

From /I/ to /fIʃ/

Using Speech Production as a Guide
to Fitting Frequency Compression
Hearing Aids in Children.

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Terminology

- Frequency compression (FC)
- Frequency transpositioning

How do frequency compressing
hearing aids differ from
conventional-style digital aids?

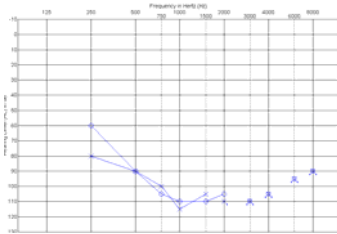
- FC hearing aids capture high frequency information (speech sounds, especially fricatives, and environmental sounds) and present it at frequencies where hearing is aidable.

Benefits of FC fittings

- Make high frequency speech sounds audible, in spite of severity of hearing loss or limits of HF gain in hearing aid.
- Eliminate concerns regarding dead regions of the cochlea in high frequency amplification
- Reduce feedback issues
- Conducive to open fittings

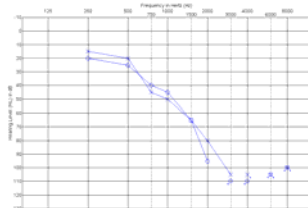
Frequency Compression Candidates

- Corner audiogram



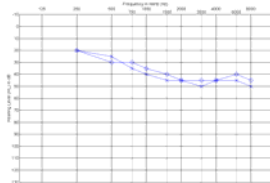
Frequency Compression Candidates

- Corner audiogram
- High frequency loss



Frequency Compression Candidates

- Corner audiogram
- High frequency loss
- Most configurations



Children with Mild-Moderate Hearing Loss

- Most frequent production errors in children are /s, ʃ, tʃ/ (Elfenbein et al., 1994)
- Delayed in vocabulary, verbal, & reasoning skills (Davis et al., 1986)
- Language samples reveal frequent errors in noun & verb morphology (e.g., cat vs. cats; keep vs. keeps) (Elfenbein et al., 1994; Norbury et al., 2001)

Recommended Reading:

Effect of stimulus bandwidth on the perception of /s/
Stelmachowicz, Pittman, Hoover, & Lewis (JASA, 2001)

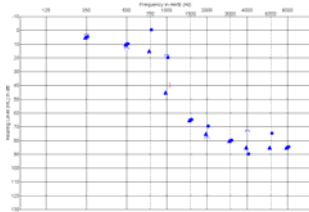
Aided perception of /s/ & /z/ by hearing-impaired children
Stelmachowicz, Pittman, Hoover, & Lewis (Ear & Hearing, 2002)

Verification

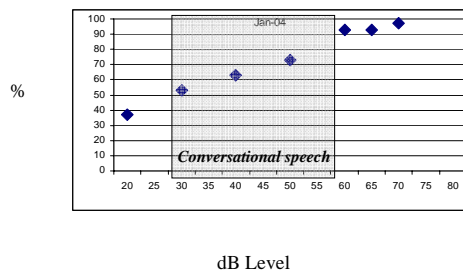
- REM - measures speech audibility, but doesn't graphically represent FC
- Functional gain provides some indication of HF audibility for soft sounds, but pure tones are not speech sounds.
- Speech production
- WR testing can show phoneme discrimination and is *repeatable*.

Case Study One - TJ

- 10 year old male
- Referred by school audiologist
- Wearing conventional hearing aids
- Articulation errors for s, sh, and other fricatives

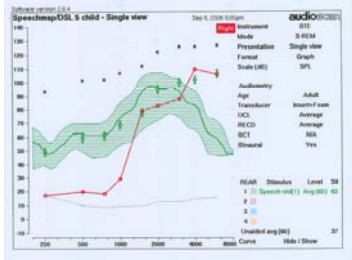


Phoneme Recognition with conventional aids

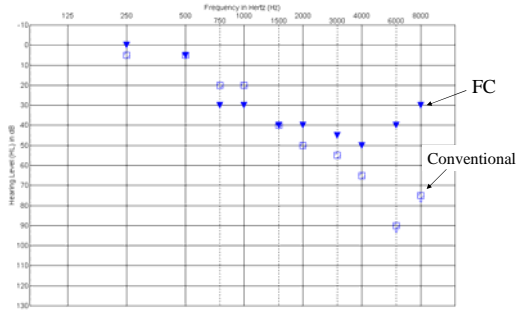


Audibility

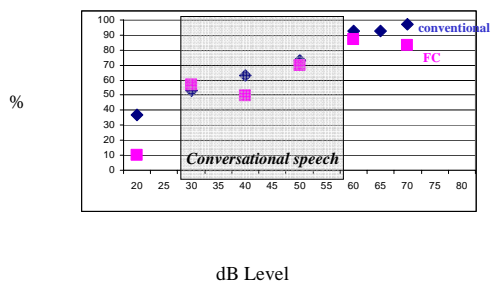
REM showed good match to DSL targets from 250-2000 Hz (same as with conventional aids).



Functional Gain



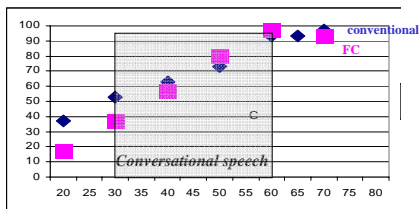
Phoneme Recognition – Day of Fitting



One month of FC

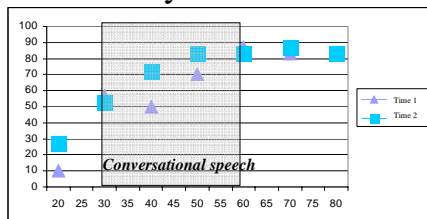
- Easy transition – TJ had no complaints about aids
- Mom says he speaks more clearly. He says the sh in her name more crisply and hears more environmental sounds

Phoneme Recognition after one month of FC



Soft speech still better with conventional aids.
Raised gain for soft inputs.

Phoneme Recognition after one year of new aids

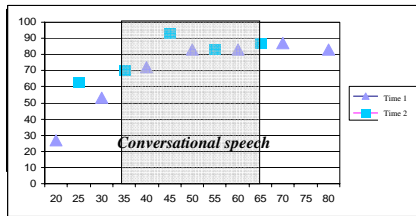


Phoneme findings-one year into FC

- Mixes up s/sh
- Mixes up t/k/b/p
- Occasional mix up of ah/ee/oo
- Increased FC to 4.00 to increase spectral information for voiceless sounds.
- Raised gain between 250-800 Hz to increase spectral information for voiced sounds.

s/sh production is still distorted

Phoneme Recognition testing after changes



Limitations of CASPA

- Adult word list may be the root of some of his errors. (name for maim, face for fate.)
- Time consuming to repeat testing after programming changes
- Can't zero in on specific error patterns (i.e.: substitution of /s/ for /th/).

Alternate test measures to adjust for audibility of /th/

Phoneme discrimination testing:

Word presentation: thick, though, thin, etc.

- Live voice
- Three feet away
- No visual cues
- TJ responds with: sick, so, sin, etc.

Adjusting for audibility of /th/

Speech mapping with "live voice" in Verifit (real ear)

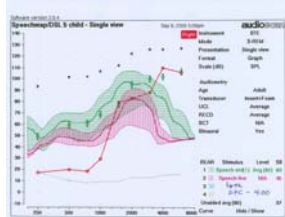
My /th/ sound peaks at 2 kHz.

-Raised gain at this frequency.

-Word presentation: sick, tick, so, sin, fin, pin, thick, though, thin.

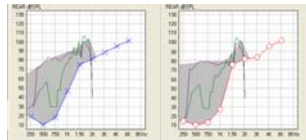
-WITH visual

-WITHOUT visual (TJ got every word correct, twice.)



Speech production

- TJ's /s/ and /sh/ continue to be distorted.
- Teachers have reported difficulty understanding him.
- Raised FC to maximum setting, 5.0

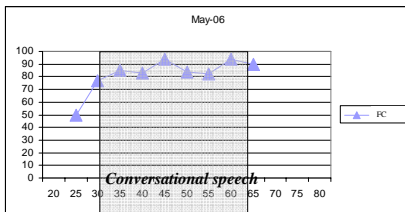


- TJ has no complaints.

Three months of full-on FC

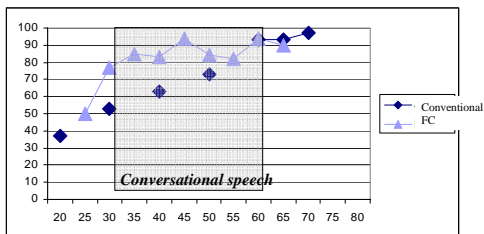
- Mom notes improvements in speech reception: he doesn't say "what" on the phone as often as he used to
- Speech continues to be unclear

3 months of increased FC



No consistent error pattern. Frequently, errors were on words his mom thought were unfamiliar to him: theme, buff, womb.

Conventional vs. DFC



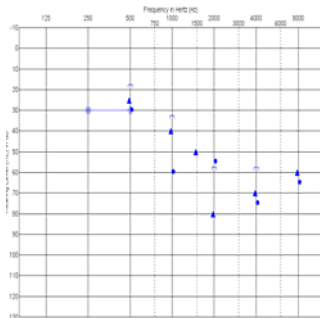
Contributing factors

- Does not receive speech services at school
- Inconsistent use of FM at school (has changed schools 3 times in past 2 years)
- Inconsistent use of hearing aids during the summer

Ongoing recommendations

- Fricative production continues to be distorted.
 - Audibility alone may not be enough at this late date. Speech therapy might help to retrain TJ's learned error patterns.

Case 2-CJ



Mom's report

Six days after fitting, mom called:

C was approximating "s":

C: "I" (asking for ice)

Mom: "Ice" (emphasizing /s/)

C: "Ish."

Mom: "You're stuck!"

C: "sssstuck!"

Mom's report

45 days after fitting

- Mom reports that C asks for HAs first thing in the morning.
- Never takes them off, unless he's about to get wet (running under sprinkler)
- "Just gets more and more clear."
- Using longer sentences.
- Repeating back s/sh/f when prompted.

Mom's report

- Four months after fitting – first unprompted possessive /s/
 - Mom: "It's mommy's."
 - C: "No, it's daddy's."
- Six months after fitting
 - Increased sentence length (from 3-4 to 6-7 words)
 - Words clearer in songs
 - Spontaneously adds d, t, k, and f endings to words.
 - Hears his name from behind
 - Distinguishes /s/ from /sh/.
 - **Substitutes g for v and k for sh .**
 - Mom reports all of her children made the g/v error. (There is no /v/ in Korean.)

Speech detection

- Mom says he consistently substitutes:
 - /k/ for /sh/ production. (“kuze” for “shoes,” “care” for “share.”)
 - She thinks there may be no /sh/ in Korean.
 - With the aid of lipreading, he can produce /sh/.

/sh/

- /sh/ in Korean is only used in front of /i/ (ee)
- Wide range of /sh/ mastery in American children, but 90% master it by 3-4 yrs.
- C was adopted at 3 ½ years.

Mom’s report

- C can distinguish between /sh/ and /k/.

Ongoing recommendations

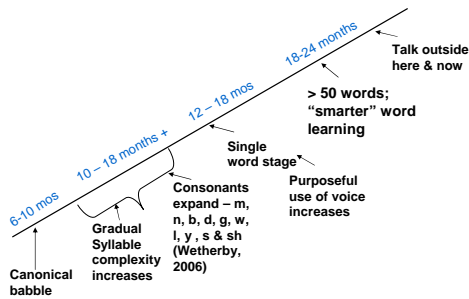
- Make /sh/ production become a goal in speech therapy.

What can infant speech production tell us about amplification benefit?



NIDCD R01 DC006681
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 Pat Stelmachowicz, Ph.D.

Early Foundations & Transitions



Fricative Development in NH Infants

- Previously no consensus in literature about WHEN fricatives first emerge
- In babble, acquired after stops and nasals
- Recent study of 26 infants (9-18 months)
 - 96% produced fricatives in babble
 - 64.5% produced fricatives in first words
- Moeller et al. (in preparation) 21 NH (10-24 mos)
 - 71% produced fricatives in babble and/or early words
- Children use fricatives
 - In early grammar (> 24 mos, some earlier)
 - cat/cats, I say/he says

Longitudinal Study Methods

Videotaped 30-minute sessions

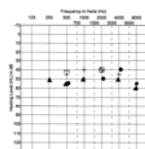
- 6 to 8 week intervals: 9 – 30 months
- Wireless lapel microphone worn with a baby vest
- Broad transcription using the International Phonetic Alphabet



Canonical Babble: NH 11.5 month old



10.5 month old HI girl aided at 4 mos

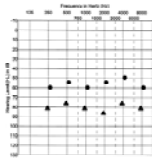


Babbles with d, b & whispers

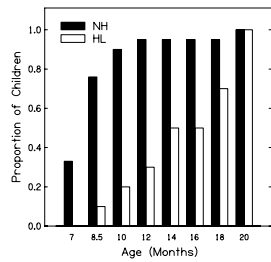
10.5 month old HI boy aided at 4 mos



æ:



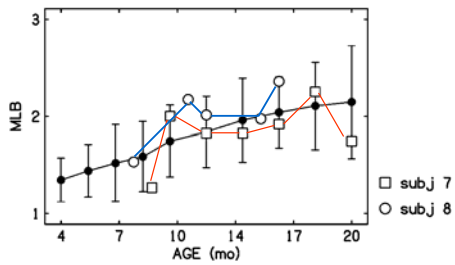
Consistent Babble Observed in Lab



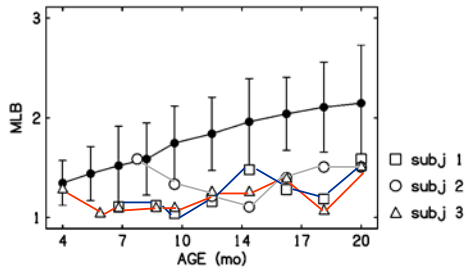
21 NH
10 HL

(Moeller et al., submitted)

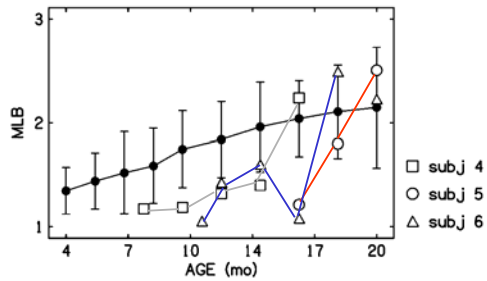
Individual differences: 2 HH infants

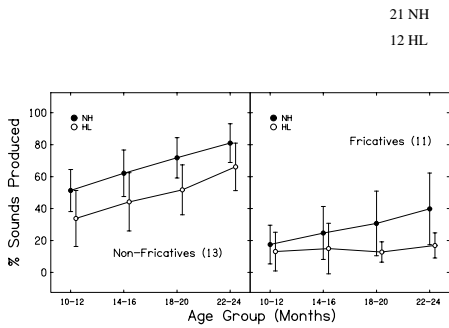


Slower than Expected Change



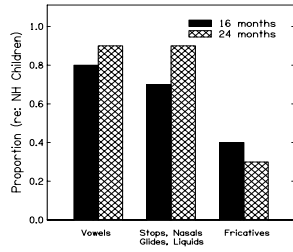
Rapid Shifts in Trajectory



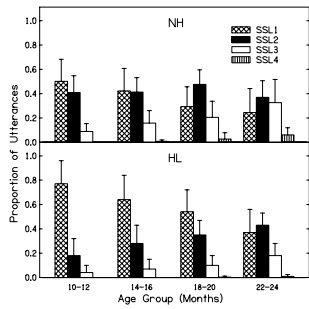


(Moeller et al., submitted)

Phonetic Development

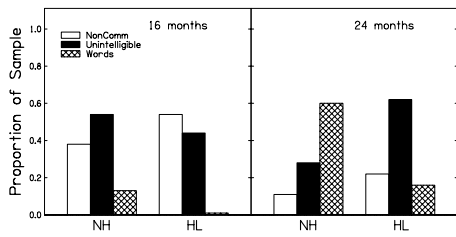


(Moeller et al., submitted)



(Moeller et al., submitted)

Transition to Words



(Moeller et al., submitted)

Cues from timelines: Transitions to Words



Cues from vocal quality



Cues from “resolving issues”



Mom: What are you doing? Child: I am putting tea for you. Mom: Are you pouring the tea? C: Yes. Mom: Good job. C: Hey momma, these are your spoon. Mom: Thank you! Mom: Where's the sugar? C: The sugar's gone.

Summary

- The developmental time course of vocal development can help us assess amplification benefit.
- Fricative acquisition is more delayed than other classes of phonemes. This may be explained partially by the limited BW of hearing aids
- A reduced phonetic inventory appears to influence the transition to production of words
- Consonant use in syllables is a predictor of later spoken language

Clinical implications

- Innovations in amplification may provide better access to consonants
- Parent report scales may be useful in monitoring responses to hearing aids
 - Kishon-Rabin, et al., (2005) Ear & Hearing
- Do the child's vocalizations fit with what you expect?
 - i.e., Vowel errors? Syllable shape? Vocal Quality?
- Consider role of consistency of amplification use
- Role for FM systems with infants?

Project Collaborators

- Mary Pat Moeller
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- Barbara Peterson
- Brenda Hoover
- Andrea Pittman
- Dawna Lewis
- Consultant: Dr. Carol Stoel-Gammon

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