Mild TBI Diagnosis and Management Strategies

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VA RR&D
NCRAR

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

Common Subjective Complaints of Blast Exposed Veterans

Poll question:

Have you encountered Veterans like this?

Yes **No**

What are the options for Rehabilitation?

Bottom-Up approaches:
Enhancement of the acoustic signal

- **Amplification**
- **FM systems**
- **Auditory Training**

Top-Down approaches:
Teaching compensatory strategies

- **Auditory Training of**
  - **Memory**
  - **Attention**
  - **Language**
- **Communication skills**

Amplification

Hearing aids - the standard rehabilitation for hearing impairment.

What a hearing aid <u>can</u> do:

- ✓ **Amplify sounds**
- ✓ **Shape output**
- ✓ **Adjust for abnormal loudness growth**

What a hearing aid <u>cannot</u> do:

- x **Determine what is 'signal' vs. what is 'noise'**
- x **Improve the signal-to-noise-ratio (yet) i.e. filter noise**
- x **Restore clarity**

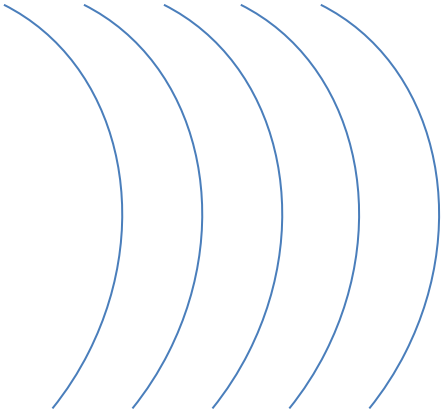
Can a hearing aid help auditory processing disorders?

Perhaps - by decreasing the effort required to hear thus freeing up more processing capacity

Personal FM system

Transmitter with microphone

FM receiver worn behind the ear picks up the signal



FM radio waves

Personal FM system

Advantages:

- ✓ Will improve signal-to-noise ratio (SNR) if used correctly
- ✓ By doing so more resources are made available for use in higher level auditory processing
- ✓ Successful for children with auditory processing problems
- ✓ Available with and without amplification

Disadvantages:

- x Requires the user to wear a device
- x Is a 'prop' not a fix

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Computerized Auditory Training (AT)

- **Aim to harness the brain's capacity for physical and functional change through repeated and persistent stimulation i.e. neural plasticity**
- **Commercially-available programs**
- **Program features:**

  Adaptive, push performance to upper end of limit

  Track performance, - can thus provide feedback rewards

  Require intensive and near-daily training over a period of weeks in order to generate cortical change

Computerized Auditory Training (AT)

Advantages:

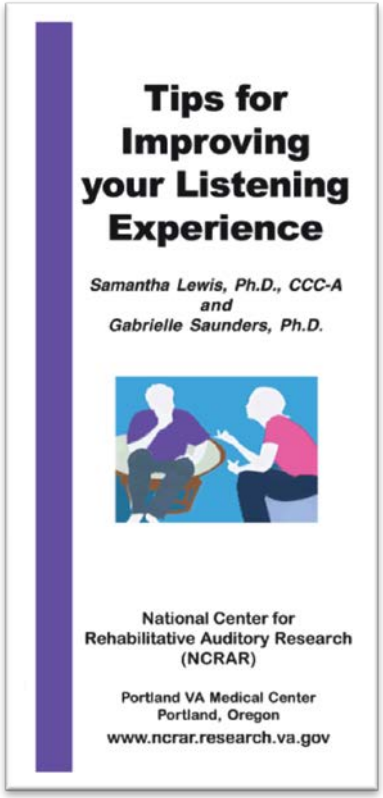
- ✓ **Potential for sustainable change (a fix) for processing difficulties.**
- ✓ **No device required**
- ✓ **Can train at own convenience**

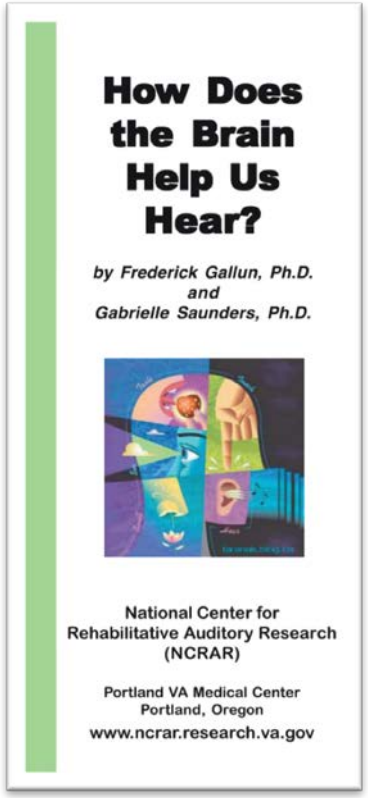
Disadvantages:

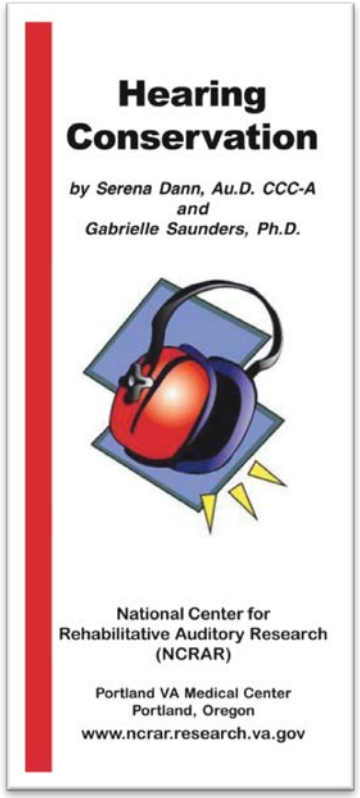
- x **Requires discipline and time commitment before any benefit <u>may</u> be realized.**

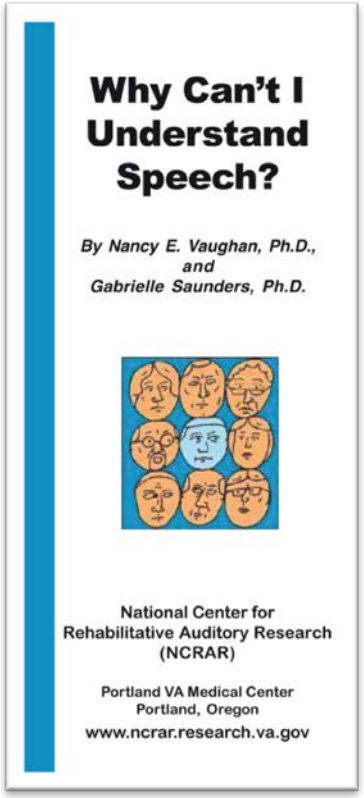
Communication strategies education

- **Train problem-solving skills in real world communication situations**









Evaluation of Approaches to Auditory Rehabilitation for mTBI

PI: Gabrielle Saunders

Co-Is: Terry Chisolm & Paula Myers

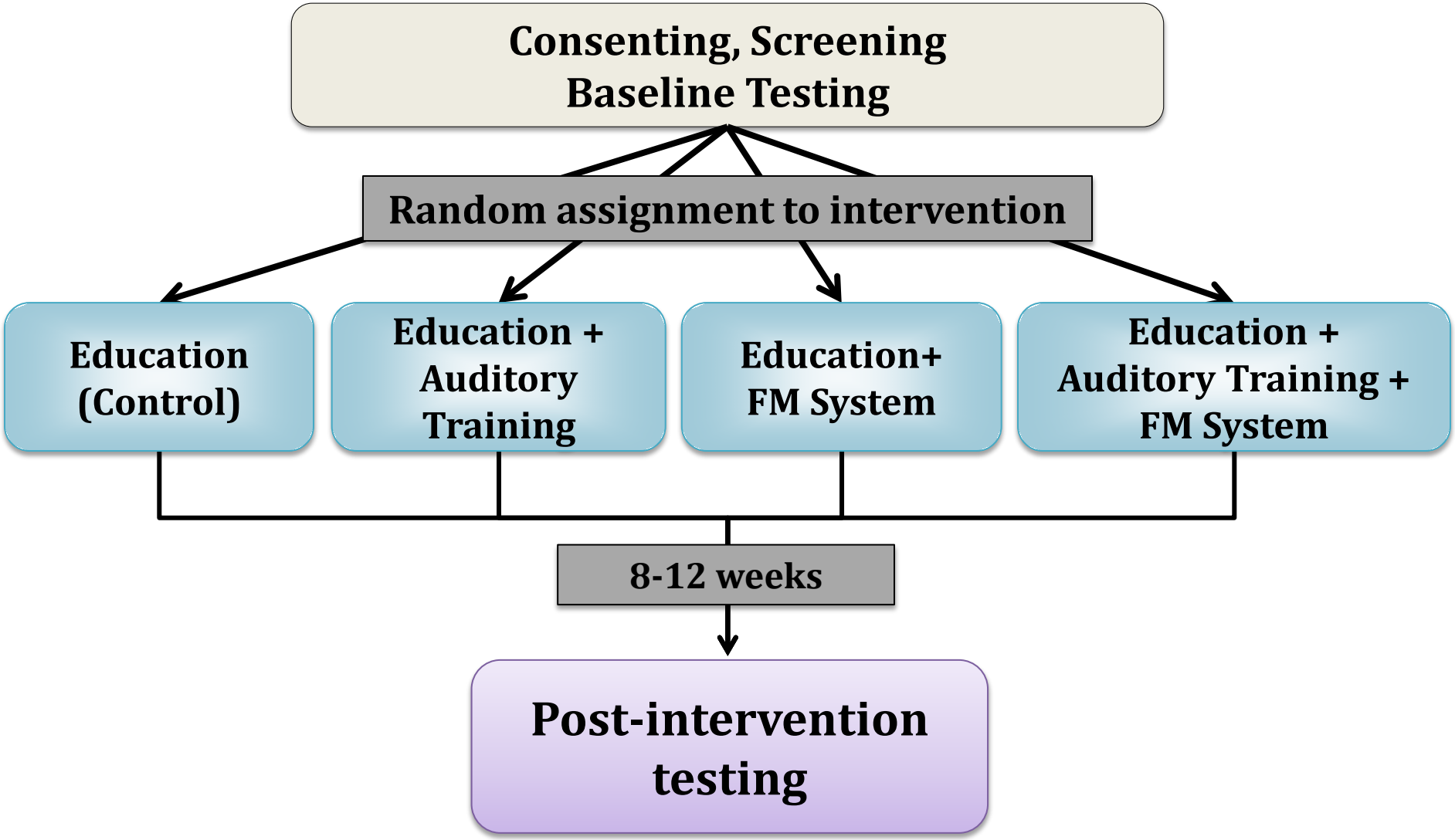
Research Audiologists: Melissa Teahen & Michelle Arnold

VA RR&D grant #: C7054R.

Participants

- **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**

2-site randomized controlled trial



Test measures

- Speech-in-noise (Listening in Spatialized Noise)
- Speech-in-noise (HINT)
- Gap detection (Adaptive Tests of Temporal Resolution)
- Time Compressed Speech
- Working memory (Digit Span Test)
- Dichotic listening (Staggered Spondaic Word test)
- Attention/Interference (Stroop Color Word Test)
- Functional Hearing Questionnaire
- Speech Spatial and Qualities Questionnaire - comparative
- Cognitive Self-Report Questionnaire
- Psychosocial Impact of Assistive Devices Scale

Speech Spatial and Qualities Questionnaire - Comparative (SSQ-C)

- **Designed to measure self-reported auditory disability for speech, spatial processing and sound quality relative to before intervention.**

Gatehouse & Noble (2004) Int. J. Audiol 43(2):85-99

Speech Spatial and Qualities Questionnaire- Compare (SSQ-C)

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?	**Comparing your ability now with your ability before this study** ***Much worse*** ***Unchanged*** ***Much better*** **-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5** **Not applicable** ☐
You are talking with one other person in a quiet, carpeted lounge-room. Can you follow what the other person says?	**Comparing your ability now with your ability before this study** ***Much worse*** ***Unchanged*** ***Much better*** **-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5** **Not applicable** ☐

Cognitive Self Report Questionnaire (CSRQ)

- **A 64-item questionnaire assessing daily functioning on 8 subscales:**

  Attention, Executive function, Memory, Language, Vision, Hearing, Energy, Satisfaction.

Cognitive Self Report Questionnaire (CSRQ)

I lose my train of thought…	Less often	Same as before	More often	Does not apply
My ability to pay attention to more than one thing at a time is…	Better	Same as before	Worse	Does not apply
My ability to remember phone numbers is…	Better	Same as before	Worse	Does not apply
My ability to hear things clearly is ….	Better	Same as before	Worse	Does not apply
My peripheral vision is…	Better	Same as before	Worse	Does not apply
I engage in activities with other people…	More often	Same as before	Less often	Does not apply
My ability to focus on a task is…	Better	Same as before	Worse	Does not apply

Case studies

2 Veterans who used an FM system

2 Veterans who used the Auditory Training program

Case 1 – FM user

Army Veteran who served 5.5 mth 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 2 – FM user

Army Veteran who served 2007-2008 in deployment in Iraq

10-20 blasts

- **No headaches or loss of consciousness**

Vehicle accident

- **No headaches or loss of consciousness**

Fall from gun turret

- **Head aches, confusion, loss of consciousness**

FM users

	Age	Gender	PTA L/R (dB HL)	Word recognition L/R (%)	PTSD	TBI
Case 1	**29**	**M**	**8.8/2.5**	**88/92**	**Y**	**Y**
Case 2	**34**	**M**	**8.8/7.5**	**88/96**	**?**	**N**

	LISN-S Talker advantage	LISN-S Spatial advantage	HINT
Case 1	> 1 SD below norms	> 1 SD below norms	Poorer than 25th percentile
Case 2	Average	Average	Better than 75th percentile

Results:

Case 1

Used FM 3-4 days/week for 8 hr./day

Very useful in classes

Obtained FM from audiology clinic

Helped him 'psychologically'

Case 2

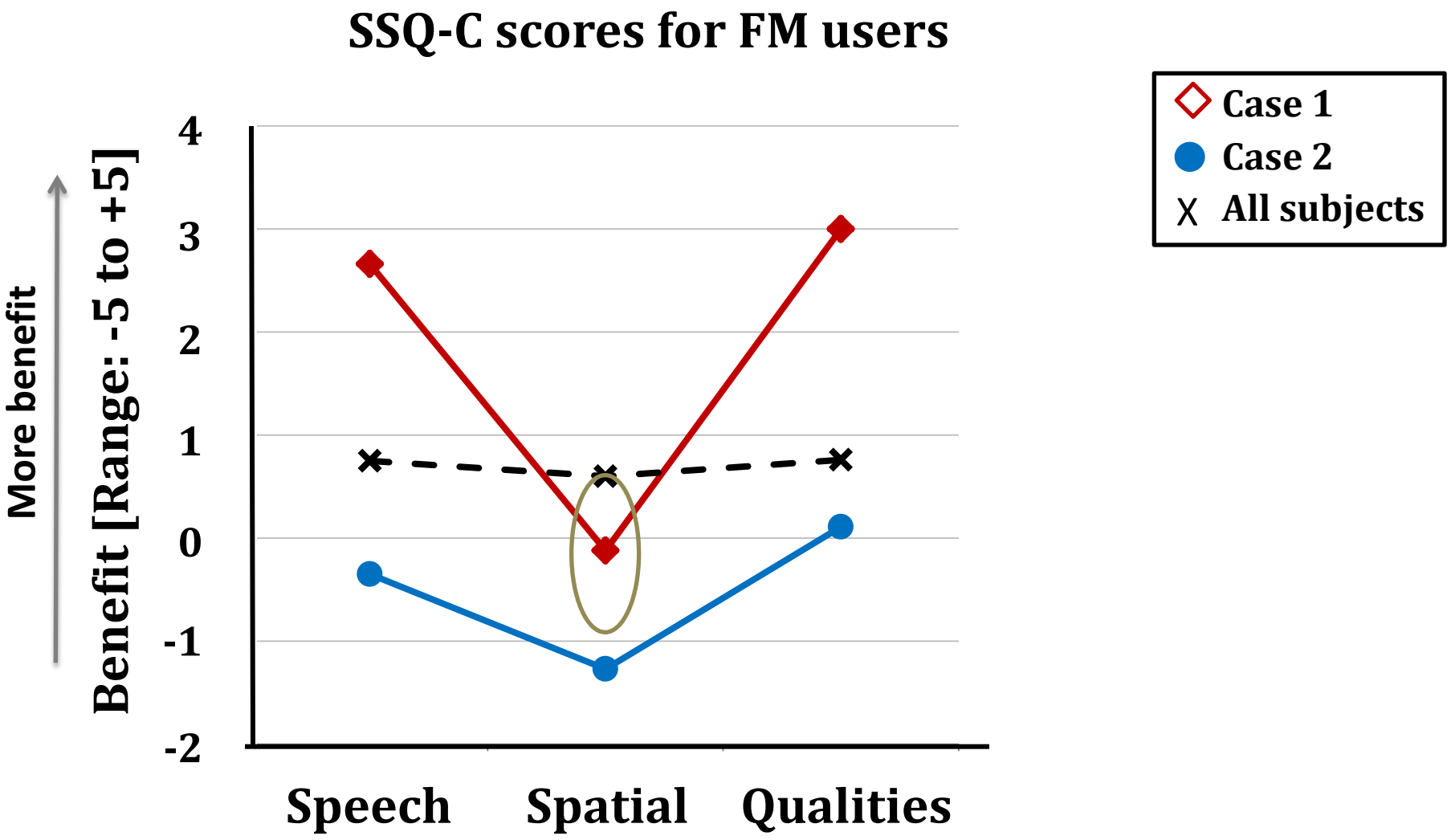
Hardly ever used it. Tried it but gave up

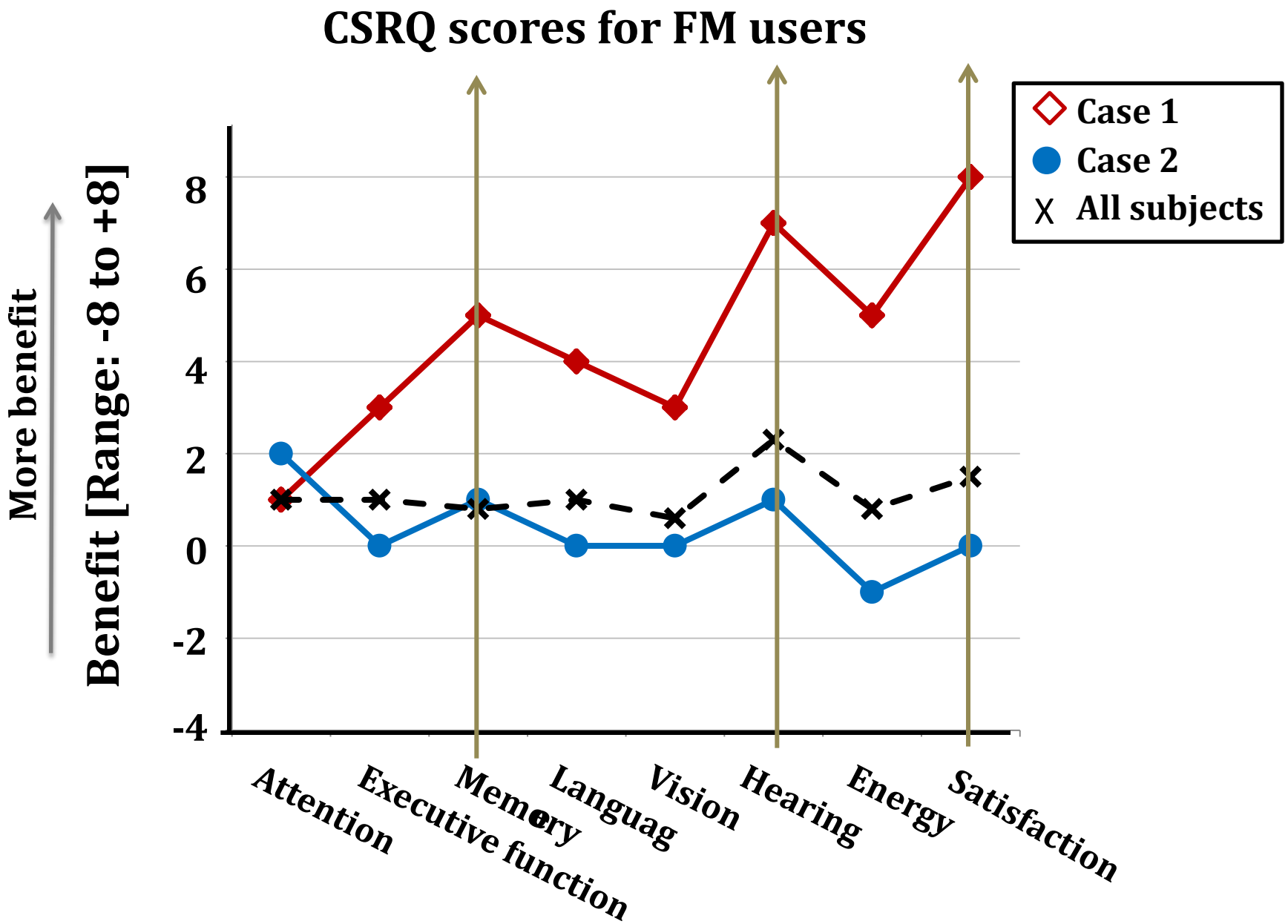
Sometimes FM worked well in restaurants and at home.

Not helpful for

System picked up background noise

Did not work well for him


SSQ-C scores for FM users
Case 1
Case 2
All subjects
More benefit
Benefit [Range: -5 to +5]
4
3
2
1
0
-1
-2
Speech
Spatial
Qualities


CSRQ scores for FM users
Case 1
Case 2
All subjects
More benefit
Benefit [Range: -8 to +8]
8
6
4
2
0
-2
-4
Attention
Executive function
Memory
Languag
Vision
Hearing
Energy
Satisfaction

Results: What seems to predict outcome?

Baseline speech in noise performance

Veteran 1 had poor performance, Veteran 2 did not

Life style

Veteran 1 used it for school, Veteran 2 didn't find a good use for it

Understanding of how and when to use it

Veteran 2 reported it picked up background noise. Surprising if used properly (system had directional settings)

Underlying etiology

Problems of Veteran 2 may be associated with PTSD not CAPD from mTBI.

Case 3 - 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 - 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

AT users

	Age	Gender	PTA L/R (dB HL)	Word recognition L/R (%)	PTSD	TBI
Case 3	**52**	**F**	**11.6/13.3**	**100/100**	**Y**	**Y**
Case 4	**46**	**M**	**6.6/10.0**	**92/92**	**Y**	**N**

Baseline scores

	LISN-S Talker advantage	LISN-S Spatial advantage	HINT
Case 3	Average	> 2 SD below norms	Average
Case 4	Average	Average	Average

Results:

Case 3

Completed 30 of 40 training sessions

Felt program really helped

Has ‘greater awareness’ and ‘keener insight’

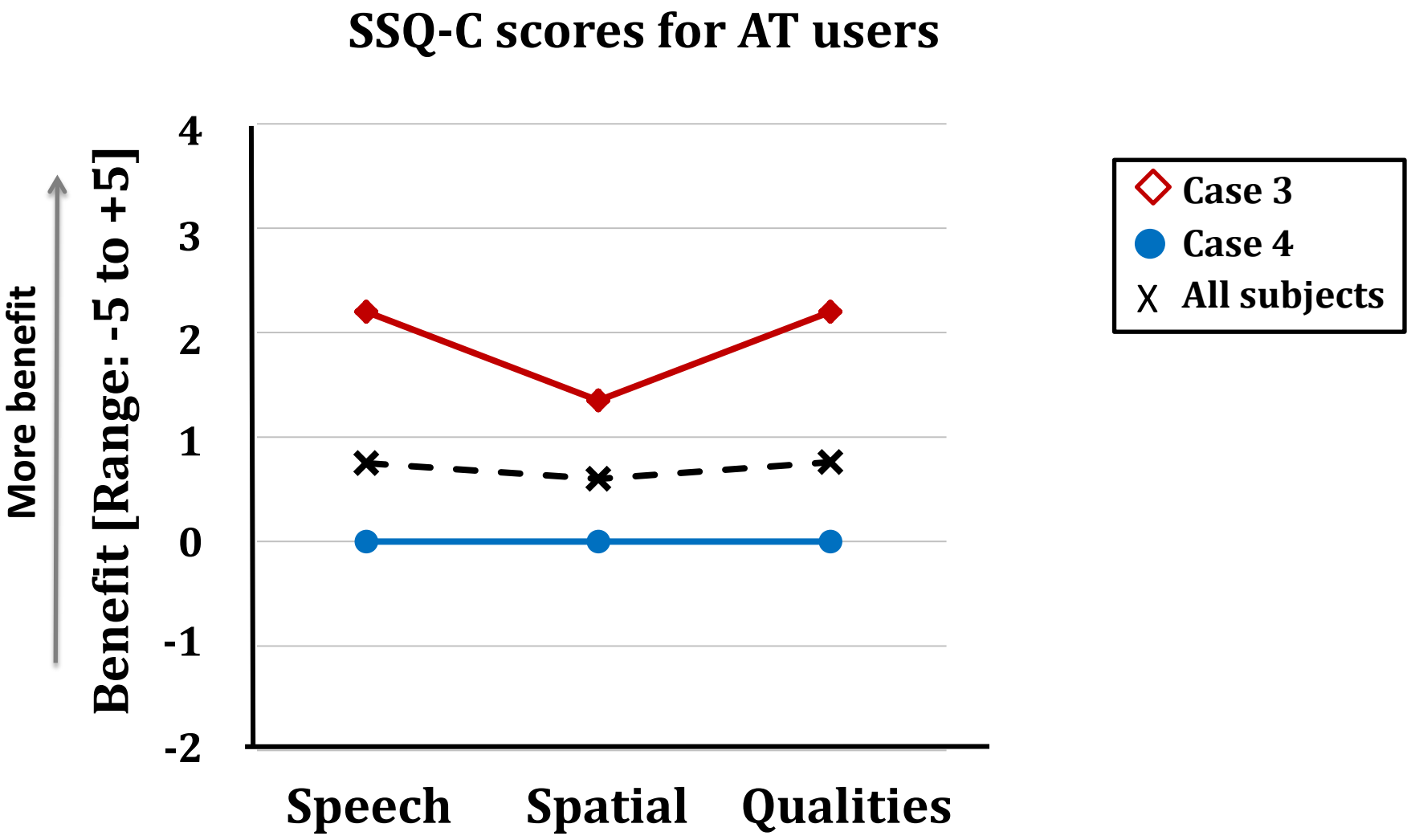
Did not like all tasks

Case 4

Completed 16 of 40 training sessions

Feels training did not improve his hearing

Some exercises were fun, some were boring, overall the training was too long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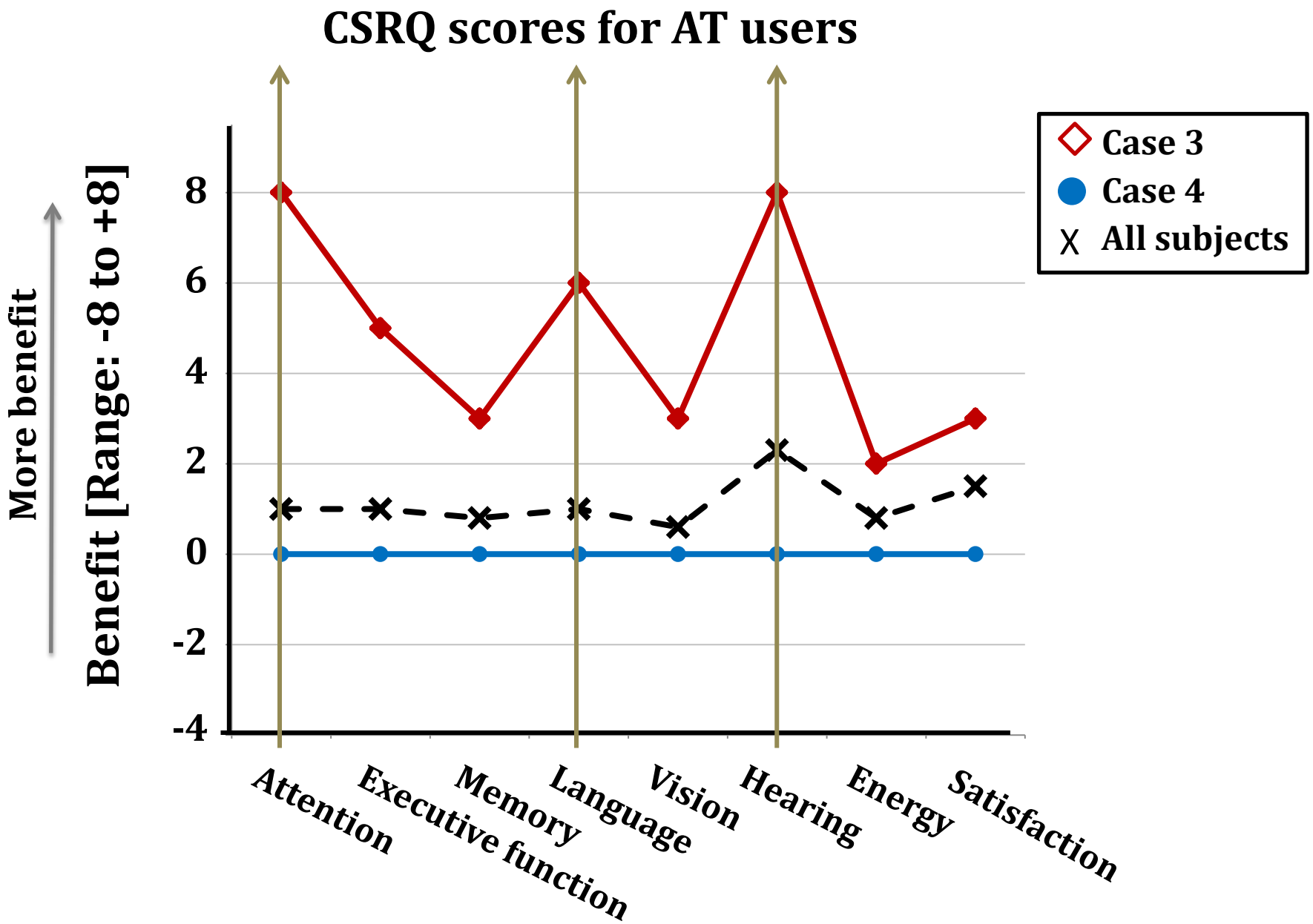
Speech
Spatial
Qualities
Case 3
Case 4
All subjects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Case 3
Case 4
All subjects
Attention
Executive function
Memory
Language
Vision
Hearing
Energy
Satisfaction

Results: What seems to predict outcome?

Baseline speech in noise performance:

Veteran 3 had poorer performance than Veteran 4

Severity of baseline reported problems:

Veteran 3 specified processing time, fast speech and following long conversations/verbal instructions as problems. Veteran 4 reported fewer and less severe problems.

Time availability and motivation:

Veteran 3 was not working but was looking for employment while Veteran 4 worked full time

Underlying etiology:

Problems of Veteran 4 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 ability**
- **Other?**

Ideally we could predict who will and won't benefit up front – but don't yet know how to.

Poll question:

Based on your clinical practice and knowledge, what else should we consider?

Open-ended responses please

Future and ongoing translational research

- **Provision of mild gain hearing aids for this population and examine the relationship between auditory symptoms in mTBI and PTSD - Sheila Pratt (PI).**
- **Correlations between multiple combat blast insults and sports concussions in collaboration (NCRAR and Oregon Health & Sciences University Sports Medicine Concussion Team**
- **Collaborating with Portland VA Audiology Clinic on clinical implementation of research findings**

Thank you for listening

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Questions?

Mild TBI Diagnosis and Management Strategies

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Pole Question
Who is in the Audience?

- Military Audiologist
- VA Audiologist
- Military SLP
- VA SLP
- Physician
- Neuropsychologist or Behavioral Health Professional
- Other

Central Auditory Processing Deficits

- Developmental
- Acquired
  - ***Trauma*** *(e.g., mTBI)*
  - Cardiovascular
  - Metabolic
  - Tumors and other structural abnormalities
  - Experiential

Mild Traumatic Brain Injury

(Hoge et al., 2008; Terrio et al., 2009; Wilk et al., 2010)

- One of the most common injuries to military service members in recent conflicts.
  - ~15-25% of military personnel deployed in Iraq and Afghanistan have experienced trauma consistent with mTBI.

Common Definition

(American Congress of Rehabilitation Medicine; Kay et al., 1993)

- A physiological disruption of brain function manifested by alteration of mental state, loss of consciousness, and/or loss of memory or focal neurological deficit that may or may not be transient, but where the severity of the injury does not exceed the following:
  - Loss or alteration of consciousness for less than 30 min
  - Post-traumatic amnesia for less than 24 hours
  - After first 30 min *a Glasgow Coma Scale* score of 13-15

Military Operational Definition

"…an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as: headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/ noise, blurred vision, difficulty remembering, and/or difficulty concentrating."

(Defense and Veterans Brain Injury Center, 2006)

mTBI and Blast

- Commonly a consequence of explosive blast (Taber et al., 2006; Warden, 2006).
  - ~75% of military mTBI cases are associated with blast exposure.
    - Pressure waves
    - Secondary, tertiary and quaternary insults
    - High-intensity noise

Neural Effects

- Typically a lack of gross abnormalities on structural neuroimaging scans (i.e., CT, MRI; Niogi & Mukherjee, 2010; Tombaugh et al.,2007).
- Biomechanical and biochemical evidence of ultrastructural brain damage and cell death(Cernak et al., 2001).
- Micro-lesions that become more diffuse with increased numbers of blast exposures (Davenport et al., 2012).
- Small cortical and sub-cortical bleeds (Taber et al., 2006).
- Changes in functional activation and white matter integrity (e.g., fMRI, diffusion tensor imaging; MacDonald et al., 2011; Matthews et al., 2011).

Physical Symptoms

- Headaches and other pain
- Impaired sensory function
  - **Hearing and tinnitus**
  - Balance
  - Dizziness
  - Vision
  - Taste and smell
  - Multisensory impairments
- Nausea
- Reduced energy

Cognitive

(Belanger et al., 2005; LeBlanc et al., 2006; McAllister et al., 2006; Ruff et al., 2010)

- Attention and concentration
- Processing speed
- Reaction time
- Memory
- Decision skills
- Speech and language difficulties

Behavioral
(Sheedy et al., 2006 and others)

- Irritability
- Quick to anger
- Anxiety
- Sadness and depression
- Hyper-arousal
- Impulsivity
- Sleep disturbances
- Overuse of drugs, alcohol and tobacco

Time Course

(Bales et al., 2009; Corrigan et al., 2010; Ivins et al., 2009; Terrio et al., 2009)

- Commonly believed that most overt symptoms tend to dissipate within days to 3 months of the brain injury for most mTBI patients.
- Subtle or sub-clinical symptoms may persist.
- Some symptoms may become evident or problematic later and in different contexts.
- Concerns about age at injury and increased neural degeneration with age.

Other Issues

- Often missed if in the presence of other more obvious or serious injuries.
- Many military personnel and veterans with mTBI do not realize they have been concussed.
- Many do not have a formal diagnosis of mTBI.
- Nature, magnitude, and frequency of blasts vary.
- PTSD?
- Substantive variability across patients.

Blast and Auditory System

(Belanger et al., 2011; Gondusky & Reiter, 2005; Helfer et al., 2005; Patterson & Hamernik, 1997)

- Most common effects of blast
  - Tympanic membrane and middle ear damage
  - Cochlear damage resulting in sensory hearing loss
  - Tinnitus
- Less common but <u>clinically remarkable</u>
  - Central auditory deficits
  - Cognitive deficits subtended by the auditory system

Central Auditory Dysfunction

- Complaints of difficulty hearing in noise and complex listening and social situations
- Many have normal results on standard audiometric testing including word recognition in quiet
- Elevated hearing handicap scores
- Impact on family, work and school
- No consensus on assessment protocol

Auditory System and Related Regions at Risk

(Chafi et al., 2010; Taber et al., 2006)

- Lower and mid brainstem
- Thalamus
- Corpus callosum
- Cerebellum
- Orbitofrontal

Central Auditory Dysfunction and Blast Exposure (Gallun et al., 2012)

- 36 blast-exposed
  - 17 non-mTBI, 19 mTBI
  - 39% reported reduced hearing in quiet since blast exposure
  - 78% reported difficulty hearing speech in noise
- 29 non-blast-exposed controls
- Normal to mild hearing loss on standard audiometric measures
  - Air and bone conduction puretone thresholds, NU-6, DPOAE

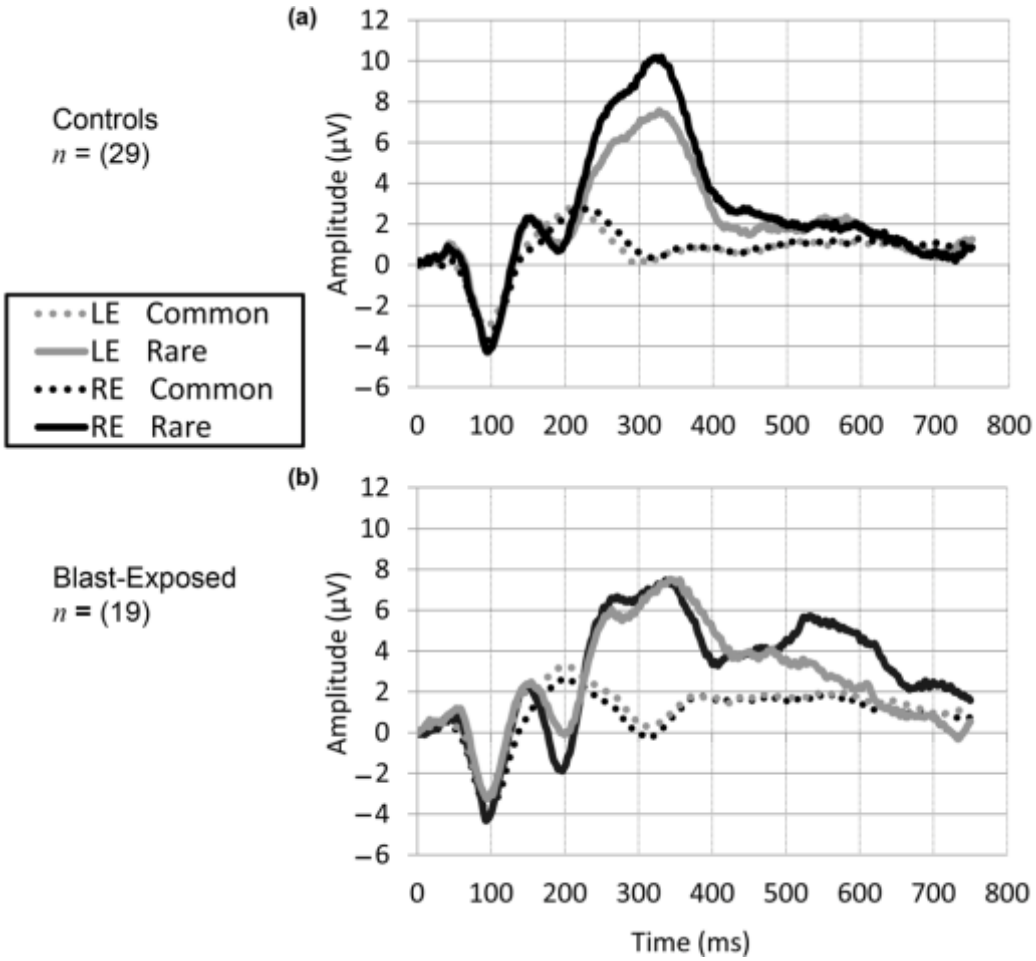
Central Tests

- Auditory electrophysiological testing
  - ABR, LLR with an oddball paradigm
- Behavioral tests of central auditory function
  - *Frequency Pattern Test*, *Gaps-in-Noise*, *Masking Level Difference*, *Dichotic Digits*, *Staggered Spondaic Words*
- Speech perception in noise
  - *Quick Speech-in-Noise* (*Quick SIN*)

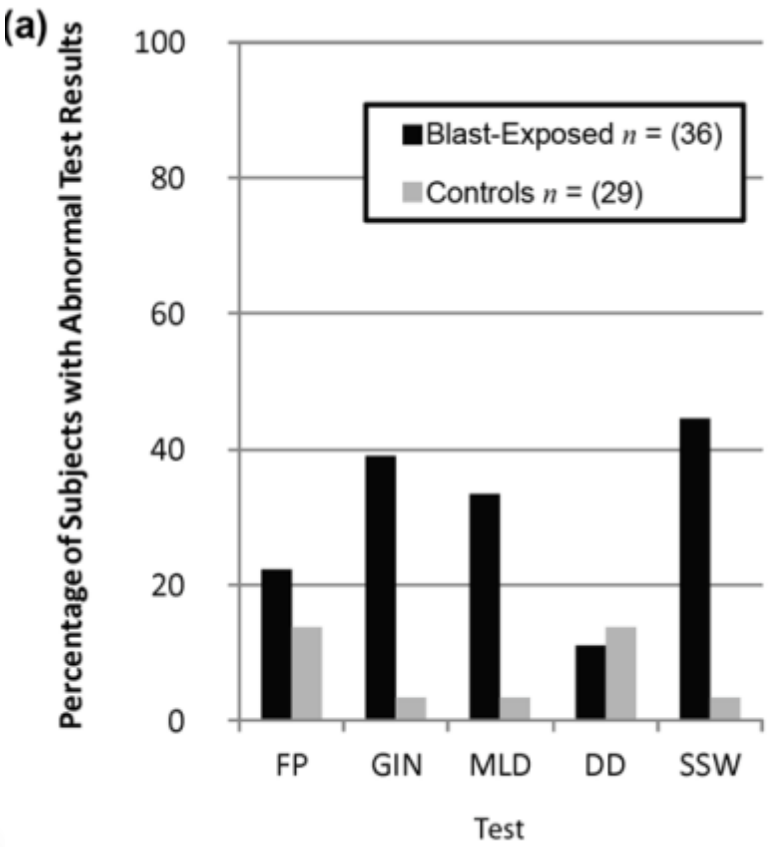
Overall Pattern of Results

- Normal ABR but abnormal LLR results (right ear P300 amplitude and latency, left ear N100 amplitude).
- Normal *Frequency Pattern Test* and *Dichotic Digits*, but abnormal *Gaps-in-Noise*, *Masking Level Difference*, and *Staggered Spondaic Words*.

Abnormal LLR Results
(N100 and P300 Components)



Number of Abnormal Behavioral Results



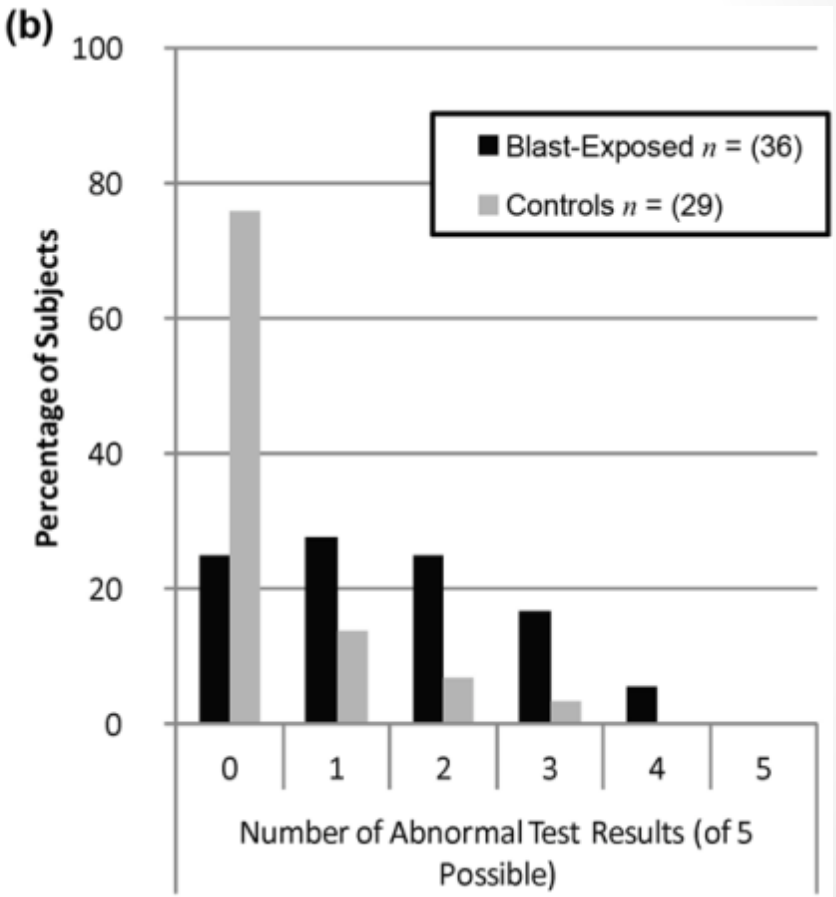


Chart Review at VA Pittsburgh
(Jorgensen et al.)

- 45 veterans with history of blast-exposure.
- Normal or near-normal standard audiometric test results.
- All complained of difficulty hearing in noise and difficult listening situations.

Characteristics	
Gender	Male-43 Female-2
Age	Median=29.5, SD=11.07
NU-6 Scores	Right-96.8% Left-96.3%
HHIA-S Score	Mean=26.39, SD=8.85
mTBI Diagnosis	15.5%

Behavioral Central Tests

- *Masking Level Difference*
- *Gap Detection*
- *Staggered Spondaic Words*
- *SCAN 3:A*

SCAN 3:A

Subtest Performance			
	Norm	**Mean**	**SD**
Auditory Figure Ground 0 dB	25-40	19.6	6.9
Competing Words: free recall	24-40	24.2	7.5
Filtered Words	23-40	34.5	3.7
Competing Words: directed ear	39-60	41.1	8.8
Competing Sentences	63-70	62.5	7.2
Auditory Figure Ground 8 dB	37-40	36.4	8.4
Time Compressed Sentences	56-60	57.5	3.1

Sample Testing Protocol

- Sample across the auditory system and functions
- Standard audiometric battery
  - Air and bone conduction thresholds
    - What to do with patients with hearing loss?
  - Speech in quiet
  - Tympanometry
  - DPOAE
  - Hearing handicap scale (e.g., HHIA)
  - Other scales and questionnaires

Central Tests

- Auditory electrophysiology
  - Minimally ABR, P300
- Possible behavioral measures
  - Temporal fine structure
  - MLD
  - GIN
  - SSW
  - Speech in noise and/or with competing signals with differing linguistic loads
  - Test of spatial hearing
  - Auditory tests of auditory memory and executive function
  - Visual processing and reading tasks

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