

Blast Exposure, mild Traumatic Brain Injury (mTBI) and Auditory Rehabilitation

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



Why are we interested in this?

Data show that:

- **About 300,000 Operation Enduring Freedom (OEF)/Operation Iraqi Freedom (OIF) Veterans have some form of traumatic brain injury (TBI)**
- **About 75% of wounds are due to exposure to a blast(s)**

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**

Subjective impacts

- **Hearing in background noise**
- **Following rapid speech**
- **Following instructions**
- **Following long conversations**
- **Tinnitus**
- **Hyperacusis**

i.e. indicative of auditory processing problems

High pressure wave is generated, followed by a vacuum

Primary injuries

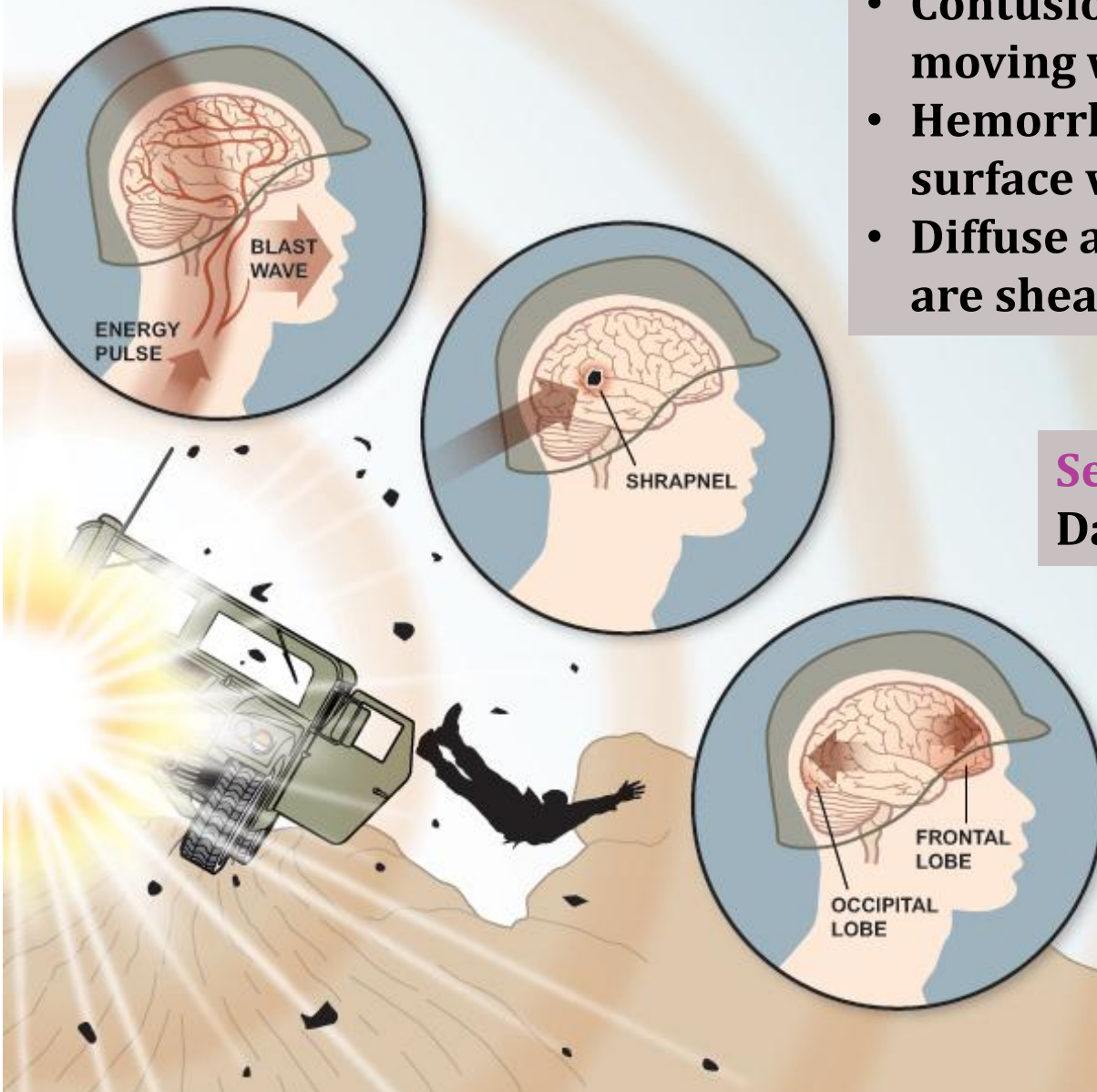
- Contusions (bruising) from brain moving within skull
- Hemorrhage from tearing of surface veins during movement
- Diffuse axonal injury as neurons are sheared and stretched

Secondary injuries

Damage from flying objects

Tertiary injuries

Damage when person is thrown into a solid object



Blast damage to the auditory system

Peripheral Damage

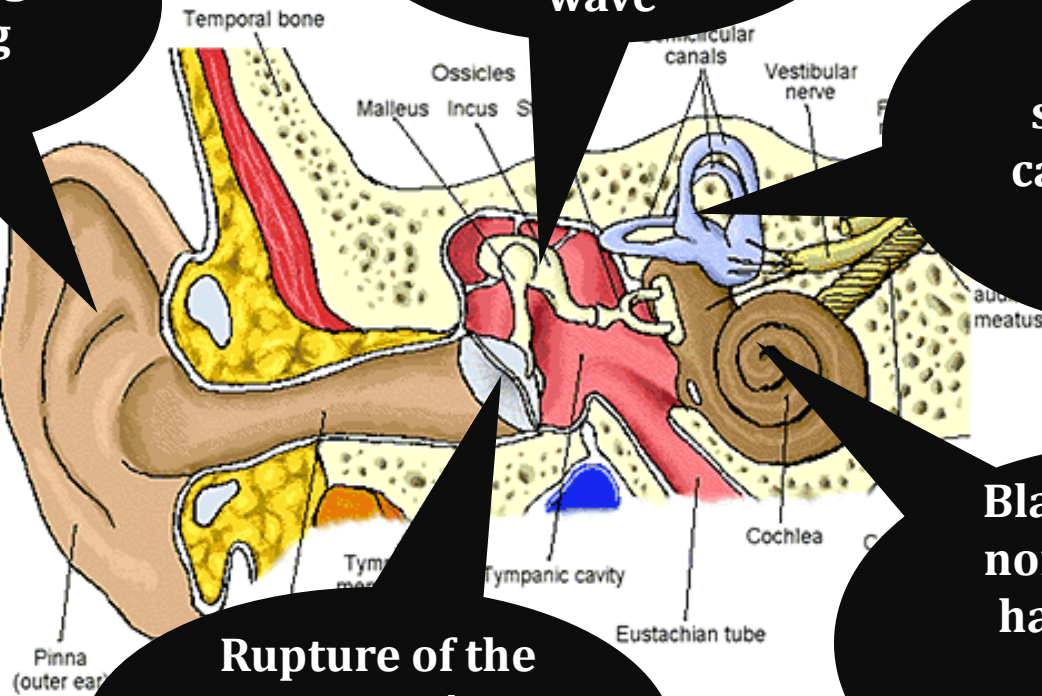
**Pinna damage:
burns/damage
from flying
debris**

**Ossicular
disruption
from pressure
wave**

**Blast wave
damages to
semicircular
canals causing
vestibular
problems**

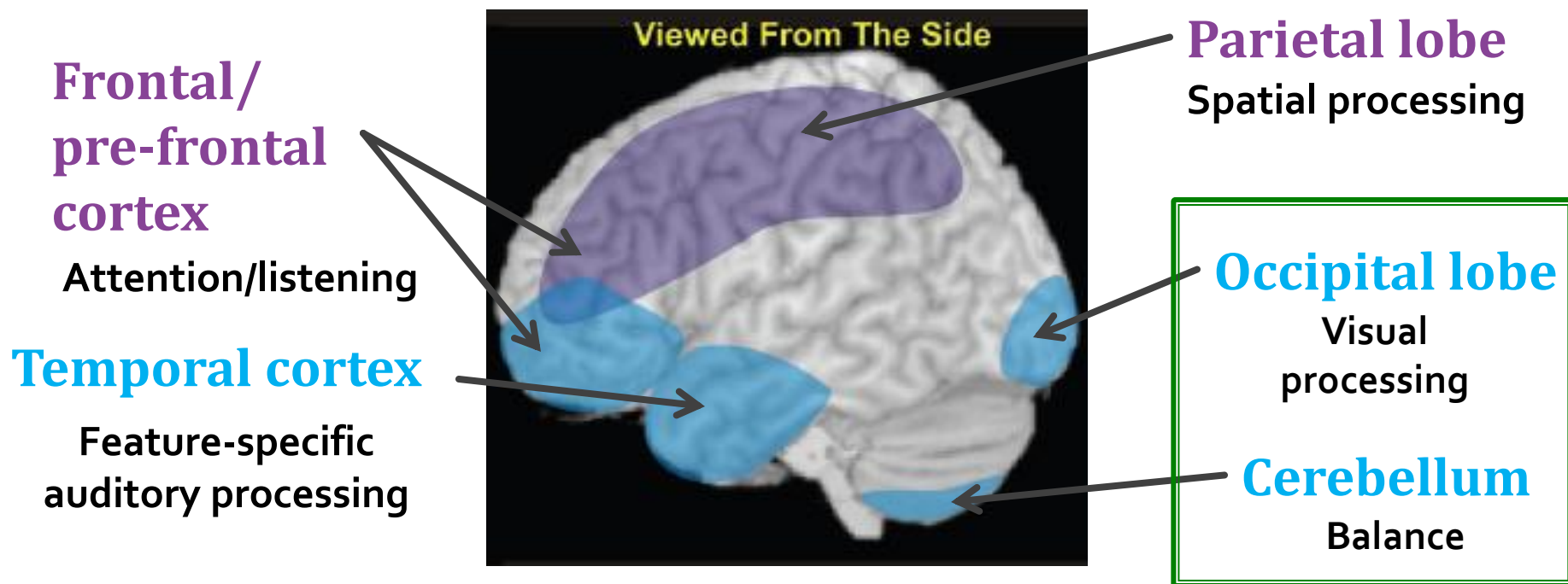
**Rupture of the
tympanic
membrane from
pressure wave**

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



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



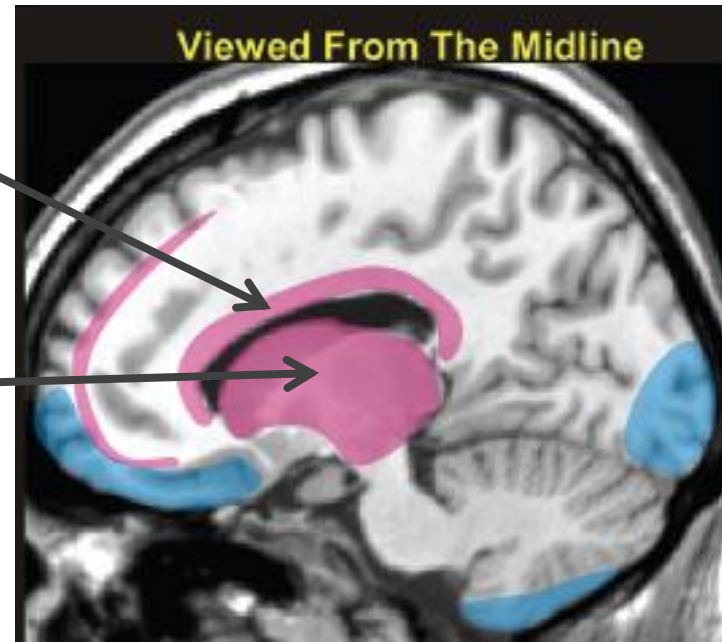
Damage to central auditory system (cont.)

Corpus callosum

Interhemispheric transfer

Thalamus

Organization and updating of cortical-brainstem connections



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

Taber et al (2006) . J Neuropsychiatry Clin Neurosci. 18(2):141-45.

Rehabilitation???

Evaluation of Approaches to Auditory Rehabilitation for mTBI

Research team:

Gabrielle Saunders, Terry Chisolm,
Paula Myers, Melissa Teahen,
Michelle Arnold, ShienPei Silverman

Study funded by VA RR&D grant #: C7054R

Reported difficulties:

- **Hearing in background noise**
- **Following rapid speech**
- **Following instructions and long conversations**
- **Tinnitus**
- **Hyperacusis**

Signal-to-noise ratio (SNR)

Temporal processing

Working memory

Interventions

FM system

- Will be effective at improving SNR, if used correctly
- A prop rather than a 'fix'; requires an external device



Auditory Training

- Potential for sustainable change (a fix) for processing difficulties.
- Requires discipline and time commitment before any benefit may be realized.



Interventions

- **Phonak Zoomlink transmitter and binaural iSense receivers**
- **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?

▲ ▼

Washington, DC

Tell Us Apart

dah gah

Niagara Falls

Match It!

○	○	○	○
	○	○	○
○	○		○
○	○	○	○

Sound Replay

bid dip tip tig

Arches National Park

Listen and Do

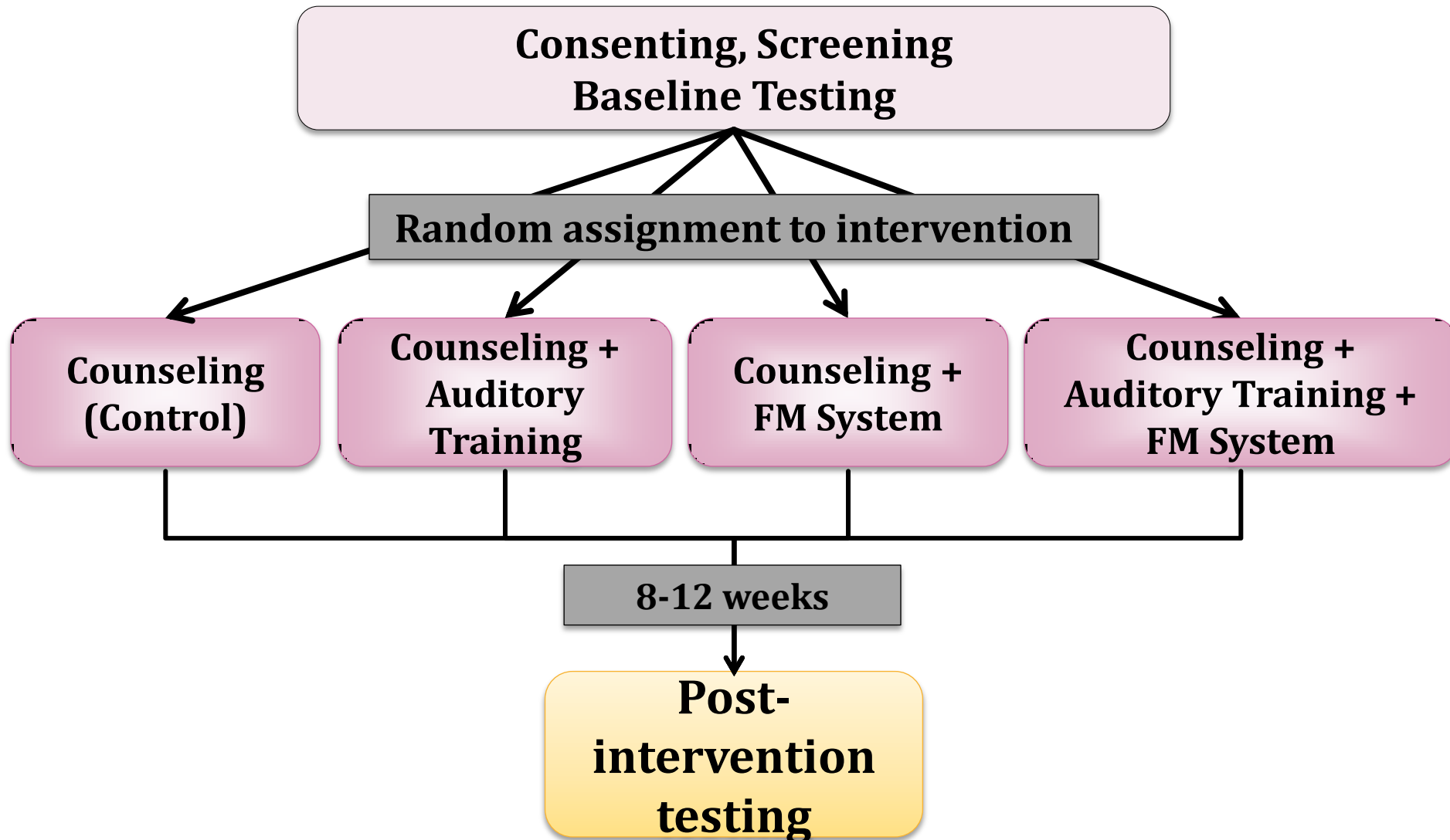
EDDIE'S ICE CREAM BANK U.S. POST OFFICE HOSPITAL

Story Teller

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 clinical trial



Outcome Measures: Performance

Test measure	Rationale for Testing
Gap detection - Adaptive Tests of Temporal Resolution ATTR	
Time Compressed Speech	
Working memory - Digit Span Test WAIS III	
Dichotic - Staggered Spondaic Word test (SSW)	

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)

Outcome Measures: Performance

Test measure	Rationale for Testing
Gap detection - Adaptive Tests of Temporal Resolution ATTR	
Time Compressed Speech	
Working memory - Digit Span Test WAIS III	
Dichotic - Staggered Spondaic Word test (SSW)	
Attention/Interference - Stroop Color Word Test	

Stroop Test

Read word

RED GREEN RED BLUE GREEN RED BLUE

Read color word is printed in - without squinting!

RED GREEN RED BLUE GREEN RED BLUE

Outcome Measures: Performance

Test measure	Rationale for Testing
Gap detection - Adaptive Tests of Temporal Resolution ATTR	Trained with AT
Time Compressed Speech	Trained with AT
Working memory - Digit Span Test WAIS III	Trained with AT. May improve with FM use
Dichotic - Staggered Spondaic Word test (SSW)	Indications from other studies
Attention/Interference - Stroop Color Word Test	Trained with AT. May improve with FM use
Speech-in-noise - HINT	Will improve with FM.

Self-Report Outcome Measures

Test	Rationale
Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)	Likely to improve with FM; may improve with AT
Cognitive Self-Report Questionnaire (CSRQ)	Some scales likely to improve following one or both interventions
Psychosocial Impact of Assistive Devices Scale (PIADS)	May improve following either intervention

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.**

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

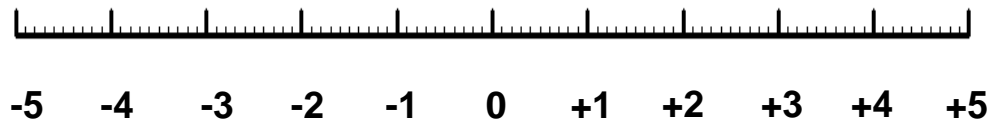
You are talking with one other person and there is a TV on in the same room. Without turning the TV down, can you follow what the person you're talking to says?

Comparing your ability now with your ability before this study

Much worse

Unchanged

Much better



Not applicable

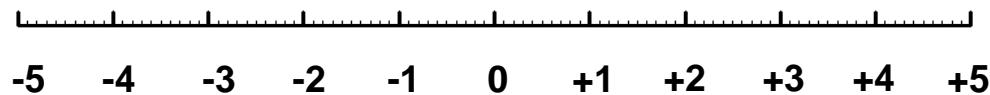
You are talking with one other person in a quiet, carpeted lounge-room. Can you follow what the other person says?

Comparing your ability now with your ability before this study

Much worse

Unchanged

Much better



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

Psychosocial Impact of Assistive Devices Scale (PIADS)

- A 26-item questionnaire assessing the impact of assistive devices on perceived:

Competence

Adaptability

Self-esteem

PIADS

Each word or phrase describes how using the _____ * might affect you.

Wording is adapted for each intervention

* FM system/auditory training program /information we gave you

Psychosocial impact of Assistive Devices Scale (PIADS)

	Decreases		No change			Increases	
	-3	-2	-1	0	1	2	3
Competence							
Happiness							
Adequacy							
Confusion							
Self-esteem							
Productivity							
Usefulness							
Well-being							

Results

Data collected from 86 participants.

	FM+AT	AT	FM	Control
n	22	15	24	25
Age	33.1	34.8	33.9	33.7
4F-PTA	13.4	11.0	12.1	12.1
Gender	Male: 22 Female: 0	Male: 12 Female:3	Male: 19 Female: 5	Male: 22 Female:3

Baseline Performance

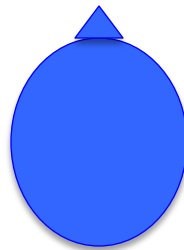
- **Do these individuals have measurable performance deficits?**
- **No control group therefore will compare data with published norms**

Listening in spatialized noise-sentences test (LISN-S)

Adaptive SRT

Target sentences **Blah blah blah**

Competing sentences **Blah blah blah**
Blah blah blah



Competing sentences **Blah blah blah**
Blah blah blah

Same voice Different location: SPATIAL ADVANTAGE

Different voice Same location: TALKER ADVANTAGE

Different voice Different location: TOTAL ADVANTAGE

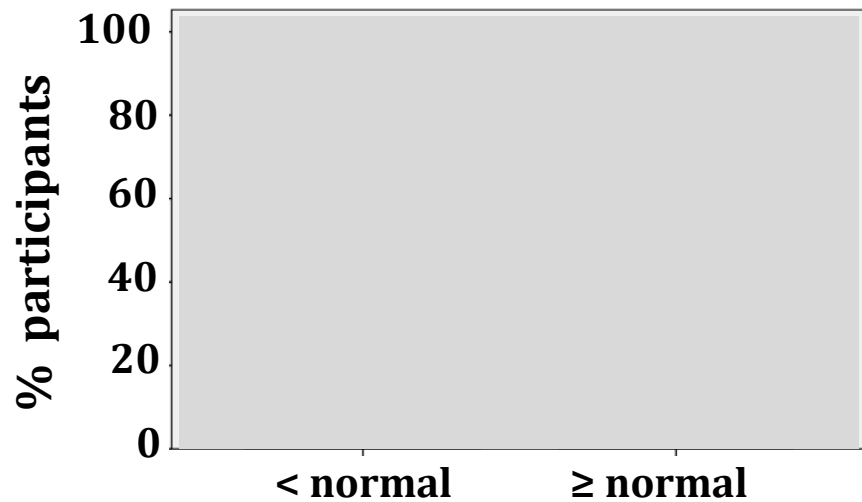
Listening in spatialized noise-sentences test (LISN-S)

Normative data from Cameron et al (2011)

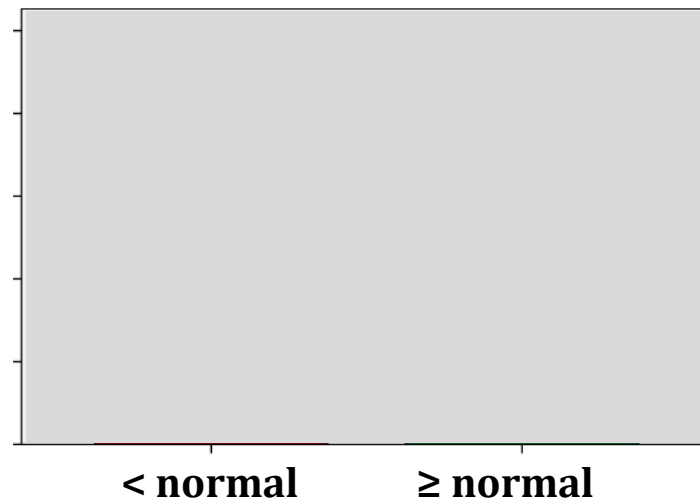
Cameron et al (2011) J Am Acad Audiol 22:697-709

LISN-S

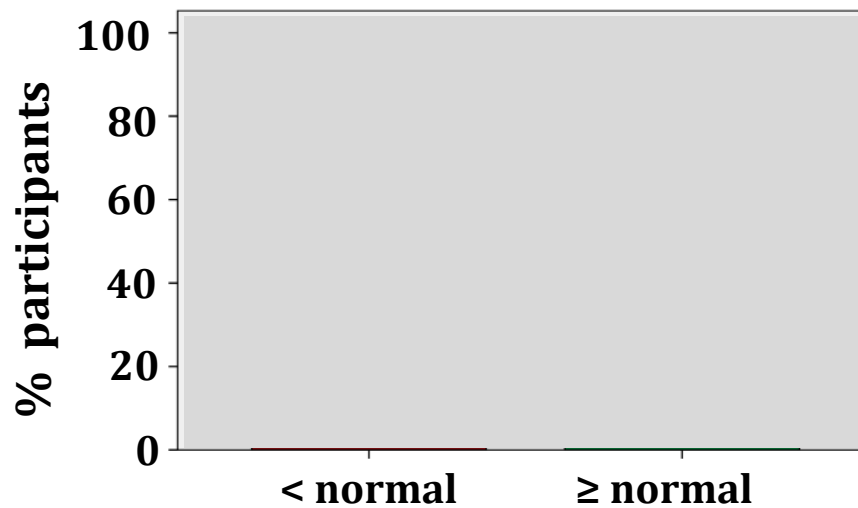
Talker Advantage



Spatial Advantage

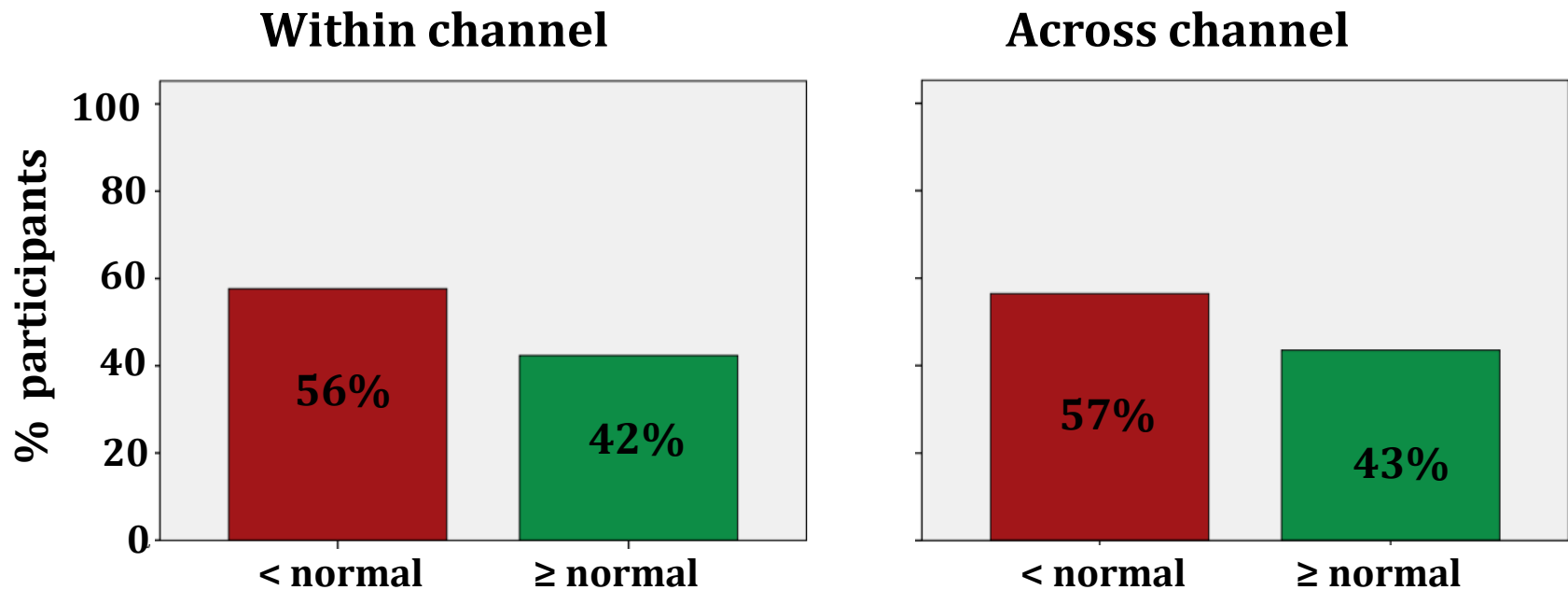


Total Advantage



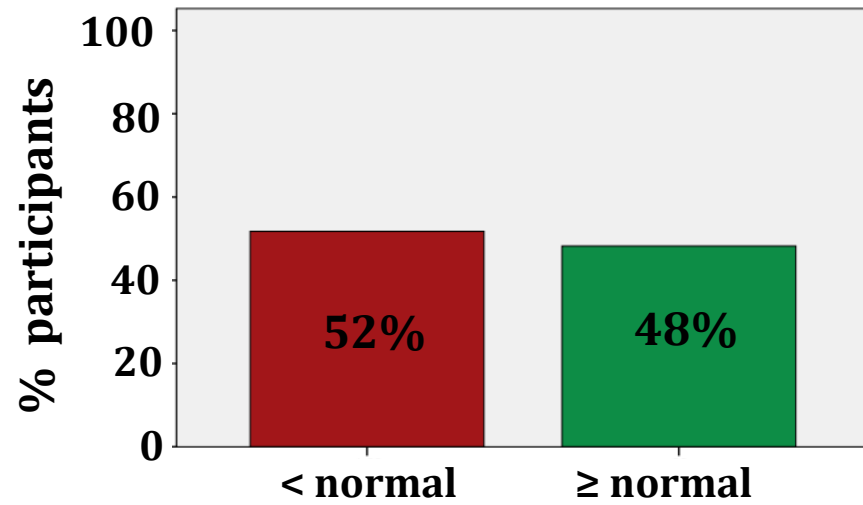
ATTR – Gap detection

- Below average performance: gap threshold +1 SD
- Data from 'young' adults)



Other measures

HINT

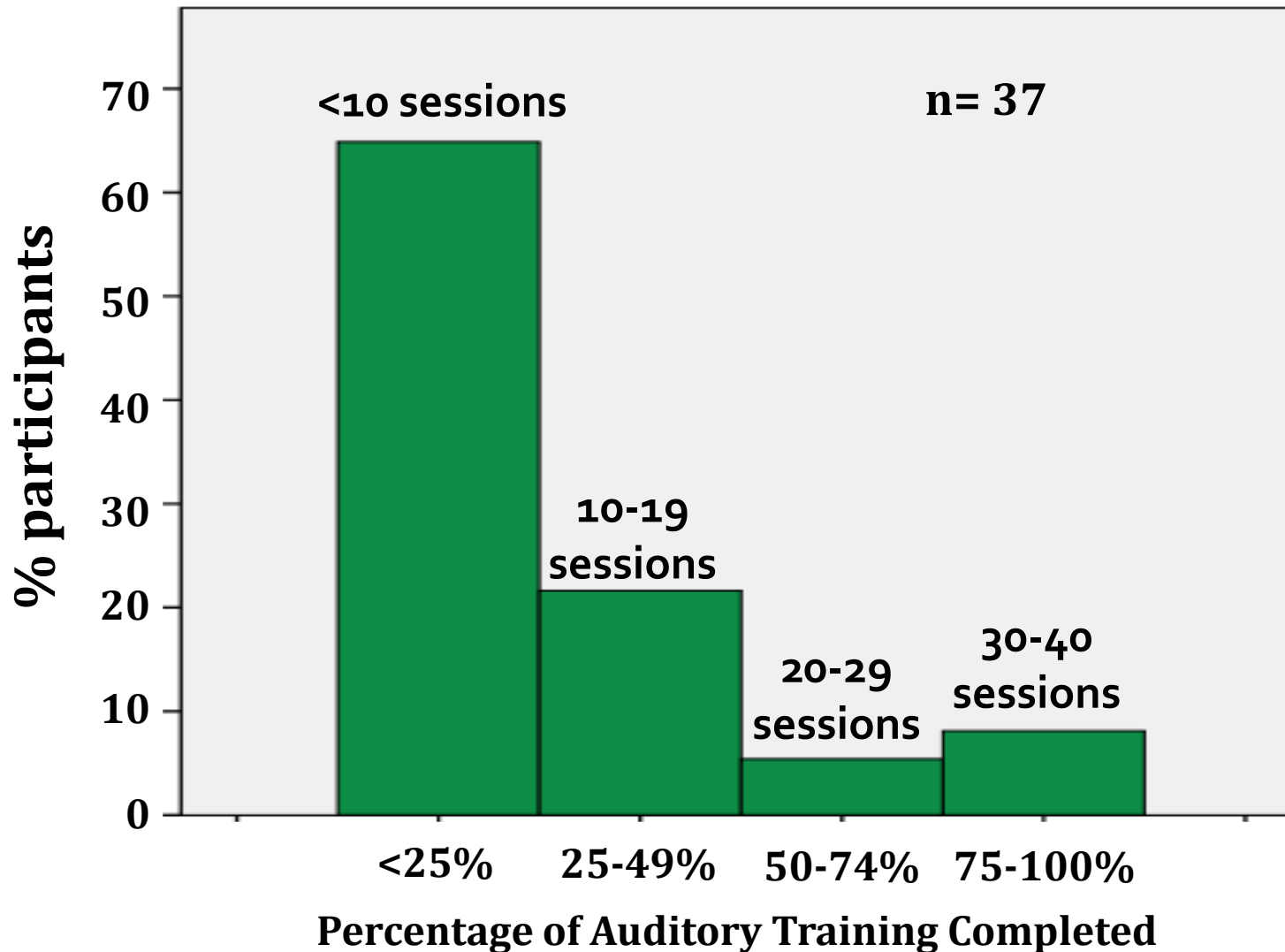


Results

Did the participants use the interventions?

Compliance with intervention

Auditory Training



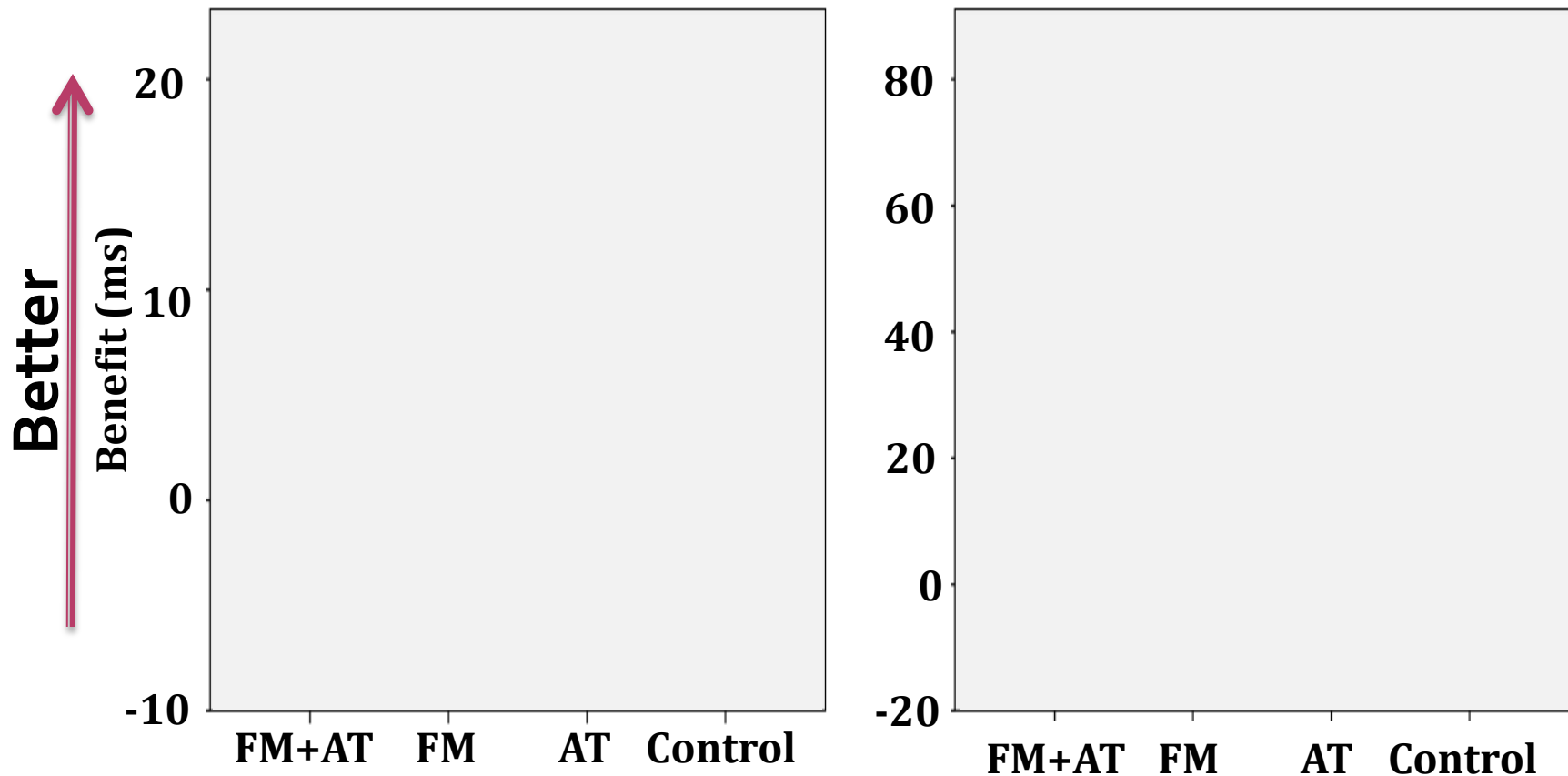
Compliance FM System

- 1 individual did not use FM at all
- 13 wore it hardly ever
- 25 wore it a few times a week
- 7 used it every day

Average use per day = 2.9 hr, range: 0-9

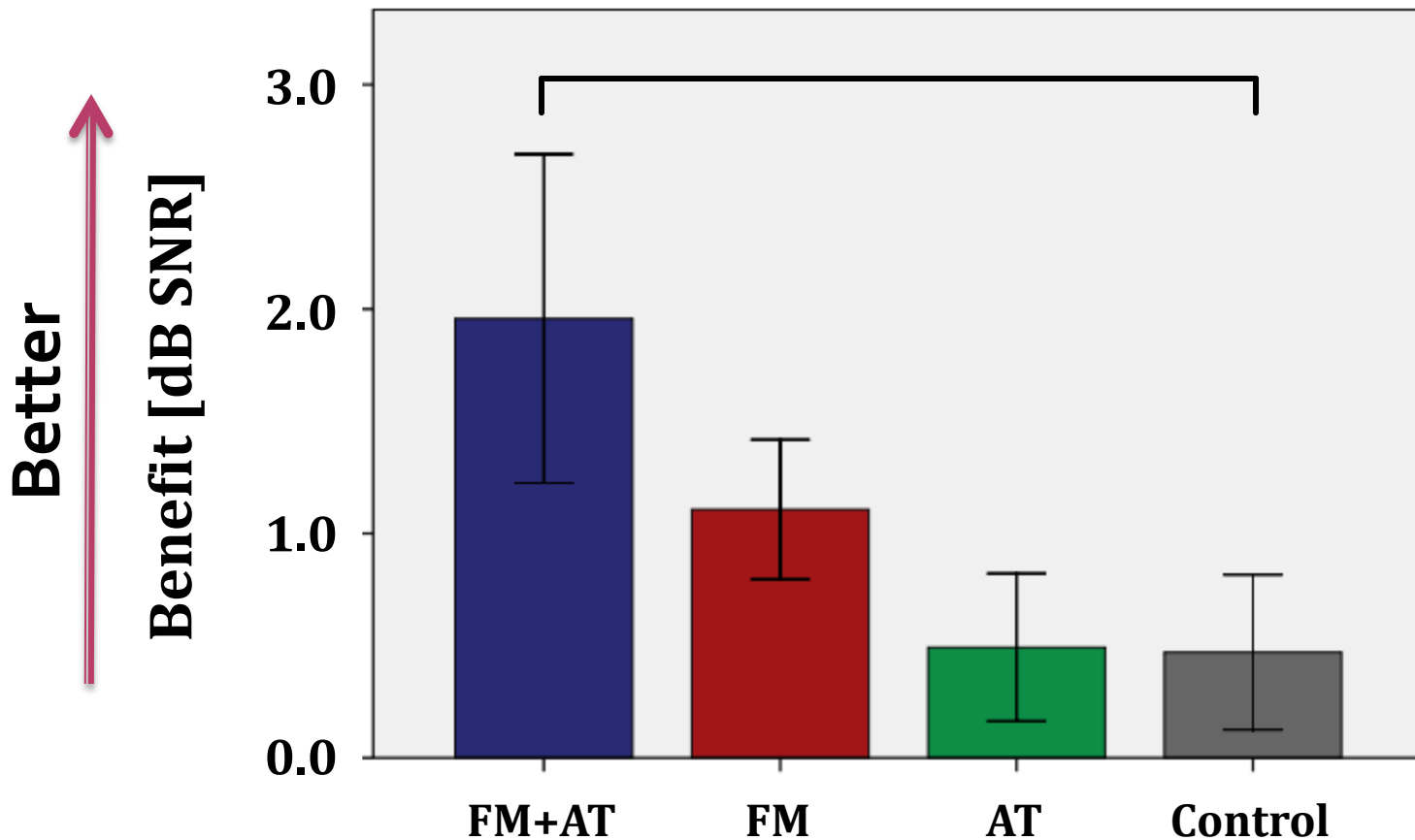
Gap detection - All subjects

$F=2.19, p=0.096, \text{partial eta squared} = 0.075$



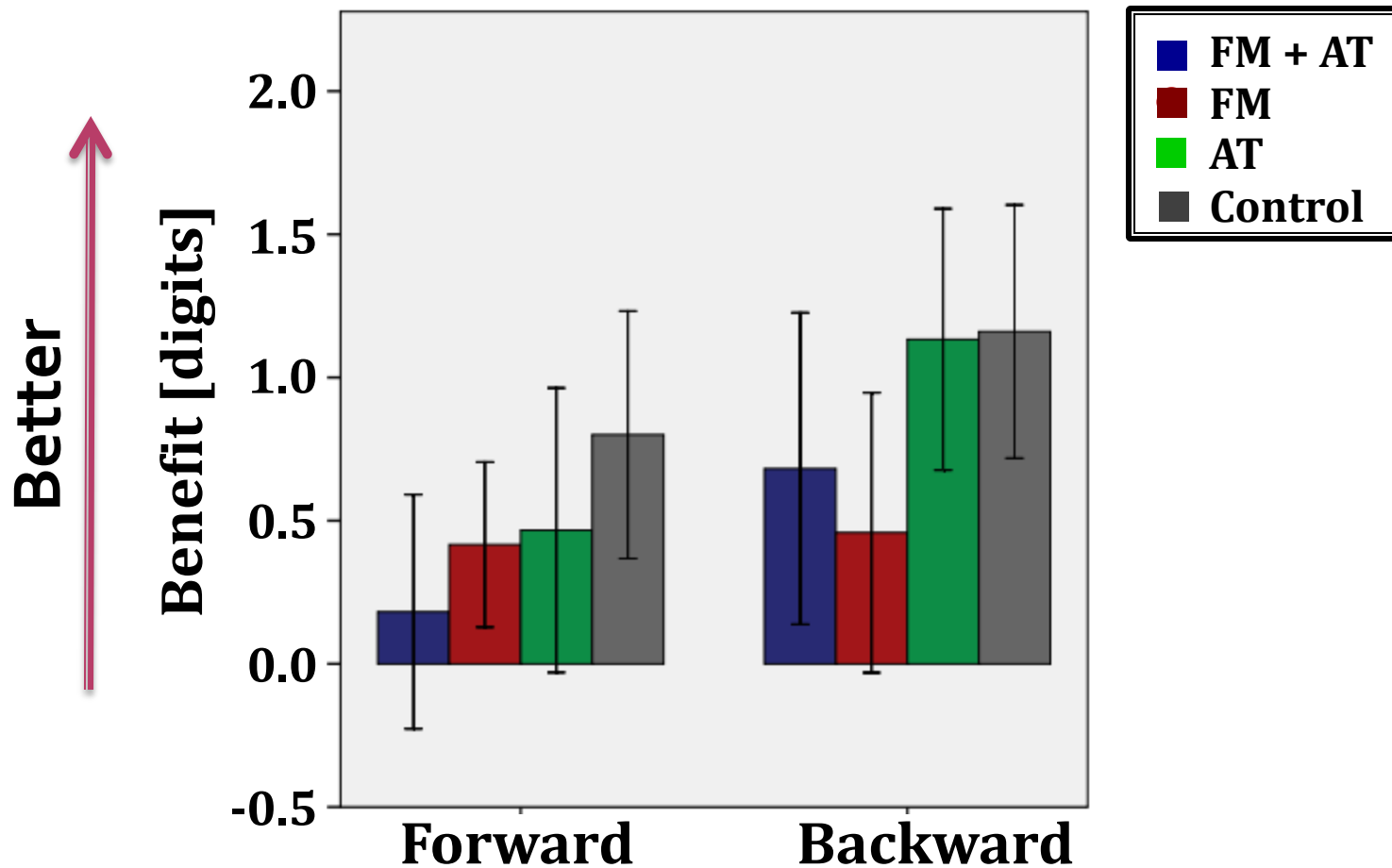
Speech-in-Noise - HINT

F=2.11, p=0.105, partial eta squared = 0.076



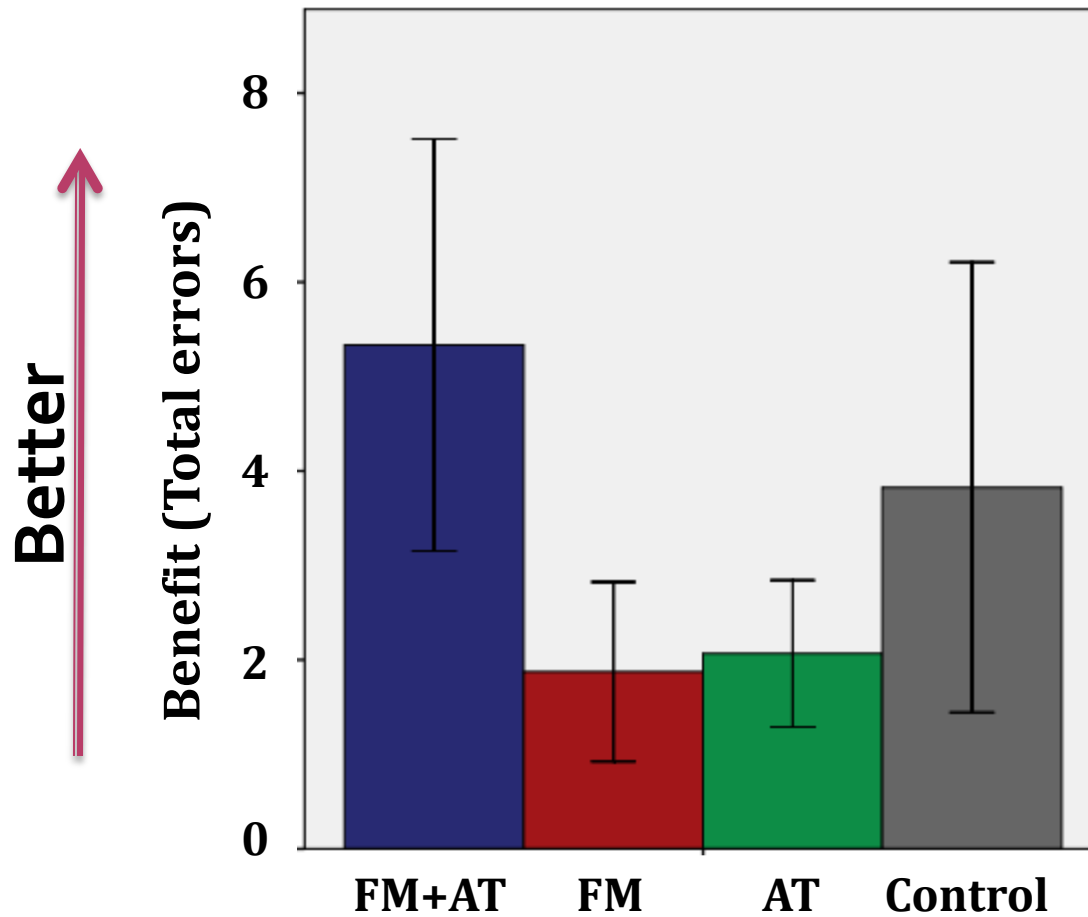
Digit Span

F=0.692, p=0.560, partial eta squared = 0.025

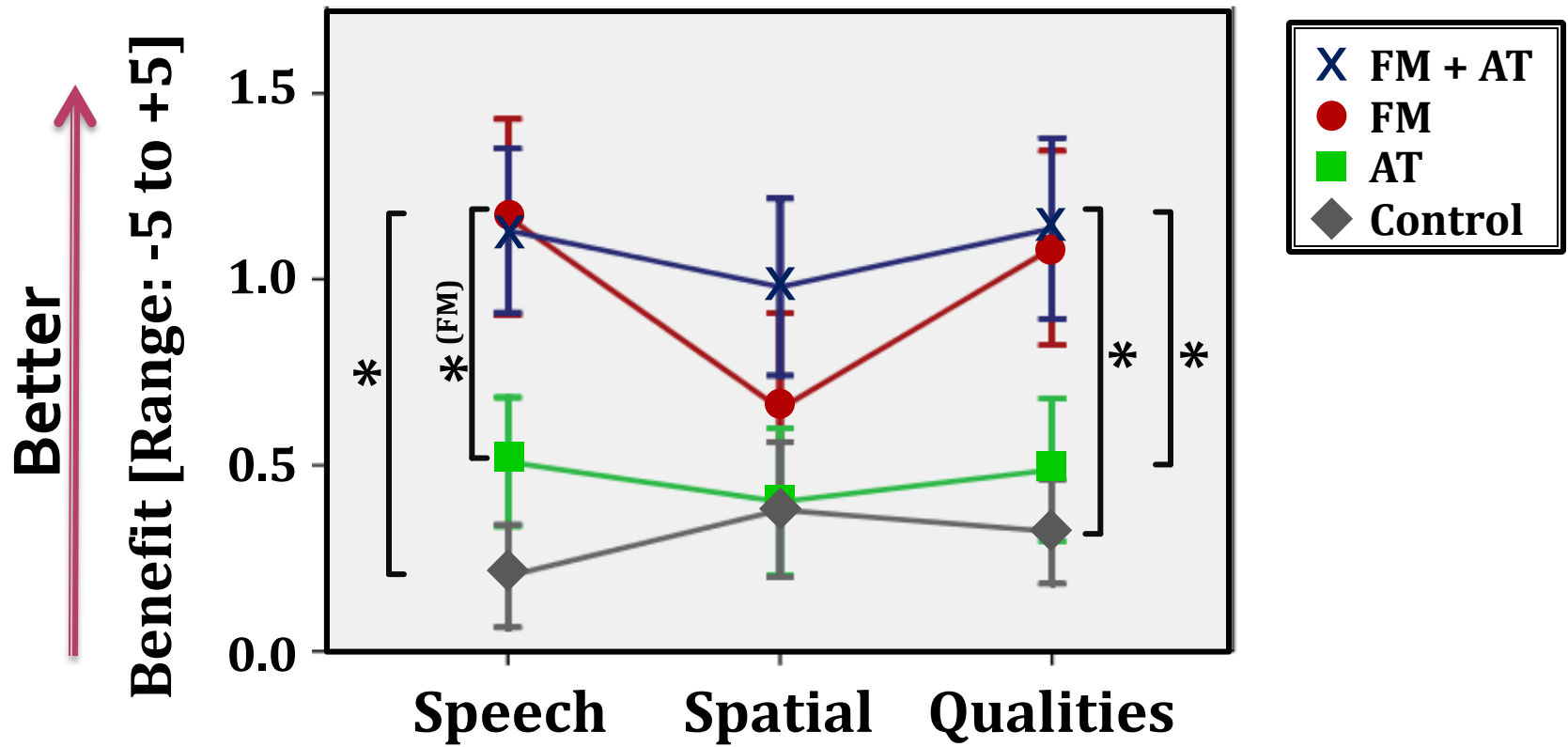


SSW

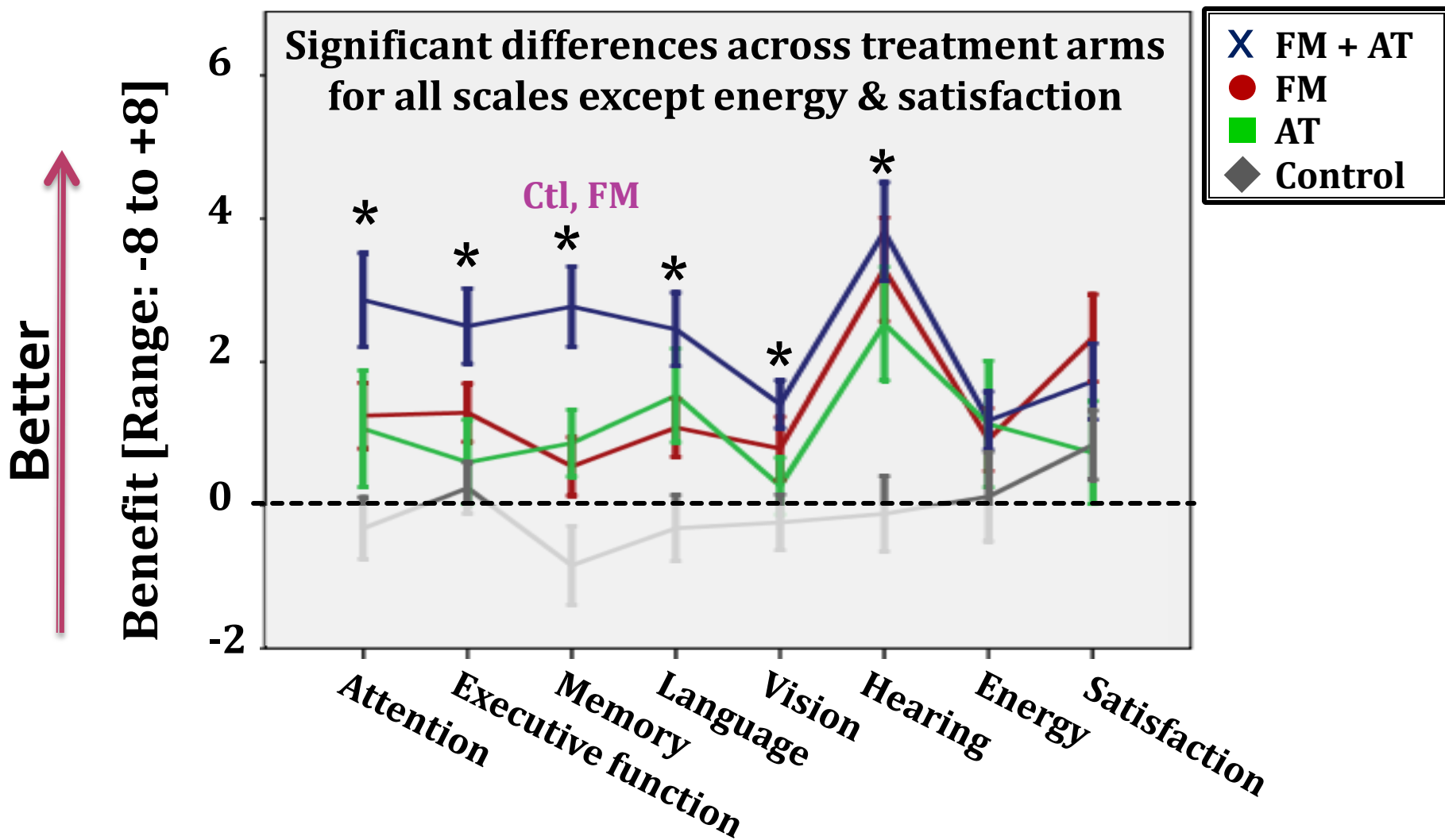
$F=0.789, p=0.504$



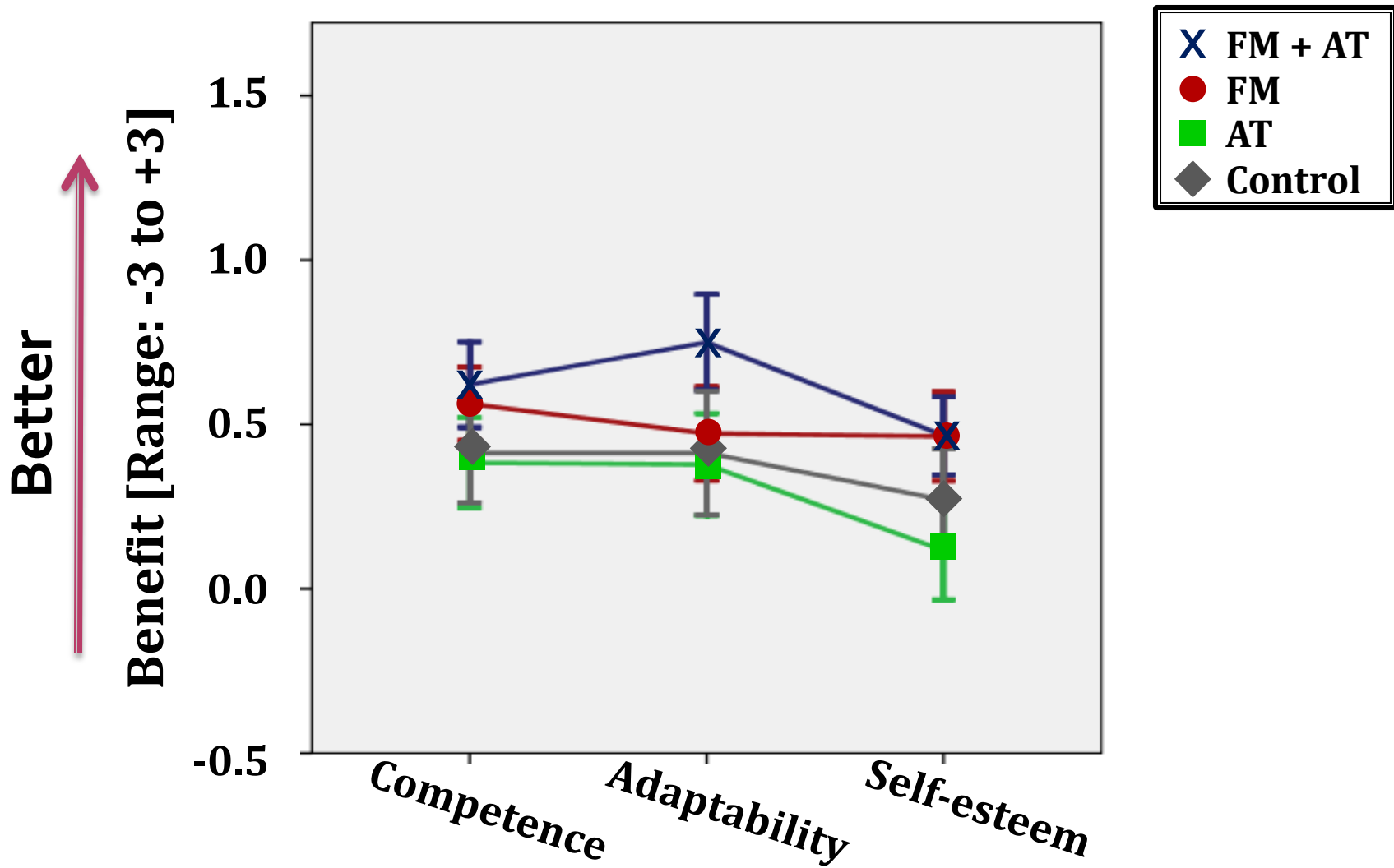
SSQ-C



CSRQ



PIADS



Summary

Interventions are showing some small but positive outcomes for

- ✓ **temporal processing**
- ✓ **speech-in-noise**
- ✓ **Reported auditory difficulties**
- ✓ **Reported cognitive processing**

Combination of AT and FM appears to be most effective

There are individual differences in compliance and in outcome

Summary (cont.)

- **Many more analyses to conduct:**
 - Relationships between compliance and outcome**
 - Predictors of outcome (individual differences)**
 - Baseline deficit on outcome**

Clinical take-home message

- **Consider FM+AT for blast-exposed patients**
- **Make sure patient is open to using the interventions – or they likely won't use them**

Check out the new format for running Brain Fitness from Posit Science: <https://brainhq.positscience.com/octnl-free/start#>

Format allows user to direct their own training

A Quick plug for

NCRAR Conference: September 18-20th 2013

***Beyond the Audiology Clinic:
Innovations and Possibilities of
Connected Health***

Elizabeth Krupinski, Ph.D. (Keynote)

Harvey Abrams, Ph.D.

Terry Chisolm, Ph.D.

Deborah Ferrari, Ph.D.

Louise Hickson, Ph.D.

Jeffrey Kaye, Ph.D.

John Kokesch, M.D.

Robert Margolis, Ph.D.

Jerry Northern Ph.D.

Chad Galdden, Au.D.

Beyond the Audiology Clinic: Innovations and Possibilities of Connected Health

Presentations on

- **Principles and methods underlying telemedicine**
- **How teleaudiology fits into the changing healthcare landscape**
- **Presentations about 2 established teleaudiology programs (Alaska and Brazil)**
- **State-of-the art in VA teleaudiology**
- **Automated hearing testing**
- **Tele-Aural Rehabilitation**
- **Attitudes towards telepractice**

Old habits die hard.....

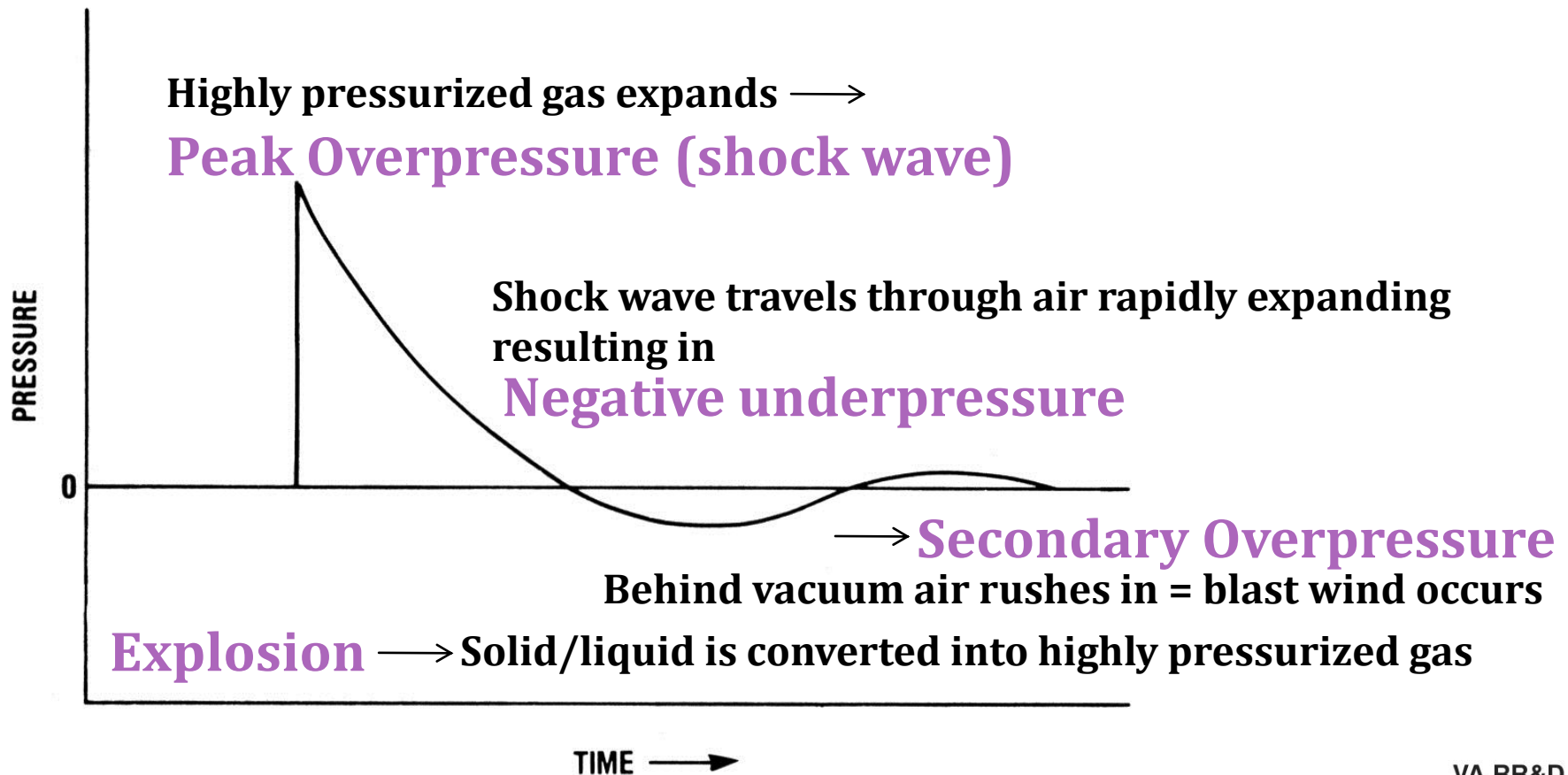




Thank you for listening
Gabrielle.saunders@va.gov



Blast wave physics



Evaluation of Approaches to Auditory Rehabilitation for mTBI

Research Team:

Gabrielle Saunders

Terry Chisolm

Paula Myers

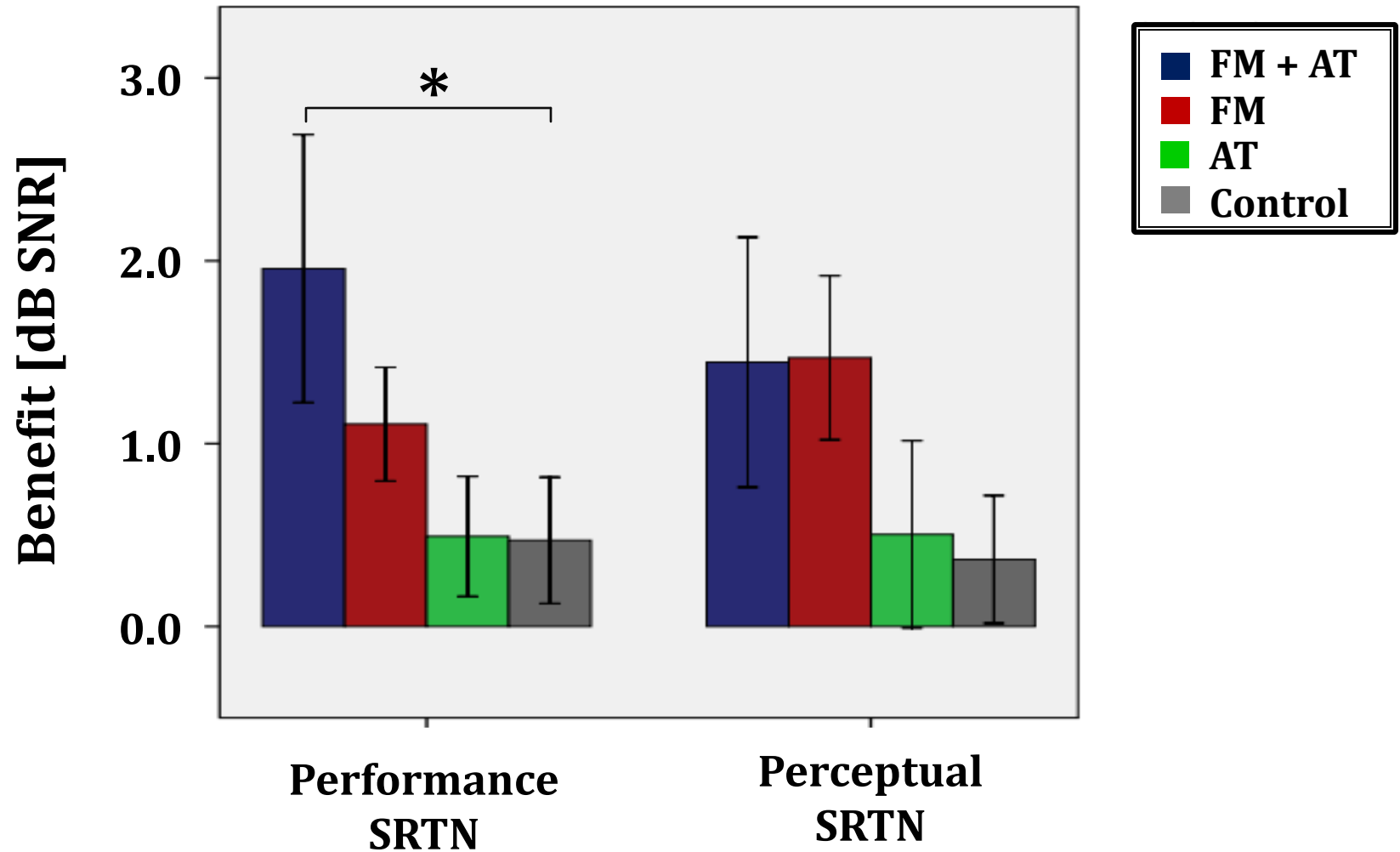
Melissa Teahen,

Michelle Arnold

ShienPei Silverman

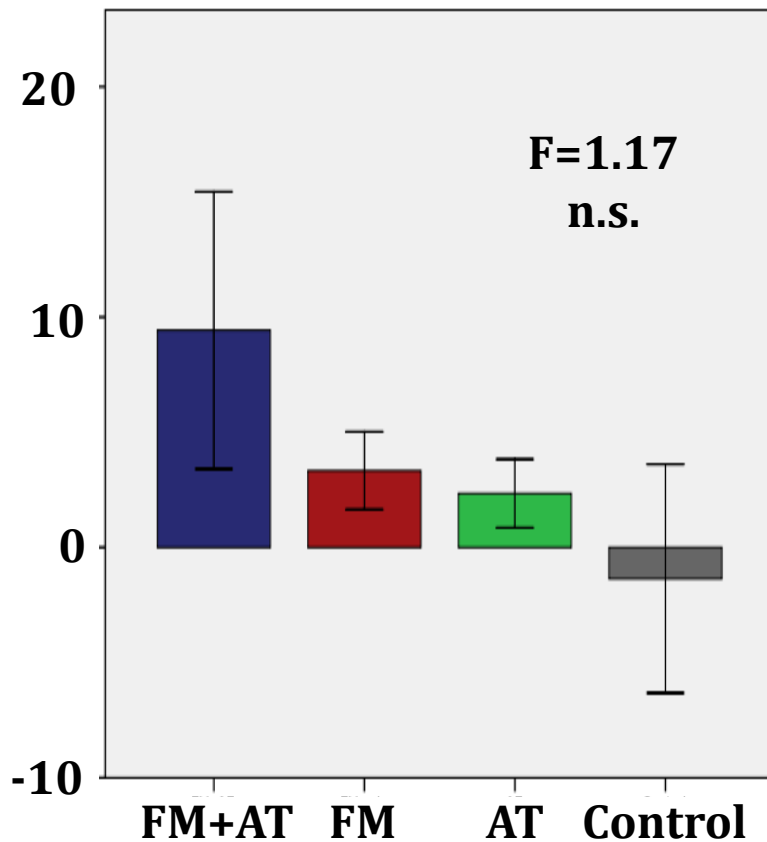
Study funded by VA RR&D grant #: C7054R

HINT – Performance and Perceptual

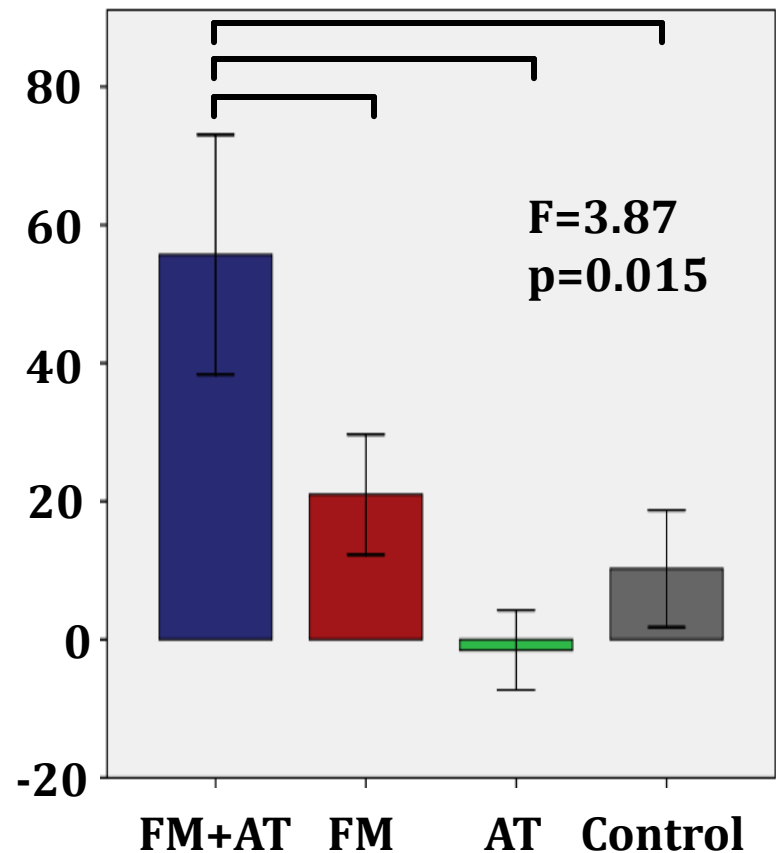


Gap detection – baseline performance below normal

Within-channel



Across-channel



Performance-based impacts

Performance on tests of central auditory processing by individuals exposed to high-intensity blasts

Participants

**36 blast-exposed
OEF/OIF soldiers;
18 with mTBI**

- Tested at Walter Reed Army Medical Center
- Treated for other blast related injuries
- Normal middle ear function
- Mean Age: 32.8 years

**29 controls, matched to
soldiers on age and
hearing**

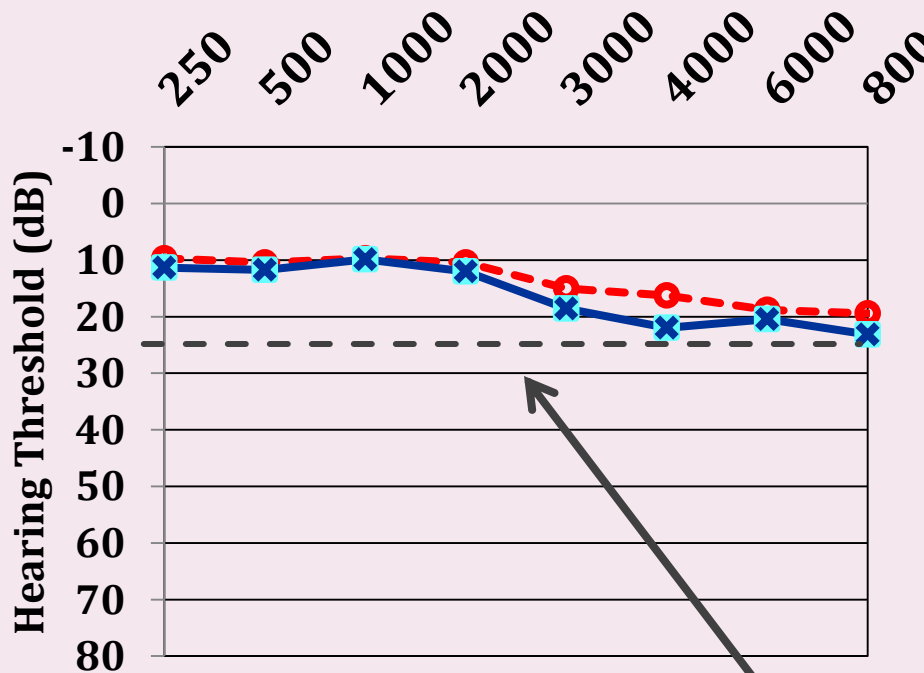
- Tested at NCRAR
- Non-blast exposed
- Mean Age: 33.4 years

Test protocol

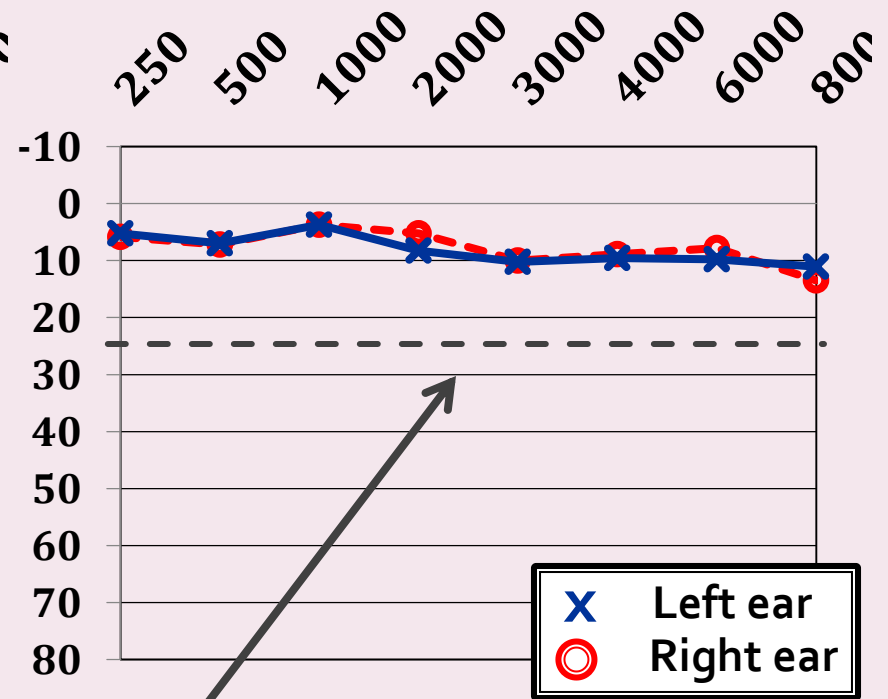
Test	Site of lesion
Audiometric evaluation	Sensorineural vs. conductive vs. none
Gaps in Noise (GIN)	Cortex; corpus callosum
Staggered Spondaic Word Test (SSW)	Cortex; corpus callosum
Masking Level Difference (MLD)	Brainstem
Frequency Pattern Test (FPT)	Cortex; corpus callosum; brainstem
Dichotic Digits Test (DDT)	Cortex; corpus callosum
Auditory Brainstem Response Waves I to VII	Auditory nerve to auditory cortex
Long-latency responses (N1, P2, P3)	Auditory cortex

Audiometric data

**Blast Exposed Subjects
(n=36)**

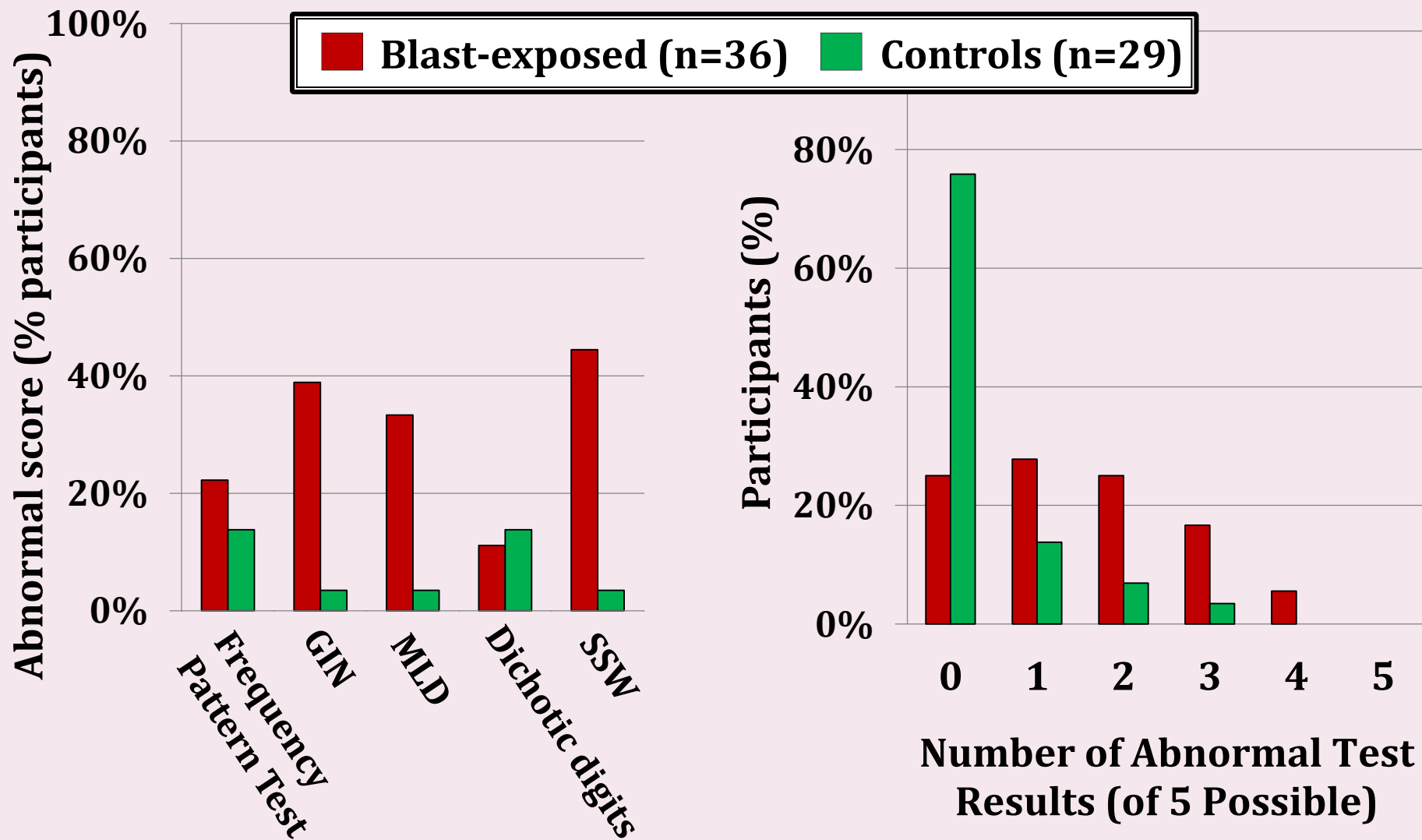


**Control Subjects
(n=29)**



Clinically normal hearing

Performance test data



Long-Latency Potentials

