# TEST RETEST RELIABILITY OF SPEECH EVOKED P300

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**Register No: 14AUD028**

**This Dissertation is submitted as part fulfillment for the Degree of Master of Science in Audiology University of Mysore, Mysuru**

**ALL INDIA INSTITUTE OF SPEECH AND HEARING**

**MANASAGANGOTHRI**

**MYSURU-570006**

**May, 2016**

DEDICATED TO

*Dearest*

*Achachan*

# Certificate

This is to certify that this dissertation entitled **"Test Retest Reliability of Speech Evoked P300"** is a bonafide work in part fulfillment for the Degree of Master of Science (Audiology) of the student (Registration No.14AUD028). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Mysuru

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# Declaration

This dissertation entitled **"Test Retest Reliability of Speech Evoked P300"** is the result of my own study under the guidance of Dr. Ajith Kumar.U, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysuru,

May, 2016 **Register No. 14AUD028**

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## Abstract

The present study was taken with the aim to assess test retest reliability of speech evoked P300. The main objectives of the study were to access intra session and inter session test-retest reliability of P300 evoked by speech stimuli. 18 normal hearing individuals in the age range of 18 to 30 years participated in the study. Basic audiological evaluations such as pure tone audiometry, speech audiometry and immittance evaluation were carried out using standard clinical procedures. P300 response was elicited using /ba/ (frequent) and /da/ (infrequent) stimuli. To check the intra session reliability recording was repeated after 20 minutes without changing the position of the electrodes. To assess the inter session reliability recording was repeated after two days. Results showed no significant difference in amplitude and latency of P300 across three recording sessions indicating good reliability of P300. Cronbach's alpha revealed moderate to good reliability for P300 latency and amplitude respectively. Reliability estimates were better for intra session recordings compared to inter session recordings.

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# Chapter 1

## Introduction

P300 is an event related cognitive potential which is widely used to assess neural correlates of cognition and working memory. P300 was first described by Sutton et al., (1965) and is evoked by active oddball paradigm. The most frequently used paradigm in P300 is two stimulus odd ball paradigm in which non frequent stimuli presented in series of frequent stimuli. Frequent stimuli will serve as standard stimuli and infrequent stimuli will be the target stimuli. Generation sites of P300 are complex with multiple sites that appear to be activated simultaneously. Generation sites includes frontal cortex (Courchesne, 1978) auditory cortex (Kileny, Robertson, 1985) and hippocampus and associated brain structures (Okada, Kaufman, & Williamson, 1983). P300 can be recorded in normal subjects as early as 250ms or as late as 400ms depending on the stimuli (Hall, 2007). Amplitude of P300 is more at centro-parietal areas at the midline compared to other electrode locations.

Any sensory modality can be used to elicit P300 response in the descending order of clinical use these are auditory, visual, somatosensory, olfactory and gustatory (Bennington & Polich, 1999). In auditory modality tones or speech sounds can be used to elicit the responses. Auditory P300 is widely used to assess cognitive processing, hemispheric asymmetries, dichotic deficits, cerebral dysfunction, auditory perception skills and evaluation of language skills and efficiency. It has also been used in many clinical conditions to assess cognitive function. Demented patients was found to have more P300 latency than normal (Neshige, Barrett, & Shibasaki, 1988). Hemispheric asymmetries were found to be present in autistic children (Dawson, Finley, Phillips, Galpert, & Lewy, 1988). P300 can be used to find the severity of processing disorder

in children with Central auditory processing disorders (Jirsa & Clontz, 1990). Study done by Guruprasad (2000) found that P300 can be used as a clinical tool in order to figure out learning disability in children. Autistic children was found to have decreased amplitude of P300 (Niwa, Ohta, & Yamazaki, 1983).

The intrasubject consistency can be referred to as "the basic reliability of the response itself" (Segalowitz & Barnes, 1993) and is a fundamental indicator of the extent to which P300 response can be considered as a valid index of cognitive function, such as memory and information processing

In literature, a few studies have assessed the repeatability of P300 using tones or in other sensory modalities. Kinoshita et al., (1995) assessed the reliability of P300 by repeating the recoding 8 times, within 7-10 days interval using two stimuli tones in oddball paradigm and the results revealed no significant difference between the waveforms. Sklare and Lynn (1984) assessed the test-retest reliability of latency and amplitude of P300 by using two stimuli oddball paradigm with tones. They investigated immediate and short term reliability on healthy adults in different time intervals and found that N1, $P_2$, $N_2$, $P_3$ latencies and amplitudes were stable even after three days. Walhovd and Fjell (2002) assessed the one year test retest reliability of P300 using tonal stimuli in young and old adults and results revealed good reliability. Amplitude measures seemed more reliable compared to latency measures.

### 1.1. Need of the study

P300 is one of the widely used event related potentials to assess cognitive processing. It has been extensively used by audiologists and related professionals due to its varied clinical applications and to investigate finer aspects of auditory and cognitive-linguistic processing both in neuro-typical as well as in atypical individuals.

However, to effectively use P300 as a clinical measure, it is very important to document the normal variations when the recording is repeated. There is scarcity of evidences regarding test-retest reliability of P300, especially speech stimuli. Hence for efficacious application of P300 reliability should be verified.

### 1.2. Aim of the study

The aim of the present study was to investigate the test retest reliability of P300 evoked by speech stimuli.

### 1.3. Objectives of the study

The objectives of the present study were

1) To assess within the session test retest reliability of latency, amplitude and morphology of P300 evoked by speech

2) To assess across the sessions test retest reliability of latency, amplitude and morphology of P300 evoked by speech.

## Chapter 2

## Literature Review

P300 is a cognitive evoked response first described by Sutton et al., (1965). It is a response with positive polarity from the baseline EEG response and has a latency around 300ms (250-400 ms) following stimulus (Angeles, Price, & Smith, 1974) with about 15 microvolt amplitude. P300 is evoked by odd ball odd-ball paradigm i.e., it contain two stimulus types, frequent stimuli series (standard stimulus) and infrequent stimuli series which comes in between the frequent stimuli string. Generation of P300 contains the process of attention, auditory discrimination, memory and semantic expectancy (Picton & Hillyard, 1974). According to the attention provided by the subject P300 can show two components. P300 elicited during passive listening condition is known as P300a (Polich, 2007) and the P300 elicited during active listening of the subject towards the infrequent stimulus is known P300b. The latency of P300 is noted to be 50ms earlier than P300b (Knight, 1996) and the amplitude of the wave is seen to be smaller with rapid habituation process.

The generation sites of P300 are complex with concurrent stimulation of various overlapping sites. The generation sites overall includes the structures in frontal cortex (Courchesne, 1978), auditory cortex (Kileny & Robertson, 1985), hippocampus and associated brain structures (Okada et al., 1983). P300 amplitude is found to be maximum at midline over centro-parietal area and as the electrode (non-inverting) moves anterior the amplitude decreases (Polich et al., 1997). Johnson.R (2007) found that P300 scalp distribution shows difference in amplitude of P300 in midline electrode (Fz, Cz, $P_z$) which increases from frontal to parietal for infrequency stimulus. Neuroinhibition is suggested as an overarching theoretical mechanism for P300, which is elicited when stimulus detection engages memory operations (Polich, 2007). With

the conventional oddball paradigm, the subject is required to attend the rare stimulus and to ignore the frequent stimulus. Close vigilance or ongoing attention to the possibility of a rare stimulus enhances the size of the P300 response. A robust P300 response can be recorded with relatively few stimuli.

### *2.1. Variables affecting P300*

There are many variables that affect the P300 response directly and indirectly. The variables that affect P300 can be of subject related or stimulus related.

#### 2.1.1. Stimulus related variables

##### *2.1.1.1. Stimulus modality and type*

To evoke P300 response we can use any sensory modality. The sensory modalities used are auditory, visual, somato-sensory, olfactory or taste stimulation (Polich & Pitzer, 1999). In auditory modality P300 can be elicited by variety of stimulus types. Amplitude and latency of P300 differs based on stimulus used.

**Tones:** In the oddball paradigm, standard and rare stimuli differ in frequency, intensity or duration. In applying stimulus-frequency based oddball paradigm clinically, patients' hearing sensitivity could be comparable for the two frequencies. Amplitude of P300 increases directly with the frequency difference between the standard and target stimuli.

**Speech sounds:** Can be elicited using speech signals such as /da/, /pa/ or using words. Relevance of speech stimuli influences P300 response. Measurement of P300 is enhanced or facilitated by first familiarizing the subjects to rare speech stimuli. Syntactically anomalous words presented in an oddball paradigm generate a positive in the 600 msec region (Osterhout, Allen, McLaughlin, & Inoue, 2002). The semantic

difference between the standards and target stimuli evoked a larger a positive peak in the 500 to 800 msec region.

*2.1.1.2Stimulus Intensity*

The effect of stimulus intensity on the P300 response can be considered in two ways. Absolute stimulus intensity has influence on the P300 response that is characteristic of all auditory evoked responses. That is P300 wave amplitude increases and latency decreases as stimulus intensity increases for both the frequent and rare stimuli. A study was done by Papanicolaou, Loring, Raz, and Eisenberg (1985) and their results revealed that the reduction of intensity from 65 dB to 15 dB made difference in the latency of P300 response but the amplitude of the response remained the same. But the study done by Vesco, Bone, Ryan, and Polich (1993) found that at low intensity levels P300 showed long latency and reduced amplitude.

*2.1.1.3. Probability of stimulus*

Probability of occurrence for the standard and the target stimuli affects P300 response characteristics. Within certain limits, amplitude of the P300 response decreases as the probability of the target stimulus increases (Johnson & Donchin, 1977), whereas the effect of target stimulus probability on P300 latency is minimal (Polich & Bondurant, 1997). However, there is little change in the P300 response when probability of the target stimulus is decreased below 20 percentage (0.20). Given this limitation in the effect of decreased probability, and the increase in test time associated with signal averaging of a response for very target stimuli, the probability in P300 measurement is usually 80 percent for standard and 20 percent for target stimuli.

*2.1.1.4. Target to target interval*

The amplitude of P300 responses increases as the number of frequent stimuli (standard) increases between two infrequent stimulus (target). The target to target interval of 6 to 8seconds or greater eliminate probability effects (Polich, 1990). A study was done by Gonsalvez and Polich (2002) in which they altered the number of preceding standard stimuli (0,1,2,3) and inter-stimulus interval (1,2,4 s). They used auditory and visual stimulus for eliciting the P300 response. The result revealed betterment of P300 amplitude with increase in the length of standard auditory/visual stimulus when ISI was constant. It was also noted that the latency of response also became shorter as the standard stimulus length increased. The latency was shorter in case of auditory stimulus than that of visual.

*2.1.1.5. Task*

Tasks given to the subject can be active or passive. In case of passive condition the client will be asked not to pay attention to the stimulus while in active tasks the client will be asked to selectively attend to the target stimulus (infrequent). A study was done by Bennington and Polich (1999) to compare the effect of passive and active task on P300 for auditory and visual stimuli and it was found that the P300 amplitude was larger in active condition than that of passive condition. The amplitude of P300 decreased with repeated stimulation during passive discrimination of standard and target stimuli (Katayama & Polich, 1998).

*2.1.1.6. Task Difficulty*

There is considerable evidence that P300 latency becomes longer and amplitude smaller as the difficulty of the listening task increases (Katayama & Polich, 1998). When the standard and the target signals are similar, reaction time and P300 latency are

prolonged and the response is less robust. Highly novel target signals produce larger responses with short latency, consistent with shorter evaluation time required to determine that the target signal was different than the standard signal (Ritter et al., 1982). Polich and Comerchero (2003) also found similar results i.e., easy task experiments elicits larger amplitude and reduce peak latency of P300.

### 2.1.2. Subject related variables

*2.1.2.1. Body temperature*

Geisler and Polich (1992) found a negative correlation between peak latency of P300 and body temperature. The latency of P300 was noted minimal when body temperature was at 38 degree Celsius. As the body temperature increased the latency reduced but there was no significant change observed in the amplitude of P300.

*2.1.2.2. Motivation*

The P300 amplitude was noted to be better for motivational instructions than that of neutral ones (Johnson, 1986). The positive influence of subject motivation and feedback is often used in studies involving older persons (Verleger, Neukäter, Kömpf, & Vieregge, 1991) and clinical populations, such as patients with depression (Diner, Holcomb, & Dykman, 1985) and schizophrenia (Louzã, Maurer, & Neuhauser, 1992). In addition, subject incentive clearly influences P300 amplitude, but not latency. It has been shown that P300 amplitude increases when the monetary value is attached to correct identification of the target stimuli (Begleiter, Porjesz, Chou, & Aunon, 1983).

*2.1.2.3. Drugs*

Lorist, Snel, Kok, and Mulder (1994) conducted a study in which they checked the effect of caffeine on P300 using visual stimuli. Results showed reduction in amplitude of P300 and prolongation of peak latency. Lukas, Mendelson, Kouri, Bolduc

and Amass (1990) studied the effect of alcohol intake on P300 and reported amplitude reductions.

*2.1.2.4. Age*

McPherson, Tures and Starr (1989) reported that P300 is not well developed till 5 years and after 5 years latency decreases with age and then after 50 years of age it increases. Buchwald, (1990) reported that P300 reach adult value at 17 years of age. Studies done by Barajas (1990) revealed that the P300 reaches the shortest latency value at 18-24 years of age and then increases.

*2.1.2.5. Gender*

In contrast to age, gender does not appear to be an important factor in P300 measurement. In a comprehensive study of normal variation of P300 using a conventional two-tone standard versus target stimulus paradigm, Polich (1986) found no significant effect between fifty males versus fifty females in latency or amplitude of P3 wave. There are however some reports of greater amplitude and shorter latency for females than males over the age of 15years (Deldin, Duncan, & Miller, 1994; Morita, Morita, Yamamoto, Waseda, & Maeda, 2001) but other investigators failed to confirm gender differences in P3 wave latency or amplitude values (Polich, 1986a; Sangal & Sangal, 1996).

*2.1.2.6. Food*

Like all other factors that we have discussed above, intake of food also affect the P300 response. A study was done by Geisler and Polich (1992) and they found that P3 latency tended to be longer for all subjects who had not eaten recently compared to those who had.

*2.1.2.7. Handedness*

Given the contributions of different regions of the cerebral hemispheres to the P300 response and the sensitivity of the P300 responses as a measure of information processing, it is reasonable to question whether the response differs for right versus left handed subjects. The study done by (Hong et al., 2013) and Alexander and Polich (1997) found that P300 latency was shorter for left versus right-handed subjects. Polich and Hoffman (1998) confirmed that the same handedness effects apply to male and female.

### 2.1.3. Applications of P300

*2.1.3.1. To check cognitive functions*

P300 can be used for diagnosis of several neurocognitive disorders like Alzheimers (Olichney & Hillert, 2004), schizophrenia (Heidrich & Strik, 1997), epileptic patients (Caravaglios et al., 2001; Resolução et al., 2010) traumatic brain injuries (Lew, Slimp, Price, Massagli, & Robinson, 2004) , speech processing in children (Henkin, Tetin-Schneider, Hildesheimer, & Kishon-Rabin, 2008).

*2.1.3.2. Detection of Auditory processing disorder*

P300 was recorded by Jirsa, 1992 on children with auditory processing disorder and normal children and found significant latency increase for P300 component in processing disordered group. (Mullis, Holcomb, Diner, & Dykman, 1985) found that the latency of P300 is directly related to speed of information processing and CAPD children have longer latency of P300 response.

*2.1.3.3. P300 as an index of Neural Plasticity*

The progress of central auditory nervous system function in children with auditory processing disorder after training was assessed with P300 responses by Azzam and Hassan (2010). Children were given auditory training for auditory memory, auditory temporal processing and auditory attention and it was found that the amplitude of P300 increased following training. Kubo et al., (2001) recorded P300 and measured word recognition scores in post lingually deaf adult before cochlear implantation. After 1 month again P300 and word recognition was checked and it was concluded that there was an increase in word recognition and decrease in P300 latency was noted.

### 2.1.4. Reliability of P300

The reliability of response functions as a fundamental indicator of the extent to which the P300 response can be considered as clinical tool in assessing clinical population. Studies have shown P300 as having good test-retest reliability. In literature, a few studies have assessed the repeatability of P300 using tones or in other sensory modalities. Kinoshita et al., (1995) assessed the reliability of P300 by repeating the recording 8 times, within 7-10 days interval using two stimuli tones in oddball paradigm and the results revealed no significant difference between the waveforms. Sklare and Lynn (1984) assessed the test-retest reliability of latency and amplitude of P300 by using two stimuli oddball paradigm with tones. They investigated immediate and short term reliability on healthy adults in different time intervals and found that N1, $P_2$, $N_2$, $P_3$ latencies and amplitudes were stable even after three days. Walhovd and Fjell (2002) assessed the one year test retest reliability of P300 using tonal stimuli in young and old adults and results revealed good reliability. Amplitude measures seemed more reliable compared to latency measures. Kileny and Kripal (1987) reported a high degree of test-

retest reliability for the P300 response elicited with tonal signals from young normal hearing adults. Several other studies have also confirmed P300 reliability (Nakamura, Kinoshita, Eisuke, & Morita, 1995; J Polich, 1986b). Alexander et al., (1994) systematically investigated interlaboratory consistency in response amplitude, latency and scalp distribution in normal hearing individuals and no significant differences were found for P300 response parameters among the laboratories.

# Chapter 3

# Method

## 3.1. Participants

Twenty young adults in the age range of 18 to 30 years (mean age= 24.8) participated in the study. All the participants had air conduction hearing thresholds within 15 dB HL at octave frequencies between 250 Hz to 8000 Hz. All participants had 'A'type tympanogram (Jerger, 1970; Lidén, 1969) and both ipsilateral and contralateral acoustic reflex thresholds were within 90 dB HL at 500 Hz and 1000 Hz. None of the participants reported exposure to loud noise, usage of ototoxic drugs, presence or history of ear discharge. All participants were right handed individuals (Oldfield, 1971) and passed screening test on auditory processing disorder (Keith, 1994) and Mini Mental Status Examination (Folstein, Folstein, & McHugh, 1975)

## 3.2. Equipment

Instruments used in the study were:

- A calibrated audiometer GSI-61 with TDH 49 Earphones with MX-41/AR ear cushions for threshold estimation.
- A calibrated GSI tympstar immitance meter for evaluating middle ear status.
- An Intelligent Hearing System (IHS) AEP system with smart EP for recording and analyzing P300.
- A computer with Adobe Audition (Version 3) for recording and editing of the auditory stimulus.

### 3.3. Test environment

All tests were carried out in a sound treated room with noise levels within the permissible limits (American National Standards Institute, 2008)

### 3.4. Procedure

Basic audiological evaluation such as pure tone audiometry, speech audiometry and immittance evaluation were carried out using standard clinical procedures. Informed consent was taken from all the participants before the actual testing and participants were informed in prior regarding the details of the testing.

#### *3.4.1. Electrophysiological testing*

*3.4.1.1. Stimuli*

Two speech sounds /da/ and /ba/ of a native male Kannada speaker was recorded using Adobe Audition (Version 3). Figure 3.1 (a) and (b) shows the spectrogram and waveform of the stimuli used in the study.

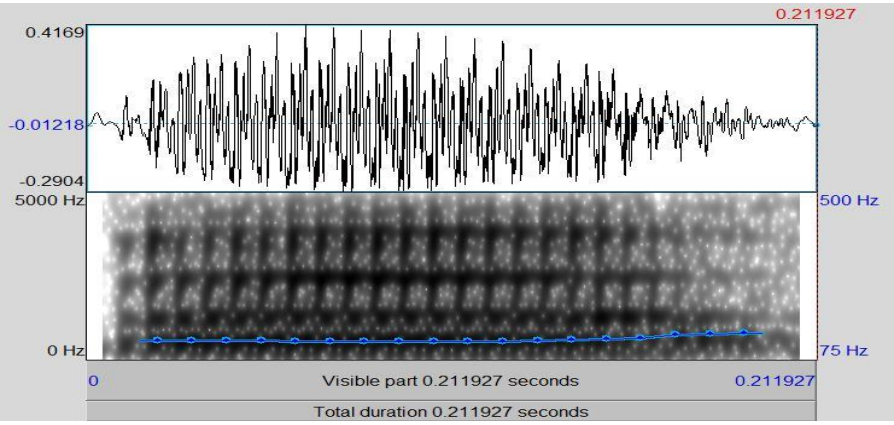


*Figure 3.1 (a): Spectrogram and waveform of the stimulus /ba/*

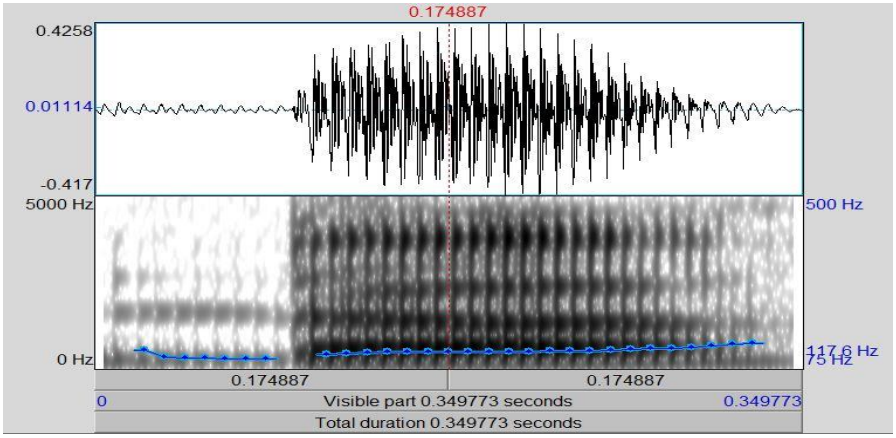


*Figure 3.1 (b): Spectrogram and waveform of the stimulus /da/*

### *3.4.1.2. Participant preparation*

EEG was recorded by placing the electrodes on frontal (Fz), vertex (Cz) and parietal (Pz) sites with nasion as reference. Ground electrode was placed on the right mastoid. Electrooculogram was recorded with electrodes placed above and below right eye. Impedances of all electrodes were kept at or below 3 kΩ. To ensure the correct and consistent positioning of the electrodes following procedure was followed: distance between nasion (bridge of the nose) to inion (occipital protrusion) and distance between both zygomatic notches were measured and the total length was noted in centimeters. The midpoint of these distances - located at 50% of the total length between nasion to inion and between both zygomatic notches was marked as the point Cz (vertex point). 20% of the total distance from nasion to inion towards front of Cz along the midline was marked as Fz and towards back of Cz along midline was marked as Pz. Table 3.1 shows the test protocol for P300 recording.

**Table 3.1:** *Protocol for P300 recording*

| Type of stimulus | Speech sounds (frequent: /da/ and infrequent: /ba/) |
|---|---|
| Polarity | Rare fraction |
| Filters | 1-30Hz |
| Intensity | 80 dBnHL |
| Number of Stimulus | 200 (80% frequent stimulus and 20% infrequent stimulus) |
| Transducer | ER-3A |
| Repetition Rate | 0.8/s |
| Presentation | Binuaral |
| Electrode Montage | Inverted: Nasion<br>Non Inverted: Fz,Cz,Pz<br>Ground : Mastoid |

*3.4.1.3. Test Procedure*

Participants were explained about the testing procedure and also the tasks to be performed. The participant was then seated comfortably and electrodes were placed. Participants were then instructed to:

- Relax and remain alert throughout the testing.
- Keep their eyes open and to fixate their vision to one spot.
- They were asked to make a mental count of infrequent stimulus (ba) in series of frequent stimulus (da). At the end of the recording they were asked to report the number of stimuli counted. This was done in order to make sure that the subjects give attention to the stimuli and these results were not used for any other purpose.

ER-3A inserts were placed in subject's ears and the stimuli were presented binaurally through the inserts. Waveforms of both frequent and infrequent stimulus response were recorded from all the three electrode sites. Electroocculogram was recorded with electrodes placed above and below right eye. Artifact rejection at ocular channel was adjusted to reject all eye blinks. Sweeps affected by eye-blinks were automatically rejected across all channels by the ocular channel artifact rejection criterion. LLR was recorded for the deviant/infrequent stimuli using the same protocol that was used to record the P300 response from all the three electrode sites (Fz, Cz, and Pz). Following the first recording, 20 minutes rest time was given to participants and after that P300 was recorded again without altering the position of the electrodes. Electrode impedances were ensured to be the same as first P300 recording. Following second recording participant was released and third P300 was recorded 3 days later using the same protocol and procedure described above. All basic audiological evaluations were repeated prior to P300 testing. Through a structured interview, it was ensured that there were no significant auditory, cognitive or neurological problems between the recordings.

# Chapter 4

# Results and Discussion

The aim of this study was to investigate the test-retest reliability of P300 evoked by speech stimuli in individuals with normal hearing. For this purpose P300 was recorded thrice and was compared across recordings sessions to determine intra and inter session reliability. Data obtained was analyzed at two levels – at group and individual level.

## 4.1. Characterization of P300

Figure 4.1 shows grand averaged waveform for deviant stimuli and LLR across three electrode sites and three recording sessions. From the Figure 4.1, it can be inferred that deviant stimuli waveform (red) had large positivity between 230 ms to 320 ms which is present in LLR (black). This confirms the presence of P300. From the Figure 4.1, it can also be seen that Pz electrode had higher P300 amplitude followed by Cz and then Fz.

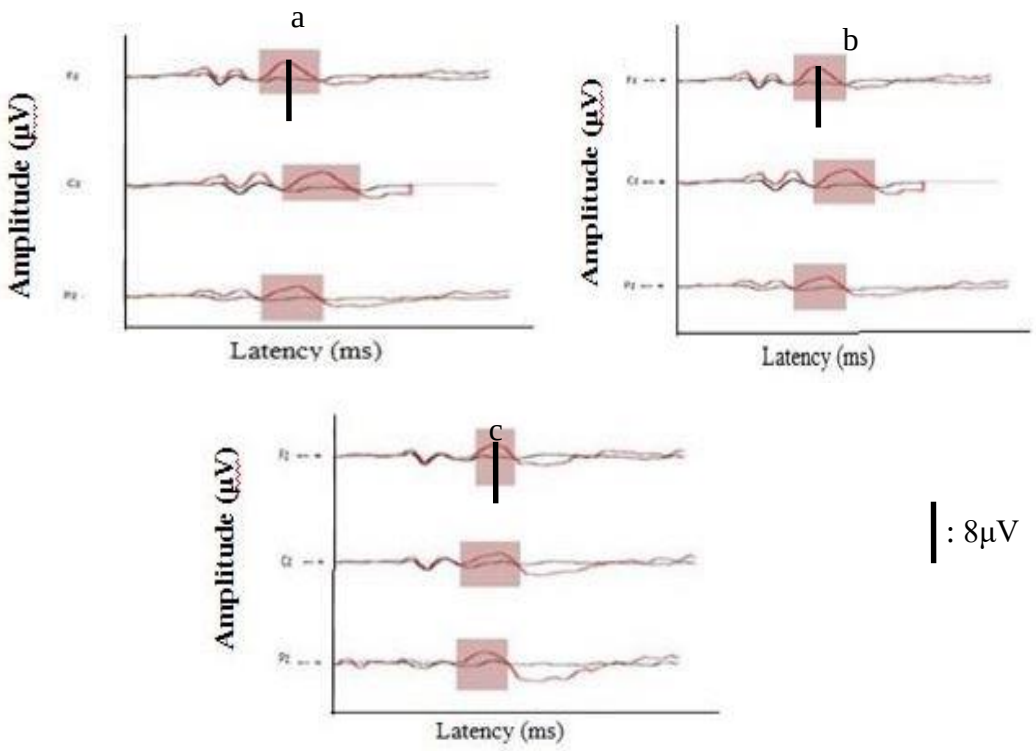


*Figure 4.1*: Grand averaged waveform for deviant stimuli and LLR across three electrode sites for a) recording 1 b) recording 2 c) recording 3

## 4.2. Group data Analysis

Repeatability of P300 was measured by assessing waveform modulation, peak latency and amplitude.

### *4.2.1. Waveform modulation*

Statistical significance of the differences between P300 wave forms recorded in intra-session (recording 1 vs. recording 2) and inter-session (recording 1 vs. recording 3) was assessed by carrying out significance tests at every time point using randomization procedure. Figure 4.2 shows grand averaged waveforms recorded in intra-session across different electrode sites. Spikes in the green bars below the waveforms represent the time regions where two waveforms differed from each other significantly ($p < 0.05$). From the Figure 4.2, it can be seen that there was no statistically significant difference between two recording sessions in all three electrode sites. Figure

4.3 shows grand averaged P300 waveforms obtained in recording 1 and 3 at three electrode sites. Spikes in the green bars below waveforms represent the time regions where two waveforms differed from each other significantly ($p<0.05$). From the Figure 4.3, it can be seen that there was no statistically significant difference between two recording sessions in all three electrode sites.

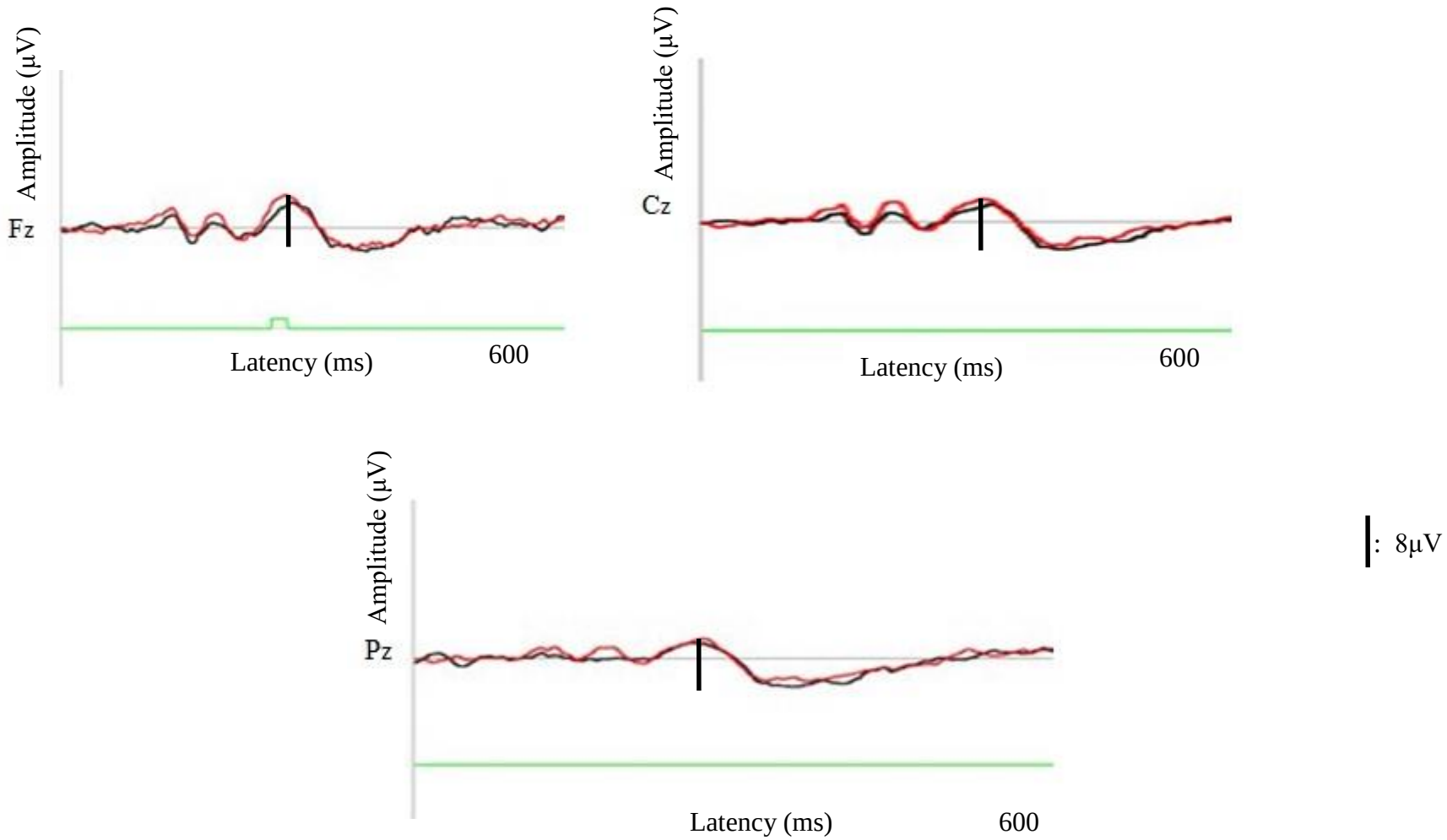


*Figure 4.2:* Grand averaged P300 waveforms obtained in recording 1 and 2 at three electrode sites.

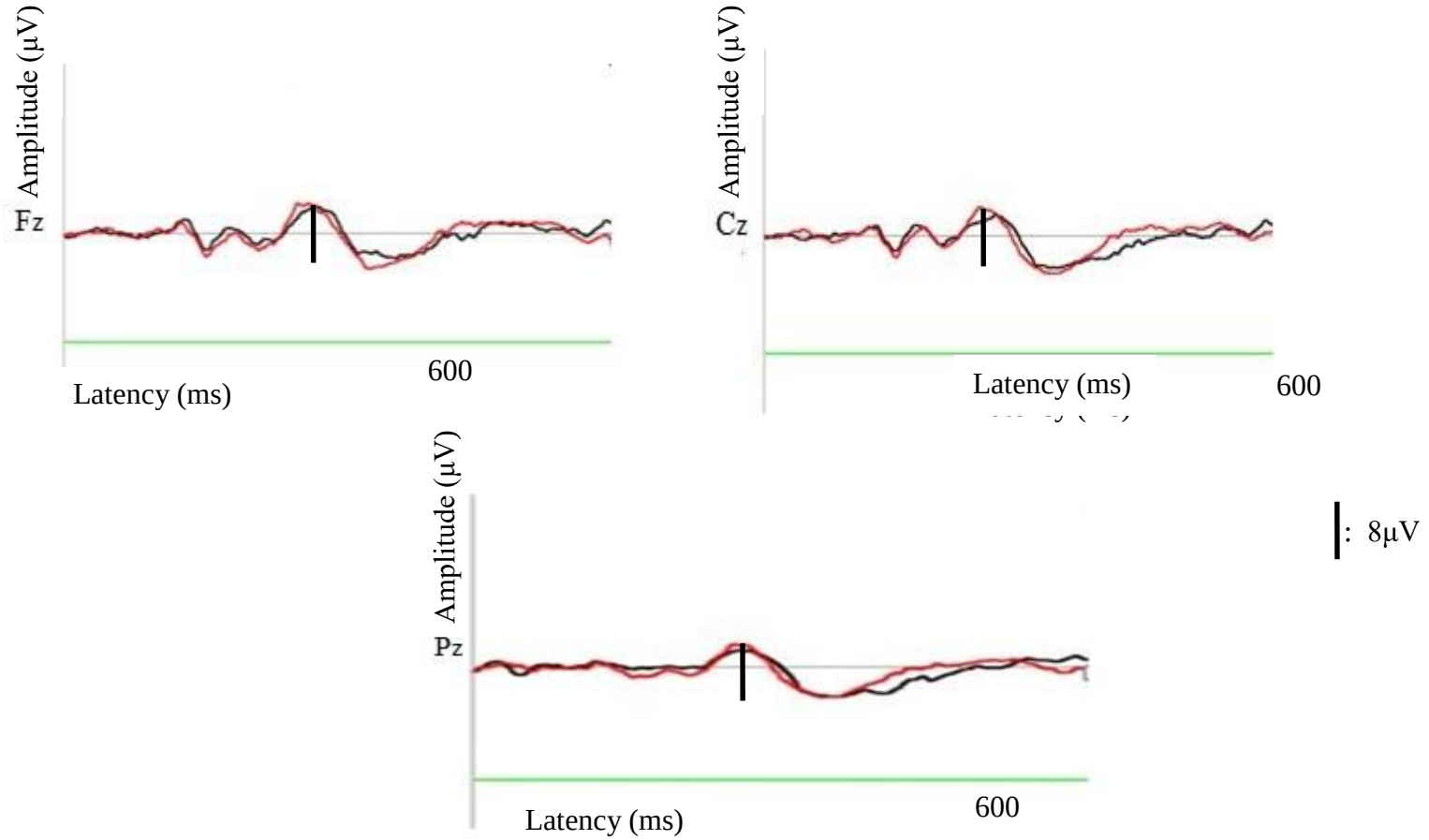


*Figure 4.3:* Grand averaged P300 waveforms obtained in recording 1 and 3 at three electrode sites.

### *4.2.2. Peak Latency and amplitude*

In the grand average P300 waveform onset and offset latency of P300 was noted for each electrode and recording sessions separately. In individual waveforms the region that had maximum amplitude between onset and offset latency of grand averaged P300 was considered as P300 and its peak amplitude and latency was noted for further statistical analyses. Figure 4.4 shows the mean and the standard deviation of P300 latency in three recordings. From the Figure 4.4, it can be seen that latency of P300 did not vary much between the recordings. To assess the statistical significance of differences in latency across recordings, a repeated measure ANOVA was performed. Repeated measures ANOVA did not reveal a significant main effect of recording condition [F (1.9, 32) = 0.66, $p > 0.05$]. However, there was significant main effect of electrodes on peak latency [F (1.8, 34) = 33.8, $p > 0.05$]. Interaction between electrodes and latency was not significant. Chronbach's alpha was calculated as reliability estimates (only for Pz electrode as it had higher amplitude). Chronbach's alpha was 0.6 for intra session and 0.5 for inter session recording of P300 latency.

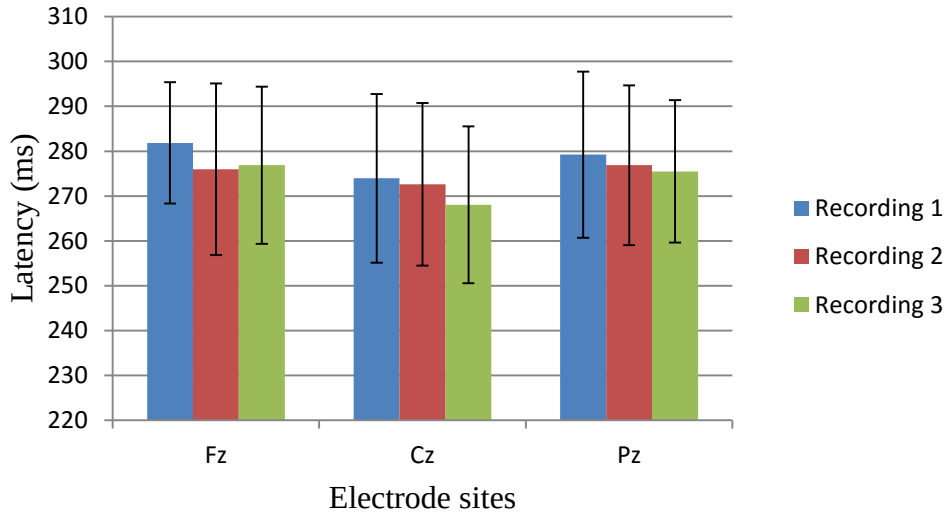


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*Figure 4.4:* Mean and the one standard deviation of P300 latency in three recordings.

Figure 4.5 shows the mean and one standard deviation of P300 amplitude in three recordings. From Figure 4.5, it can be seen that amplitude of P300 did not vary much between the recordings. To assess the statistical significance of amplitude differences across recordings, a repeated measure ANOVA was performed. Repeated measures ANOVA did not reveal a significant main effect of recording condition [F(1.3, 23.1)=0.54, $p$>0.05] and electrodes [F(1.2, 21.7) =3.5, $p$>0.05] on amplitude. Interaction between electrodes and amplitude was also not significant. Chronbach's alpha was 0.7 for intra session and 0.5 for inter session recording of P300 amplitude.

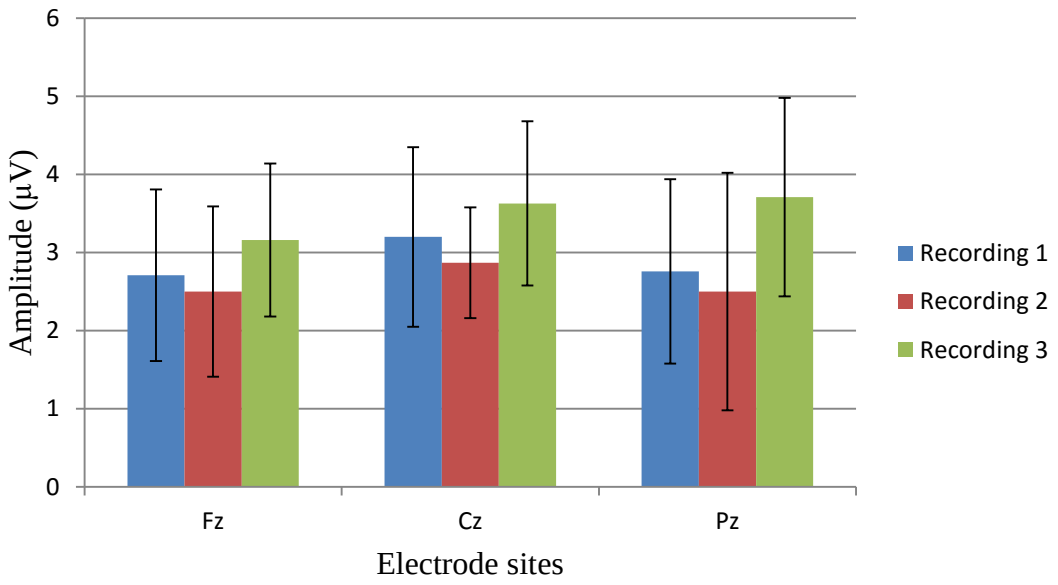


*Figure 4.5:* Mean and one standard deviation of P300 amplitude in three recordings.

### 4.3. Individual data analysis

Figure 4.6, shows peak latency of P300 obtained across three recordings at Fz, Cz and Pz electrodes for individual participants. Similarly, Figure 4.7, shows peak amplitude of P300 obtained across three recordings at Fz, Cz and Pz electrodes for individual participants. Inspection of the individual data supports the inferences drawn

from group data. Variations seen in latency and amplitude were small in majority of the participants. Variations in amplitude and latency were smaller in intra-session recordings compared to intersession recordings.

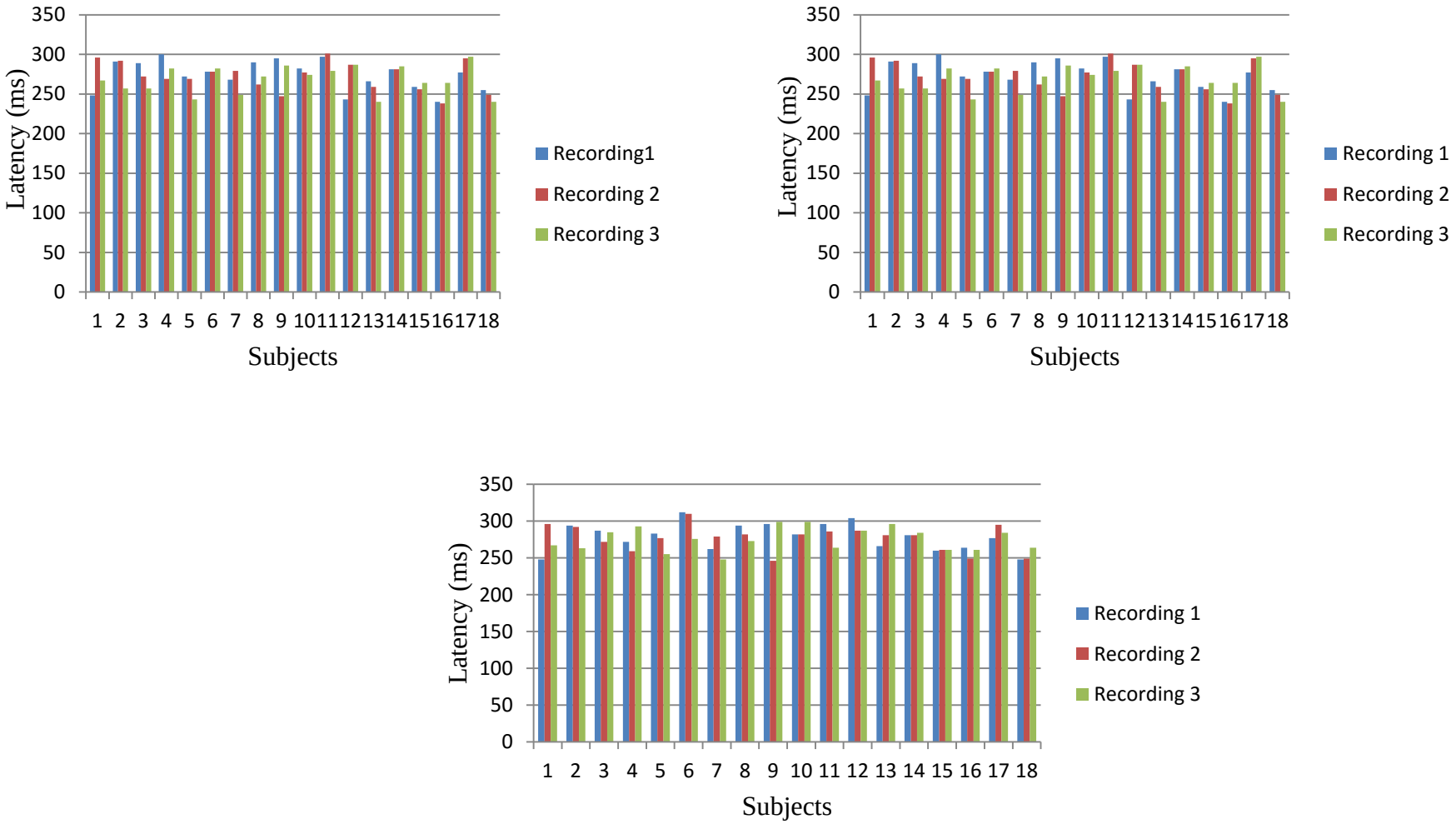


*Figure 4.6:* Peak Latency of P300 obtained across 3 recordings at Fz, Cz and Pz electrodes.

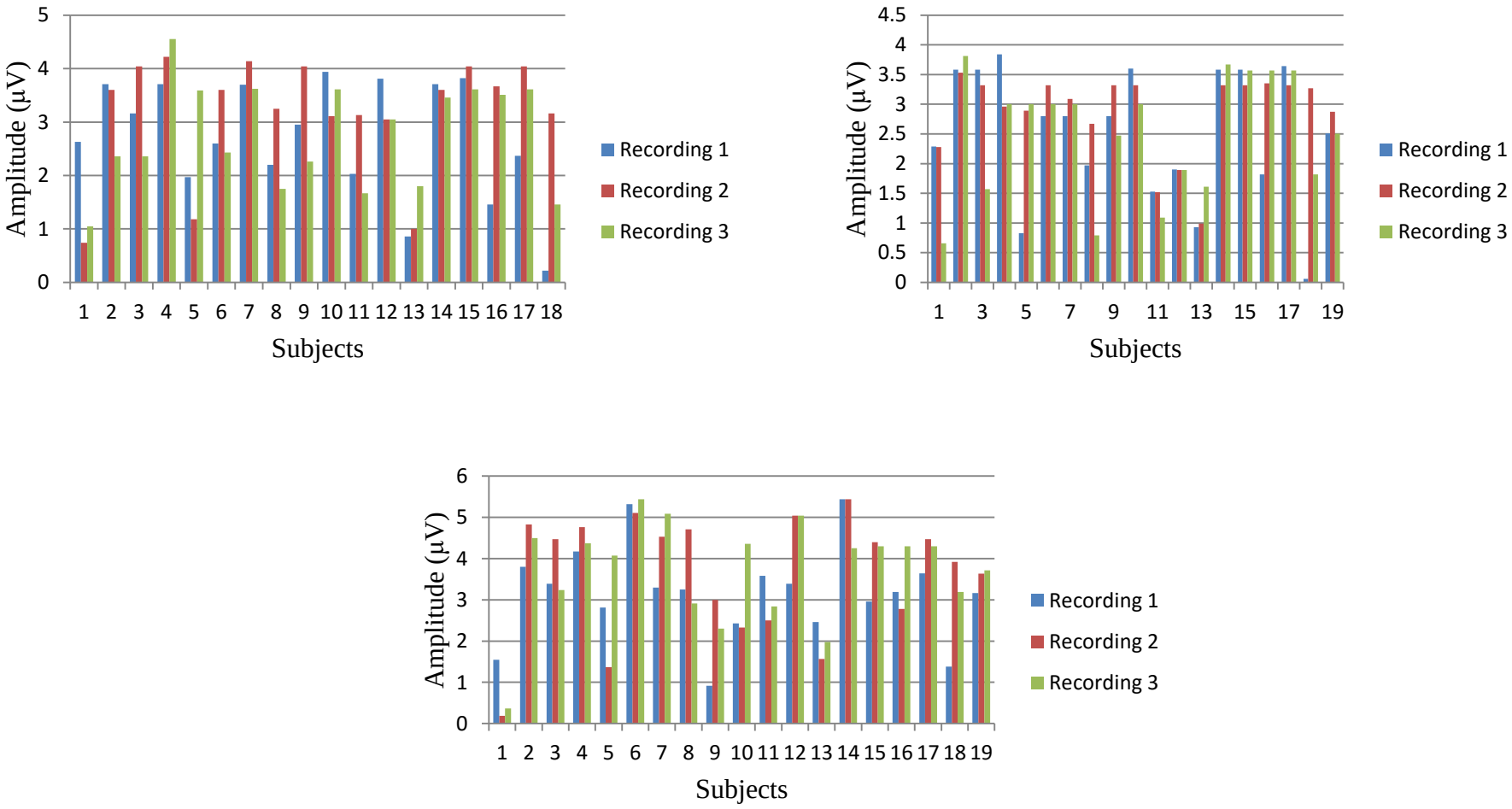


*Figure 4.7:* Peak amplitude of P300 obtained across 3 recordings at Fz, Cz and Pz electrodes.

The present study aimed at assessing the intra and inter session reliability of speech evoked P300. Results indicated that P300 latency had moderate intra and inter session reliability and amplitude had good intra inter session reliability. To our knowledge, this is the first study to evaluate the intra and inter session reliability of speech evoked P300. Previous studies have measured reliability of tone evoked P300 and found reliability estimates similar to current study (Sklare & Lynn, 1984). Segalowitz and Barnes (1993) measure reliability of tone evoked P300 on 19 adolescents across 1 year 10 months interval. They assessed within session as well as across session reliability of P300 amplitude and latency. Their results indicated that P300 had good within session and across session stability both for amplitude and latency. P300 latencies were slightly more stable compared to amplitudes. Katayama and Polich (1996) measured reliability of tone evoked P300 on 100 undergraduate students and concluded that P300 amplitude and latency was highly reliable. Similarly Hong et al. (2013) also reported good intra session reliability of tone evoked P300. They measured P300 in an odd ball paradigm for 1000 Hz standard and 2000 Hz deviant tones on 30 normal hearing adults. P300 latency had excellent reliability and whereas reliability of the amplitude was fair to good. Hall (2007) assessed the test retest reliability amplitude and latency of P300 in 19 monozygotic twins twice at the interval of 7 and 56 days. Their results showed very high reliability estimates for both amplitude and latency of P300.

Consistent with the previous report even the current study found high reliability of P300. Reliability estimates were higher for amplitude compared to latency. Reliability estimates were higher in intra session recordings compared to intersession recordings. Our

results suggest that P300 is a reliable measure and has necessary stability required for group research. Reliability estimates are not satisfactory for individual applications. Among the parameters, amplitude had higher reliability estimates and is a more stable measure for individual application. However, it is advised to interpret P300 parameters for clinical purpose with caution.

# Chapter 5

## Summary and Conclusion

P300 is one of the widely used event related potentials to assess cognitive processing. It has been extensively used by audiologists and related professionals to investigate finer aspects of auditory and cognitive-linguistic processing. However, to effectively use P300 as a clinical measure, it is very important to document the normal variations when recording is repeated. Therefore, the present study was taken with the aim to assess test-retest reliability of speech evoked P300. The main objectives of the study were to access intra session and inter session test-retest reliability of P300 evoked by speech stimuli.

18 normal hearing individuals in the age range of 18 to 30 years were included in the study. Basic audiological evaluations such as pure tone audiometry, speech audiometry and immittance evaluation were carried out using standard clinical procedures. P300 response was elicited using two speech sounds /da/ and /ba/. /da/ sound was given as the frequent stimuli and /ba/ sound was presented as an infrequent stimuli. Waveforms of both frequent and infrequent stimuli were recorded from three midline electrode sites (Fz,Cz,Pz). Sweeps affected by eye-blinks were rejected across all channels by the ocular channel artifact rejection criterion. LLR was recorded for the deviant/infrequent stimuli using the same protocol that was used to record the P300. To check the intra session reliability, recording was repeated after 20 minutes without changing the position of the electrodes. To assess the inter session reliability, recording was repeated after two days.

P300 could be recorded in all participants. Data obtained was analyzed at two levels– at group and individual level. The peak latency and amplitude of P300 was compared across recordings sessions to determine intra and inter session reliability. Repeated measure ANOVA was performed to assess the significance of differences of latency and amplitude across recording sessions. Results showed no significant difference in amplitude and latency across three recording sessions indicating good reliability of P300. Cronbach's alpha revealed moderate to good reliability for P300 latency and amplitude respectively. Reliability estimates were better for intra session recordings compared to inter session recordings. These results suggest that P300 is a reliable measure and has necessary stability required for group research. Reliability estimates are not satisfactory for individual clinical applications. Among the parameters amplitude had higher reliability estimates and is a more stable measure for individual application. However, it is advised to interpret P300 parameters for clinical purpose with caution.

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