N400: Objective measure of speech Understanding in Noise

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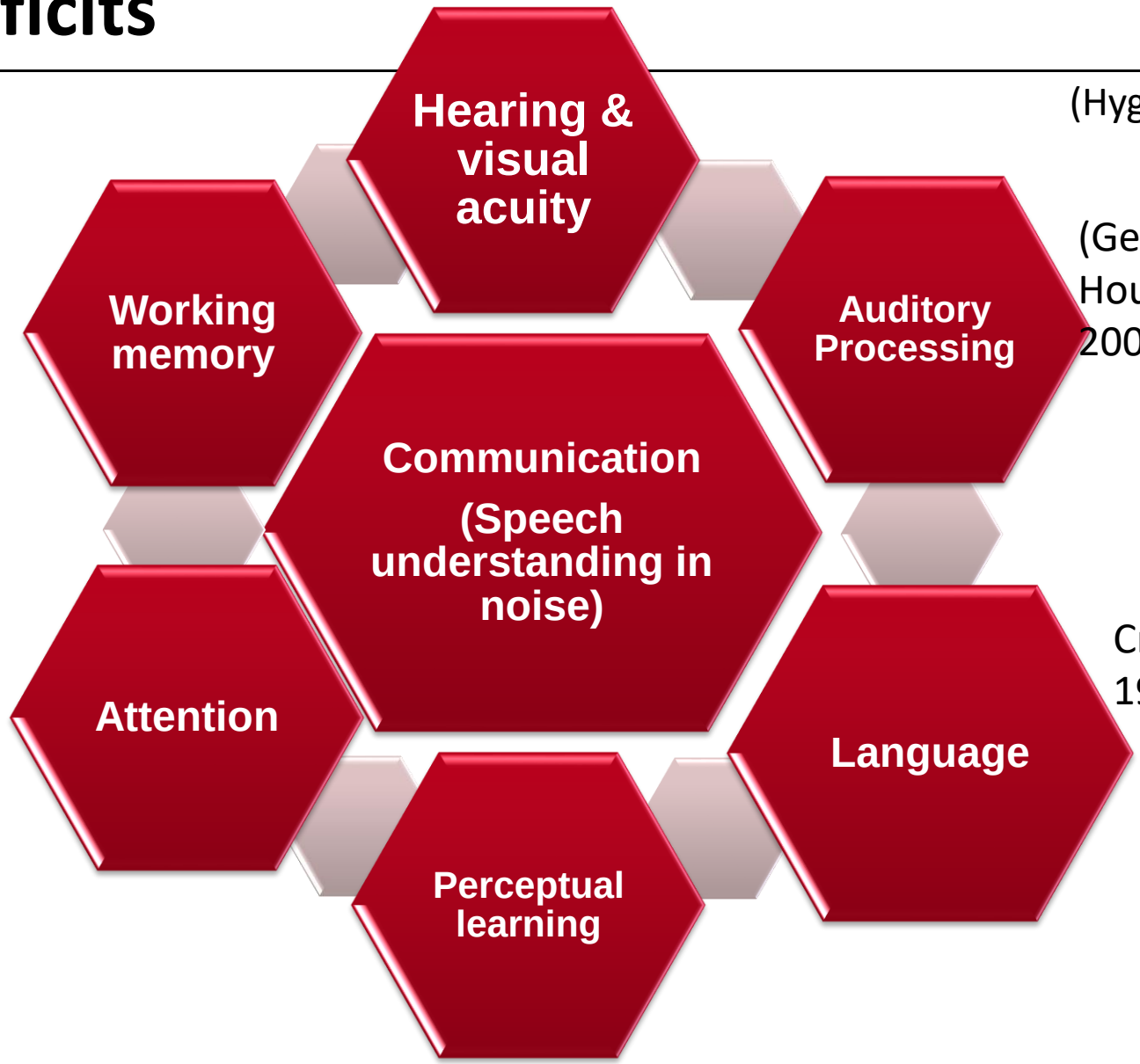
Q. What are the factors in explaining word recognition in noise?

- Benichov et al. (2012), in a study of 53 adults aged 19-89 years, found that pure-tone hearing loss, age, and cognitive function were all significant predictors of word-recognition performance

- Fullgrabe, Moore and Stone (2015) in 20 older adults and 9 young NH adults Found temporal-processing measures, and cognition predicted the speech perception in noise.

Factors contribute to understanding speech in noise/listening deficits

Speech in noise relies not only on the audibility of the signal, but a complex interaction between auditory processes and cognitive functions (*CHABA, 1988*)



(Hygge et al 1992; Moore, 2003)

(George et al, 2007; Houtgast & Festen, 2008)

Crandell & Smaldino, 1996)

Modified from Humes 1996

Cognitive factors
- Hougast et al 2008;
- Fritz et al 2007;
- Hallgren 2005;
- Ronnberg et al 2010
- Conway et al 2010

N400

- Event related potential that is said to be measure of language comprehension

- Negative deflection presented with semantically incongruent sentences and considered a marker of semantic violations
  - (Kutas & Hillyard, 1988)

- Occurs approximately 400 ms after sentence onset

(Kutas & Hillyard, 1980; Ousterhout & Houlcomb, 1995)

CONTEXT

There have been several studies in adults with clinically normal audiograms that have reported difficulty understanding speech in adverse listening conditions

Alvord 1983; Kujala et al. 2004; Kumar et al. 2012; Hope et al. 2013; Prendergast et al. 2017a, b; Yeend et al. 2017

A prevalence study by Hind et al., (2011) showed 4% of 1025 adults (17-60 years) had normal hearing sensitivity, and reported listening in noise difficulties.

A retrospective study carried out by Shinn et al. (2016) showed that 13% adults who attended clinics for hearing check reported of hearing difficulties despite normal audiograms

Current Study

Aim

To explore the neural processing involved in speech understanding task in individuals with listening in noise concerns using N400

Hypothesis

Individuals with listening concerns will have a reduced N400

Participant Candidacy

Participants:

Age range of 19 to 62 years were recruited

Screening tests:

1) Montreal Cognitive Assessment (MoCA)

2) Pure-tone audiometry

Study population: Individuals with reported Listening concerns (LC and normal hearing (CG)

Difficulties listening in noise

SSQ 12

SSQ 49 category	SSQ 12 questions	Normal Hearing (n=103) mean (SD)	LC group (n=20) mean (SD)
Selective Attention	Q1: Speech in noise	9.5(0.7)	6.8(2.4)*
	Q3: Speech in speech	9.2(1.1)	4.1(2.7)*
	Q4: Speech in noise	8.8(1.2)	5.5(2.6)*
	Q5: Multiple speech streams	9.4(1.2)	5.3(2.4)*
	Q9: Segregation	9.1(1.3)	5.9(2.9)*
Divided Attention	Q2: Multiple speech streams	6.2(2.7)	7.2(2.3)
Spatial	Q7: Distance and movement	8.1(1.4)	7.3(1.7)
	Q8: Distance and movement	9.2(1.2)	7.5(2.5)*
	Q6: Localization	8.7(1.9)	5.8(3.2)*
Quality	Q11: Quality and naturalness	9.6(1.4)	7.0(1.9)*
	Q12: Listening effort	8.5(2.3)	8.2(2.5)
	Q10: Identification of sound	7.5(2.4)	6.2(2.7)

Methods

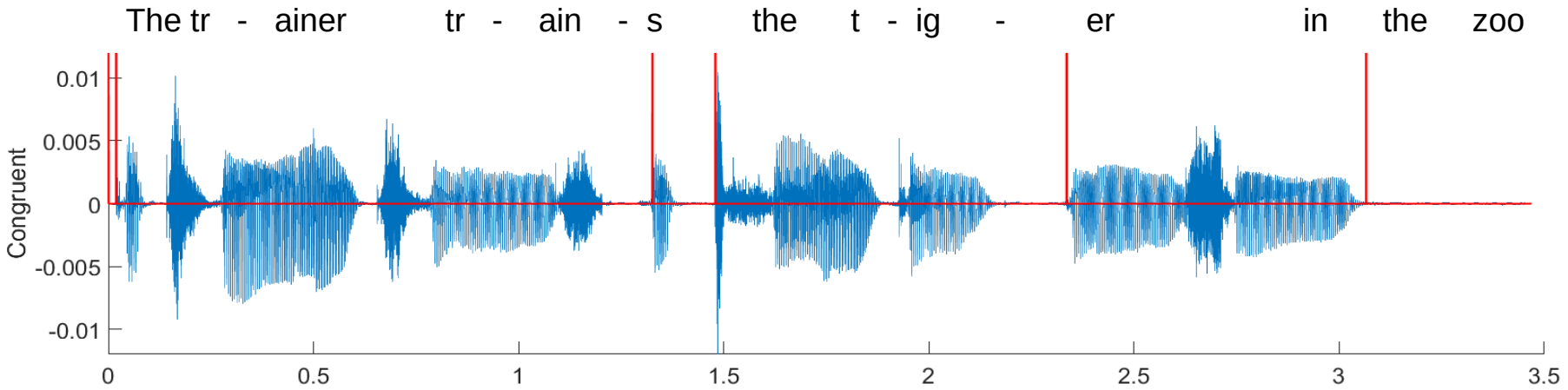
Adults with listening difficulties when compared to control

AUDITORY TESTS	COGNITIVE TESTS
Iterated ripple noise (IRN)	Digit span test (Forward and backward)
Spectral-temporally modulated ripple test (SMRT)	Auditory & visual (aSL & vSL)
Modulation detection threshold (MDT)	Cognitive spare capacity test (CSCT)
Pitch discrimination (PD)	Attention: selective and switching
N400, language processing, time-frequency analysis	

Stimuli

- 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
- 160 congruent and incongruent sentences were chosen

Language processing: N400 to semantic violations



To create incongruent sentence:

The granny plants the flower **in the pot** + The trainer trains **the tiger** in the zoo

= **The granny plants the tiger in the pot**

Analysis

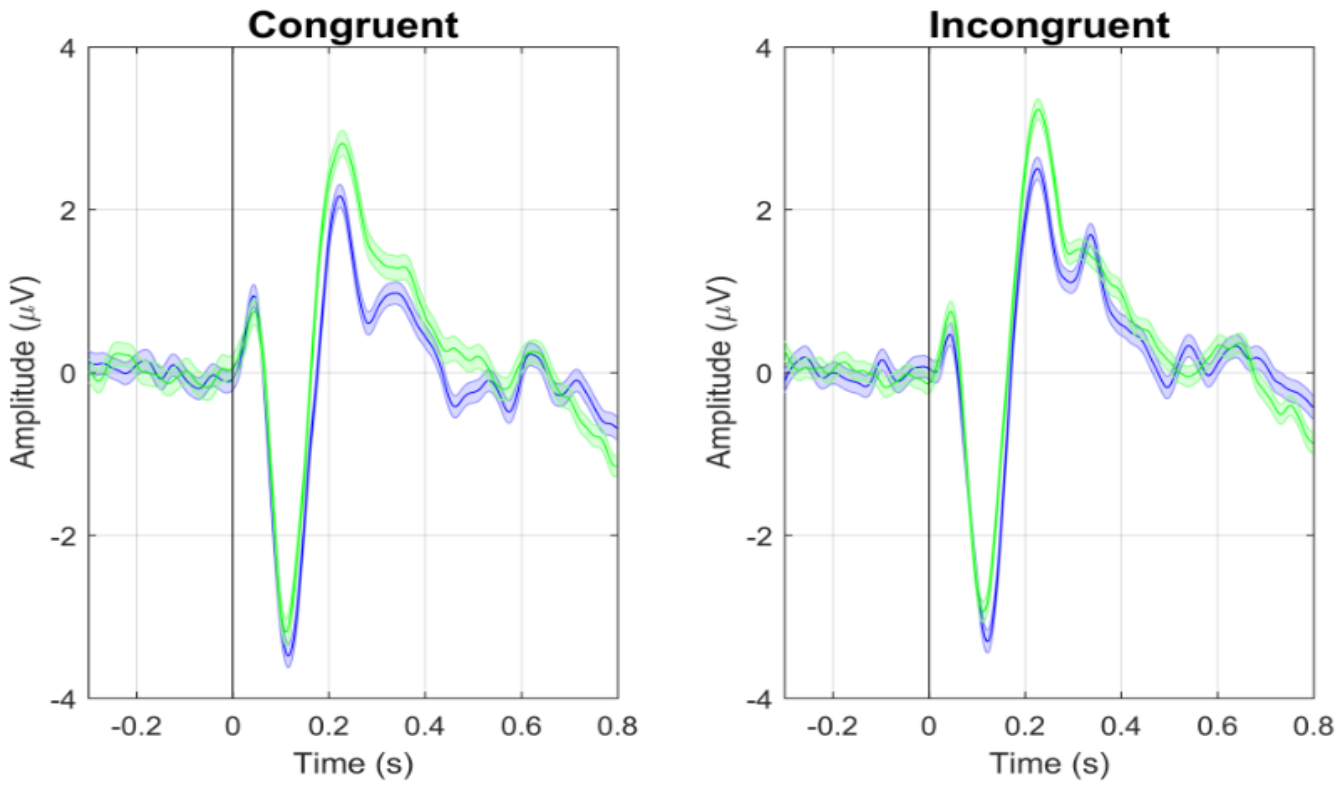
1) The onset responses i.e., P1-N1-P2 were identified for both types of sentences

2) N400 magnitude was estimated as the area under the curve on the difference waveform in the time frame [0.4-0.8] seconds following the onset of the critical word

3) Time frequency analysis of the recorded EEG

Results: Onset responses

- 64 channel EEG recording was carried out
- Across two groups, no difference observed between the two conditions on global field power and cluster permutation analysis (p>0.05)



Cz grand average at 100-150ms

Results: N400

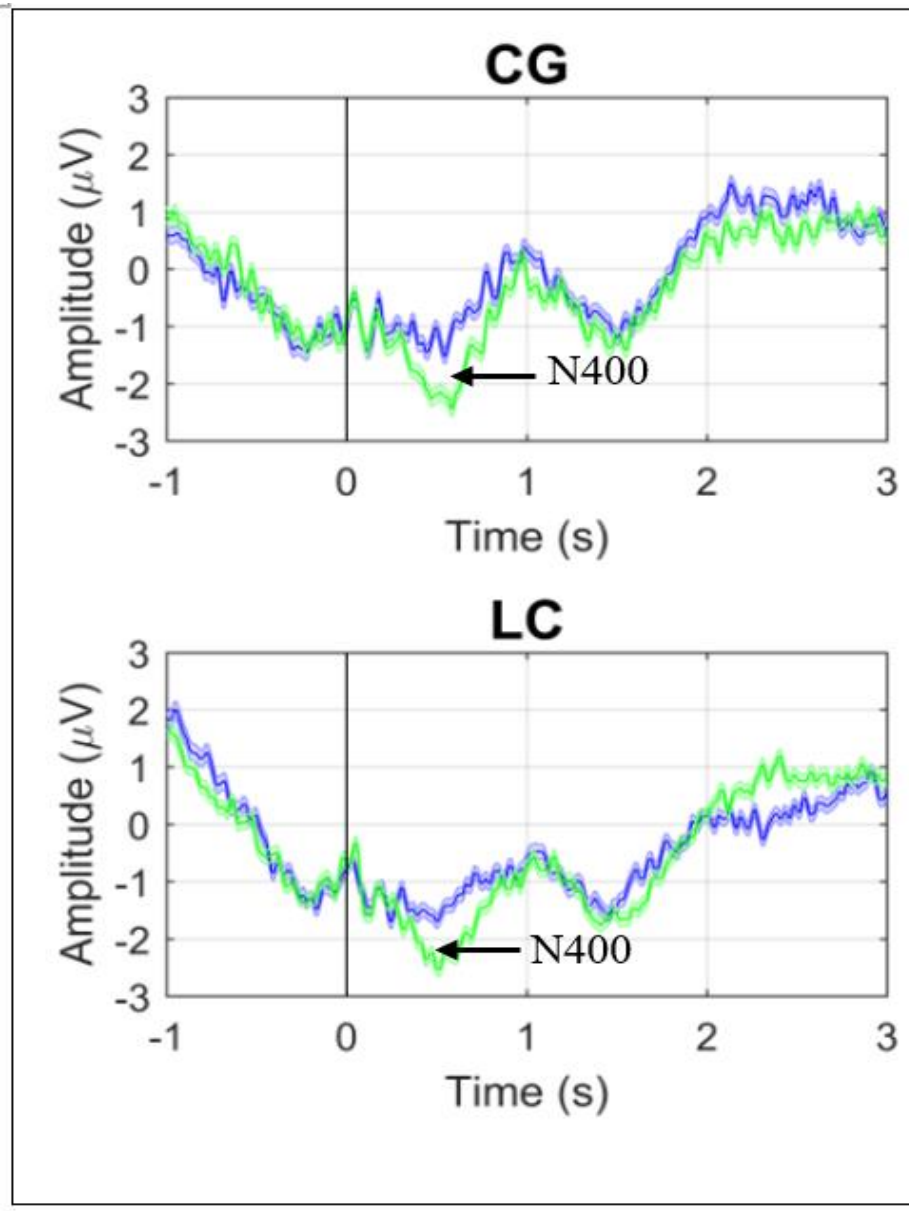
- Across group analysis between two conditions showed no significant difference on both two-sample t test and cluster permutation analysis($p>0.05$)

- Within group analysis between two conditions showed significant difference only for the control group on most of the fronto-central electrodes on both one sample t test and cluster permutation analysis ($p<0.05$)

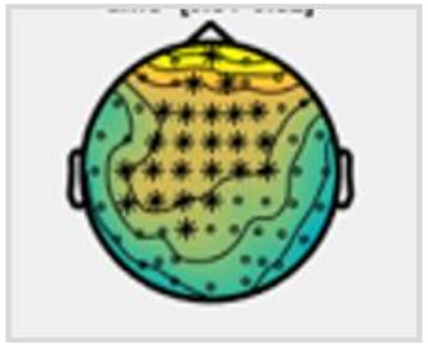
- For the one sample t test only the fronto-central electrodes were chosen for analysis as N400 responses are most prominent in these regions (Kutas and Federmeier, 2011; Jamison et al., 2016)

Results

Grand average at Cz

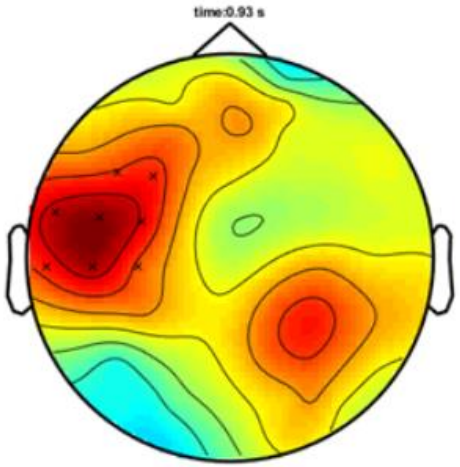


CLUSTER analysis

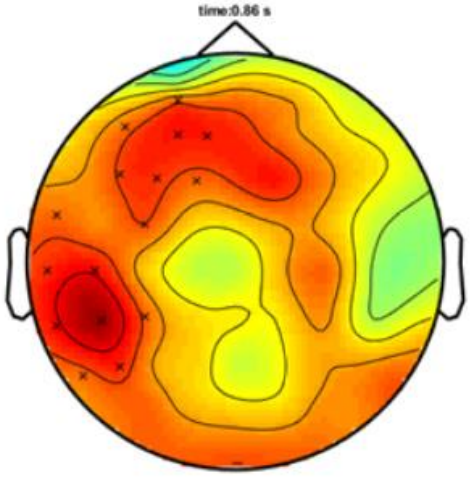


N400 response= Significant Clusters in control group

Time-frequency analysis



Congruent



Incongruent

- The control group had more Event related Synchronisation (ERS) while the adults with listening concerns had minimal ERS.
- The differences were found in the **alpha band**
  - Congruent : 800-1060ms (p-val = 0.014) – left temporal regions
  - Incongruent : 760-960ms (p-val = 0.026) – left temporal & left frontal regions
- Left frontal lobe and temporal activation sites were suggested to be associated, when there are semantic violations, with language processing
- *(Birn, et al., 2010; Frith et al., 1991; Paulesu et al., 1997; Friederici et al, 2003; Maess et al 2006)*

Discussion

Are the individuals in the Listening concern group different from control?

- Only the CG had measurable N400 when compared to the LC group
- On time frequency analysis the CG showed relatively stronger alpha oscillations than the LC group

Discussion

Few reasons for the observed differences

- Differences in the ability to predict

No differences were observed on measuring the onset response, shows LC group doesn't have an issue with perception

- Inability to maintain attention

Stronger synchronised alpha oscillations observed in tasks where one needs to pay attention to the given stimuli and remember them even while not responding to them (Tuladhar et al., 2007; Scheeringa et al., 2009)

- Cortical neural processing

Take home message

The N400 shows promising results to be used as a speech understanding measure in the clinics. However we may need to perform further research before it gets applied into the clinical practice