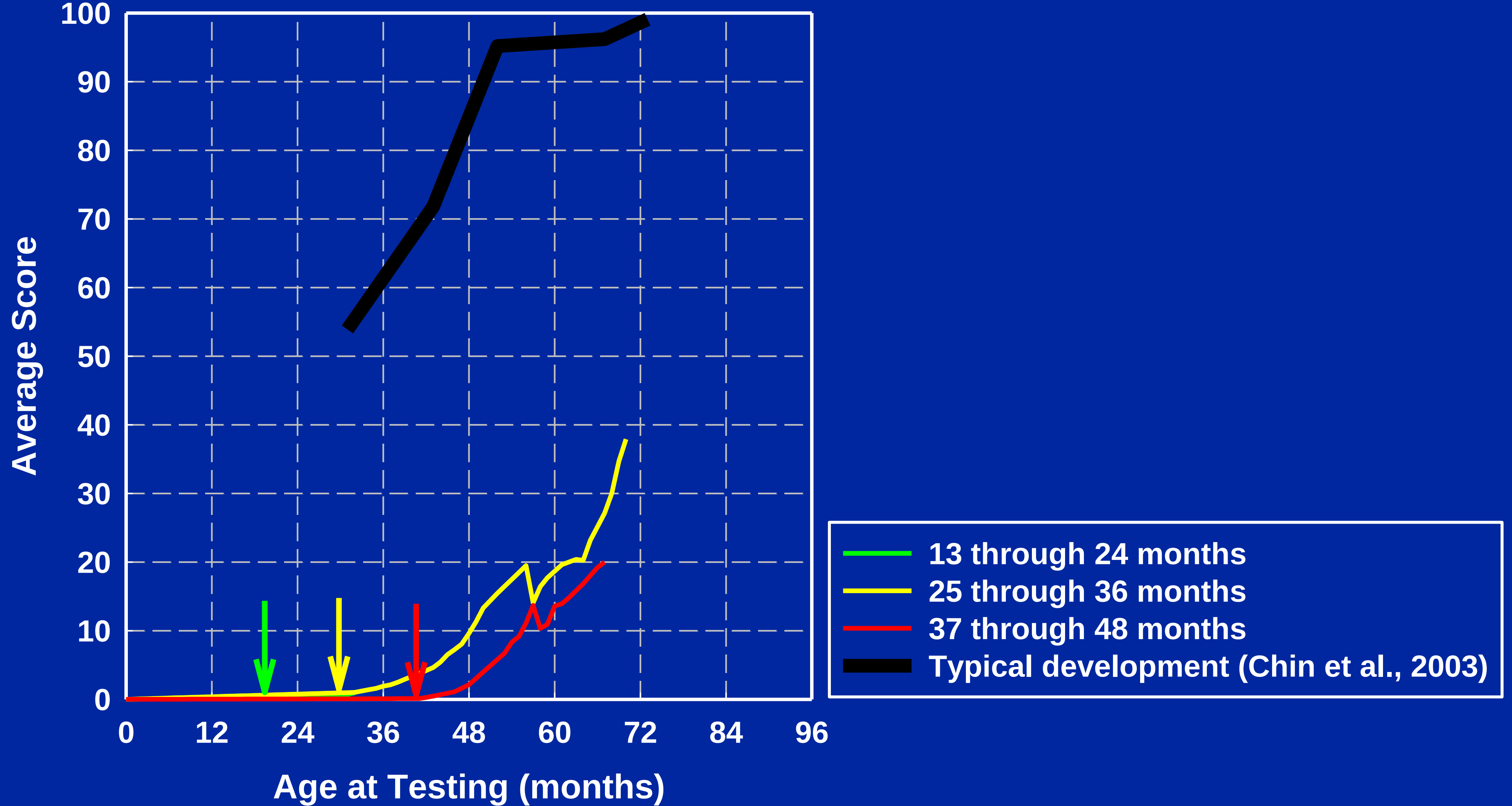
RECEPTIVE LANGUAGE
average curve by age-at-implant



SPEECH PERCEPTION
average curve by age-at-implant



INTELLIGIBILITY
average curve by age-at-implant



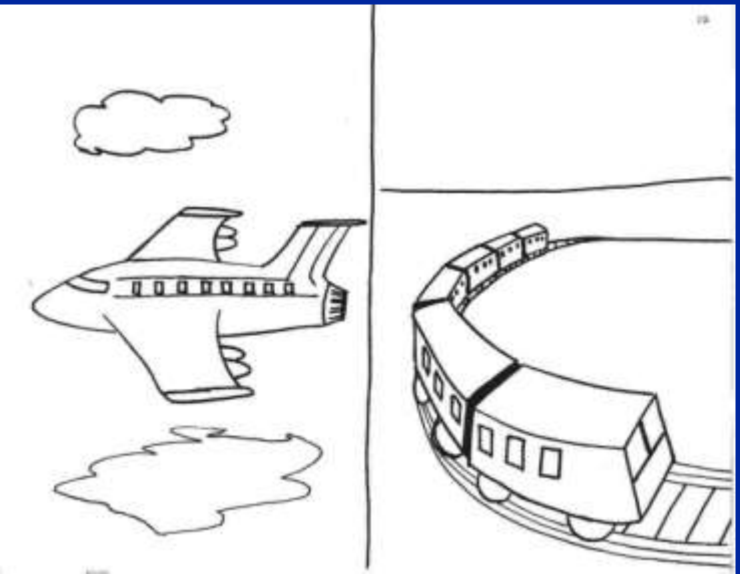
Language development in pediatric CI users: Words and Rules

- Many of the “half-full cup” results in studies of language development by CI users (including ours) were based on measures that are heavily influenced by lexical skills, such as RDLS and PPVT.

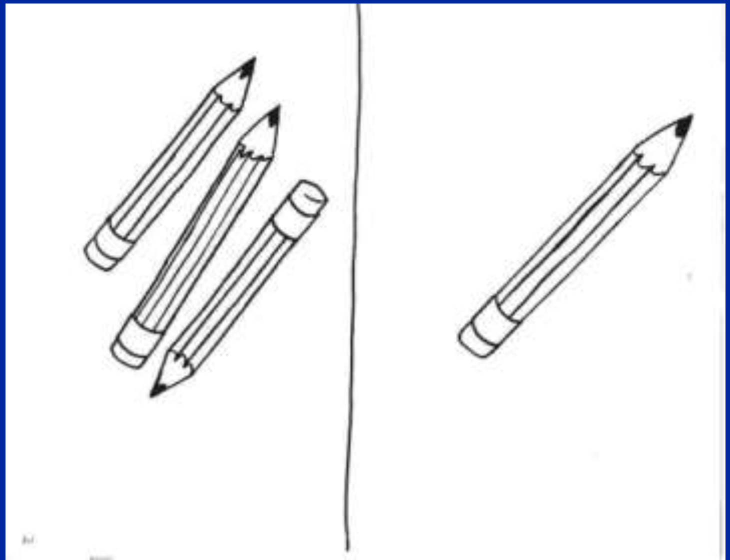
- Are results similarly positive when we examine specific grammatical skills?

NOUN PLURAL (examples):

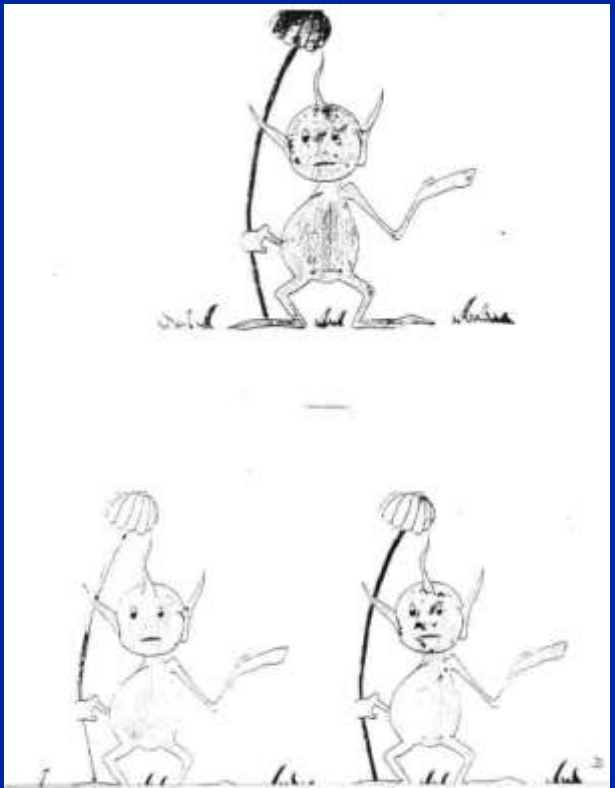
"Here is a plane, and here is (a train)".



"Here is one pencil, and here are three (pencils)".

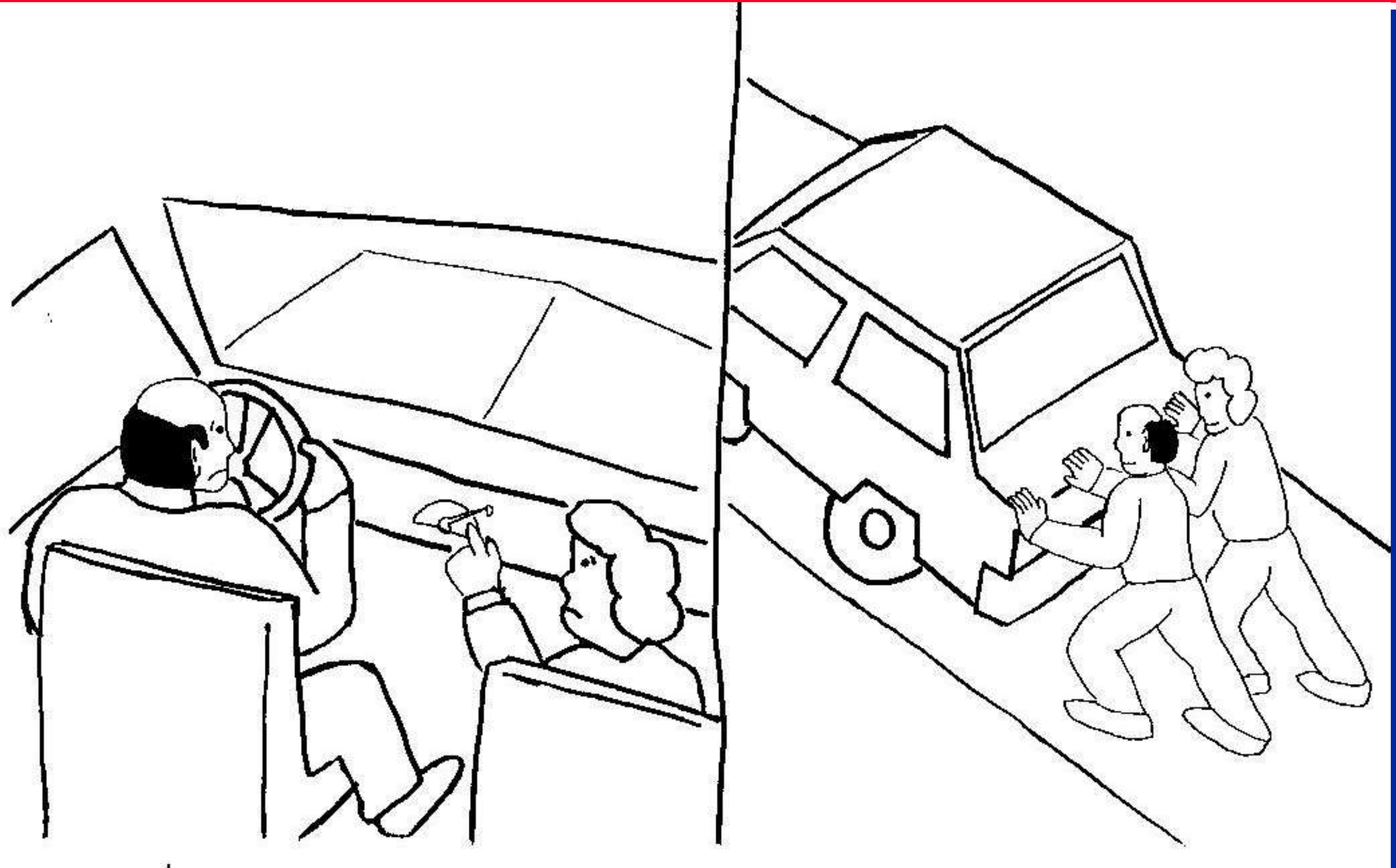


"This is a muke. These are two (mukes)".

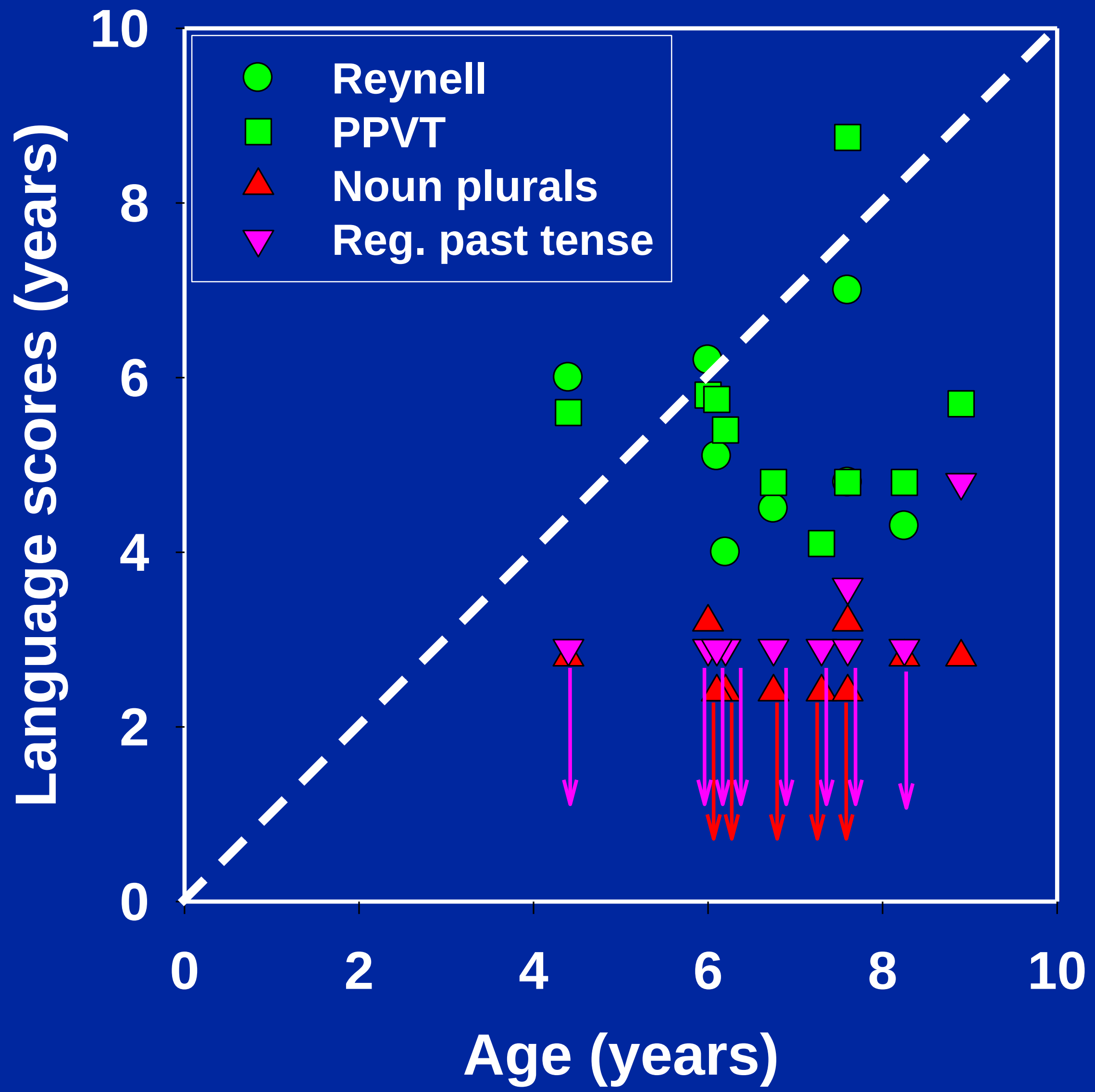


REGULAR PAST TENSE:

"Mom and Dad were driving but then the car wouldn't go any more because it ran out of gas. So what did they do to the car? They…" <u>(pushed it).</u>



Adequate lexicon, delayed grammar



Conclusions

- Significantly smaller language delays and better speech perception for children who are implanted earlier ($2^{nd}>3^{rd}$; $3^{rd}>4^{th}$). This advantage persists for several years.
- However, this effect does not appear when we compare children implanted in the 1^{st} vs. the 2^{nd} year of life. This is an important results that requires follow-up studies with a greater N, because there may be potential additional risks from implantation in the first year, and particularly in the first six months.
- Our study represents a low level of clinical evidence. It is not a randomized, double-blind study. Potential confounds: SES, others?

Conclusions

- The half-full glass: many children implanted in the first two years of life achieve near-normal scores in some measures of language development (RDLS, PPVT).
- The half-empty glass: most children implanted later, and even some children implanted in the first two years show very substantial language delays using the same measures.
- The reasons for these individual differences are largely unknown. The differences are not reliably predictable.

Conclusions

- Even children who obtain near-normal scores in some global language measures show very severe delays in other areas that are important for communication (tests of grammatical development; the ability to speak intelligibly).

Conclusions

- Pediatric cochlear implantation is a safe and effective intervention in children with congenital severe or profound deafness, particularly if it takes place early in life.
- Individual differences: are they due to limitations of present day technology, inappropriate rehabilitation, or a basic limitation of pediatric cochlear implantation?

THE END

Assessment of language skills for very young children: MacArthur Communicative Development Inventories

- 2 Parent Report Inventories
  - Words & Gestures (8-16 months)
  - Words & Sentences (16-30 months)

- Measures gestural, receptive, and expressive language abilities

MacArthur Words & Gestures Inventory

- Signs of Understanding
  - Name
  - No No
  - ‘There’s mommy/daddy’
- Phrases Understood
- Words Understood

- Starting to talk
  - Imitation
  - labeling
- Words Produced
- Early Gestures
- Late Gestures
- Total Gestures

MacArthur Words & Sentences Inventory

- How children use words
- Words Produced
- Mean Length Utterance
- Irregular Words
  (e.g., feet, ate)

- Grammatical suffixes
  - Plural
  - Possessive
  - Progressive
  - Past tense
- Overgeneralizations
  (e.g., foots, eated)

Regression functions, Reynell scores as a function of MacArthur scores

- Regression equations

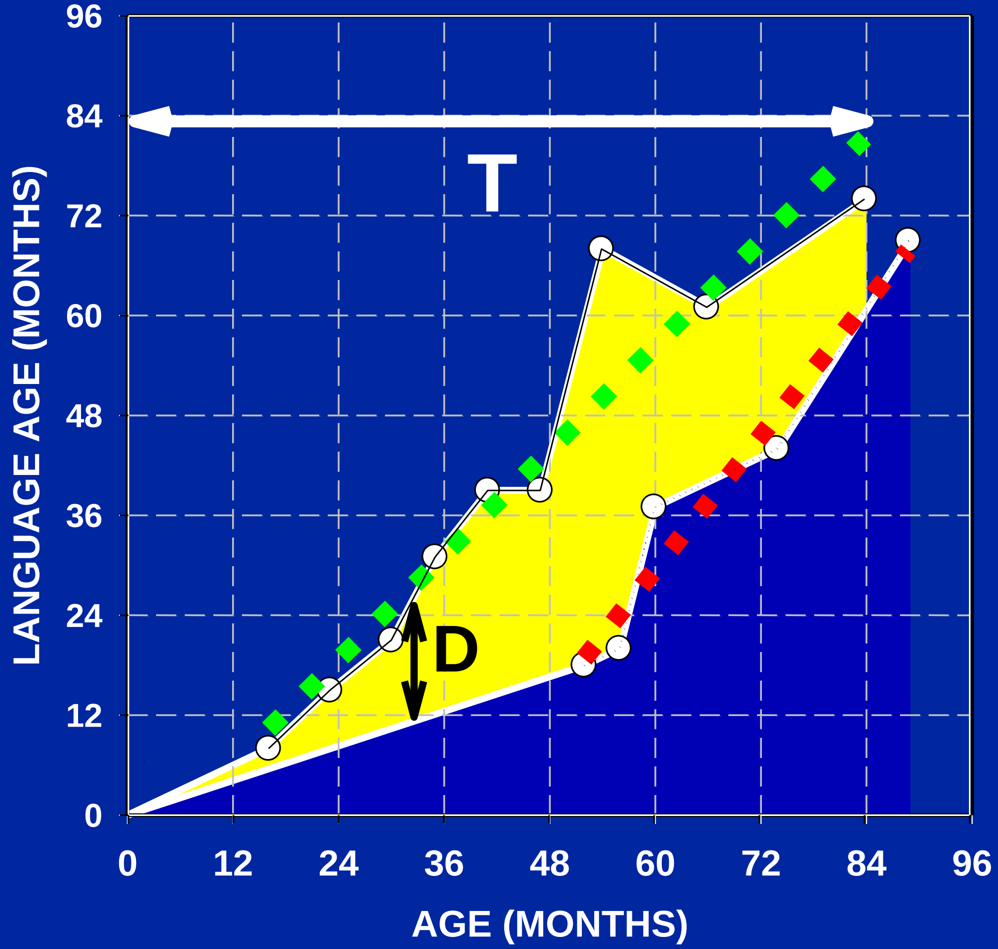
  RRECae=-5.57+0.39*age + 0.04*words prod + 0.02*words und. – 1.57*gender +2.68*nono

  - **Multiple R = +0.902 R^2 =0.81   Adj R^2 =0.80**

  REXPae = 1.20+0.28*age + 0.02*words prod. +0.01*words und. + 1.23*momdad

  - **Multiple R = +0.872 R^2 =0.76   Adj R^2 =0.75**

A new analysis method: Developmental Trajectory Analysis



- **Group X, $x_j(t)$ j=1 to n**
- **Group Y, $y_i(t)$ i=1 to m**

- **Average curve in group Y**

$$Y(t) = \sum_{k=1}^{m} y_k(t) \,/m$$

Developmental Trajectory Analysis (cont.)

- "mean developmental difference" D between each member of group X (for j=1 to n) and the average of group Y:

$$D_{j,Y} = \int_{t=0}^{T_{j,Y}} [x_j(t) - Y(t)]\, dt \Big/ T_{j,Y}$$

•where $T_{j,X}$ is the maximum value for which both $x_j(t)$ and $Y(t)$ are defined.

•$D_{j,Y}$ = area between two curves/integration interval = average size of difference

•Null hypothesis:

•*H_0: The set of developmental differences $D_{j,Y}$ (j=1 to n) are a sample taken from a normal distribution with a mean of zero.*

Advantages of Developmental Trajectory Analysis

- Graceful handling of missing data.
- No assumptions are made concerning the shape of developmental trajectories.
- All available data points can be used.
- High face validity.
- Assesses whole developmental trajectory rather than individual points.
- Effect of confounding variables can be easily assessed (not shown).