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Use of a FM Systems for Veterans with blast exposure, perceived hearing problems, and normal hearing sensitivity

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http://www.ncrar.research.va.gov/

Learner outcomes

1. Specify behavioral and self-reported auditory deficits associated with blast-exposure

2. Describe three questionnaires that yield useful information about auditory and other difficulties associated with blast exposure.

3. List three factors to consider when assessing whether an FM system is appropriate for a Veteran with blast-exposure, normal hearing sensitivity and perceived hearing difficulties
Why are we interested in blast exposure?

Data show that:

- About 75% of wounds from Operation Enduring Freedom (OEF)/Operation Iraqi Freedom (OIF)/Operation new Dawn (OND) are due to exposure to a blast(s)
- Many blast-injured personnel receive diagnoses of TBI
- Over 300,000 Veterans have some form of traumatic brain injury (TBI) and of these 82.5% of these TBIs are classified as mild


This is particularly problematic because the service member often times returns to full status duty soon after the event that caused the injury, and thus potentially sustains further blast-related injuries.

**Blast wave physics**

Highly pressurized gas expands

**Peak Overpressure (shock wave)**

Shock wave travels through air rapidly expanding:
resulting in:

**Negative underpressure**

**Secondary Overpressure**

Behind vacuum air rushes in = blast wind occurs

**Explosion** Solid/liquid is converted into highly pressurized gas

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**Blast damage: Four levels**

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[Image: continued]
Primary injuries
- Contusions (bruising) from brain moving within skull
- Hemorrhage from tearing of surface veins during movement
- Diffuse axonal injury as neurons are sheared and stretched

Secondary injuries
Damage from flying objects

Tertiary injuries
Damage when person is thrown into a solid object

Quaternary injuries
Injuries not directly related to blast wave but associated with blast exposure (burns, crushing, Inhalation of toxic materials)

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**Blast damage to the auditory system**

**Peripher al Damage**

- Pinna damage: burns/damage from flying debris
- Rupture of the tympanic membrane from pressure wave

**Ossicular Disruption from Pressure Wave**

- Blast wave damages to semicircular canals causing vestibular problems

- Blast wave and noise damages hair cells and basilar membrane in cochlea

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**Continued**
**Damage to central auditory system - MRI following blast exposure**

Contusions (blue) - brain moving within skull causing bruising
Hemorrhage (purple) - brain moving in skull tears surface veins

Frontal/pre-frontal cortex
Attention/listening

Temporal cortex
Feature-specific auditory processing

Parietal lobe
Spatial processing

Occipital lobe
Visual processing

Cerebellum
Balance


---

**Damage to central auditory system (cont.)**

Corpus callosum
Interhemispheric transfer

Thalamus
Organization and updating of cortical-brainstem connections

Diffuse axonal injury (pink) - shearing & stretching of neurons

66% of Veterans with deployment-related TBI and blast complained of auditory difficulties. Of these:

- 35-54% have SNHL
- 7% conductive (ruptured TM)
- 20% have ‘normal or almost normal’ thresholds

Saunders & Echt (2012), JRRD, 49(7): 1043-1058 2012

Common subjective complaints of blast exposed Veterans

- I can’t follow a conversation in a crowded room
- I have a very hard time when people talk too fast or mumble
- I have difficulty following long conversations or instructions
- I have constant tinnitus
- Sounds are too loud
What do these complaints have in common?

They are indicative of auditory processing problems

Study to characterize and examine auditory rehabilitation for these individuals
Participants

- Ninety-nine OEF/OIF Veterans
- Normal or near normal peripheral hearing sensitivity
- Reported blast exposure during deployment
- Self-reported functional hearing difficulties
- Recruited from Portland and Tampa VA Medical Centers

Mean age = 34.1 yr. SD = 8.1 yr., Range: 22-53

- Male (89%)
- Female (11%)
- Caucasian (74%)
- Black (11%)
- Hispanic (10%)
Audiometric data

Word recognition
25-word list
Maryland CNCs
40 dB SL

Left ear
96.0%, SD: 5.5%

Right ear
95.8%, SD 4.7%

Test measures and baseline scores
Developed for use in VA Audiology clinics

**Purpose:** To quantify the degree and areas of perceived hearing difficulty amongst Veterans with mTBI and normal or near normal audiogram.

**Process:** Questions were derived from common complaints encountered by Audiologists, Speech-Language Pathologists, and a TBI Neuropsychologist at the James A. Haley Veterans’ Hospital.


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**Functional Hearing Questionnaire (FHQ) items**

<table>
<thead>
<tr>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have a difficult time understanding what others are saying in background noise.</td>
</tr>
<tr>
<td>I have difficulty understanding what is being said on the phone.</td>
</tr>
<tr>
<td>I have a difficult time understanding fast speech.</td>
</tr>
<tr>
<td>I have problems understanding what is being said in rooms that have an echo.</td>
</tr>
<tr>
<td>I have problems following a series of spoken instructions. I need to hear only one instruction at a time.</td>
</tr>
<tr>
<td>I have problems following long conversations. I tend to miss things that were said.</td>
</tr>
<tr>
<td>I need more time than others to process spoken information</td>
</tr>
<tr>
<td>I have problems paying attention when people talk to me.</td>
</tr>
<tr>
<td>I have problems understanding when I am looking at the person who is speaking.</td>
</tr>
</tbody>
</table>

Respond: Not at all true/Slightly true/Mostly true/very true
Speech Spatial and Qualities Questionnaire (SSQ)

- Designed to measure self-reported auditory disability for speech, spatial processing and sound quality
- Can be completed for actual difficulties (SSQ) or relative to before intervention (SSQ-C)


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Speech Spatial and Qualities Questionnaire (SSQ)

You are talking with one other person and there is a TV on in the same room. Without turning the TV down, can you follow what the person you're talking to says?

- Not at all
- Somewhat
- Slightly
- Fairly
- Perfectly

Not applicable

Much worse Much better

-5 -4 -2 -3 0 -1 +2 +1 +4 +3 +5

Unchanged

Not at all Perfectly

Not applicable

---

12/11/2017
SSQ

SSQ score (Range: 0-10).

Fewer hearing problems

Current study  Older HI  Older NH  Younger NH


Performance measures
Listening in Spatialized Noise - Sentences test (LISN-S)

Target sentences
Competing sentences

Adaptive SRT

Voice
Same + 0°
Different + 0°
Talker advantage

Location
Same ± 90°
Same ± 90°
Examine performance relative to Same voice/Same location

Hearing in Noise test (HINT)

Target sentences
0°

HINT speech-shaped noise 270°

Adaptive SRT

HINT speech-shaped noise 90°
Gap detection - Adaptive Tests of Temporal Resolution (ATTR)

Noise burst 1

Gap in noise burst
Duration varies adaptively

Noise burst 2

Two alternative forced choice paradigm to assess 70.7% correct threshold (2-up 1-down)

Time Compressed Speech Test (TCST)

IEEE sentences compressed by 60%

Presented from a loudspeaker at 0°
### Working memory - Digit Span Test

DS-Forward: Strings ranging from 2 digits to 9 digits  
DS-Backward: Strings ranging from 2 digits to 9 digits

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</tbody>
</table>

### Dichotic listening - Staggered Spondaic Word Test (SSW)

- Fruit  
- Juice  
- Cup  
- Cake

Four Test Conditions:  
- Right non-competing (RNC)  
- Right competing (RC)  
- Left competing (LC)  
- Left non-competing (LNC)
**Attention/Interference - Stroop Test**

Read word

RED GREEN RED BLUE GREEN RED BLUE

Read color

XXXX XXXX XXXX XXXX XXXX XXXX XXXX

Read color word is printed in (without squinting!)

RED GREEN RED BLUE GREEN RED BLUE

Score = no. items read (of 100) in 45 seconds.
Interference score = color-word score – predicted color-word score

---

**Working memory for spoken language - Woodcock Johnson Tests of Achievement-III Story Recall subtest (WJ-III)**

- Listen to a short story
- Length increases from 2 sentences/3 content units to 5 sentences/21 content units
- Recall content
- Responses recorded for later scoring
Based on properties of a normal distribution, 15.9% of individuals would be expected to perform more than 1 SD below the mean on any particular measure.
**Do these individuals have measureable performance deficits?**

![Bar chart showing percentage of participants at or above mean and below mean for various tests.]

**Number of tests on which participants performed below normative data mean.**

- Mean no. tests: 3.1

![Histogram showing distribution of test measures (range 0-10).]

No. test measures (range 0-10)
Examines face validity

<table>
<thead>
<tr>
<th>FHQ item and TCST 60% compression</th>
<th>r-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty understanding on the phone</td>
<td>-0.306</td>
</tr>
<tr>
<td>Difficulty understanding fast speech</td>
<td>-0.284</td>
</tr>
<tr>
<td>Need more time to process spoken information</td>
<td>-0.303</td>
</tr>
<tr>
<td>Problems paying attention to speech</td>
<td>-0.291</td>
</tr>
<tr>
<td>Problems understanding when looking at the person who is speaking</td>
<td>-0.415</td>
</tr>
<tr>
<td>FHQ item and Digit Span (scaled score)</td>
<td>r-value</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Problems following a series of spoken instructions</td>
<td>-0.310</td>
</tr>
<tr>
<td>Problems following long conversations</td>
<td>-0.280</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FHQ item and WJ-III (standard score)</th>
<th>r-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems following a series of spoken instructions</td>
<td>-0.379</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FHQ item and SSW (total errors)</th>
<th>r-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need more time than others to process spoken information</td>
<td>0.311</td>
</tr>
<tr>
<td>Problems understanding when looking at the person who is speaking</td>
<td>0.395</td>
</tr>
</tbody>
</table>

**Summary so far**

Not only do these Veterans have subjective auditory difficulties, there is evidence of objective performance deficits also for:

- Speech-in noise (HINT/LISN-S)
- Temporal processing (ATTR)
- Speech segregation (SSW)

Deficits are specific to certain tasks not global

- Unlikely to be malingering/lack of effort
- Unlikely to be a global head injury
Intervention study

Approaches to rehabilitation

- Hearing in background noise
  - Signal-to-noise ratio (SNR)
- Following rapid speech
  - Temporal processing
- Following instructions and long conversations
  - Attention
  - Working memory
- Tinnitus
- Hyperacusis
**Interventions**

**FM system**
- Will be effective at improving SNR - if used correctly
- A prop rather than a ‘fix’; requires an external device

Phonak Zoomlink transmitter and binaural iSense receivers

**Interventions**

**Auditory Training**
- Aim to harness the brain’s capacity for physical and functional change through repeated and persistent stimulation i.e. neural plasticity
- Potential for sustainable change (a fix) for processing difficulties.
- Requires discipline and time commitment before any benefit may be realized.
Computerized Auditory Training (AT)

Brain Fitness Program
Computer-based training program developed by Merzenich et al., distributed by Posit Science.
Designed to train:
- Temporal processing
- Auditory working memory
- 40 sessions, 60 min/day

The Brain Fitness Program: Training Tasks

- High or Low?
- Tell Us Apart
- Match It!
- Sound Replay
- Listen and Do
- Story Teller
Communication strategies education

- Train problem-solving skills in real world communication situations

2-site randomized controlled trial

Consenting, Screening
Baseline Testing

Random assignment to intervention

Education (Control)
Education + Auditory Training
Education + FM System
Education + Auditory Training + FM System

8-12 weeks
Post-intervention testing
Results of interventions: Case Studies

3 Veterans who used an FM system

2 Veterans who used the Auditory Training program

Outcome measures to be discussed

- Functional Hearing Questionnaire
- SSQ
- PIADS
- CSRQ
A 26-item questionnaire assessing the impact of assistive devices on perceived:

- Competence
- Adaptability
- Self-esteem

Day et al. (2001), Disabil Rehabil 23(9):400-404

Each word or phrase describes how using the FM system and/or auditory training program might affect you.

Wording was adapted for each intervention

* FM system/auditory training program/information we gave you
Psychosocial impact of Assistive Devices Scale (PIADS)

<table>
<thead>
<tr>
<th></th>
<th>Decreases</th>
<th>No change</th>
<th>Increases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>Competence</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Happiness</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Adequacy</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Confusion</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Self-esteem</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Usefulness</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Well-being</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

Cognitive Self Report Questionnaire (CSRQ)

- A 64-item questionnaire assessing daily functioning on 8 subscales:
Cognitive Self Report Questionnaire (CSRQ)

<table>
<thead>
<tr>
<th>Question</th>
<th>Less often</th>
<th>Same as before</th>
<th>More often</th>
<th>Does not apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>I lose my train of thought…</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My ability to pay attention to more than one thing at a time is…</td>
<td>Better</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My ability to remember phone numbers is…</td>
<td>Better</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My ability to hear things clearly is …</td>
<td>Better</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My peripheral vision is…</td>
<td>Better</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I engage in activities with other people…</td>
<td>More often</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My ability to focus on a task is…</td>
<td>Better</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Case 1 – FM user

Army Veteran who served 5.5 month deployment initial Iraq invasion

5 blasts within 100m and dozens of others further away
- Experienced headaches (maybe due to protective gear)
- Not sure whether he lost consciousness

Vehicle accident – humvee fell into a 6ft hole
- Thrown from vehicle and hit head

Fall in civilian life
- Concussion
Case 1 cont. – FM user

Since, but not prior, to blasts Veteran reports

- Tinnitus
- Trouble hearing in noise
- Balance problems (slight)
- Memory problems
- Sleep problems

Case 2 – FM user

Army Veteran who served 15-month deployment in Iraq between 2003 & 2005

5 blasts from IEDs/rocket-propelled grenades – one within 40 ft. of Veteran
- Confusion, headache, amnesia

Head injury following fall onto concrete following a blast
- Confusion, headache, amnesia
Case 2 cont. – FM user

Since, but not prior, to blasts Veteran reports
- Hearing loss
- Tinnitus
- Trouble hearing in noise
- Sensitivity to noise
- Memory problems

Case 3 – FM user

Army Veteran who served in Afghanistan for 9 months during 2008

Blast from rocket-propelled grenade detonated ‘close by’
- Loss of consciousness, amnesia, headaches

Head injury during firefight
- Loss of consciousness, amnesia, headaches

Flying object hit Veteran in face
- Loss of consciousness, amnesia, headaches
Case 3 cont. – FM user

Since, but not prior, to blasts Veteran reports
  • Hearing loss
  • Tinnitus
  • Trouble hearing in noise (pre-deployment also)
  • Sensitivity to noise
  • Memory problems
  • Irritability
  • Sleep problems

Demographic data

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Gender</th>
<th>PTA L/R (dB HL)</th>
<th>Word recognition L/R (%)</th>
<th>PTSD</th>
<th>TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>29</td>
<td>M</td>
<td>8.8/2.5</td>
<td>88/92</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Case 2</td>
<td>46</td>
<td>M</td>
<td>8.8/11.3</td>
<td>96/96</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Case 3</td>
<td>52</td>
<td>M</td>
<td>8.8/7.5</td>
<td>92/92</td>
<td>Y</td>
<td>?*</td>
</tr>
</tbody>
</table>

*Confirmed concussion
Speech in Noise performance

Baseline speech in noise performance

<table>
<thead>
<tr>
<th></th>
<th>LISN-S Talker advantage</th>
<th>LISN-S Spatial advantage</th>
<th>HINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>&gt; 1 SD below norms</td>
<td>&gt; 1 SD below norms</td>
<td>Poorer than 25th percentile</td>
</tr>
<tr>
<td>Case 2</td>
<td>Average</td>
<td>&gt; 1 SD below norms</td>
<td>At 95th percentile</td>
</tr>
<tr>
<td>Case 3</td>
<td>&gt; 1 SD below norms</td>
<td>&gt; 1 SD below norms</td>
<td>Above 75th percentile</td>
</tr>
</tbody>
</table>

Results: FM use

Case 1
- Used FM 3-4 days/week for 8 hr./day
- Very useful in classes, meetings and restaurants but not at movies or when around small children
- Obtained FM from audiology clinic
- Helped him 'psychologically'

Case 2
- Used FM daily for 8-10 hr./day
- Very at work and in car on speaker phone
- Wanted to continue use of FM following study
Case 3

- Initially used system daily for 8 hr/day but stopped usage as it ‘wasn’t worth the struggle’
- Slightly helpful at meetings and restaurants and one-on-one with wife.
- Overall not a positive experience

Was this reflected in questionnaire scores?
FHQ benefit: (Baseline to post-intervention)

SSQ-C scores for FM users

Case 1
Case 2
Case 3
All subjects

Speech
Spatial
Qualities

More benefit

Benefit [Range: -27 to +27]

More benefit

Benefit [Range: -5 to +5]
Results: What seems to predict outcome?

Baseline speech in noise performance

<table>
<thead>
<tr>
<th></th>
<th>LISN-S Talker advantage</th>
<th>LISN-S Spatial advantage</th>
<th>HINT</th>
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<tbody>
<tr>
<td><strong>Case 1</strong></td>
<td>&gt; 1 SD below norms</td>
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<td>Average</td>
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<td>At 95th percentile</td>
</tr>
<tr>
<td><strong>Case 3</strong></td>
<td>&gt; 1 SD below norms</td>
<td>&gt; 1 SD below norms</td>
<td>Above 75th percentile</td>
</tr>
</tbody>
</table>

Veteran 1 had poor speech performance across the board

Results: What seems to predict outcome?

Life style
Veterans 1 and 2 found appropriate uses for FM system

- Veteran 1 used it for school
- Veteran 2 worked in a location in which remote communication was helpful. He gave transmitter to colleagues

Veteran 3 worked in a quiet office and used phone often. Family didn’t like using it at home or in restaurants.
Results: What seems to predict outcome?

Understanding of how and when to use it

Despite working in a quiet office, Veteran 3 tried wearing FM system all day even though there is no reason to think he would benefit

Presumably this is what took place

Educate Family too

The family of Veteran 3 were resistant to using the system. Education of family may have helped too. His family resisted use.

Presumably this is why it became ‘a struggle to use’ the system

Results: What seems to predict outcome?

Underlying etiology (PTSD versus TBI)

Symptoms of blast exposure often overlap those of PTSD

- Impaired executive function
- Poor attention and memory

The presence of TBI versus PTSD is unknown

There is no reason to expect an FM system would help PTSD

All 3 Veterans had positive diagnoses of PTSD
Perhaps cases 1 & 2 also had TBI?
Summary

FM systems seem to be beneficial for some blast-exposed individuals with normal hearing sensitivity and hearing difficulties but must also consider:

- Speech in noise assessment
- Lifestyle
- Presence of PTSD
- Family support/motivation
- Make sure to educate user

Case 4 - AT

Army Veteran who served 2006-2007 deployment in Afghanistan

4-5 mortar and rocket blasts a week
- No headaches or loss of consciousness

Fall
- Head injury, loss of consciousness and amnesia for the event
Case 4 cont. – AT

Since, but not prior, to blasts Veteran reports
- Hearing loss
- Trouble hearing in noise
- Balance/dizziness problems
- Sensitivity to noise
- Memory problems
- Irritability

Case 5 - AT

Army Veteran who served in Iraq during 2004

Exposed to about 20 IED/mortar/rocket blasts
- Experienced headaches

One humvee blast
- Hit head on window, lost consciousness, felt dazed

Two vehicle accidents within two weeks
Case 5 cont. – AT

Since, **but not prior** to blasts Veteran reports

- Hearing loss
- Tinnitus
- Trouble hearing in noise (pre- also)
- Memory problems
- Sleep problems

AT users

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Gender</th>
<th>PTA L/R (dB HL)</th>
<th>Word recognition L/R (%)</th>
<th>PTSD</th>
<th>TBI</th>
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</thead>
<tbody>
<tr>
<td>Case 4</td>
<td>52</td>
<td>F</td>
<td>11.7/13.3</td>
<td>100/100</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>Case 5</td>
<td>46</td>
<td>M</td>
<td>6.7/10.0</td>
<td>92/92</td>
<td>Y</td>
<td>N</td>
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</table>
Baseline scores

<table>
<thead>
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<th>HINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 4</td>
<td>Average</td>
<td>&gt; 2 SD below norms</td>
<td>Average</td>
</tr>
<tr>
<td>Case 5</td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
</tr>
</tbody>
</table>

Results:

Case 4
- Completed 33 of 40 training sessions
- Felt program really helped
- Has ‘greater awareness’ and ‘keener insight’
- Did not like all tasks

Case 5
- Completed 17 of 40 training sessions
- Feels training did not improve his hearing
- Some exercises were fun, some were boring, overall the training was too long
**FHQ benefit: (Baseline to post-intervention)**

- **Case 4**: Benefit [Range: -27 to +27]
- **Case 5**: Benefit [Range: -8 to +5]
- **Group**: Benefit [Range: -2 to +5]

**SSQ-C scores for AT users**

- **Case 4**: Benefit [Range: -5 to +5]
- **Case 5**: Benefit [Range: -2 to +5]
- **All subjects**: Benefit [Range: -2 to +5]

**Quality Themes**

- **Speech**: [Graph showing change in speech quality]
- **Spatial**: [Graph showing change in spatial quality]
- **Qualities**: [Graph showing change in quality of life]
Results: What seems to predict outcome?

Baseline speech in noise performance:
Case 4 had poorer performance than Case 5

<table>
<thead>
<tr>
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<tr>
<td>Case 4</td>
<td>Average</td>
<td>&gt; 2 SD below norms</td>
<td>Average</td>
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<tr>
<td>Case 5</td>
<td>Average</td>
<td>Average</td>
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**Results: What seems to predict outcome?**

Severity and type of baseline reported problems (FHQ)
Case 4 more and more severe problems than Case 5

![Bar chart showing severity and type of baseline reported problems for Case 4 and Case 5.]

- **Time availability and motivation:**
  - Case 4 was not working but was looking for employment while Case 5 worked full time

- **Underlying etiology:**
  - Problems of Case 5 may be associated with PTSD not CAPD from mTBI
Summary

Data show both interventions can work BUT there is individual variability

Clinical take-home message

Factors to consider:
- Baseline problems
- Motivation to use intervention
- Life style
- Time availability
- Speech-in-noise performance
- Education provided for use
- Other?

Ideally we could predict who will and won't benefit up front – but don't yet know how to.
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Thank you for listening
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**Questions?**

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