

# POPULATION-APPROPRIATE NORMS FOR VETERANS COMPLETING TESTS OF CENTRAL AUDITORY PROCESSING

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## Introduction

- ❖Increasing numbers of Veterans with mild traumatic brain injury (mTBI) following blast exposure report substantive self-perceived hearing handicap despite normal or near-normal hearing on standard audiometric testing.
- ❖Many of these Veterans also are comorbid for Post-Traumatic Stress Disorder (PTSD).
- ❖Clinical tests of Central Auditory Processing Disorder (CAPD) commonly are used to further evaluate these hearing complaints when results of standard audiometric testing are normal.
- ❖A drawback is that performance on CAPD tests typically is compared to published norms established from non-Veteran populations.
- ❖Veterans and non-Veterans are thought to differ significantly in many domains relevant to central auditory processing.
  - ❖Thus, use of non-Veteran norms can misguide the interpretation of CAPD test results in Veterans.

## Research Questions

- ❖To what extent does diagnosis of abnormal performance on tests of CAPD differ when using normative cutoffs derived from a sample-specific control group versus published norms established from non-Veteran populations?

## Participants

- ❖ 217 Veterans, aged 20-50 years, with and without histories of blast exposure and PTSD, normal or near-normal hearing on standard audiometric testing

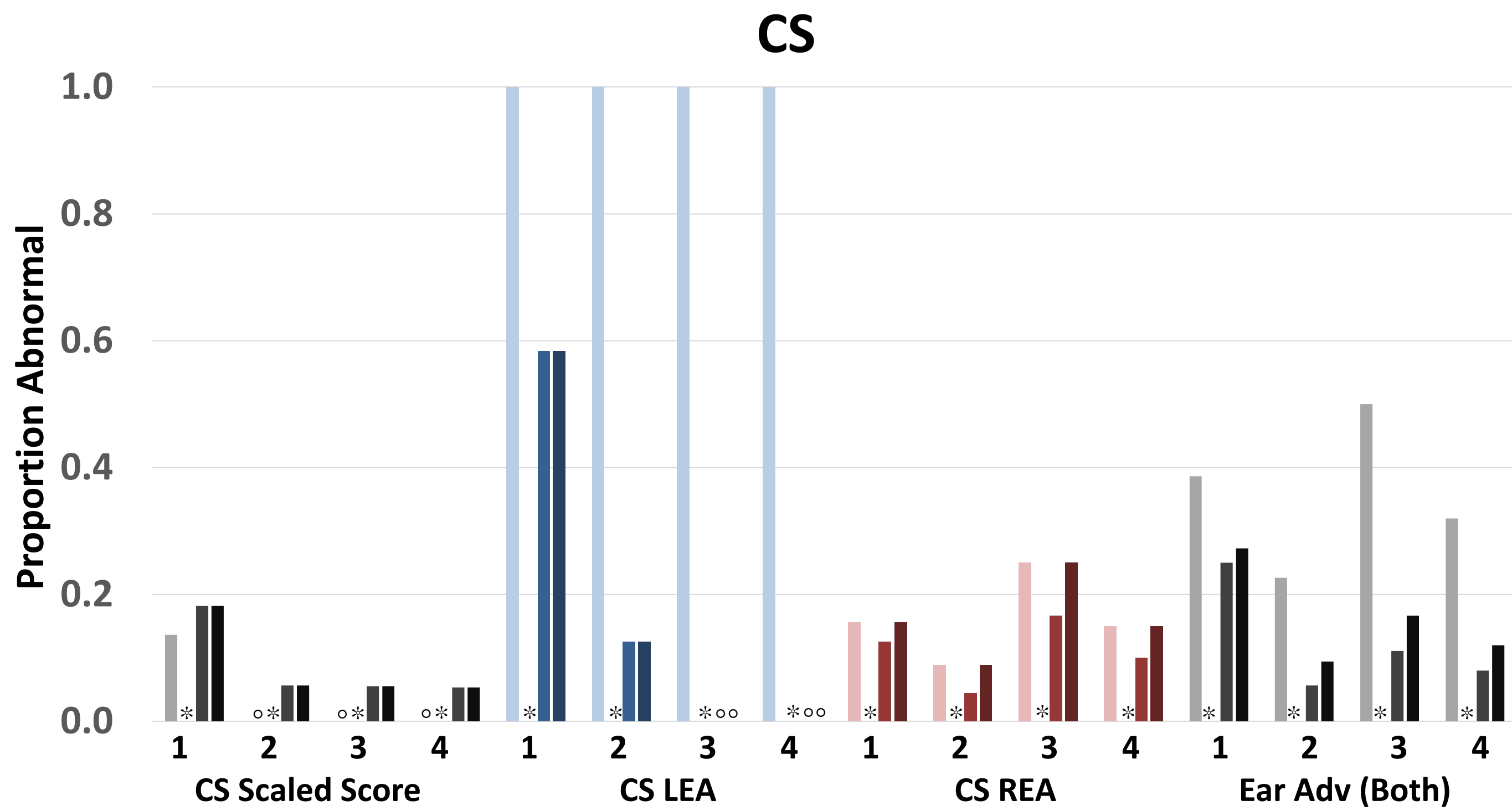
VARIABLE		mTBI+PTSD	mTBI	PTSD	Control
N		55	61	19	82
Sex	M	48	54	10	56
	F	7	7	9	26
		<i>M (SD)</i>			
Age (years)		35.1 (6.5)	36.3 (7.4)	34.8 (8.1)	35.2 (8.3)
PTA (dB HL)	R	12.7 (5.1)	12.2 (5.0)	10.3 (4.3)	8.5 (4.2)
	L	12.9 (4.9)	11.6 (5.1)	10.0 (5.0)	9.7 (4.6)
SRT	R	9.8 (5.3)	8.8 (5.0)	7.3 (4.6)	7.1 (3.4)
	L	10.0 (5.5)	9.1 (4.4)	8.2 (4.4)	7.4 (4.1)
HHIA		52.4 (20.2)	36.7 (14.4)	27.6 (24.9)	2.3 (5.0)
PCL – M		60.8 (6.8)	32.9 (9.0)	59.4 (8.6)	22.1 (7.2)

**Table 1.** PTA = Pure tone average for .5, 1, 2, 4 kHz; SRT = Speech Recognition Threshold; HHIA = Hearing Handicap Inventory–Adults; PCL-M = PTSD Checklist–Military Version

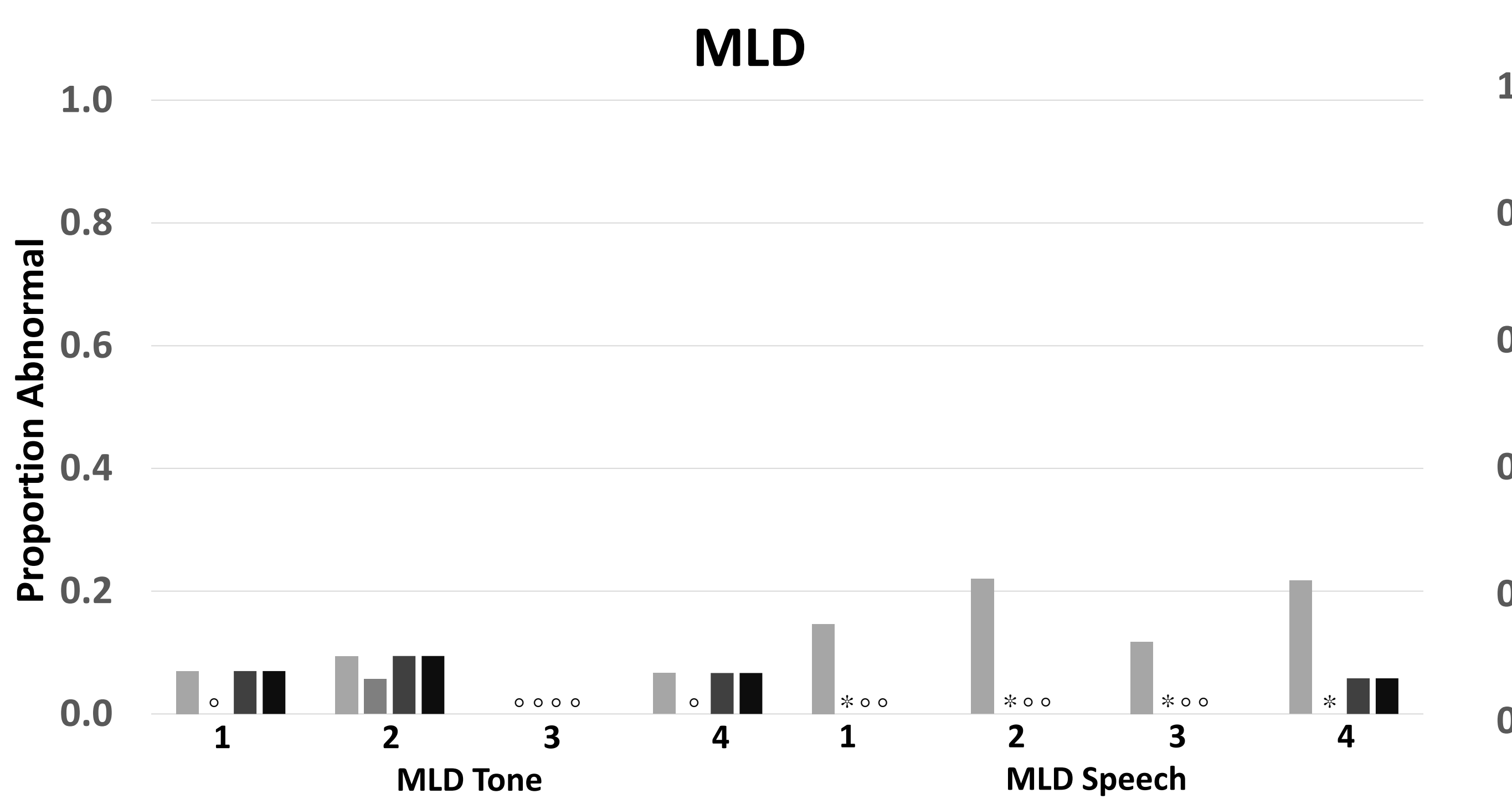
## Methods

- ❖ Tests of CAPD:
  - Competing Sentences (CS)
  - Dichotic Digits Test (DDT)
  - Gaps in Noise (GIN)
  - Masking Level Difference (MLD; tone and speech)
  - Staggered Spondaic Words (SSW)
- ❖ Cutoffs for each of the CAPD tests were determined using norms established from:
  1. Typically used published norms
  2. Gallun et al. (2016), which used a sample of normal hearing Veterans (age:  $M=39.2$ ,  $SD=13.9$ ) without mTBI and with and without PTSD
  3. A study-specific control group, where abnormal performance was defined as:
    1.  $\pm 2$  SD beyond the control group’s mean
    2. Using the N=1 method referencing the control group

## Results



**Figure 1.** CS Scaled Score and Ear Advantage by normative cutoff and group. n (scaled, LEA, REA, Both): mTBI+PTSD (44,12,32,44); mTBI (54,8,45,53); PTSD (18,6,12,18); Control (75,15,60,75)



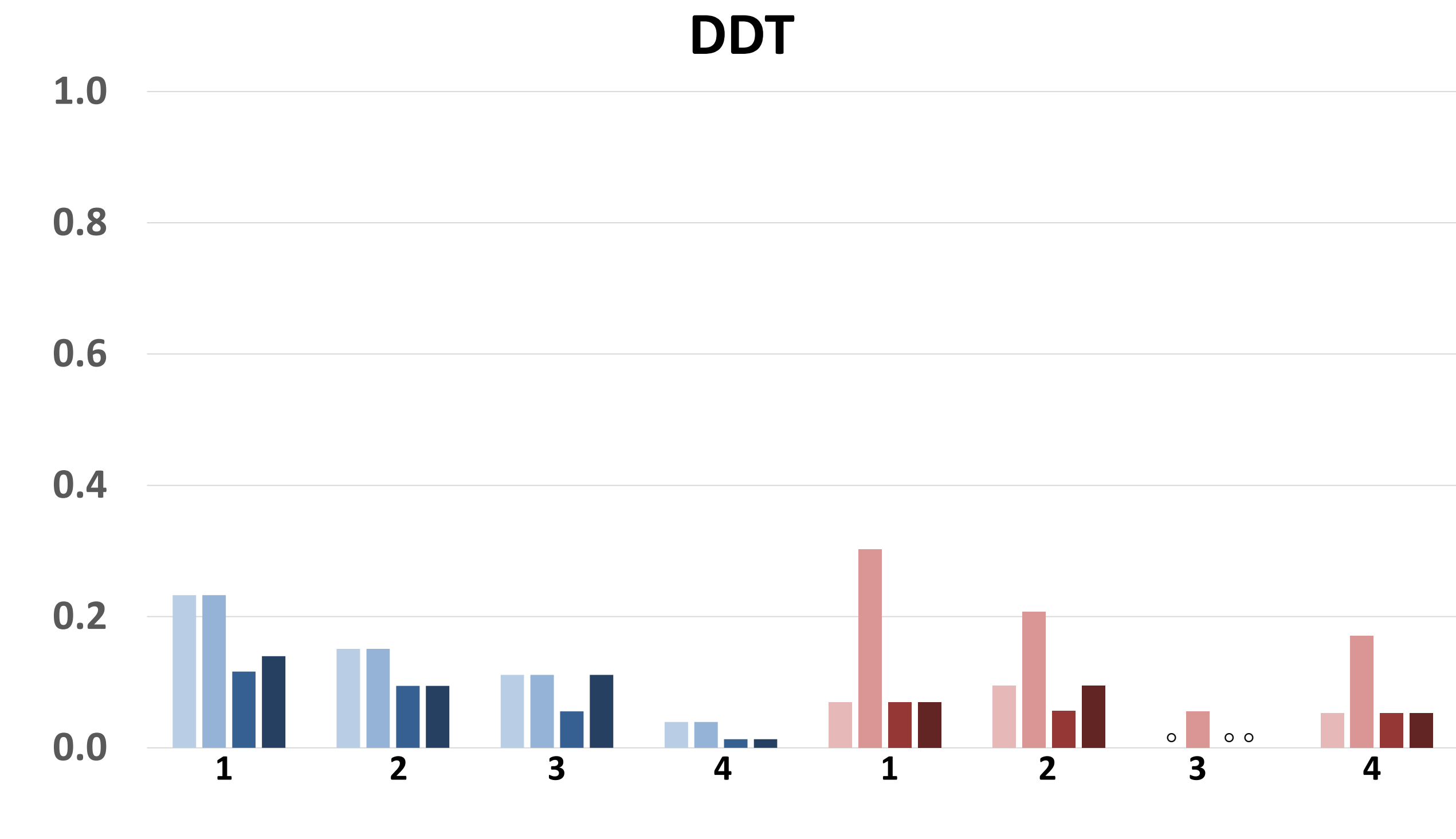
**Figure 4.** MLD by group and stimuli. n (tone, speech): mTBI+PTSD (43,41); mTBI (53,50); PTSD (18,17); Control (75,69)

Tests	Direction	Cutoff Value				n <sub>completed</sub> mTBI+PTSD; mTBI; PTSD; Control	Chi-Squared (Effect Size)			
		Published Norms	Control (Gallun)	Control (2SD)	Control (N=1)		Published Norms	Control (Gallun)	Control (2SD)	Control (N=1)
GIN [1,7] (Right/Left)	>	6.0/6.0	6.0/6.1	6.0/6.2	6.0/6.3	43/42; 53/52; 18/18; 75/75	<b>9.30 (0.22)</b>	<b>11.22 (0.24)</b>	6.48 (0.19)	7.33 (0.20)
DDT [2,7] (Right/Left)	<	90.0/90.0	94.0/88.0	86.2/84.8	87.8/86.7	43/43; 53/53; 18/18; 76/76	<b>8.67 (0.21)</b>	<b>10.39 (0.23)</b>	3.21 (0.13)	4.16 (0.15)
SSW [3,7]	RNC	>	3	0.4	1.7	43; 53; 18; 76				
	RC	>	4	3.3	3.0	43; 53; 18; 76				
	LC	>	9.0	4.3	7.1	43; 53; 18; 76				
	LNC	>	3.0	1.2	2.3	43; 53; 18; 76				
	Reversals	>	1.0	11.4	6.4	43; 53; 18; 76				
	Total	>	6.0	7.15	12.2	43; 53; 18; 76	6.25 (0.18)	<b>9.00 (0.22)</b>	0.10 (0.02)	0.61 (0.06)
MLD Tone [4], Speech [5] [7]	Tone	<	8.0	5.5	6.74	43; 53; 18; 75	1.88 (0.10)	7.82 (0.20)	1.88 (0.10)	1.88 (0.10)
	Speech	<	7.0	*	-8.41	41; 50; 17; 69	1.70 (0.11)	<b>*</b> (*)	6.41 (0.19)	6.41 (0.19)
CS [6]	Scaled	<	7.0	*	8.4	44; 54; 18; 75	<b>20.56 (0.33)</b>	<b>*</b> (*)	7.08 (0.19)	7.08 (0.19)
	LEA	<	0.0	*	-2.3	12; 8; 6; 15				
	REA	>	2.0	*	3.4	32; 45; 12; 60				
	Both		*	*	*	*	5.61 (0.17)	<b>*</b> (*)	<b>10.50 (0.24)</b>	6.94 (0.19)

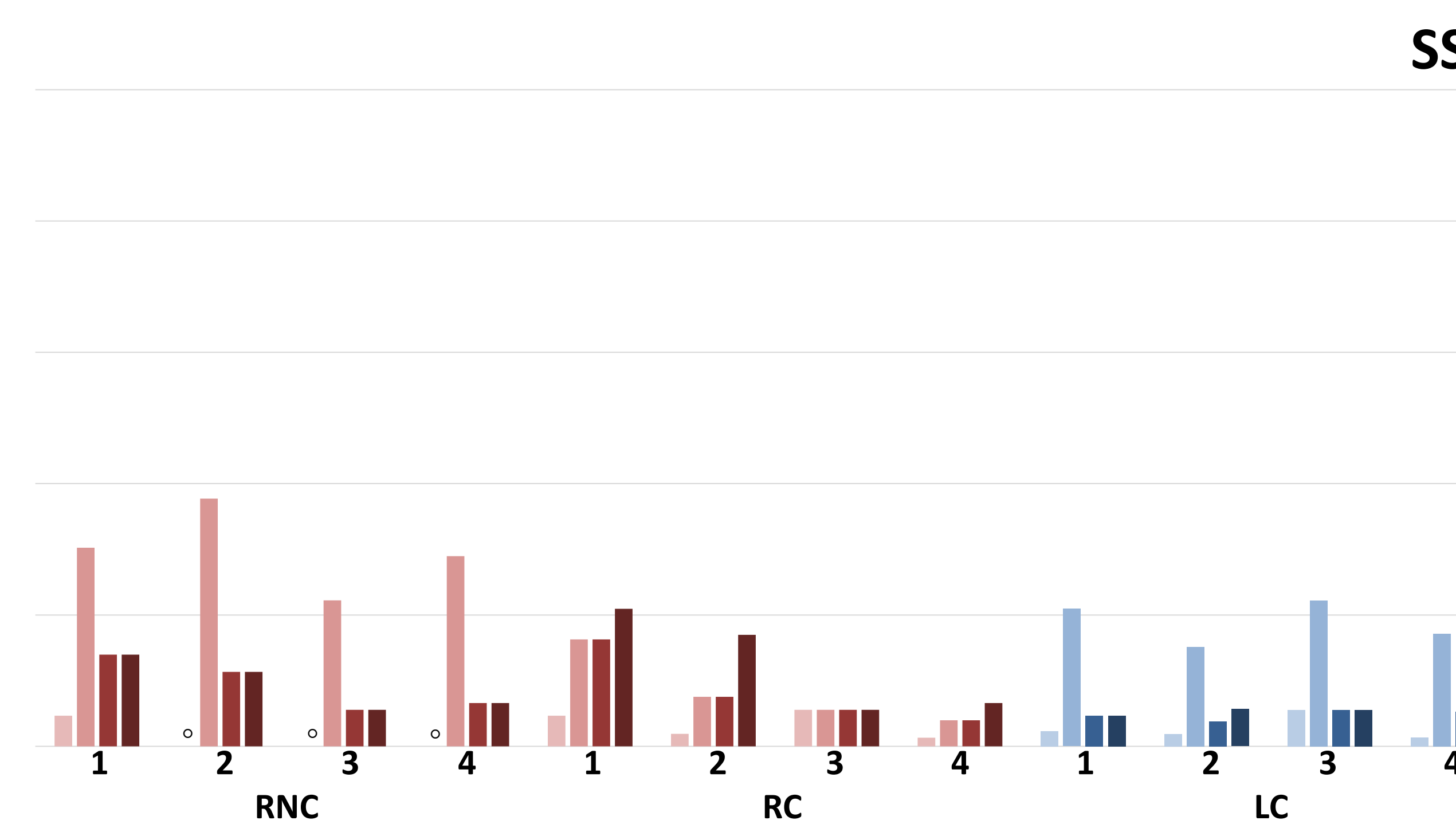
**Table 2.** RNC = Right Non-Competing; RC = Right Competing; LC = Left Competing; LNC = Left Non-Competing; LEA = Left Ear Advantage; REA = Right Ear Advantage. For statistical analyses, overall performance was considered “abnormal” if an abnormal test result was observed for either ear in cases where the ears were tested individually. Numbers in brackets link to the references from which cutoff values were derived for Published Norms and the control group in Gallun et al. (2016).

## Acknowledgements

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**Figure 2.** DDT by normative ear and group. n (right, left): mTBI+PTSD (43,43); mTBI (53,53); PTSD (18,18); Control (76,76)



**Figure 5.** SSW by error types and group. n: mTBI+PTSD (43); mTBI (53); PTSD (18); Control (76)

- ❖ Several **chi-squared tests** were performed to assess the association between group and counts of participants with abnormal test results.
  - ✓ Bolded values in Table 2 represent  $p < .05$
  - ✓ Monte Carlo simulations of p-values used in cases with small expected cell counts
  - ✓ Effect sizes estimated using **Cramer’s V**
- ❖ Fisher’s Exact tests returned similar conclusions (not shown)

Left

Right

Other

Published Norm

Control (Gallun)

Control (2 SD)

Control (N=1)

Groups

1 = mTBI+PTSD

2 = mTBI

3 = PTSD

4 = Control

\* = Norms not available

o = Value is 0

(Clinical group comparisons for each CAPD tests)

## Conclusions & Discussion

- ❖Overall, the proportion of abnormal cases identified based on the sample specific Veteran control group was:
  - ✓ Lower than that found with the typically used published norms for all CAPD tests.
  - ✓ Roughly equivalent or less than that found with Gallun et al. (2016).
- ❖Veteran and non-Veteran populations differ significantly in areas relevant for performance on tests of CAPD.
- ❖Compared to non-Veterans, Veterans are more susceptible to deficits on several hearing-related cognitive and executive domains that are thought to influence performance on tests of CAPD.
- ❖Comparing Veterans’ CAPD test performance to non-Veteran normative values can result in overestimations of central auditory processing pathologies.
- ❖Establishing and using population-appropriate normative values are critical for accurately diagnosing CAPD in Veterans.