

*The Bionic Ear: Challenges of Educating  
Deaf Teenagers in the 21<sup>st</sup> Century*



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# *Acknowledgements*

- *National Institutes of Health*
- *Dana Foundation*
- *National Science Foundation*

## *Today, I wish to:*

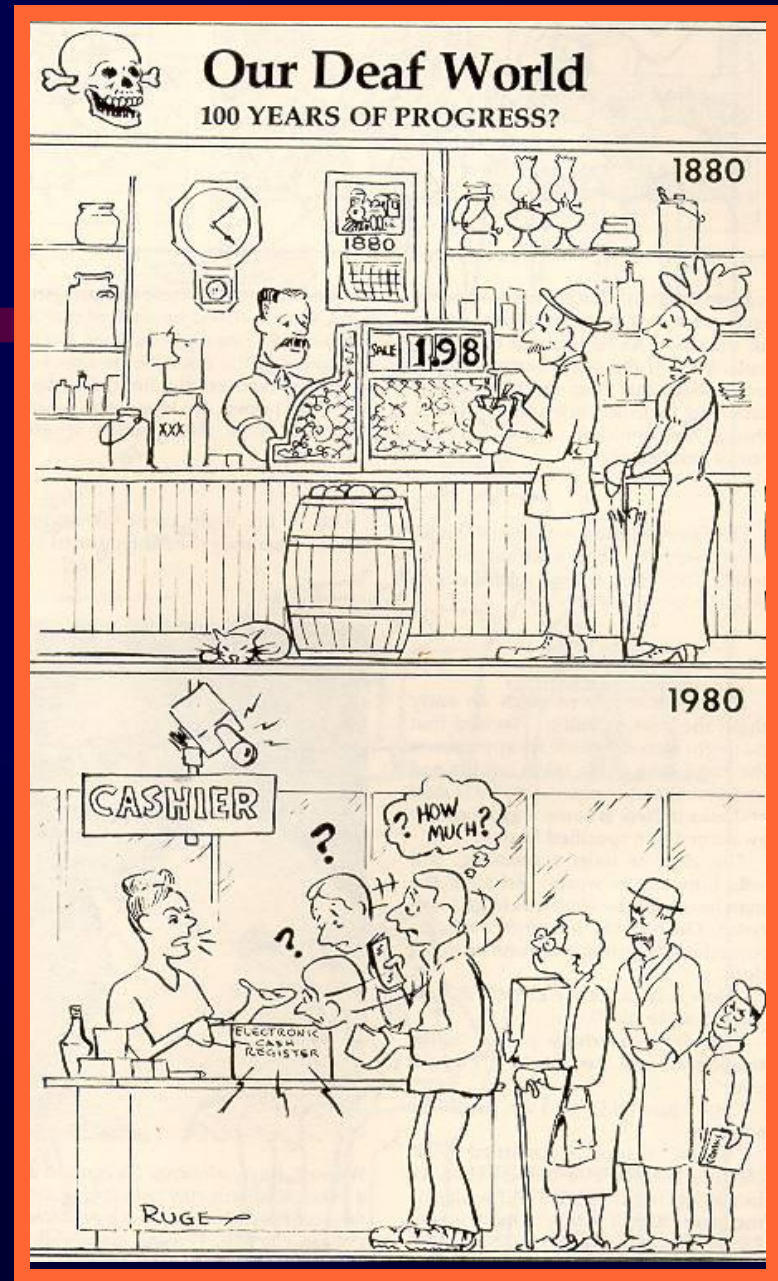
- **Focus on the big picture:**
  - Long term outcomes in teenagers using implants
- **Describe:**
  - bionic ear technology
- **Report:**
  - communication performance
  - challenges associated with current population
- **Muse of Future Challenges**

# *Our Current Challenges*

**Hearing loss effects over  
30 million Americans**

**90% of deaf babies  
are born to normal  
hearing parents**

***Average reading level  
of deaf students  
graduating from high  
school is third grade***



# *Historical Attitudes*

- deaf and dumb
- deaf and mute



# *Historical Attitudes*

- Deaf



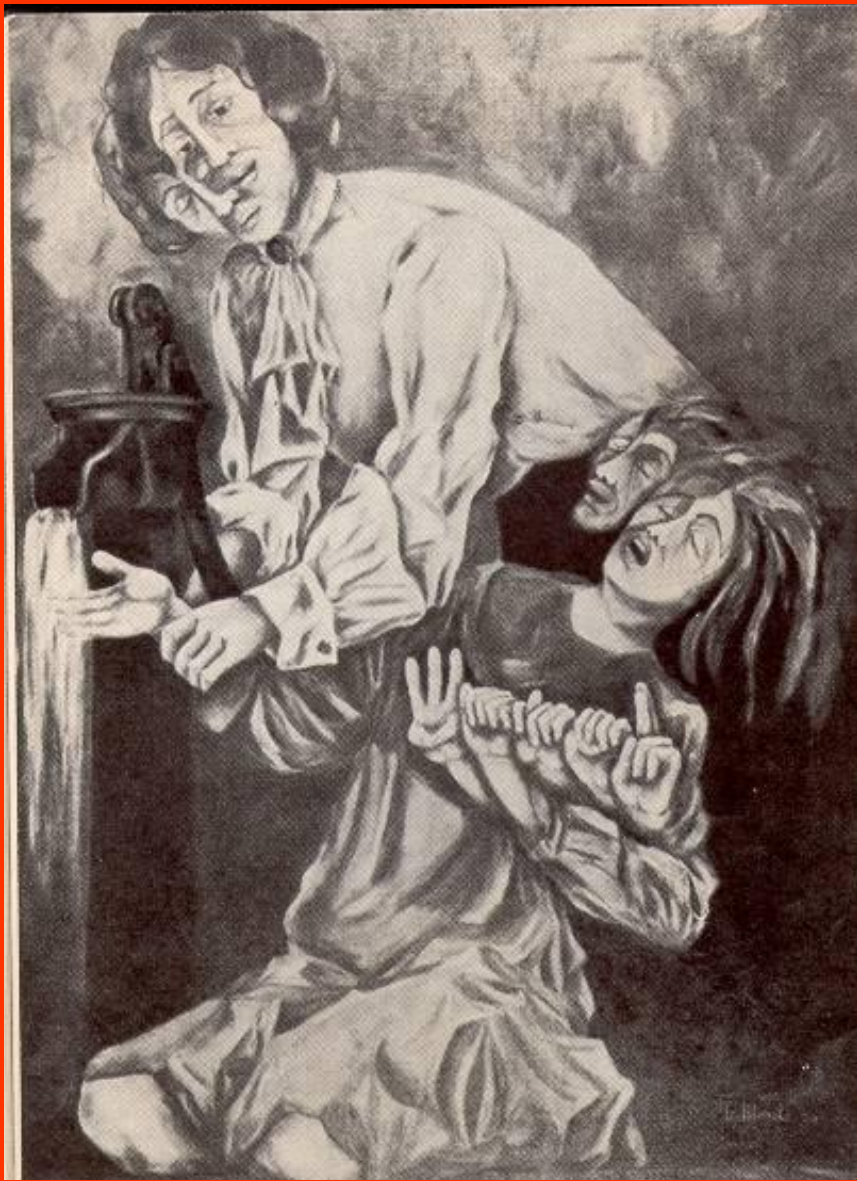




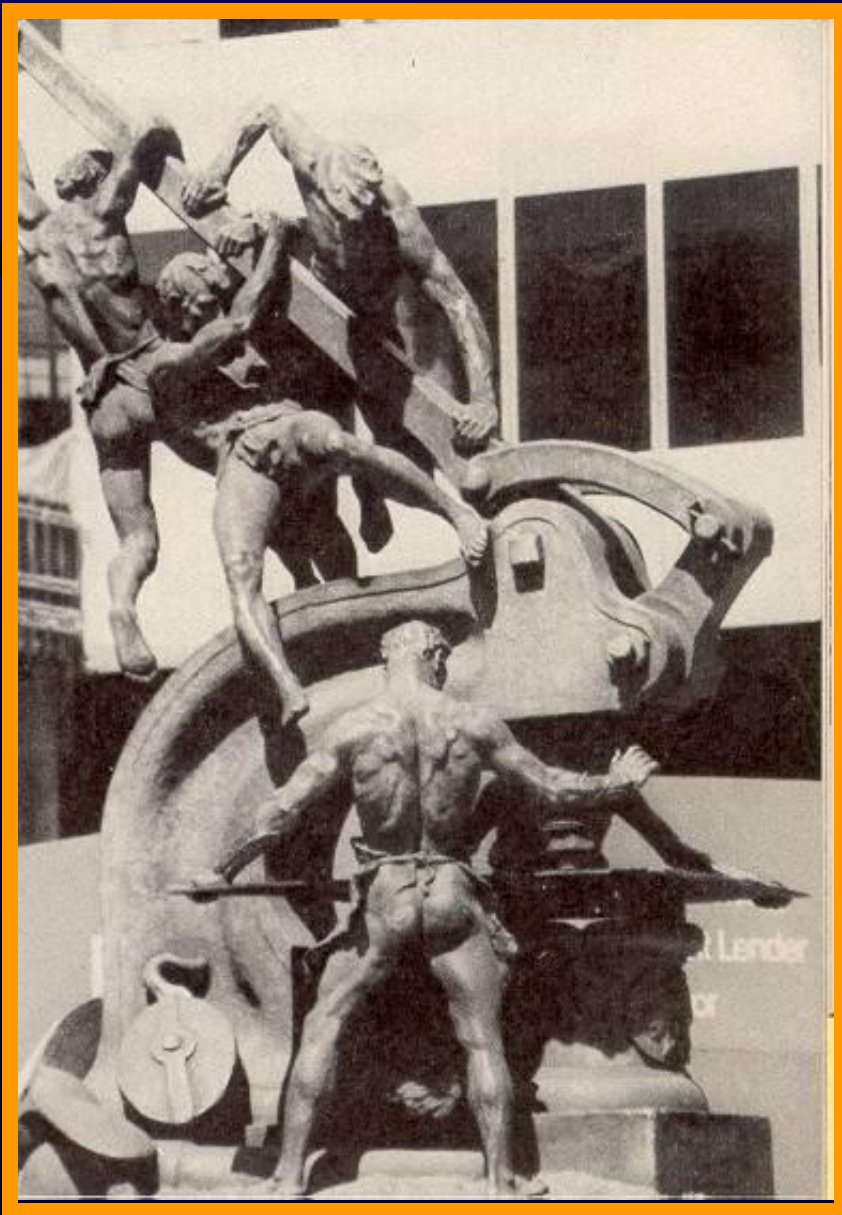
- “Girl in Green”
- By John Brewster



- **“Chesapeake Bay Retriever with Goose”**
- **By Louis Frisino**



- **“Helen Keller’s Breakthrough”**
- **By Frederick LaMonto**



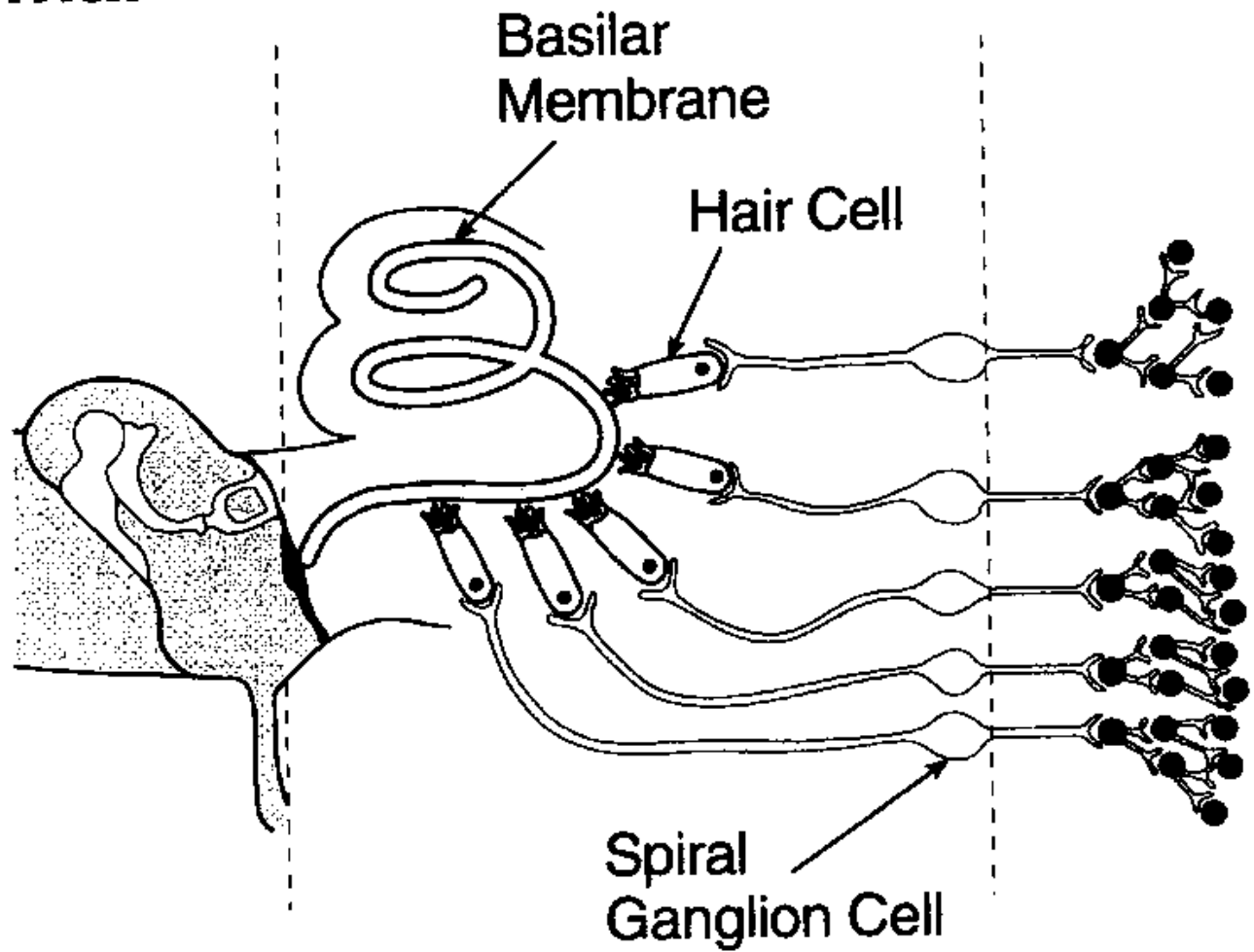
- **“The Mechanics”**
- **By Douglas Tilden**



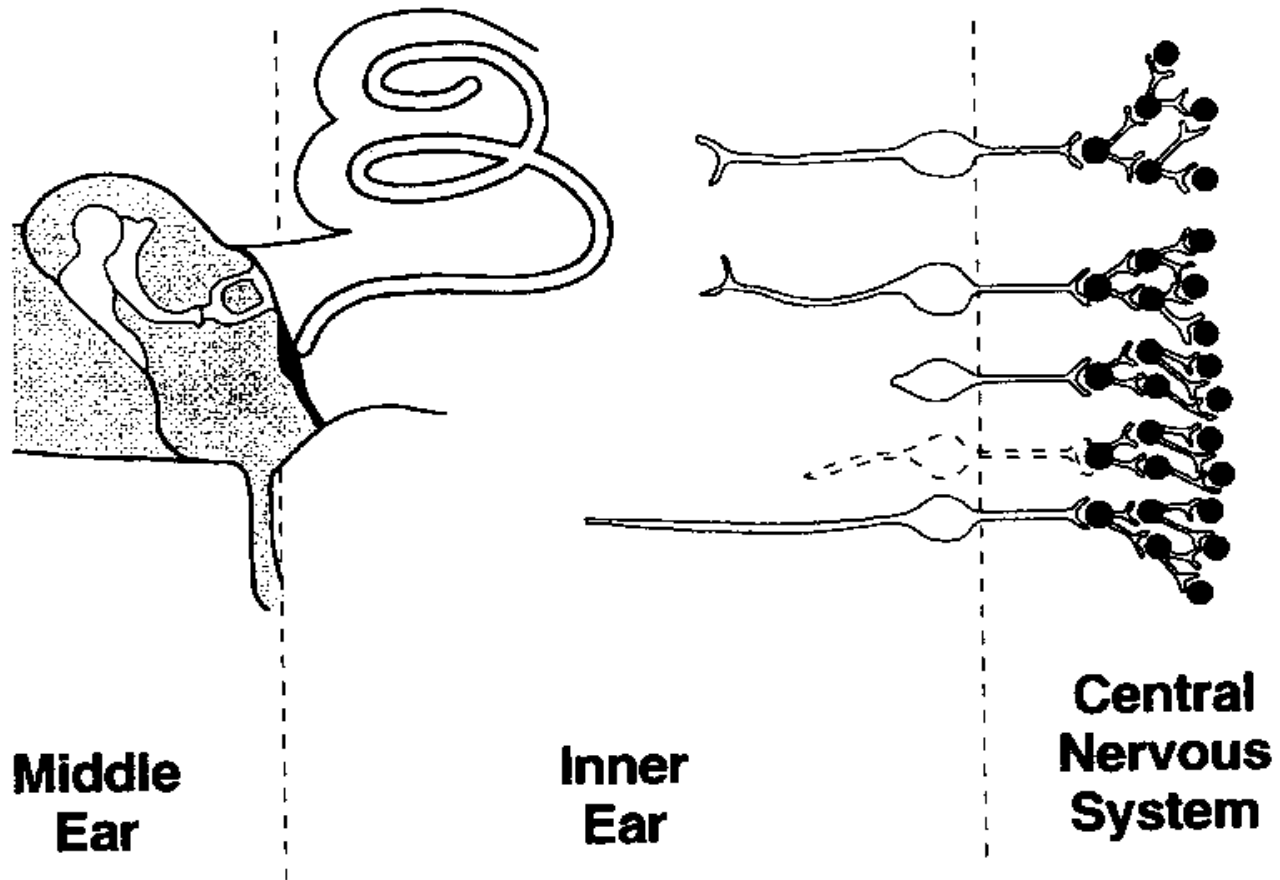


*Is deafness a medical problem?*

# Normal



# Deafened







*Is deafness a communication  
problem?*

- **“Oh you men who think or say that I am malevolent, stubborn or misanthropic, how greatly you wrong me. You do not know the secret cause which makes me feel that way to you.....”**

- **“...for six years now I have been hopelessly afflicted, made worse by senseless physicians, from year to year, deceived with hopes of improvement, finally compelled to face the prospect of a lasting malady (whose cure will take years or, perhaps, be impossible)...”**

- **“...My misfortune is doubly painful to me because I am bound to be misunderstood; for me there can be no relaxation with my fellow men, no refined conversations, no mutual exchange of ideas. I must live alone, like one who has been banished...”**

- “...I am compelled to withdraw myself, to live life alone. If at times I tried to forget all this, oh how harshly, I was flung back by the experience of my bad hearing. Yet it was impossible for me to say to people, “*Speak louder, shout for I am deaf...*”

**Beethoven, “The Hiligenstadt Testament”, a letter to my Brothers Carl and Johann Beethoven, 6 October 1802.**

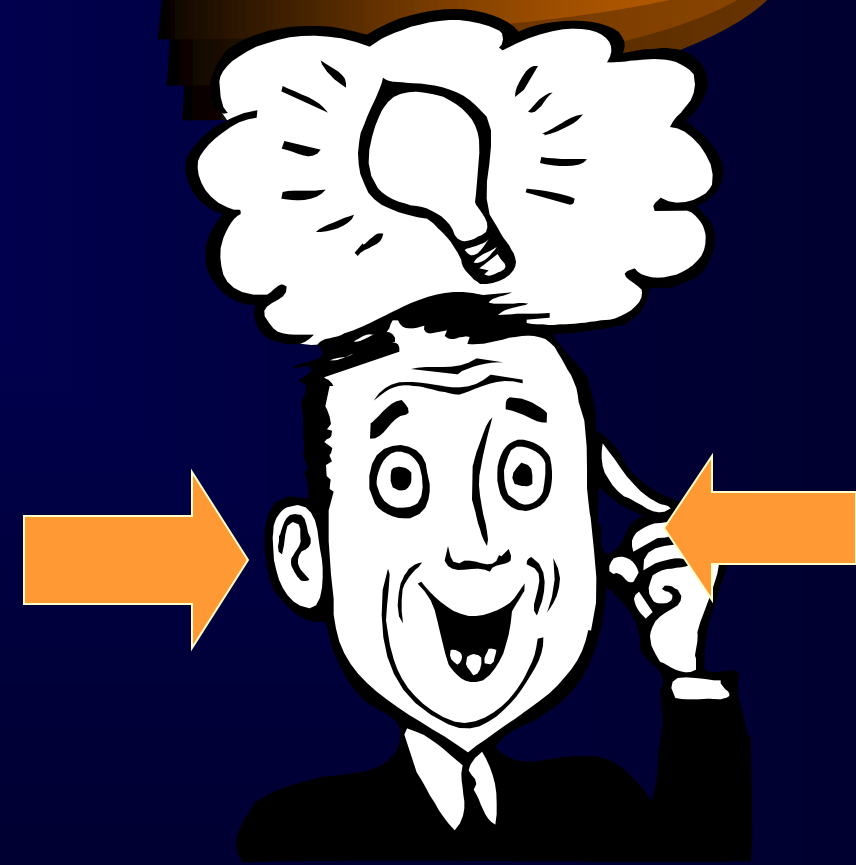


# *deafness and technology*



# *Volta:* Subject of first cochlear implant study

- Inventor of battery
- 50 V application
- “..a boom within the head” followed by a sound similar to that of thick, boiling soup.





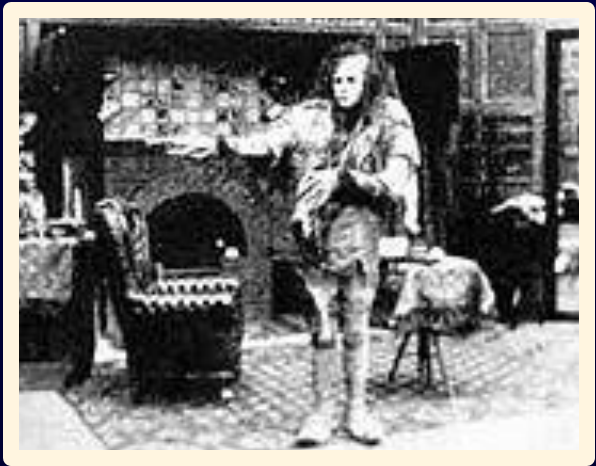
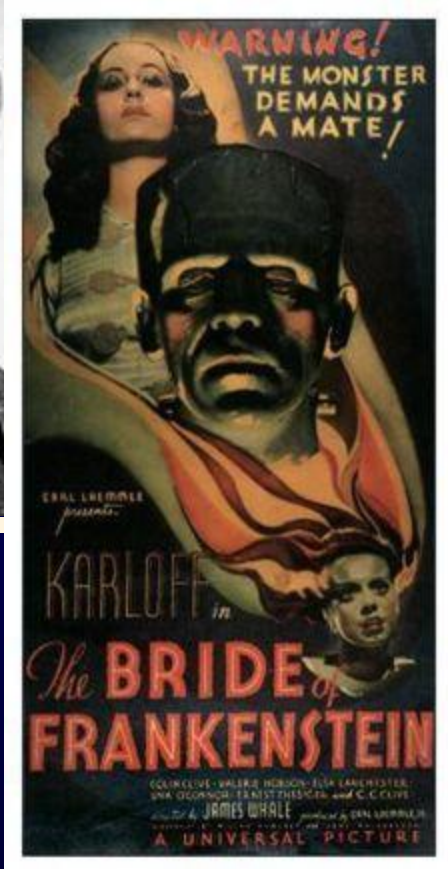
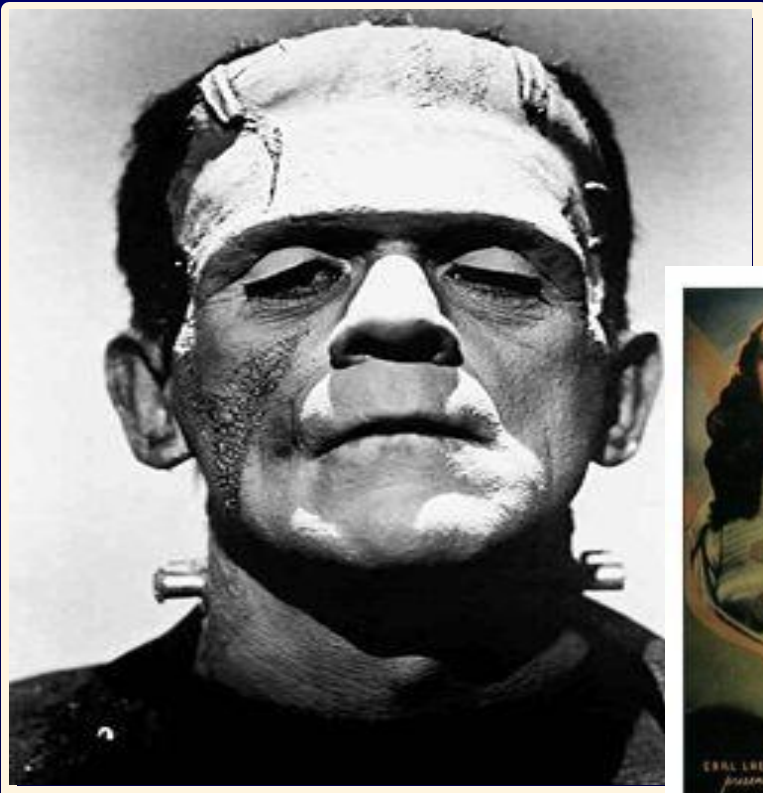
# International Development of Bionic Technology in Literature and Theatre

Volta

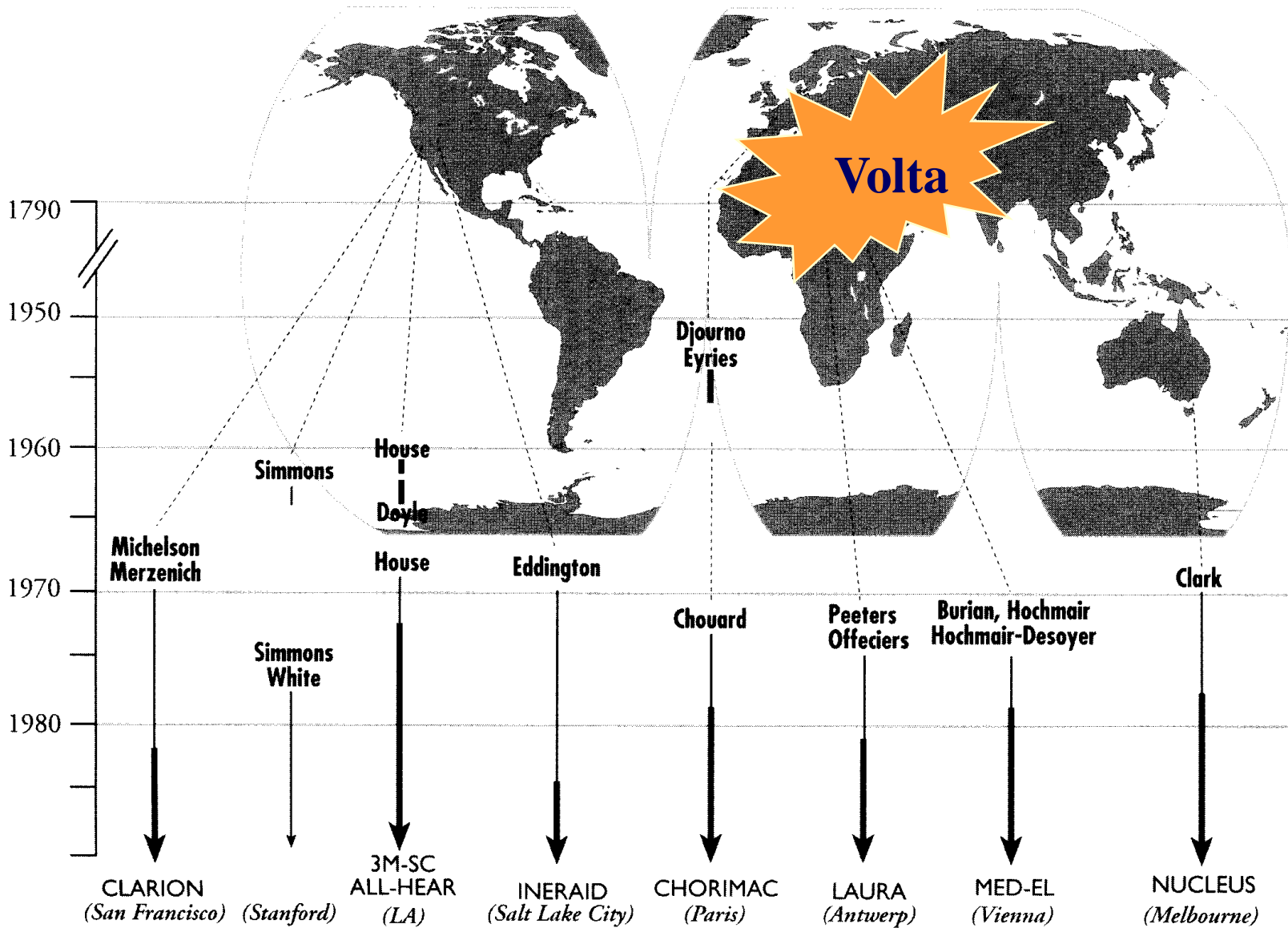


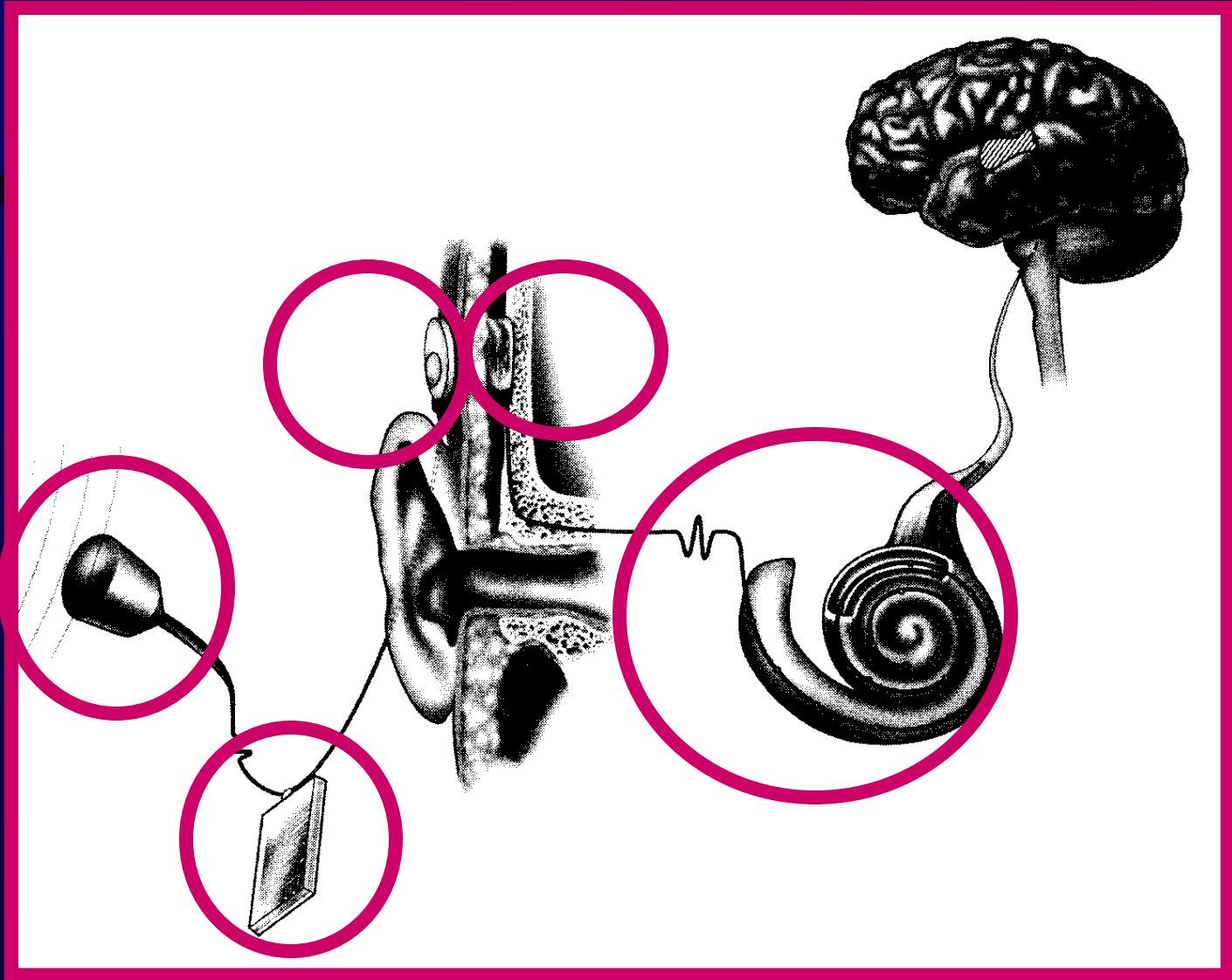
Chapter 1  
There was a heavy night of November  
that Voltaire had been completed and  
with an earnest that almost seemed  
to be agony. I recall the appearance of  
around me and immediately before a  
species of being in the light of  
that lay at my feet. It was a creature  
one in the morning the same species  
known against the London streets  
in small numbers but not then  
in the chamber of the high  
to light, I saw the dull yellow eye of  
the creature. It breathed hard  
and a convulsive motion agitated  
its limbs.  
But how Italian, I should say,  
London at the cathedral, for you will  
recall the British when with a not  
defiant, fierce and one that induces  
to form. The bomb was in possession  
of the creature. It had a face that was  
a mixture of human and brute. Great but  
yellow hair then curled about the head  
of the creature and under beneath the hair  
the flowing and the rest of a head that  
was but that brown and only some  
formed a more human contact with  
the body. Its face was almost  
the same colour as the hair white  
and it was which the hair





# International Development of Cochlear Implants

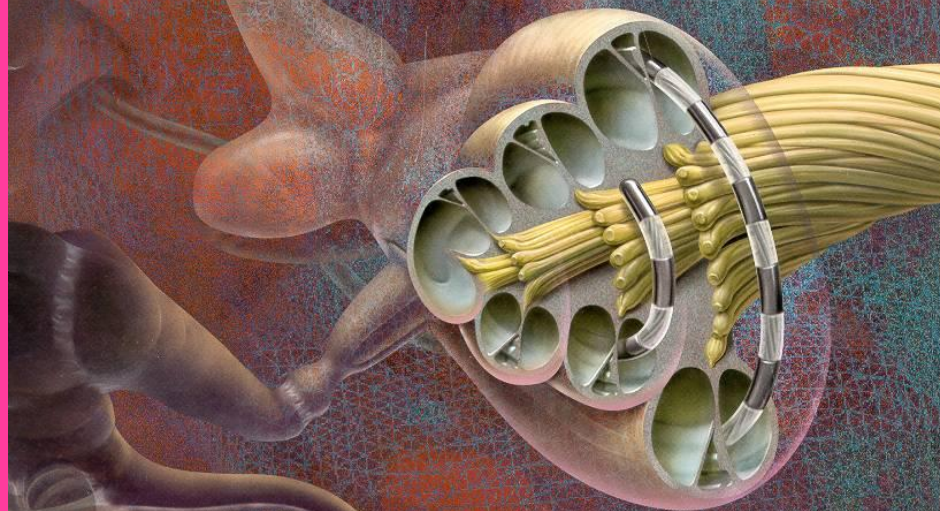




# CLINICAL

PERSPECTIVES

VOLUME IX, NUMBER 1

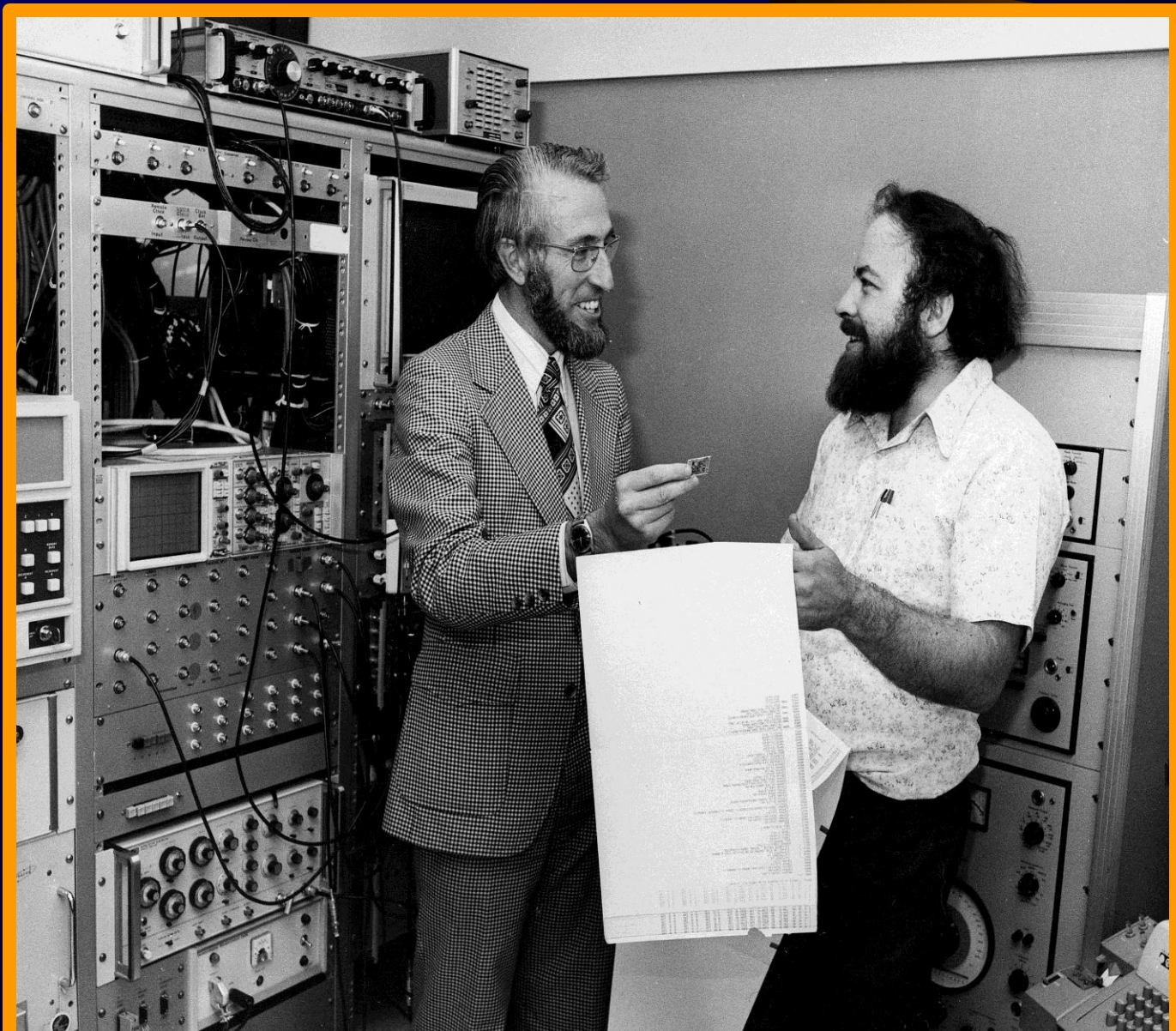


THERAPEUTIC ADVANCES IN

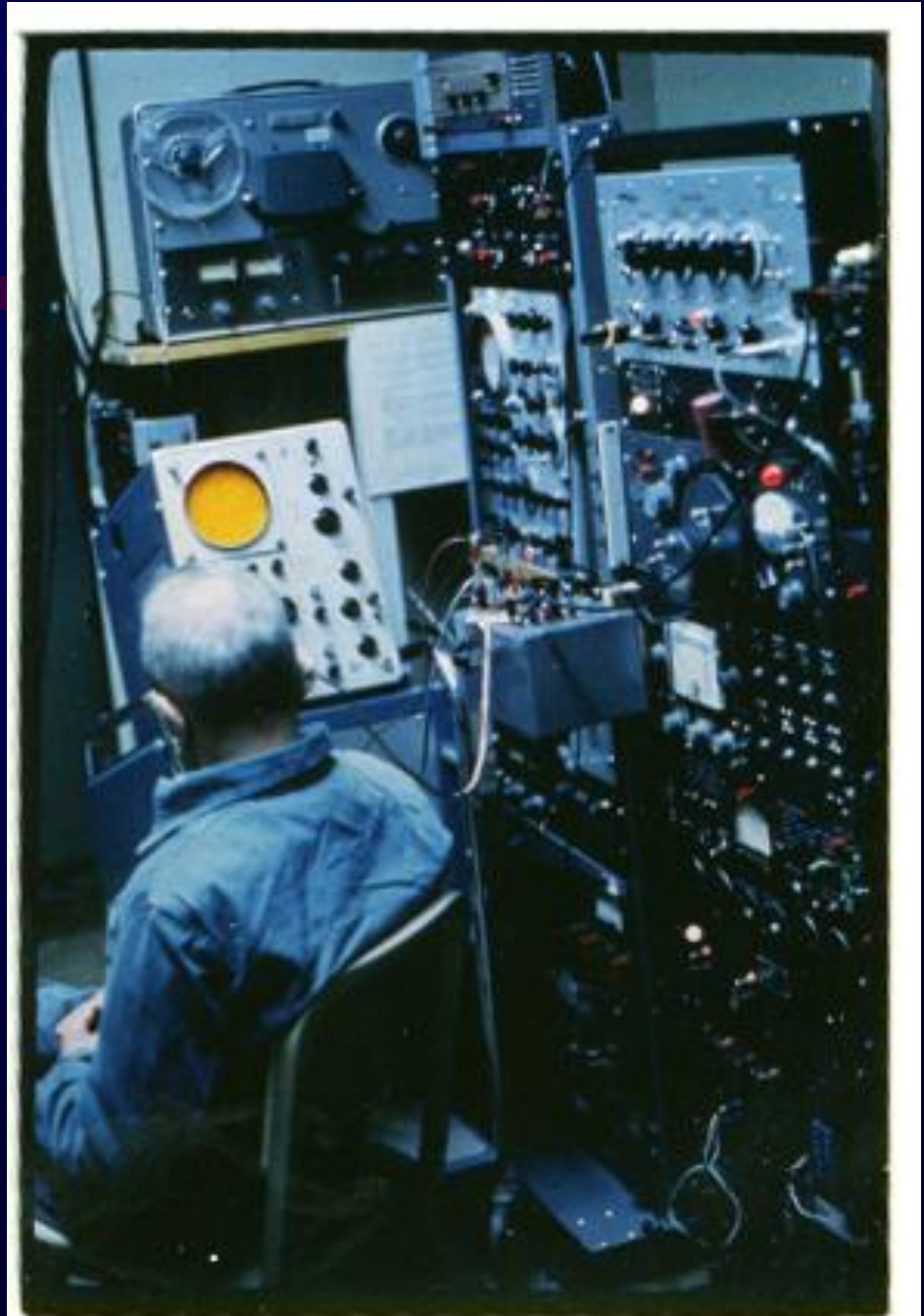
- HEARING AND BALANCE DISORDERS
- LIVE DONOR NEPHRECTOMY
- INSULIN RESISTANCE AND CARDIOVASCULAR DISEASE
- OVERACTIVE BLADDER
- MULTIPLE SCLEROSIS
- OVARIAN CANCER

SOUTHWESTERN

# Professor Graeme Clark, First Nucleus Cochlear Implant



**Professor Blair Simmons,  
UCSF Cochlear Implant,  
1964**



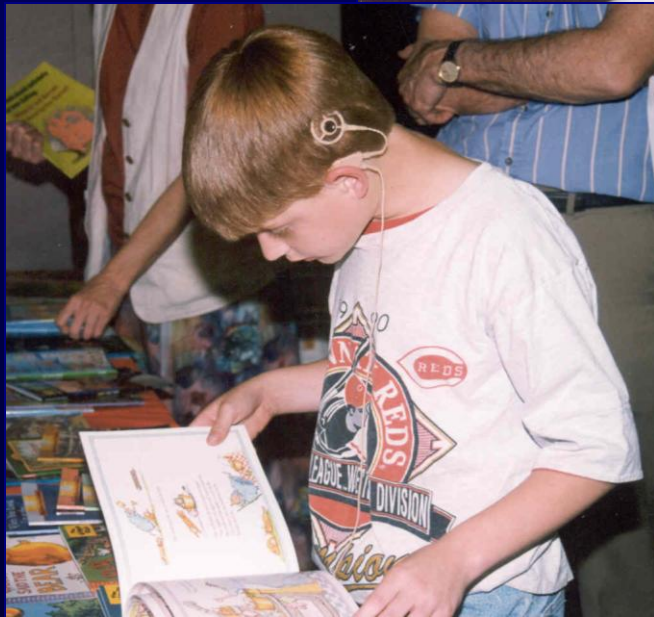






*Archive Photo, Sonotone, c.1967*

# *Students wearing Cochlear Implants*





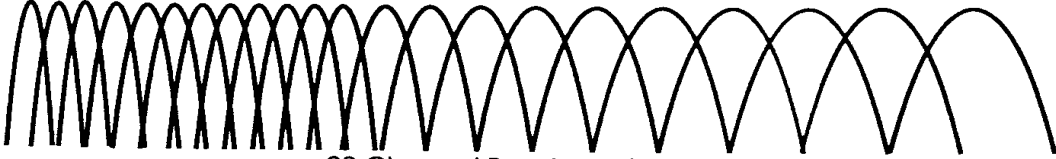
*What does communication sound  
like through a cochlear implant?*

ah /a/

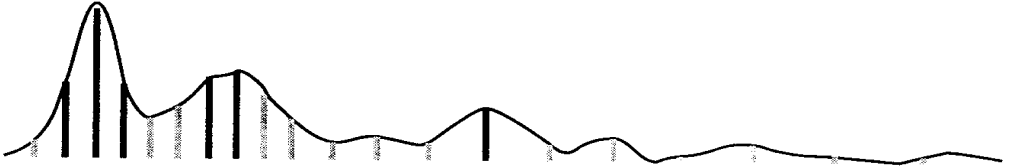
# Philip Loizou



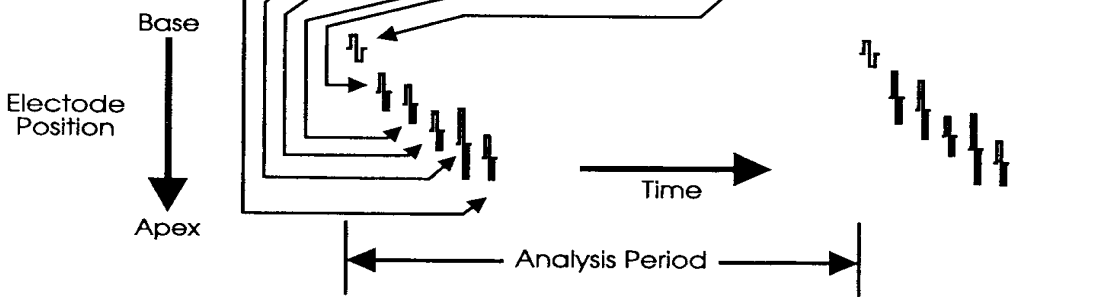
Speech Waveform



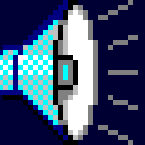
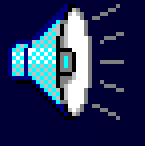
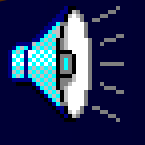
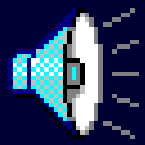
22 Channel Bandpass Filter Bank



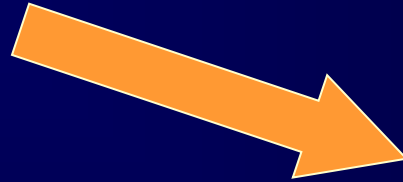
Instantaneous Spectrum - Select 6-10 largest outputs of Filter Bank



Stimulate Electrodes (non-simultaneously)

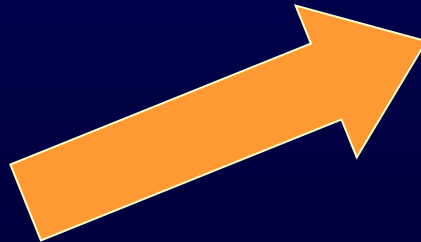


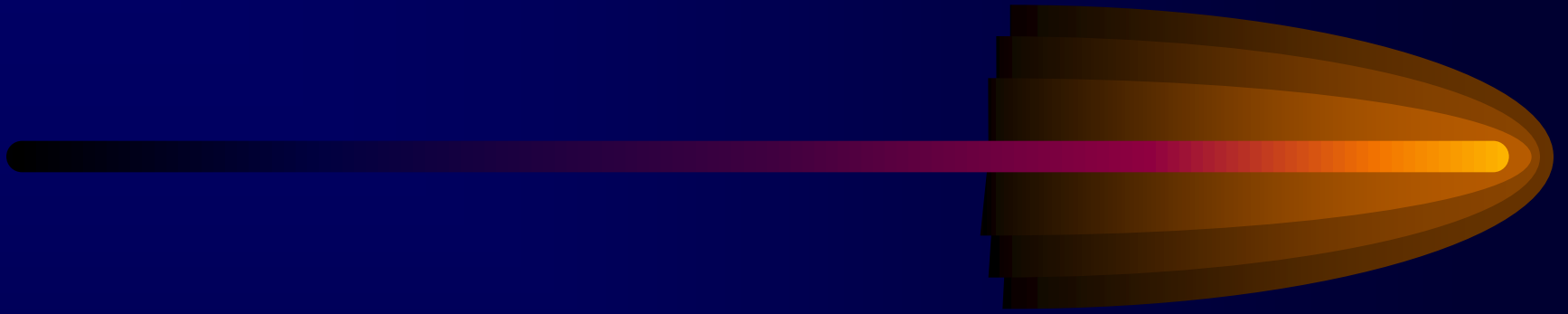
**Reliance  
on  
Speech**



**Good  
Communicator**

**Speech  
Intelligibility**





# *Communication Outcomes*

# *Study Design*

**Children tested first in elementary school  
when they were 8 and 9 years old (N=181)**

***Ear and Hearing Supplement, 2003***

**Children tested again in high school  
when they were 15 – 17 years old (N=112)**

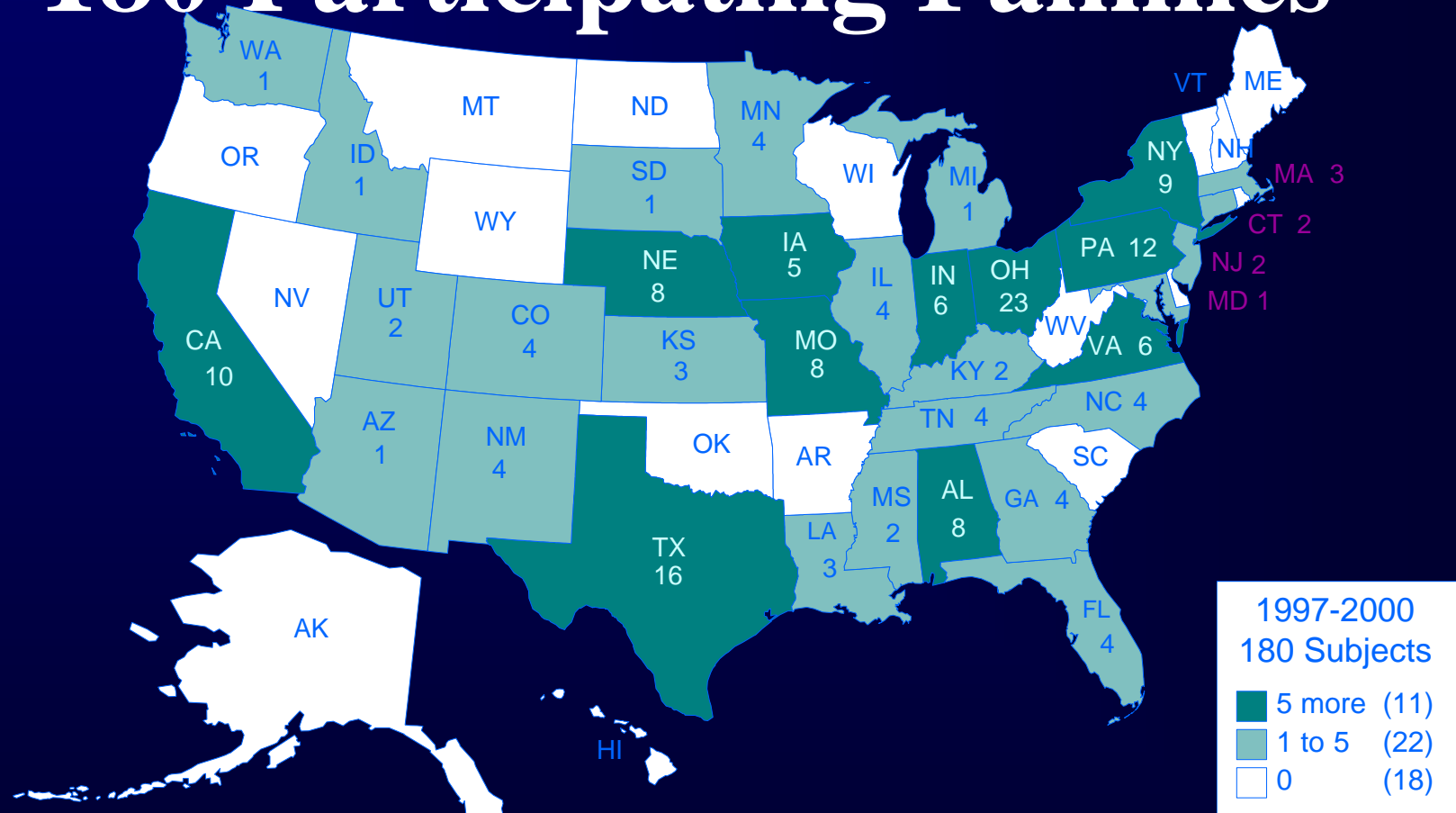
***Ear and Hearing Supplement, Jan/Feb  
2011***

# **Elementary: Sample Selection**

- 1. Between 8 and 9 years of age**
- 2. Onset of deafness by age 3**
- 3. 4-6 years of implant use**
- 4. Implanted before 5 years of age**
- 5. No additional disabilities**
- 6. Monolingual English home environment**
- 7. No open set speech perception**

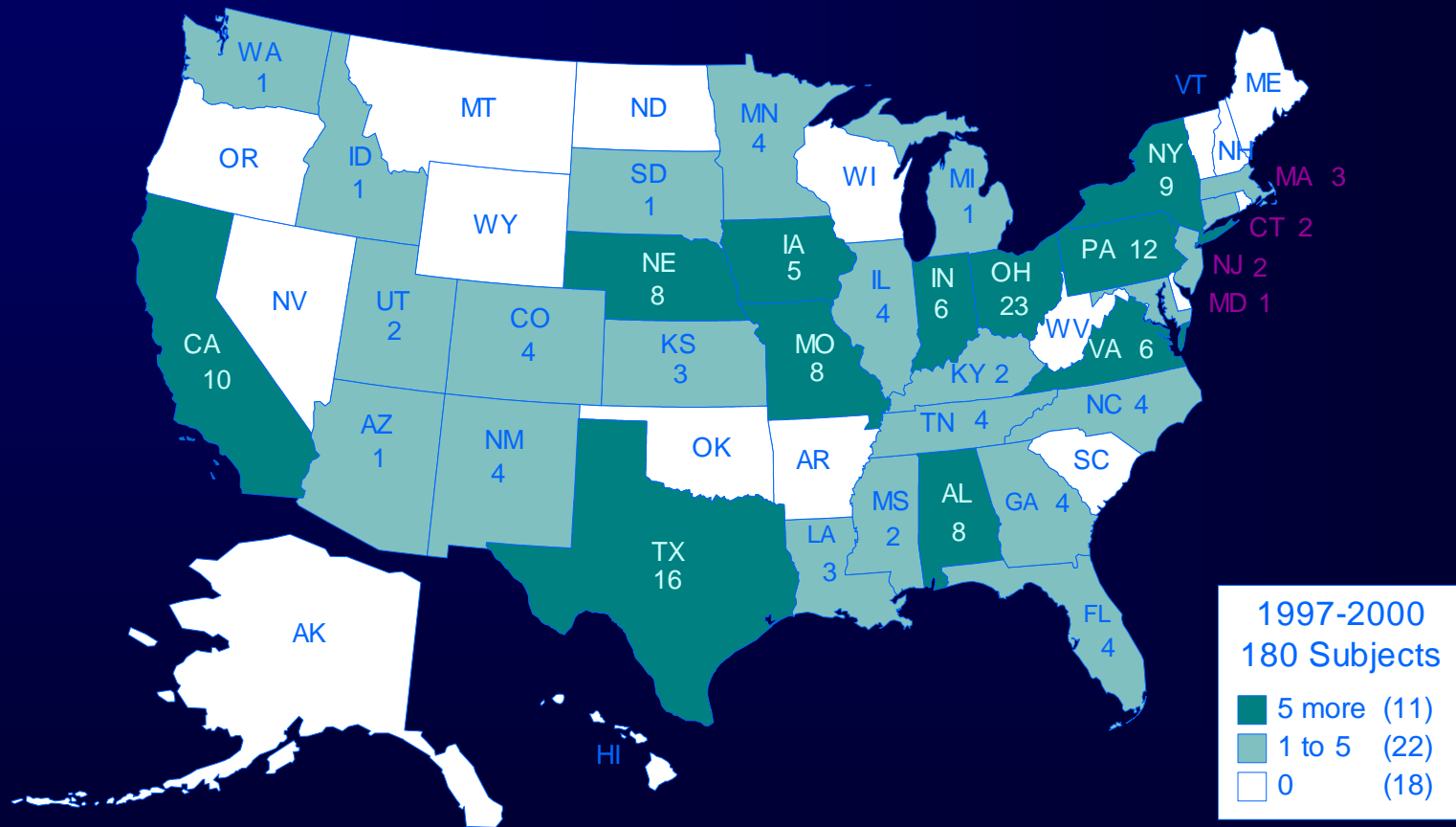


# 180 Participating Families



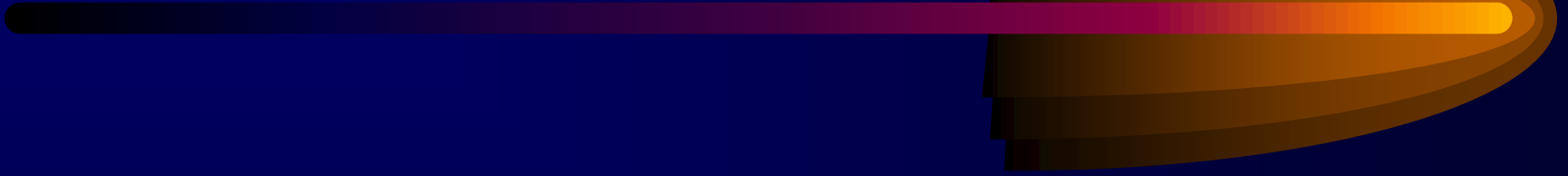
*From 33 U.S. States & 5 Canadian Provinces*

# 112 Participating Families

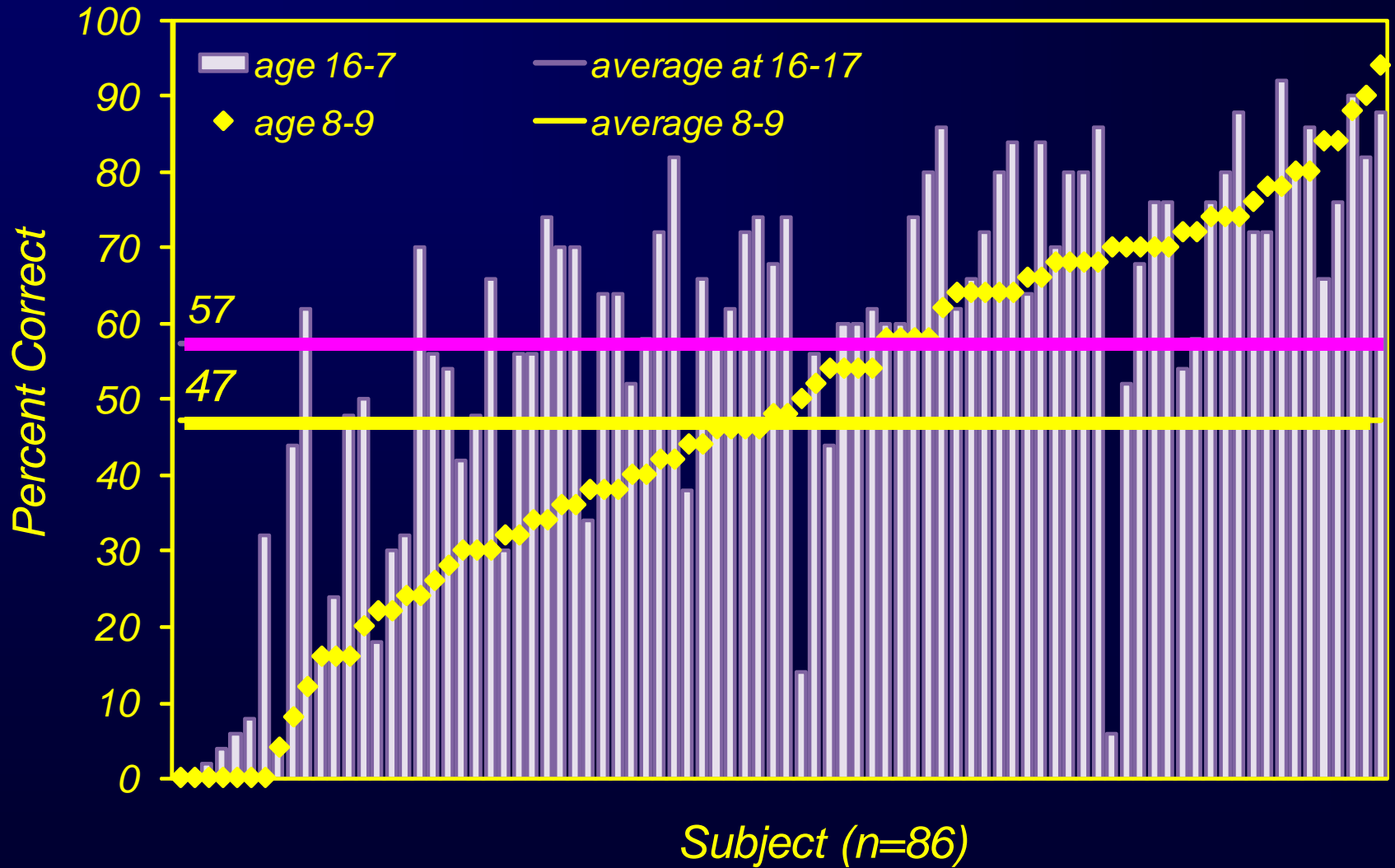


*From 33 U.S. States & 5 Canadian Provinces*

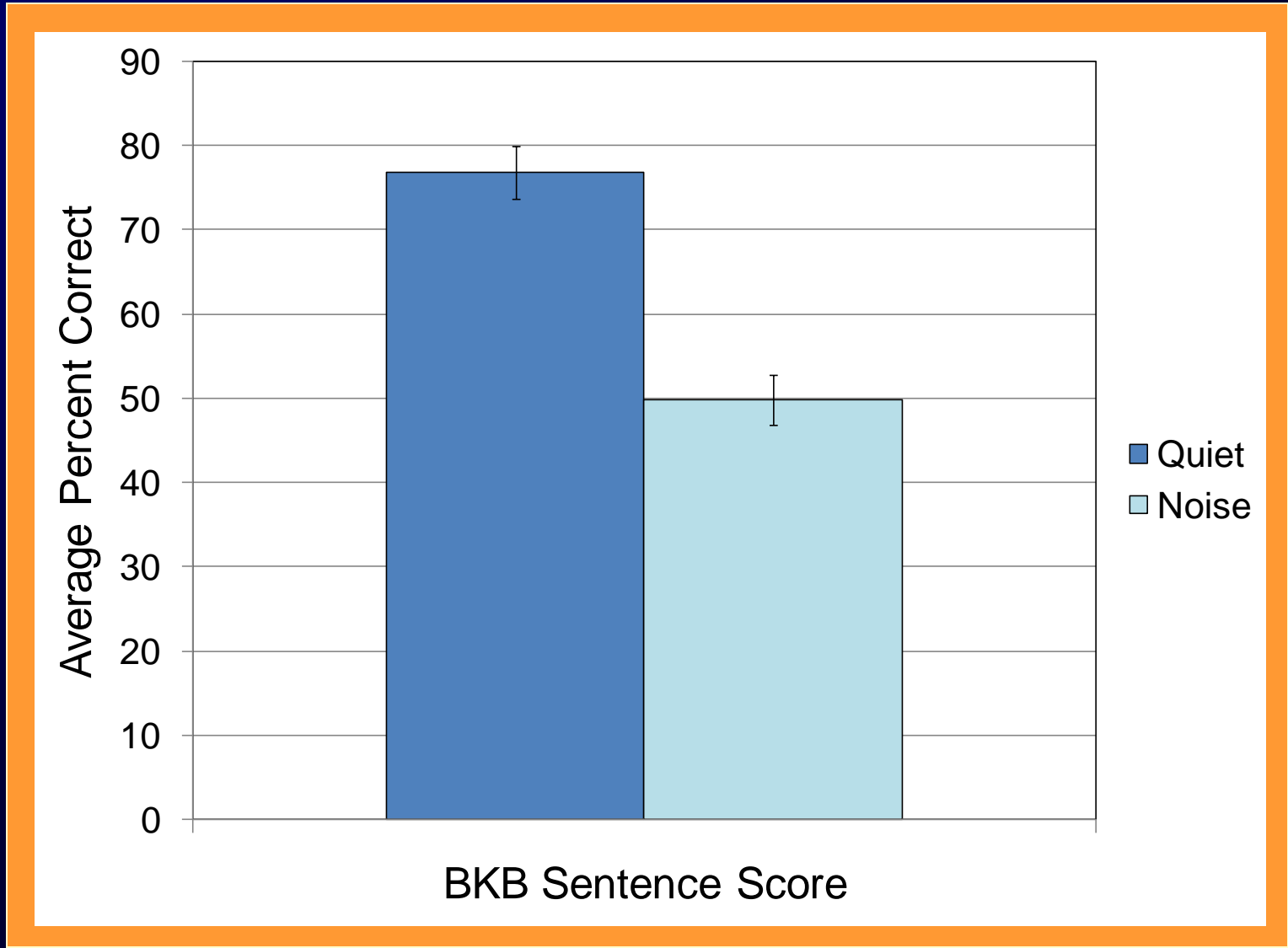
# *Speech Perception*



# Word Perception: LNT List



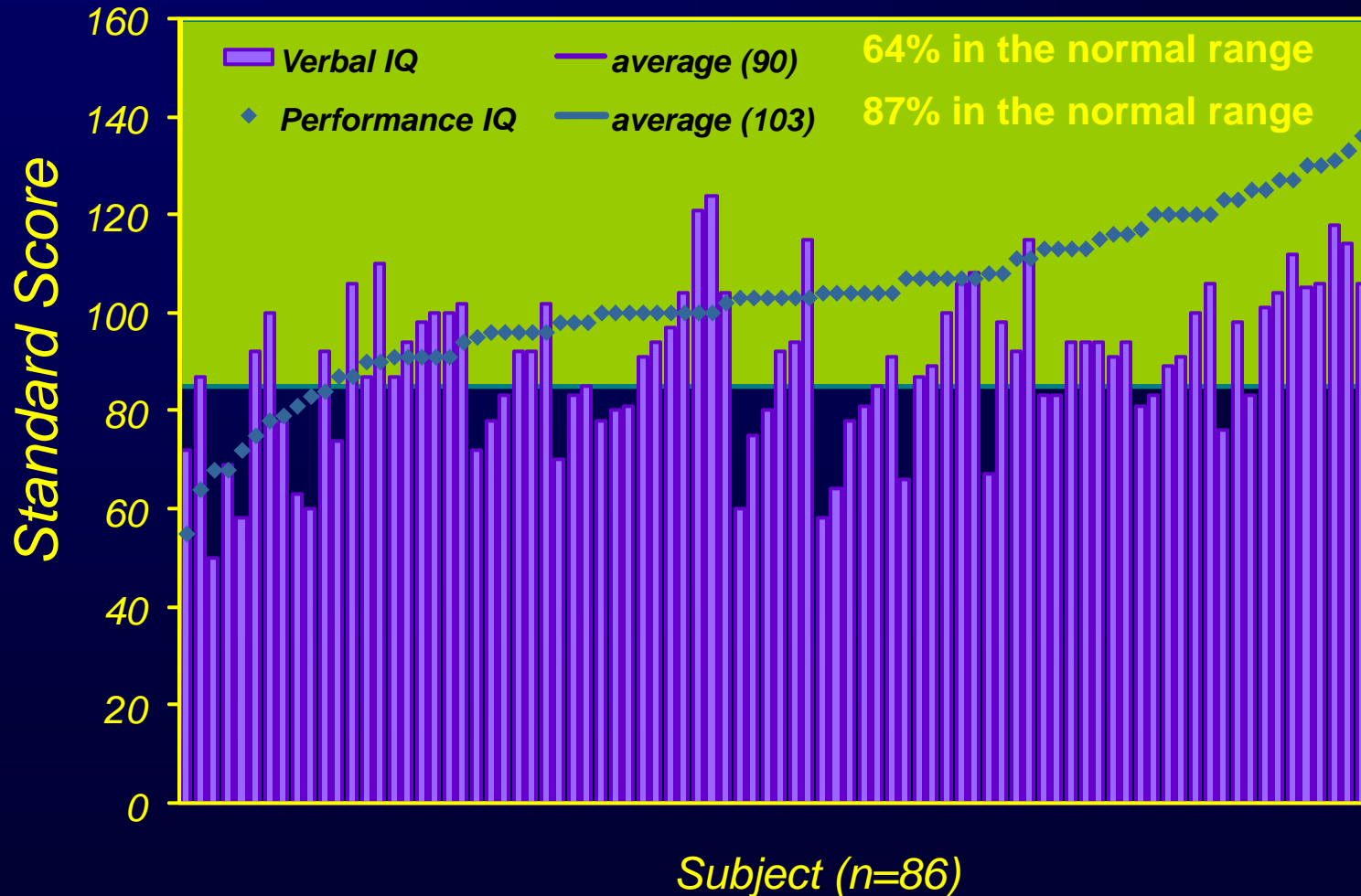
# Listening in quiet and noise, ages 16-17



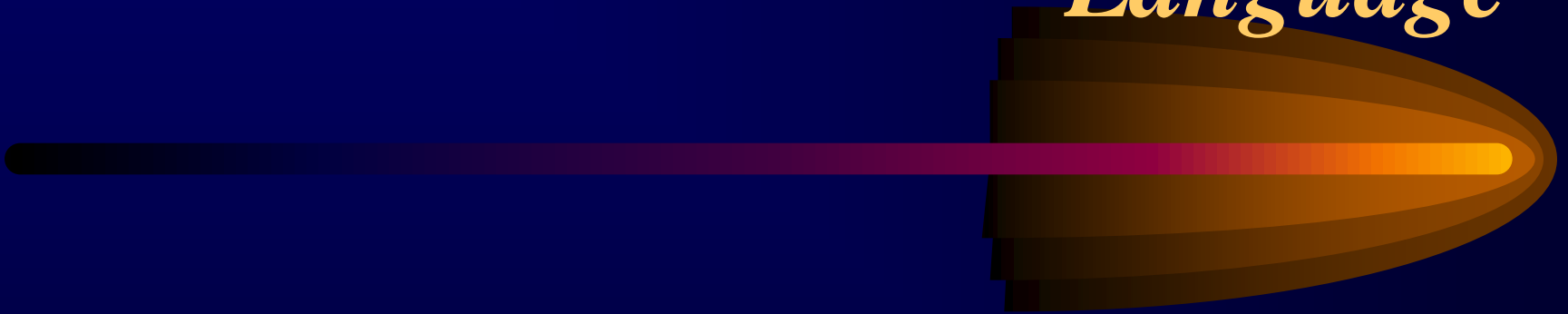
*Intelligence*



# WISC Verbal & Non-Verbal Quotients

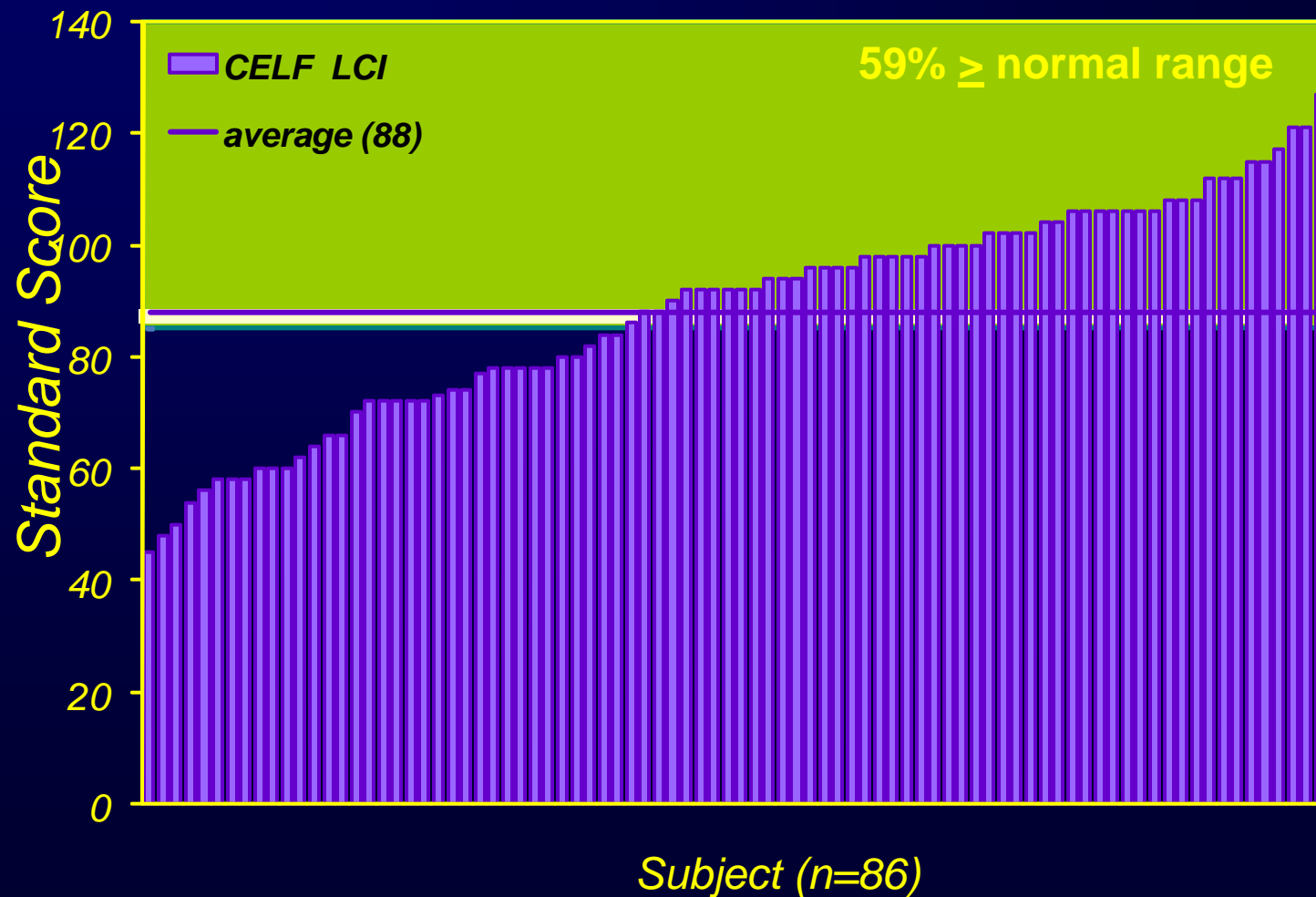


*Language*





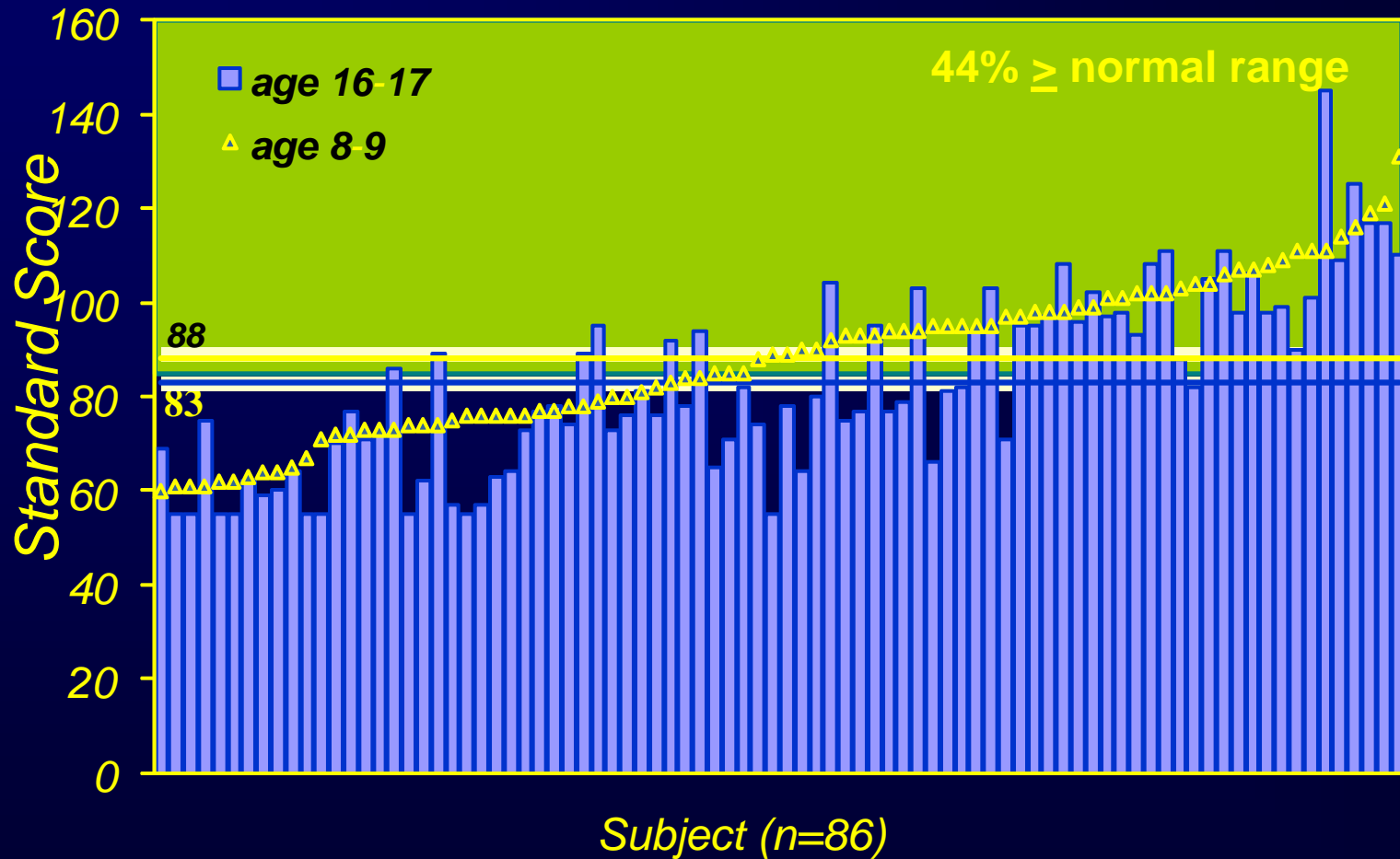
# Clinical Evaluation of Language Fundamentals – Language Content Index



*Reading*

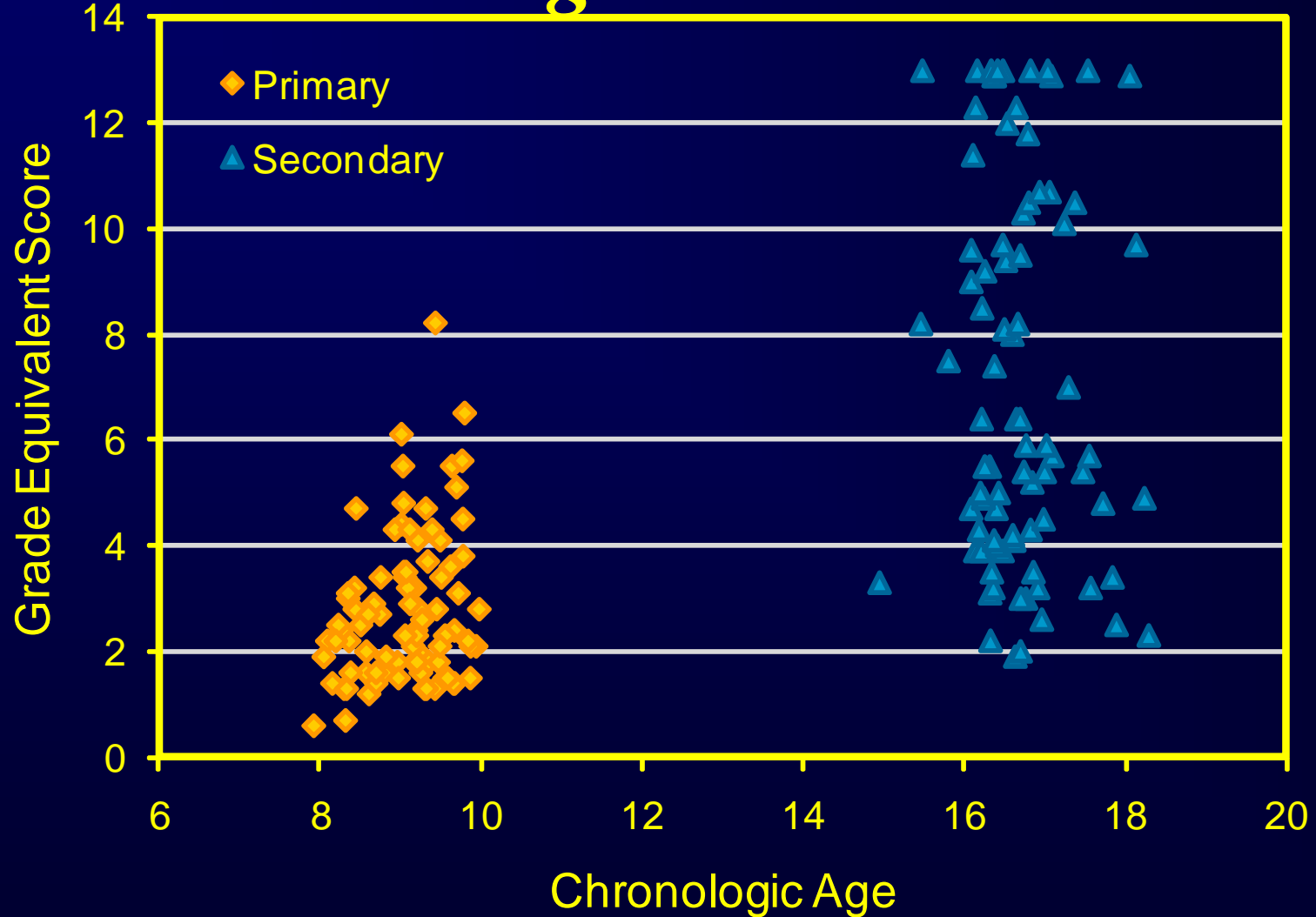


# PIAT Reading over Time

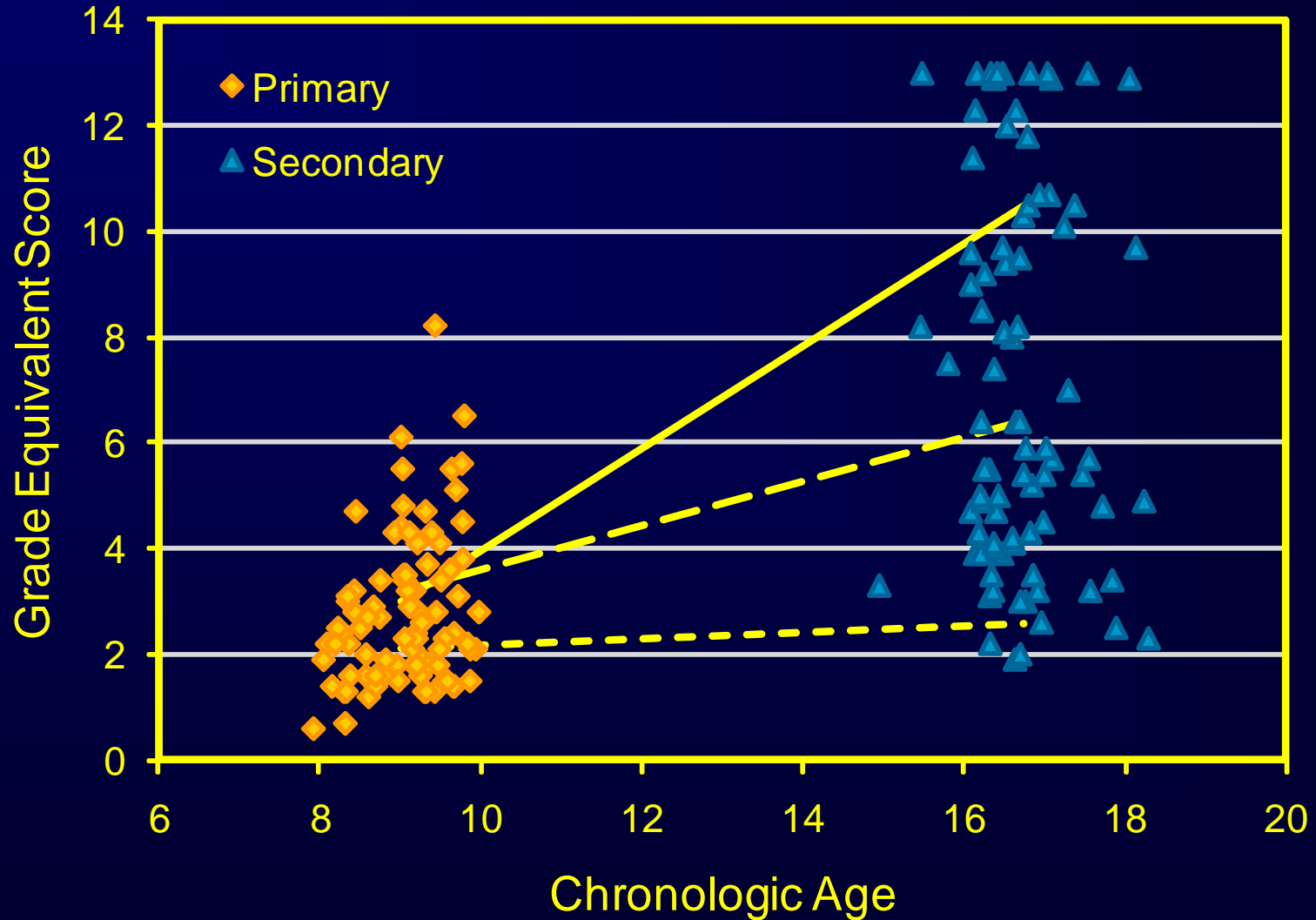


**Note: 88 is the mean at the younger age, 83 is the mean at age 16-17**

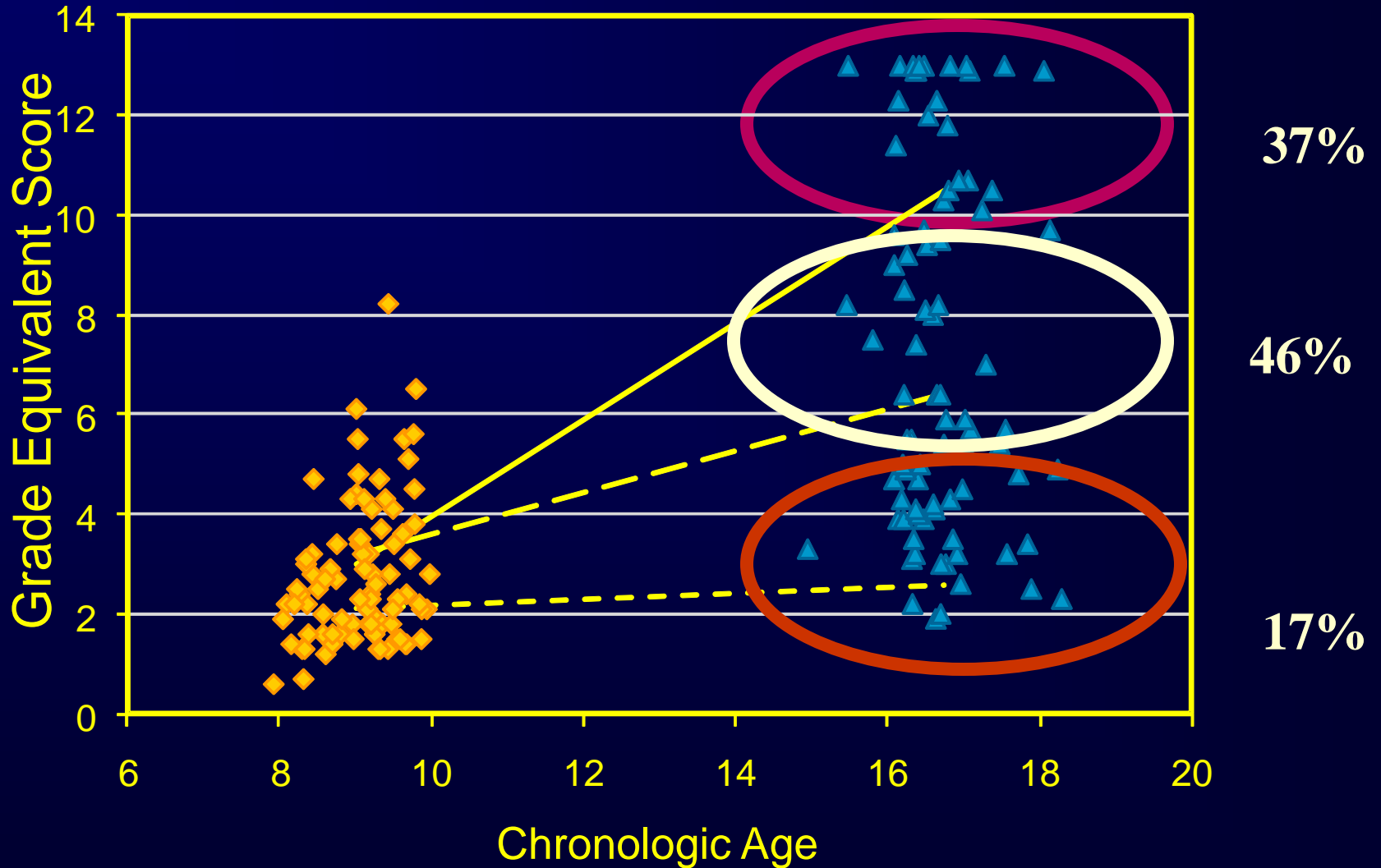
# *PIAT Reading Grade Score and Age*



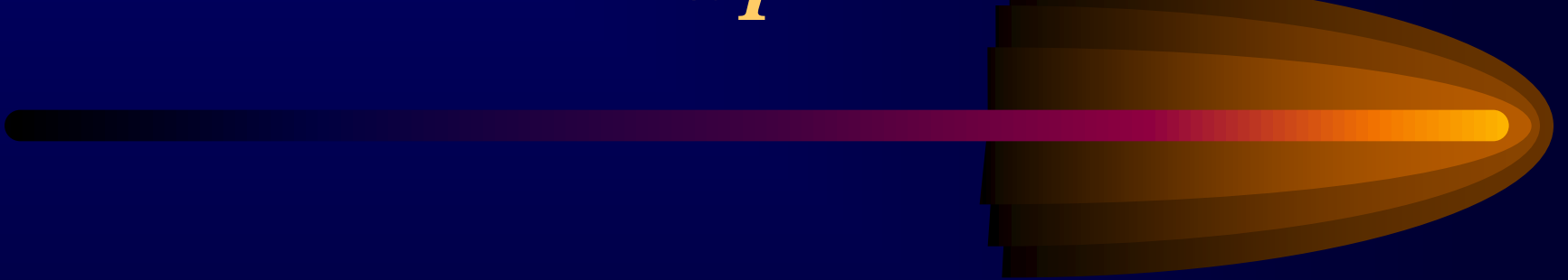
# *PIAT Reading Grade Score and Age*



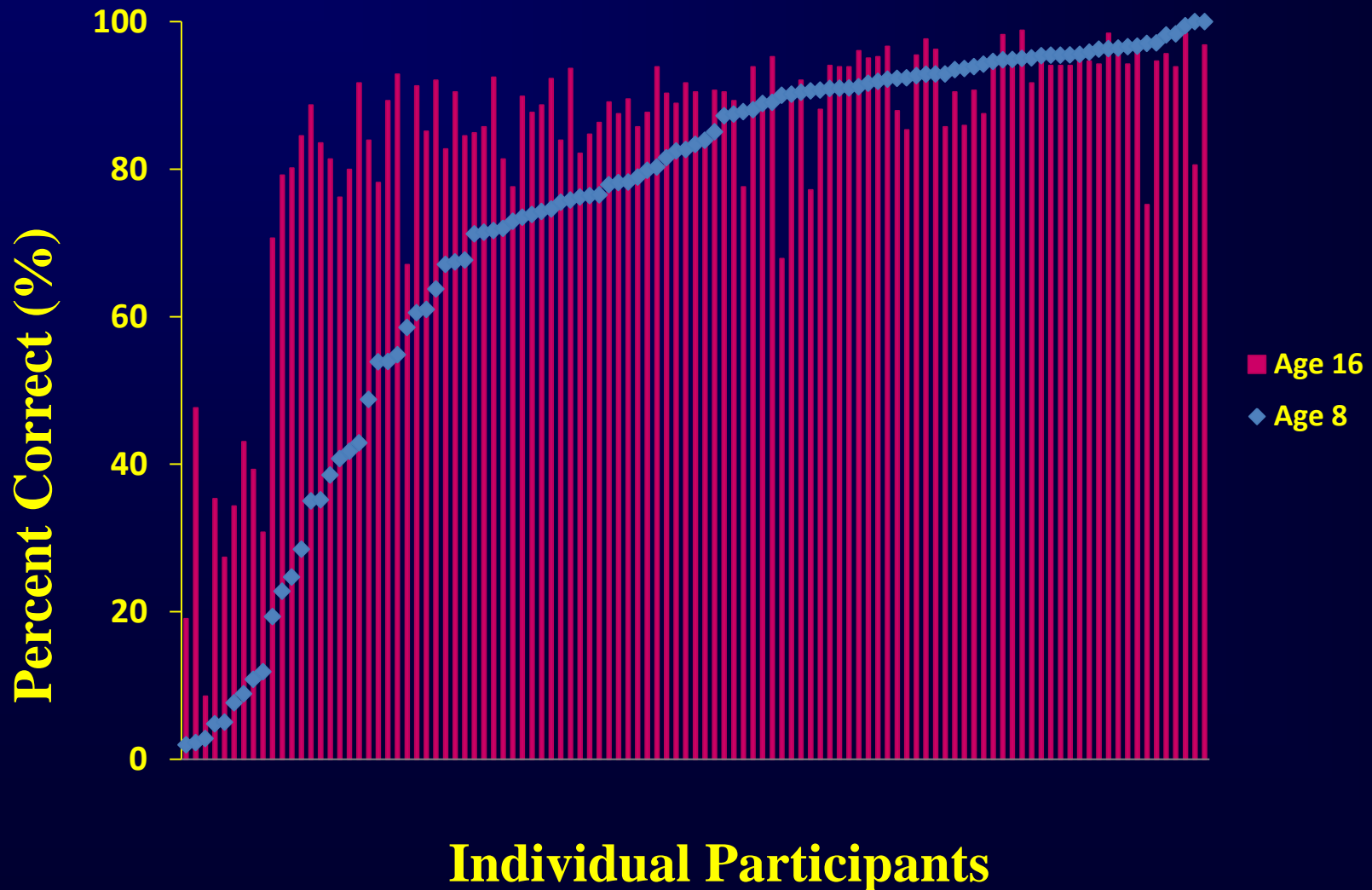
# *PIAT Reading Grade Score and Age*



# *Speech Production*

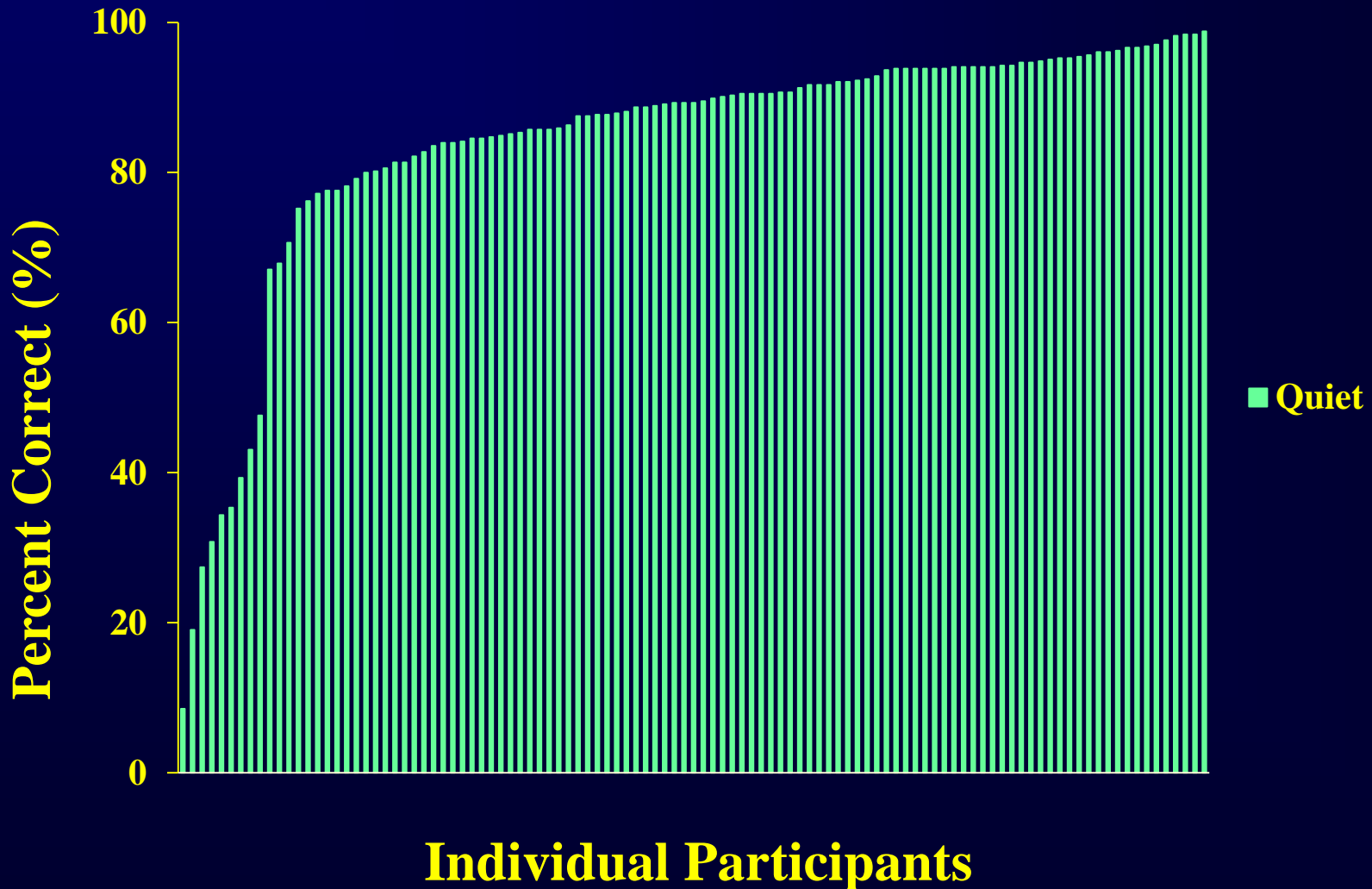


# *Speech Intelligibility of Children at Ages 8 and 16 years in Quiet*

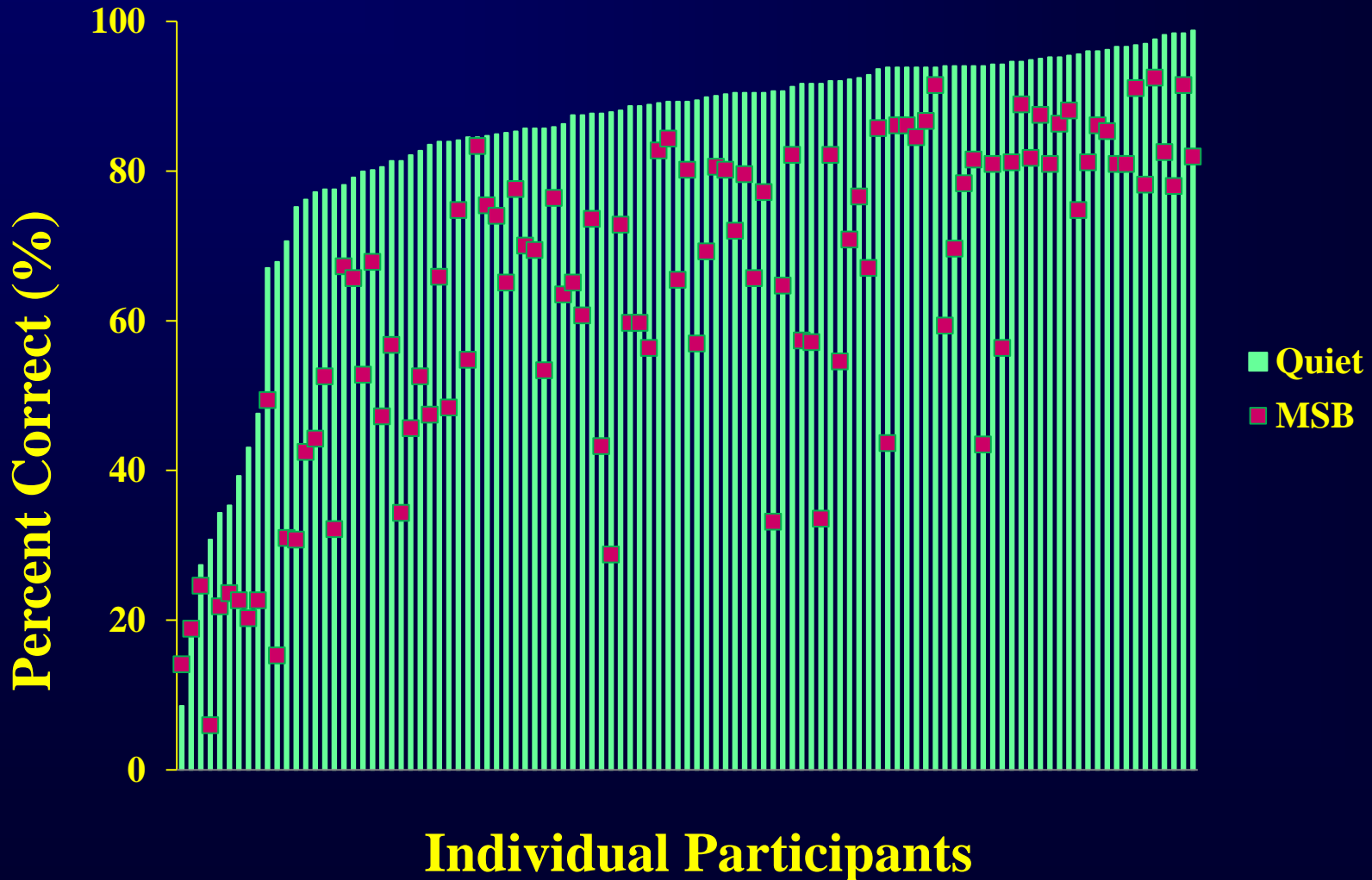




# *Speech Intelligibility at 16 years in Quiet and Multi-Speaker Babble*



# *Speech Intelligibility at 16 years in Quiet and Multi-Speaker Babble*



# *Child & Family Characteristics for Elementary School*

	Speech Production	Speech Perception	Language	Reading
Gender				
Performance IQ			+**	+*
Family Size	-*	-**		
SES	+**	+**	+**	+**
Explained Variance	22%	23%	17%	13%

*\*p<.05, \*\*p<.01; \*\*\*p<.001*

# *Deafness Characteristics for Elementary School*

	Speech Production	Speech Perception	Language	Reading
Duration of Deafness				—*
Sign Enhancement	—***	—***	—**	—**
Explained Variance	<b>35%</b>	<b>22%</b>	<b>14%</b>	<b>7%</b>

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$

# *Processing Speed for Elementary School*

	Speech Production	Speech Perception	Language	Reading
Verbal Rehearsal Speed	-.***	-.***	-.***	-.***
Explained Variance	13%	16%	31%	23%

*\*p<.05, \*\*p<.01; \*\*\*p<.001*

# *Processing Speed for Elementary School*


	Speech Production	Speech Perception	Language	Reading
Verbal Rehearsal Speed	-.***	-.***	-.***	-.***
Explained Variance	13%	16%	31%	23%
Total Explained Variance	69%	61%	62%	43%

\* $p < .05$ , \*\* $p < .01$ ; \*\*\* $p < .001$

# *Processing Speed for Elementary School*

	Speech Production	Speech Perception	Language	Reading
Verbal Rehearsal Speed	-.***	-.***	-.***	-.***
Explained Variance	13%	16%	31%	23%
Total Explained Variance	69%	61%	62%	43%

\* $p < .05$ , \*\* $p < .01$ ; \*\*\* $p < .001$

- 
- **Does communication status during elementary school predict communication status in high school?**



# *Child & Family Characteristics for High School*

	Speech Production	Speech Perception	Language	Reading
Gender				
Performance IQ				+*
Family Size	-*	-**		
SES	+**	+**	+**	+**
Explained Variance	13%	15%	19%	17%

\* $p < .05$ , \*\* $p < .01$ ; \*\*\* $p < .001$

# *Deafness Characteristics for High School*

	Speech Production	Speech Perception	Language	Reading
Duration of Deafness			—**	—*
Sign Enhancement	—****	—****		
Explained Variance	36%	15%	6%	4%

*\*p<.05; \*\*p<.01; \*\*\*p<.001*

# *Processing Speed for Elementary School*

	Speech Production	Speech Perception	Language	Reading
Verbal Rehearsal Speed	<b>-.***</b>	<b>-.***</b>	<b>-.***</b>	<b>-.***</b>
Explained Variance	<b>7%</b>	<b>11%</b>	<b>20%</b>	<b>24%</b>

*\*p<.05, \*\*p<.01; \*\*\*p<.001*

# *Elementary School Predicting High School*

	Speech Production	Speech Perception	Language	Reading
Elementary School Performance	+***	+***	+***	+***
Explained Variance	10%	33%	24%	24%

*\*p<.05, \*\*p<.01; \*\*\*p<.001*

# *Elementary School Predicting High School*

	Speech Production	Speech Perception	Language	Reading
Elementary School Performance	+***	+***	+***	+***
Explained Variance	10%	33%	24%	24%
Total Explained Variance	65%	71%	70%	69%

*\*p<.05, \*\*p<.01; \*\*\*p<.001*

# *How are they doing in High School?*

- **95% mainstreamed**
- **72% use the telephone**
- **Majority comfortable with Deaf and hearing friends**
- **Most expected to go to college**

## *Students from Early Oral Communication Settings*

- **93% --intelligible speech**
- **38% -- report using sign language**
- **10 % -- use sign interpreter for some classes**
- **95%-- use speech without sign in everyday communication**
- **13%-- report minimal proficiency in sign language**

# *Communication for Early Sign Users*

- **50%** --communicate using only speech
- **67%** -- have intelligible speech
- **64%** -- use sign interpreter in some classes
- **11%** -- discontinue sign by high school



# Executive Functioning

Adults execute planning  
in elementary school



Teenagers must learn to:



Plan



Prioritize



Stick with a task to completion



Organize

Multitask



# *Executive Functioning*



- **Working Memory and Recall**
- **Activation, Arousal and Effort**
- **Emotional Control**
- **Language Internalization**
- **Problem Solving**



# *Promoting Executive Functioning*



- **Initiate**
- **Inhibit**
- **Shift**
- **Plan**
- **Organize**
- **Self-Monitor**
- **Emotional Control**

# *Rehabilitation Works*

- **Group mean scores for language, reading and social adjustment were within one standard deviation of typical age mates with normal hearing.**

# *Rehabilitation Works*

- **Performance of children in early elementary grades (age 8-9) was highly predictive of their relative standing in high school.**

# *Rehabilitation Works*

- **Variability in performance was accounted for by factors underlying information processing measures associated with verbal rehearsal speed and executive functioning.**

# *Rehabilitation Works: Early Counts*

- **Children in early elementary grades who relied on spoken language (as indicated by receiving no benefit from manual signs) demonstrate higher verbal rehearsal skills and higher levels of speech perception, speech intelligibility, language and literacy in high school.**