# Understanding speech in noise in adults with listening concerns

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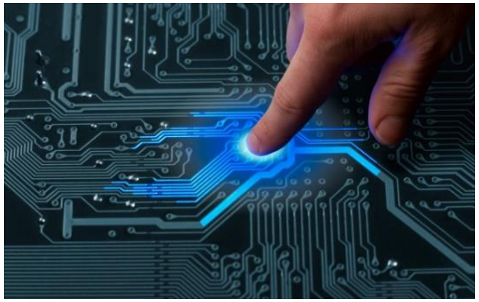


## Speech comprehension

**Attention**
(Pichora-Fuller, 2003

**Memory**
(Caplan, Waters, 2005; Rönnberg et al., 2010

**Perception of sound affected in presence of hearing loss**
(Abel, Krever, & Alberti, 1990)

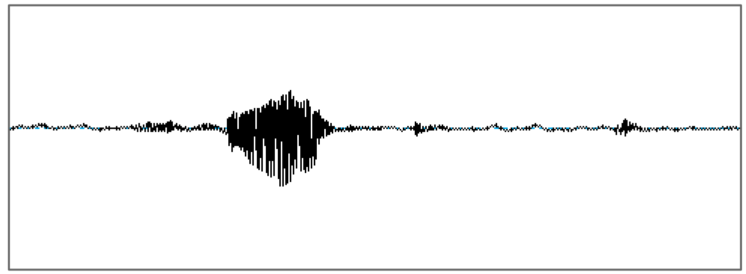
**Lack of language proficiency**
(Goh, 2000)

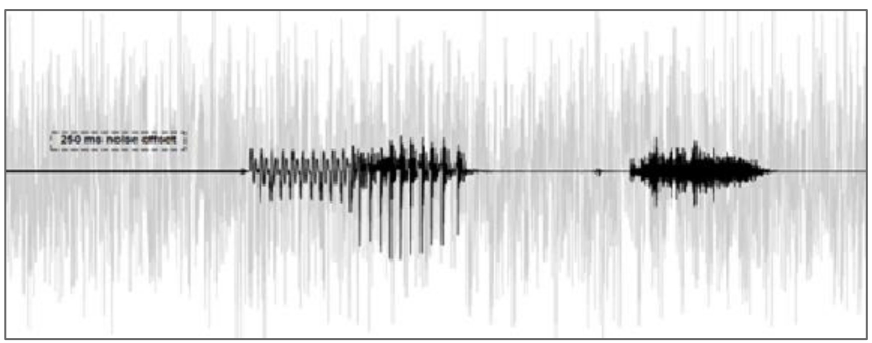
**Comprehension affected despite normal hearing**
(Kumar, Ameenudin, & Sangamanatha, 2012)

**Phonological processing**
(Andersson, 2002)

# Why is it important?

**Signal**






**Signal + Noise**

## Listening concern: Why have we used the term listening concern?

In previous literature people with difficulty understanding speech in noise have been categorized as having:

1) Central Auditory Processing Disorder (ASHA, 2005)
2) Auditory Processing Disorder (APD; British Society of Audiology APD Special Interest Group, 2011)
3) Hidden Hearing loss (Schaette & McAlpine, 2011)

# How did we evaluate Listening concern

- Speech, Spatial and Qualities of Hearing Scale (SSQ12): Comprises 12 questions assessing different Speech in noise scenarios
- Noise exposure Questionnaire (National Acoustics laboratories)

**Why noise exposure questionnaire?**

Evidence from literature indicates, individuals exposed to noise exhibit speech understanding in noise difficulty (Kumar et al., 2012; Hope et al., 2013)

| DIFFICULT LISTENING SITUATIONS | LCG (N=20) (PARTICIPANTS WITH LISTENING DIFFICULTY) |
|---|---|
| Face to face conversation in presence of background noise | 90% (n=18) |
| Face to face conversation in presence of background music | 85% (n=17) |
| Conversation in rooms with poor acoustics | 70% (n=14) |
| Conversation in car/train | 55% (n=11) |
| Understand actors speech in background noise | 65% (n=13) |

## Aim

The aim of the present study was to determine the differences on auditory, cognitive and linguistic factors in adults with listening concerns

## Hypothesis

Individuals with listening concerns will show poor performance on auditory, cognitive and linguistic skills, more pronounced difference in noise condition

# Method

## Participant Candidacy: LCG

**Participants**:

age range of 18 to 70 years were recruited



**Screening tests:**

1) Montreal Cognitive Assessment (MoCA)

2) Pure-tone audiometry

**Study population:**

1) Individuals with reported Listening concerns and normal hearing

# Method

## Participant Candidacy: Normal hearing

**Participants**:

age range of 18 to 50 years were recruited

**Screening tests:**

1) Montreal Cognitive Assessment (MoCA)

2) Pure-tone audiometry

**Study population:**

1) Individuals with normal hearing

# Test battery

## Independent variables

Auditory tasks

Cognitive tasks

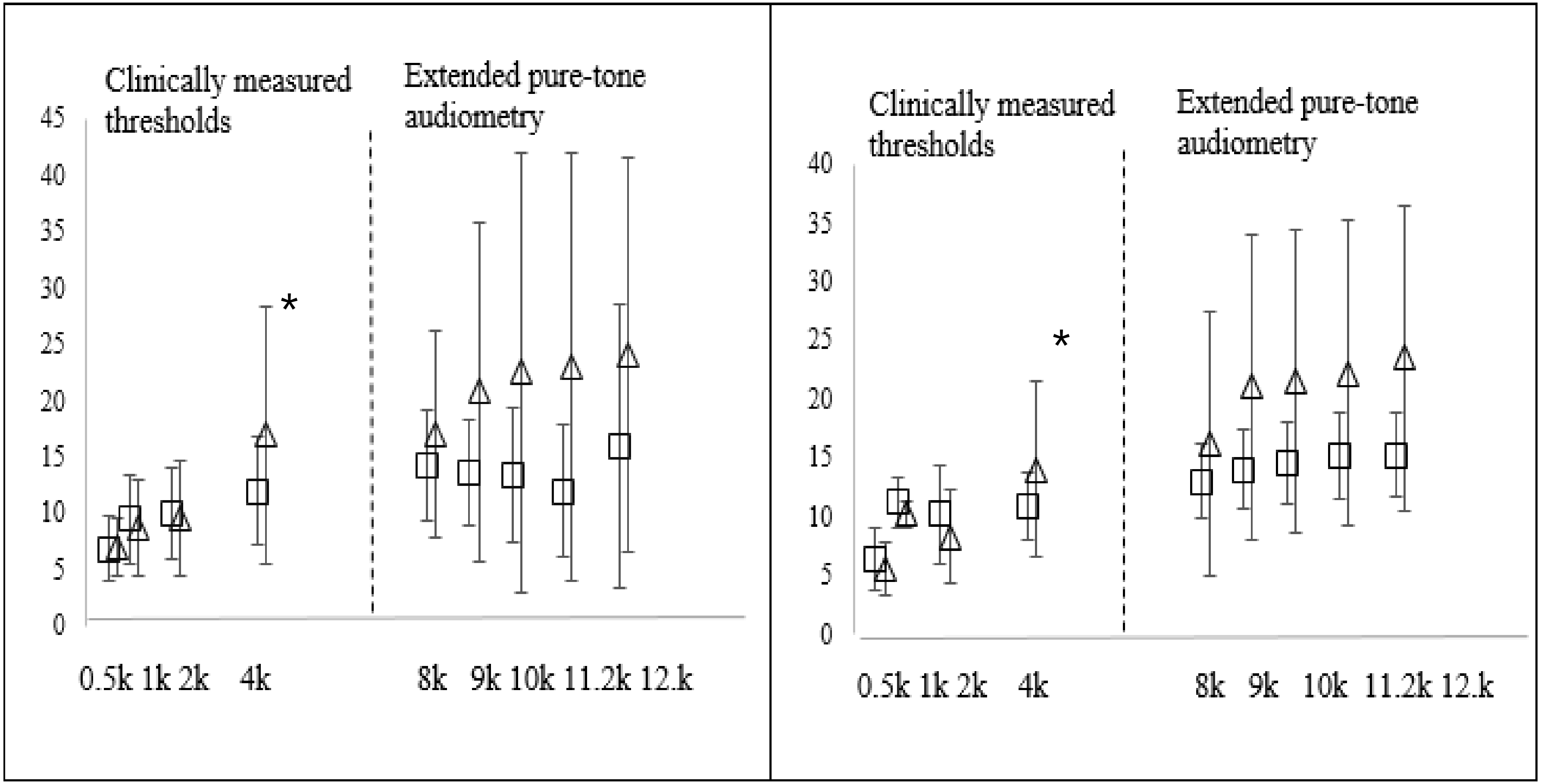
## Outcome measures

NAL-Dynamic conversations test (DCT)

Speech recognition threshold assessed Beautifully Efficient Speech Test (BEST sentences) (SRT)

# Audiogram, n=20 (LCG) and n=22 (Control)

Right ear CG: ■ LCG: ▲ Left ear



# Tests

| Auditory tests | Description |
|---|---|
| Iterated ripple noise (IRN) | Temporal pitch processing ability |
| Spectral-temporally modulated ripple test (SMRT) | Spectral resolution |
| Modulation detection threshold (MDT) | The temporal envelop information |
| Pitch discrimination (PD) | Spectral resolution |
| N400 (event related potential) | Speech understanding |

| Cognitive tests | Description |
|---|---|
| Digit span test (Forward and backward) | Short term and working memory |
| Auditory & visual (aSL & vSL) | Ability to identify statistical regularities implicitly |
| Cognitive spare capacity test (CSCT) | Uptake, inhibition control, memory, when listening to series of numbers in noise |
| Attention | Selective attention and attention switching |

| Linguistic tests | Description |
| --- | --- |
| Auditory rhyme judgement test | Phonological processing |
| Visual rhyme judgement test | Phonological processing |

# Results

## All behavioral tests

## Number of Participants

Control group: 22, age 18-50 years (15 females)

Experimental group (LC): 22, age 18-70 years (12 females)

(two were not included in LC as they showed high frequency SN hearing loss)

## Across group effects

- No significant differences on Multivariate analysis of variance between groups ($p>0.05$), when age used as co-variate

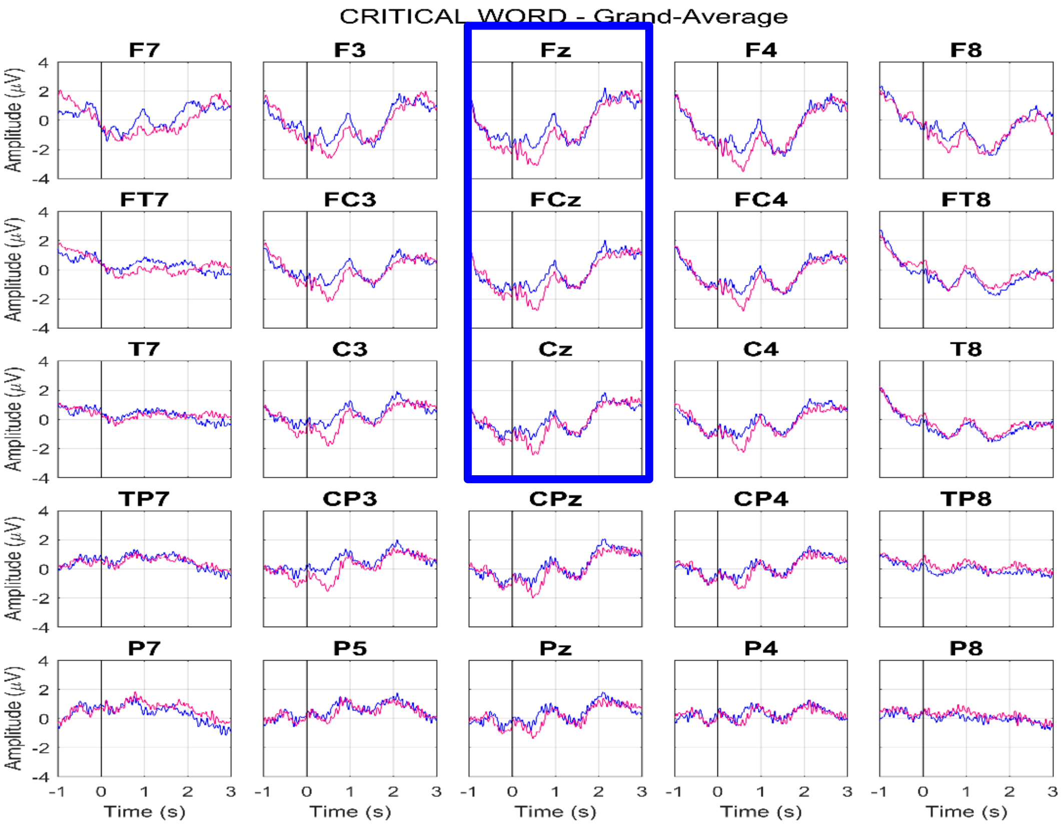
# Results

## Objective measure: N400

N400 magnitude was estimated as the area under the curve between the ERPs elicited by incongruent and congruent sentences in the time frame [0.4-0.8] seconds following the onset of the critical word

- 64 channel EEG recording was carried out

- At present, results obtained from Cz and FCz will be discussed



# Stimuli for N400

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THE HEARING CRC

- 640 sentences with a reasonable amount of complexity, homogeneity and sentence length
- Chosen based on a survey that was given to native English speakers
- Each sentence was rated based on a scale of 1 to 6
- For example: "the uncle spills the tiger from the mug" indicates a meaningless sentence. " The pilots judge the distance from the map" indicates a meaningful sentence
- 320 congruent and incongruent sentences were chosen

# Sentence structure

- The + [2 syllables substantive] + [monosyllable verb] + the + [Keyword: 2 syllables substantive starting with occlusive consonant – e.g. d, t, p, k, etc. (we avoided vowels and ‘w’, ‘y’, etc. to facilitate splitting)] + [3 syllables ending]

- Sentences were presented in a randomised order

- The test also consisted of questions and fillers

- Test was carried out in two scenarios Quiet and Noise (8dB SNR)
- The  Noise stimuli was later removed from testing

# Task

To focus on the sentences presented & respond to only the questions asked in between the test

## N400 Analysis

N400 magnitude was estimated as the area under the curve between the ERPs elicited by incongruent and congruent sentences in the time frame [0.4-0.8] seconds following the onset of the critical word

# Results

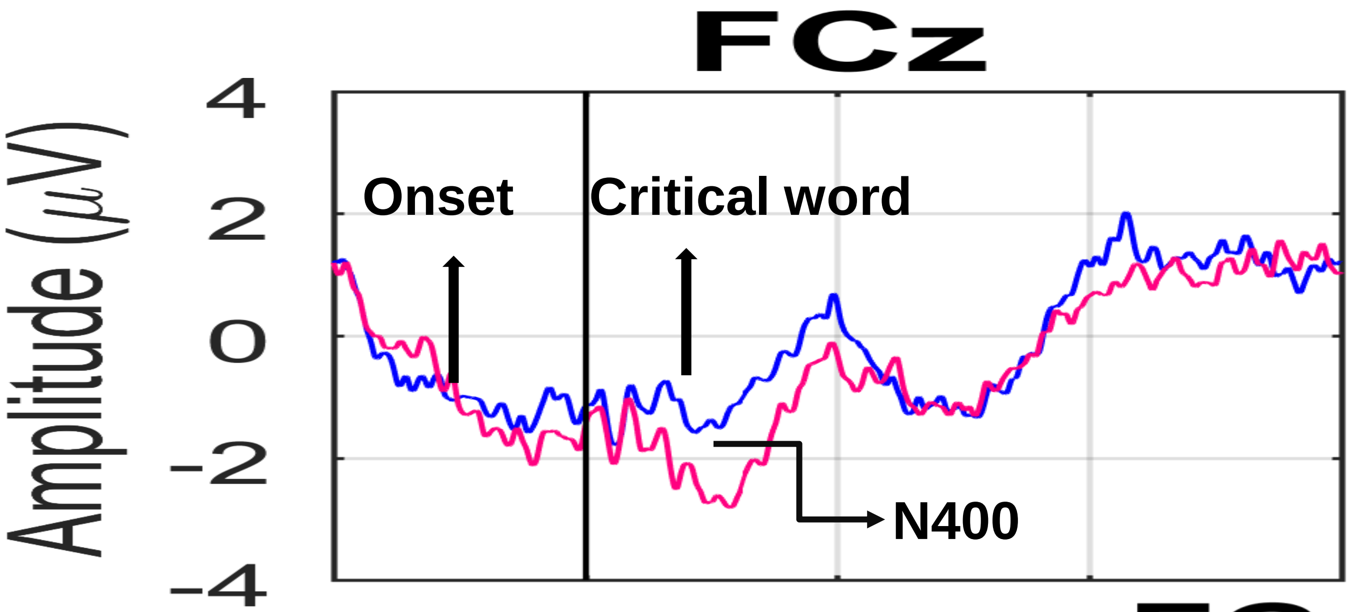
WITHIN GROUP EFFECTS

- Control group: Within group comparison when compared congruent & incongruent sentences → t-test ($p=0.02$) showed significant difference at 400ms after the onset of the incongruent response

- Listening concern group: Within group comparison when compared congruent & incongruent sentences, t-test ($p>0.05$) indicating absent N400.

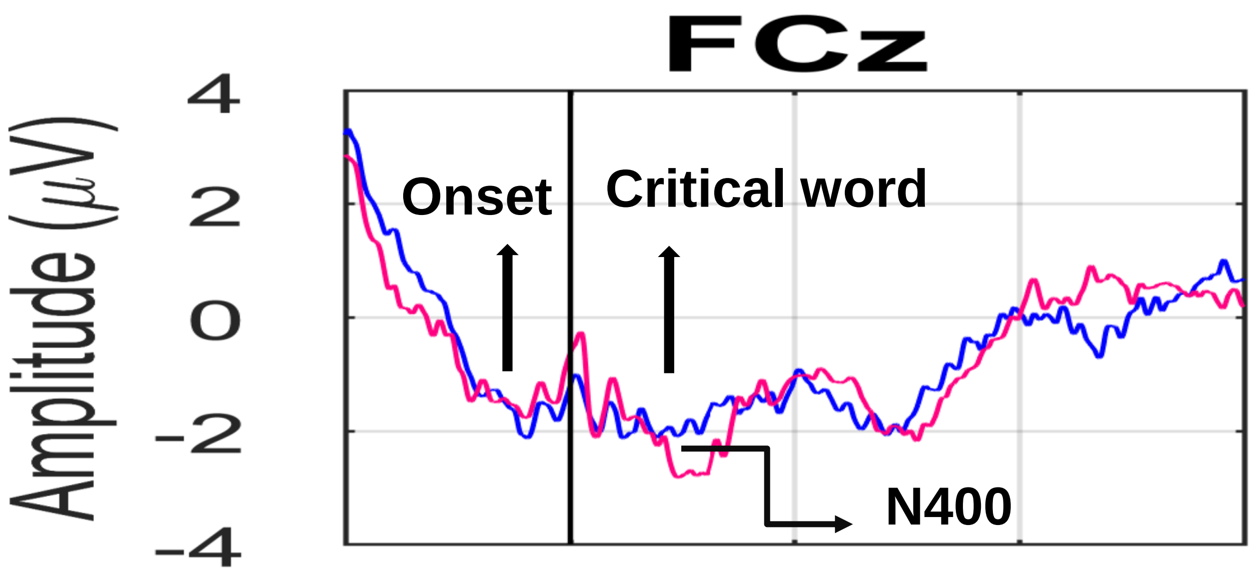
# Results

Congruent
Incongruent




**Control group**

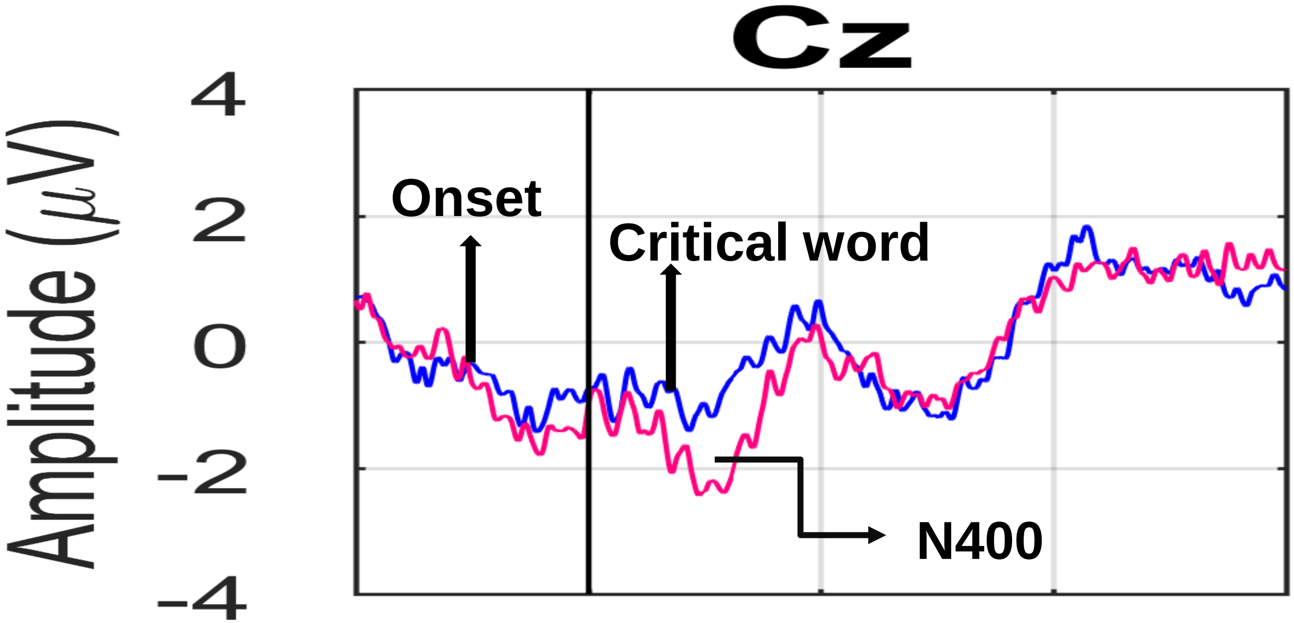
**Listening concern group**



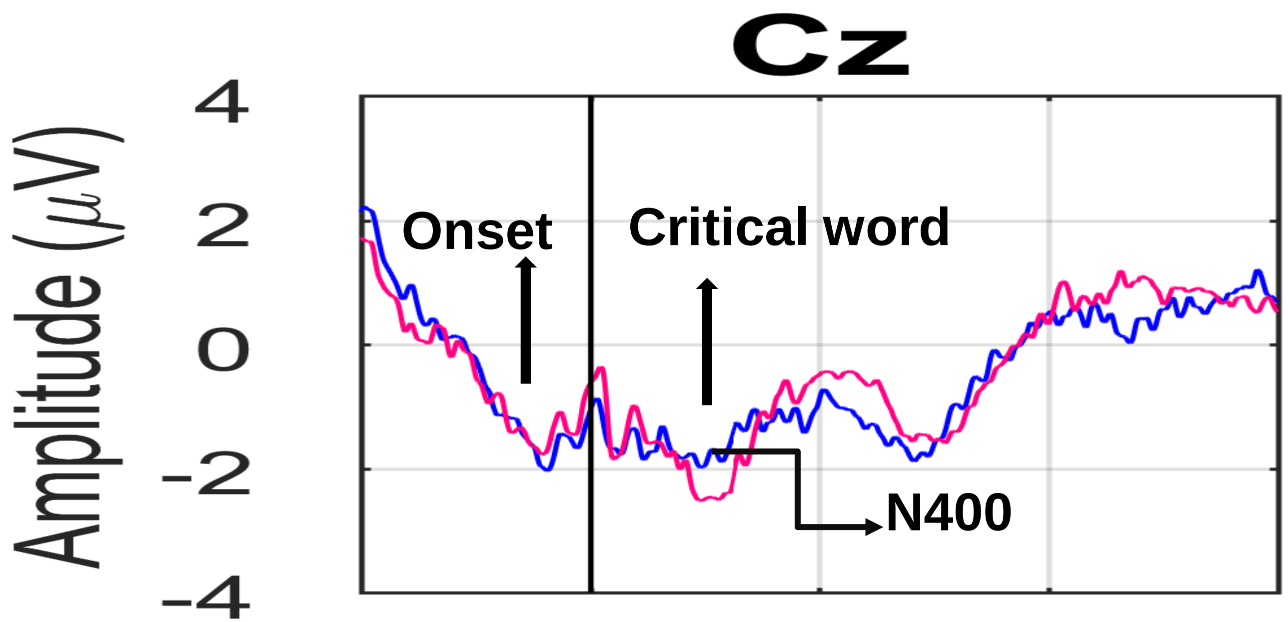
# Results



Congruent
Incongruent




Control group




Listening concern group

# ACROSS GROUP EFFECTS

- No significant differences on Multivariate analysis of variance between groups ($p>0.05$), when age used as co-variate

# Individual analysis: Standardization was carried out for all the tasks

**Calculating the Standard Score (Z-Score)**

$$\text{Standard Score, } z = \frac{X - \mu}{\sigma}$$

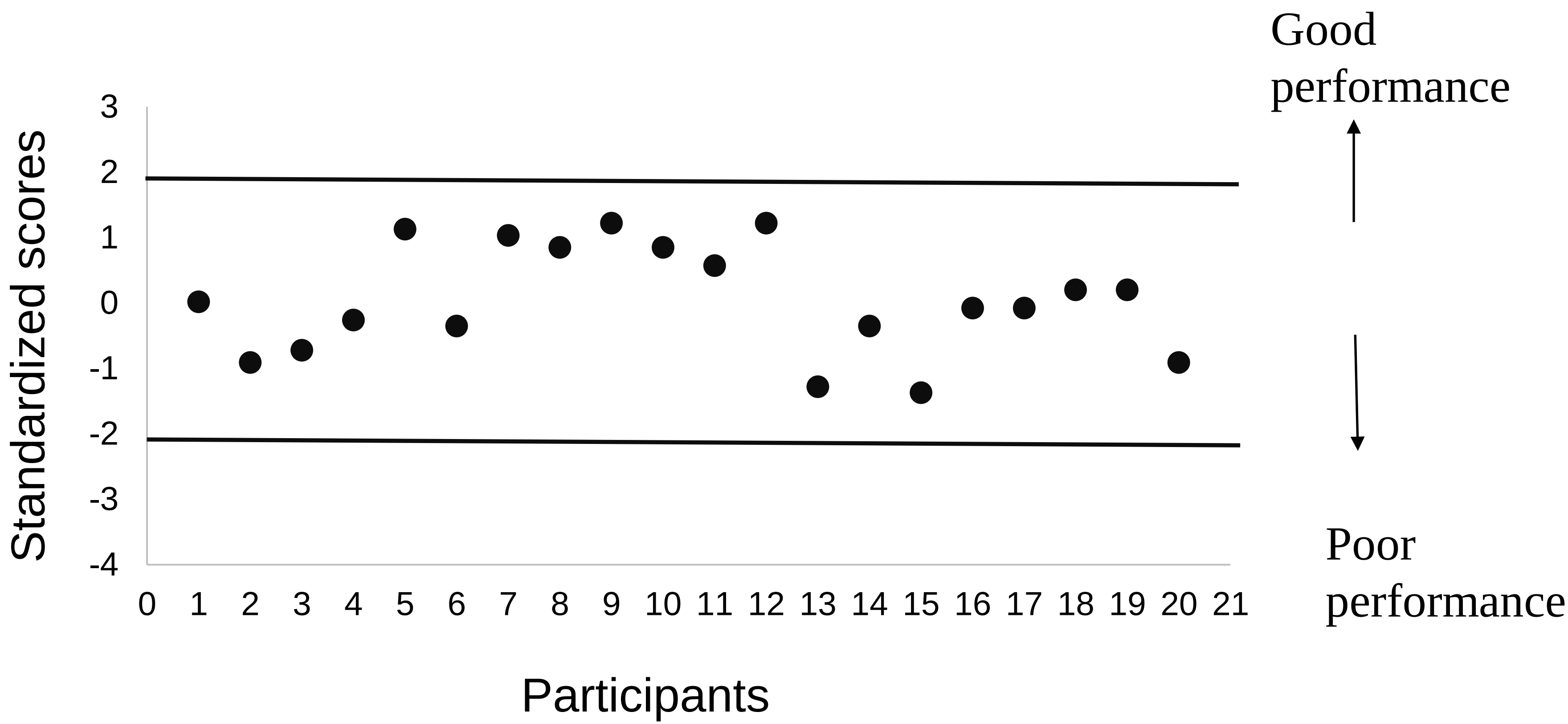
TERMS:

μ = mean (pronounced 'mu')

X = score

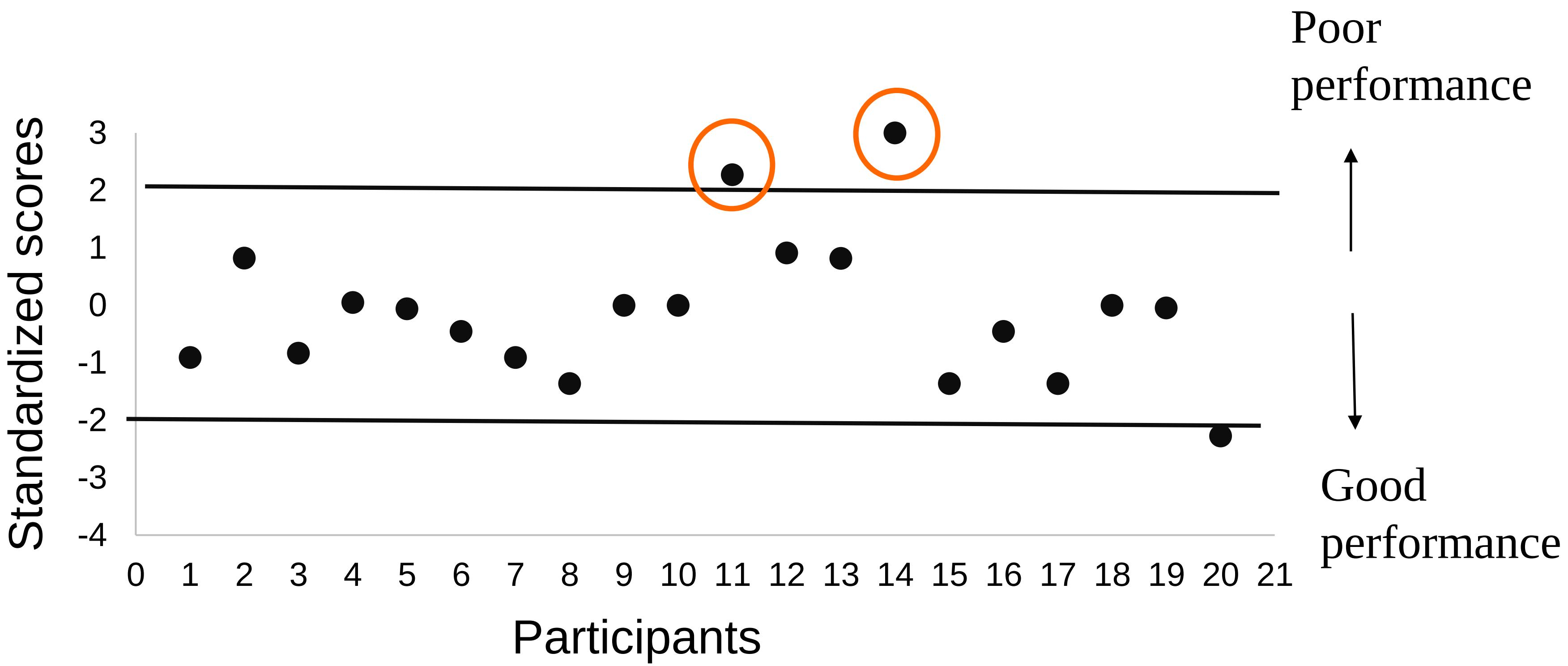
σ = standard deviation (pronounced 'sigma')

# NAL-DCT

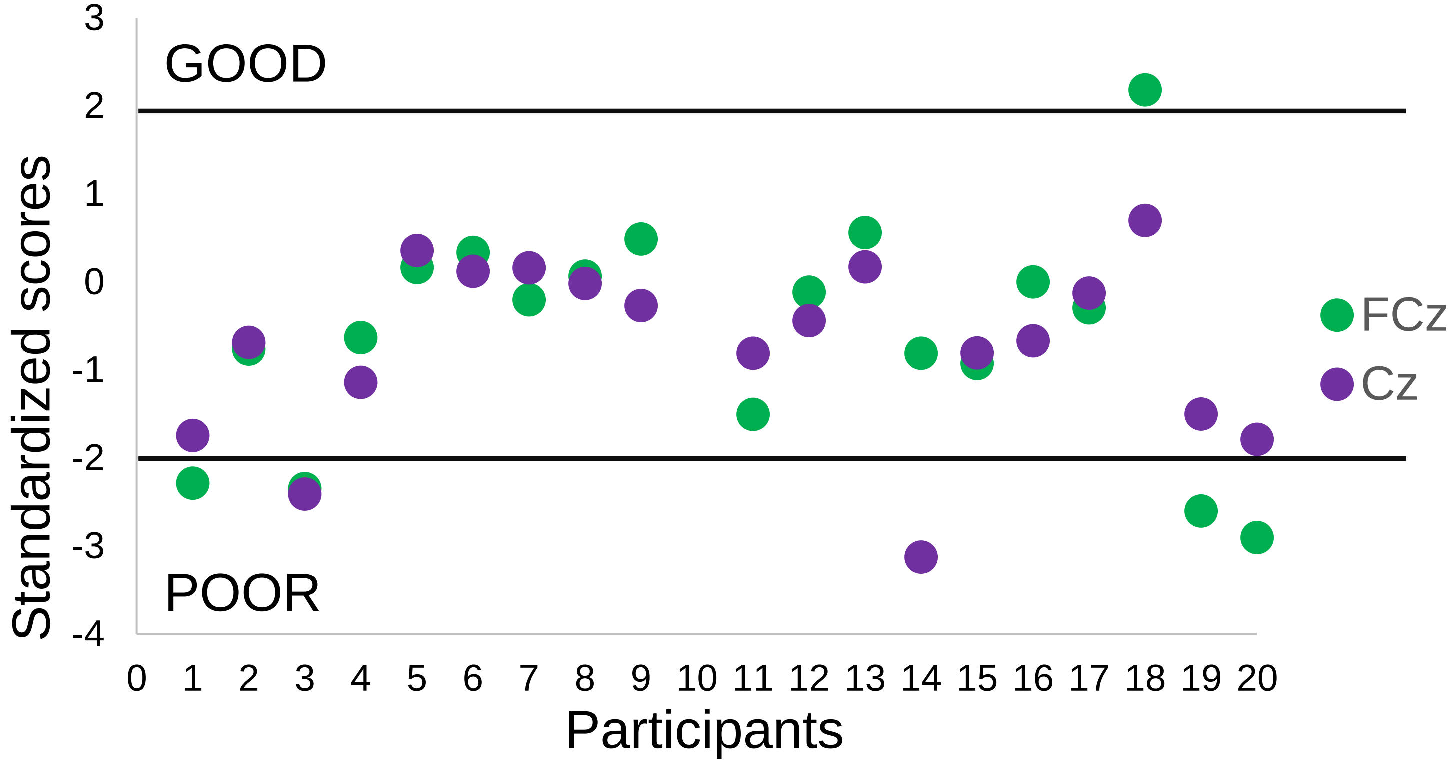


Standardized scores
3
2
1
0
-1
-2
-3
-4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Participants
Good performance
Poor performance

# Speech recognition threshold



# N400



GOOD
POOR
3
2
1
0
-1
-2
-3
-4
Standardized scores
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Participants
FCz
Cz

# Discussion

**Why we did we not see an evident difference?**

1) Amount of noise exposure

(Kumar, Ameenudin, & Sangamanatha, 2012; Alvord, 1983; Kujala et al., 2004; Hope, Luxon, & Bamiou, 2013)

2) Type of Noise exposure: recreational V/s occupational

(Le prell et al., 2016 & Yeend et al 2017)

3) Questionnaire information: over-estimate/ underestimate their difficulties

# Future directions

- Implement more realistic based scenario tests that could possibly answer this question
- For N400: Further analyses including clusters (groups of EEG channels) may clarify the potential of the N400 as an objective measure of speech understanding

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