

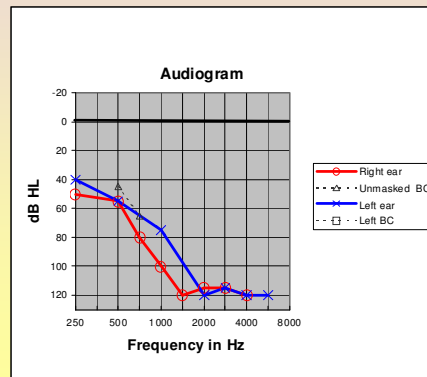
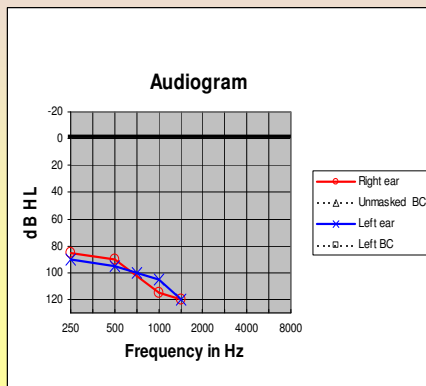
# Case Studies in Use of Frequency Compression for Children

Josephine Marriage PhD

Phonak Sound Foundation  
Stuttgart April 2010



## Frequency transposition/compression: Traditionally Frequency Lowering for Profound HL



## Aim: to make inaudible HF speech cues audible by lowering frequency

By: 1. Frequency compression

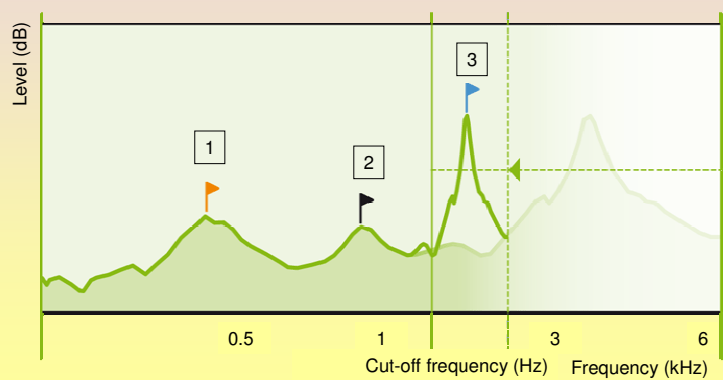
Compressing the frequency range down from a specified frequency (compression threshold)

2. Frequency transposition

Mixing or overlapping HF with uncompressed low frequency information

SoundRecover, non-linear frequency compression

## Consequences of a high frequency hearing loss



## Frequency Compression – Research Studies

Adult studies have reported:

- Increased detection, discrimination and recognition of sounds
- Fast acclimatization
- Significant improvement in intonation and overall voice quality
- Improved hearing of high pitched sounds and better speech understanding
- Reduced whistling in the hearing instrument
- Better perception of accent of speaker

## Paediatric Audiologist rule:

“If child well aided, don’t change amplification unless good evidence for benefit”

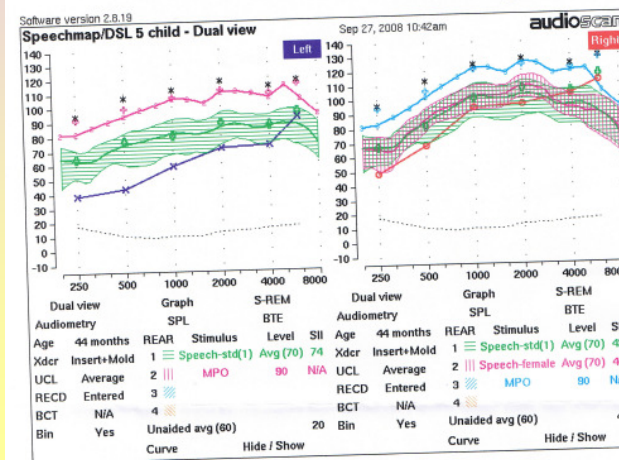
Can we demonstrate speech recognition benefit on individual basis?

How long will it take for child to acclimatise to new signal?

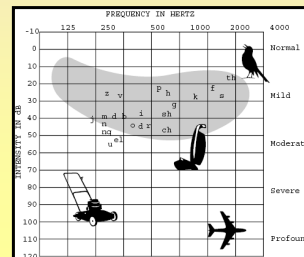
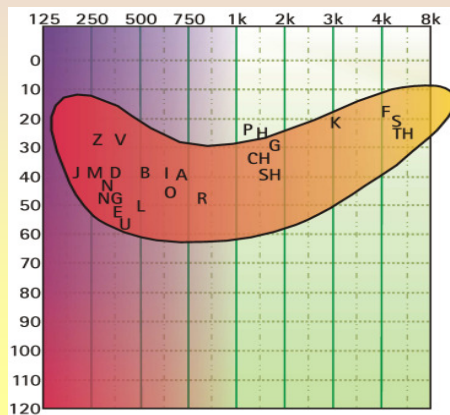
Is there acoustic feedback?

Is the device robust, also with FM? etc etc

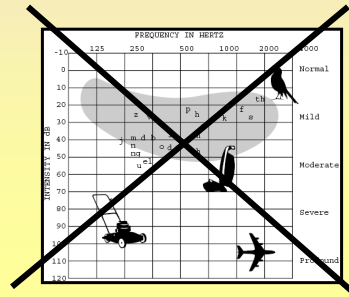
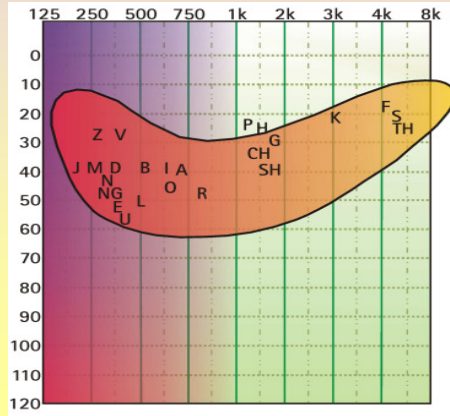
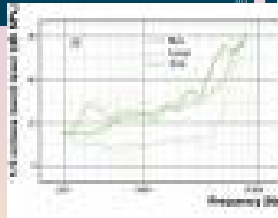
## Need to compare hearing aid amplification prescription fitting



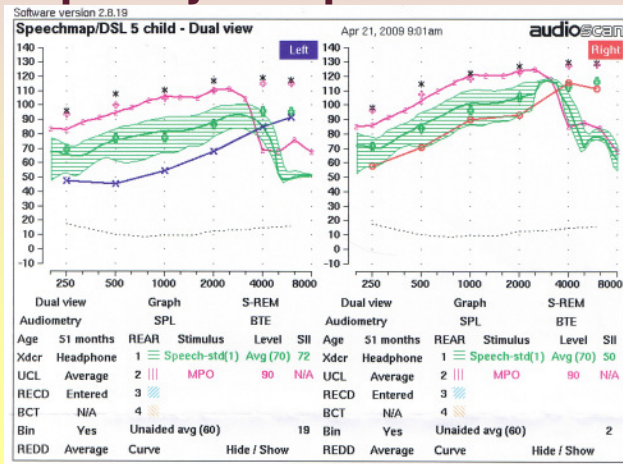
## Speech banana



# Speech banana



# Hearing aid amplification prescription with frequency compression



## What type of speech testing may be sensitive to additional HF cues?

Might expect:

Perception of fricatives eg /s/, /f/, /sh/

Can do plural test: eg cat vs cats

But what about more general speech testing?

## What do we want to check?

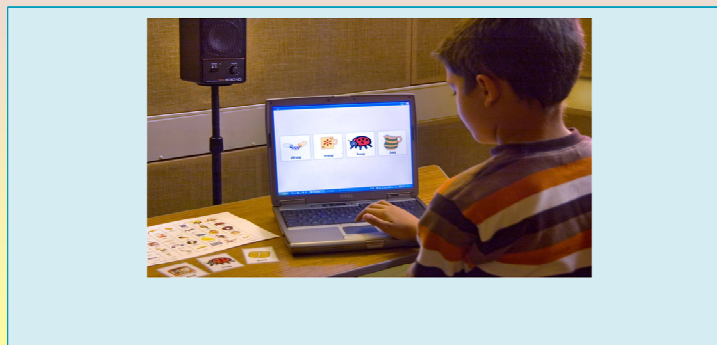
Comparison between trad HA and Freq Comp in:

- Detection of high frequency speech sounds
- Discrimination of vowels
- Discrimination between consonants
- Recognition of words
- Understand running speech
- Informal observation
- Opinion of child, including detection of noise floor

## Computerised Auditory Performance Test (CAPT) or Consonant Confusion Task (CCT) for younger age group

- Pictures on screen with pre-recorded word
- Smaller number of pictures for younger age groups (3, 4 or 5 pictures)
- Touch sensitive screen or mouse to click on pic
- Different difficulty of contrasts and vocab level
  - eg easy: house cow mouse owl (CCT)
  - Or hard: thin shin tin fin (CAPT)
- Results stored as output file of errors made

## Closed set speech test



*Picture cards used for vocabulary test. Stimuli presented through speaker and response using laptop keyboard*

## Detection of phonemes

- Closed set detection task:  
eye, ice, lice, slice (/s/)  
pay, pace, space, face  
eye, wine, why, wise (/z/)
- Ling 5 (Ling 6 had /u/ /m/ confusions for NH)  
Repetition task: oo ar ee sh ss (not live voice)

## Consonant discrimination

Closed set testing with four item picture task

- Age 2 – 4 years (40 items)

Eg horse, fork, ball, door  
hen, peg, egg, bed

- 4 - 7 years (40 items or 60 items)

Eg fat, cat, bat, mat (word-initial)  
cheese, cheat, cheap, cheek (word-final)

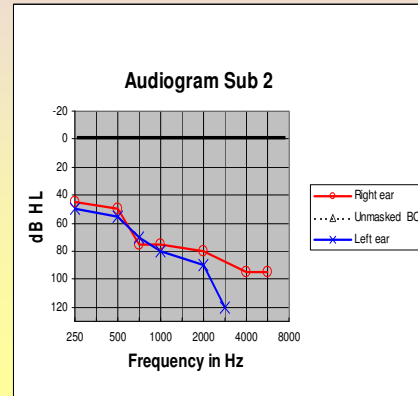
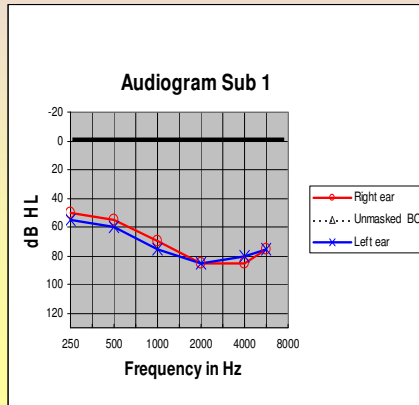
Derive confusion matrix of the errors

Significant difference if > 7.6% (10%) change in score,  
(s.d.=2.3)



## What configuration of hearing loss?

Good speech and language dev (8 yrs and 10 yrs)



## Sub 1 Speech scores (no acclim)

Open and closed set pre-recorded words

Open set words	Trad HA	Freq Comp
60 dB	97%	91%
50 dB	54%	82%
Closed set Det 60 dB	84%	100%
Closed set Disc 60 dB	89%	93%

## Sub 2 Speech scores (no acclim)

Open set pre-recorded words

Open set words	Trad HA	Freq Comp
70 dB	88%	88%
60 dB	63%	88%

## Parent and teacher observations: Subject 1

Dad on watching speech testing: "He is more confident and quicker in responses"

Report back of improved performance with whole words and connected speech

More confident in class, putting his hand up more to answer class questions

Clearer speech articulation

Enjoying being read to more

*Can't rely on these informal observations for decision to change hearing aids, need robust assessment*

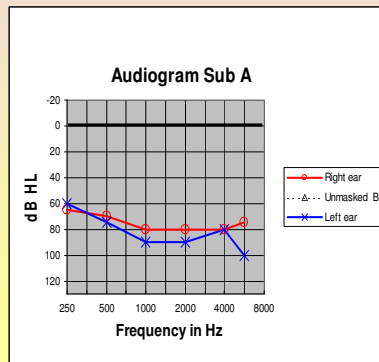
Subject 2: no overt functional change noted by family

## Subject A: female 6 years old

### Closed set test

Take best ear 3 freq  
 average: 80dB x 0.4  
 = 32 dB

Add to NH level  
 for test = 30 dB  
 Present at 62 dB



## Subject A: Scores (no acclim, in one 2 hour appt)

Open set wds	Trad HA	Freq Comp
60 dB	88%	97%
50 dB	76%	91%
Ling 5 /u i a/ /sh s/	45 dB 55 dB	45 dB 45 dB
<b>Closed set</b>		
detect	71%	100%
discrim	75%	97%
vowel in noise	91%	100%

## Subject A: phoneme analysis

Errors on closed set: Trad HA

Disc: kick/tick, bug/buzz, stork/chalk, fat/cat,  
white/right

Vowel: cat/cut, tar/tie, bark/buck

Det: bee/bees, shoe/sue, bean/bee

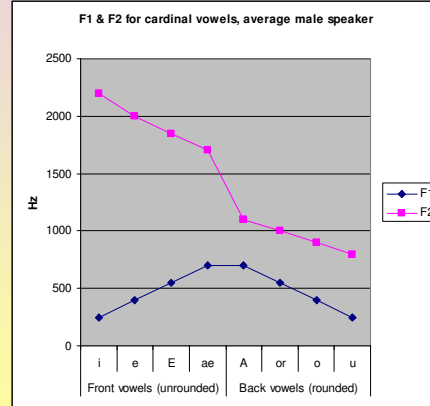
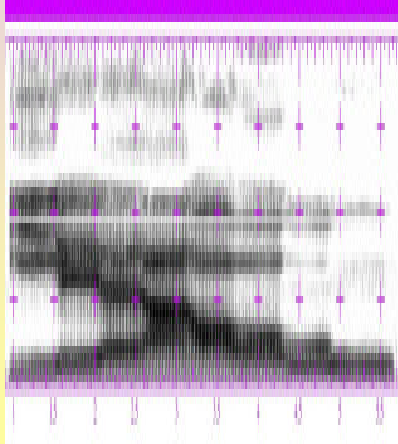
Errors on closed set: FC HA

None, except Disc: pick/thick

## Why would HF compression improve vowel discrimination?

- Formant frequencies vary widely between speakers
- Vowels give context for identification of consonants
- Cannot separate the consonants from vowels
- Vowel formant frequencies extend to 2500 Hz
- Adult subjects report improved perc of accent

# Cardinal vowels



# Subject B: female 4 years old

## Closed set test

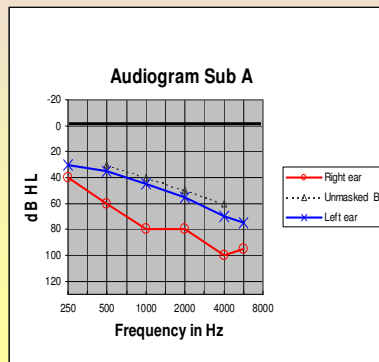
Take best ear 3 freq  
average: 57 dB x 0.4

= 22 dB

Add to NH level

for test = 30 dB

Present at 52 dB



## Video clips: 4 year old

No 1: changing hearing aid to Freq Compression

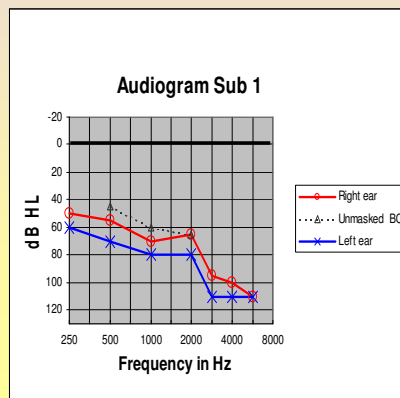
No 2: giving some experience of Ling 5 sounds and closed set testing

No 3: closed set testing

No 4: open set testing at 50 dB

No 5: her opinion of the hearing aid sound quality

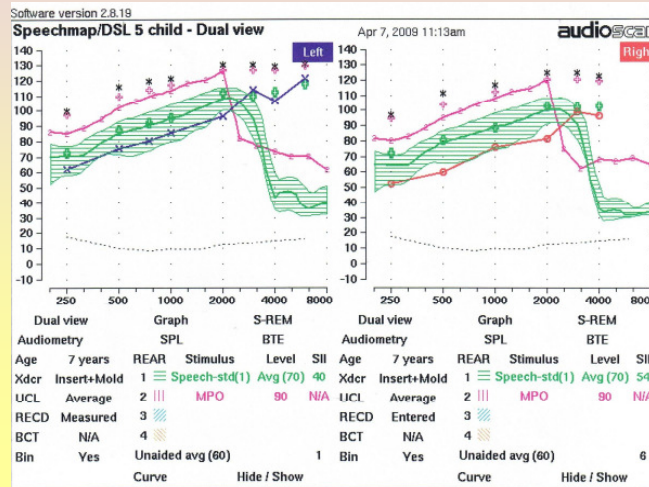
## Subject C: Consideration for FC for steeply sloping HL in complex needs



7 years (twin)

- Pre-term 24 weeks
- Severe delay sp and lg
- Cerebral palsy
- Mild dysarthria
- Dyspraxia
- Total communication support in early years

## Check real ear measure prescription, especially compression threshold (CT)



## Video of closed set testing

- Video
- Notice high pitched voice quality  
Can't do open set testing due to scoring difficulties

## Immediate results:

Testing 65dB	Eterna 311	Naida VUP
Vowel	67%	25%
Cons Detect	33%	25%
Cons Disc	80%	47%

## One month on:

Refuses to wear Eterna 311, wants to use Naida

Why? "better"

Hears new high frequency sounds (reversing lorry beeps, birds etc)

Joining in more to spoken conversation

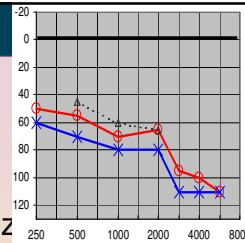
Less problems with acoustic feed back



### 3 months later results:

Testing 65dB	Eterna 311	Naida VUP
vowel in noise	67%	70%
Cons Detect	33%	60%
Cons Disc	80%	77%

### Discrimination performance



- May assume dead regions (DR) above 3 kHz
  - Freq Comp reduces constraints of DR on disc.
 Important consideration for potential CI candidates
- HA at 18 months, consistent use from 3 years only due to frequent ear infections
- Discrimination may be constrained by limited early exposure to HF sound, extensive auditory work now
- Underlines importance of early amplification to develop neural pathways for speech recognition

## Five Individual Cases:

Can we demonstrate significant speech recognition benefit for an individual child?

*Broadly, yes, need careful attention to test-type and presentation levels*

How long will it take for child to acclimatise to new signal?

*May depend on established listening skills, but often very fast change in performance*

## Five Individual Cases:

Is there acoustic feedback?

*Easier to prevent feedback*

Is the device robust, also with FM?

*Check audible noise level, self and ask child*

*Need good FM as always with acoustic HAs*

What age would children benefit from FC?

*If limited hearing above 4000 Hz then probably, from first years of life.*

What can the child tell you?

*We need to be able to listen to them.*

## **A case-study isn't a controlled trial**

but it's a good place to develop ideas  
for research studies