AUDITORY DIFFERENTIAL SENSITIVITY FOR FREQUENCY, INTENSITY, DURATION IN ABSTINENT ALCHOLICS

NIVEDHA RAO. N

Register number : 18AUD026

This dissertation is submitted as a part fulfillment

For the degree Masters of Science Audiology

University of Mysore, Mysuru

ALL INDIA INSTITUTE OF SPEECH & HEARING,

MANASAGANGOTHRI, MYSURU-570 006

JULY-2020

CERTIFICATE

This is to certify that this dissertation entitled **"Auditory differential sensitivity for frequency, intensity, duration in abstinent alcoholics."** is the bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student Registration Number: 18AUD026. This has been carried out under the guidance of the faculty of the institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
July,2020

Dr. M. Pushpavathi
Director
All India Institute of Speech and Hearing
Manasagangothri, Mysuru-570006

CERTIFICATE

This is to certify that this dissertation entitled **"Auditory differential sensitivity for frequency, intensity, duration in abstinent alcoholics."** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
July,2020

Dr. N. Devi
Guide
Reader in Audiology
Department of Audiology
All India Institute of Speech and Hearing

DECLARATION

This is to certify that this dissertation entitled **"Auditory differential sensitivity for frequency, intensity, duration in abstinent alcoholics."** is the result of my own study under the guidance of Dr. Devi N, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No: 18AUD026**

July, 2020

I WOULD LIKE TO DEDICATE THIS DISSERTATION TO ALL THE HARD WORKING FRONTLINE WORKERS IN CORONA PANDEMIC, AND THE TWENTY MARTYRED INDIAN ARMY SOLDIERS IN INDO-CHINA FACEOFF.

ACKNOWLEDGEMENT

"If you cast your burden on me, I shall surely bear it."

- Sai Satcharita

First and foremost, I would thank **SAIRAM** for blessing me with this great opportunity and for his presence throughout my research work to complete this successfully.

In particular, I must mention a few people who had helped me, guided me and encouraged me while conducting the study.

I extend my gratitude to **Dr. Pushpavathy,** Ph.D, Director of All India institute of speech and hearing for her support, enlightened ideas, guidance and Motivation and taking care of students .

I wish to express my sincere appreciation and a deep sense of gratitude to my guide **Dr. N Devi, Ph.D** for her guidance and direction, patient listening, valuable feedback constant encouragement, reassurance at the time, throughout the project. Her valuable suggestions were of immense help.

My deepest felt gratitude to **Dr. Prawin Kumar**, **H.O.D of Department of Audiology** who shared his valuable suggestions by which I could complete my project as per the norms.

I extend my deep sense of thanks to all the members of the **Faculty** of AIISH, for their suggestions and guidance at various stages of the study.

I am incredibly grateful to my **dear parents Mr. Nagarajan R and Mrs. Kalaiselvi B** and my **family members** for their love, caring, and support.

I am extremely thankful to my grandmother **Mrs. Padmavathi** for showering unconditional love and belief towards me.

I would be more thankful to my lovable **Ms. Shreeshaa Jodidhar,** for keeping me engaged always.

I thank my friend **Mr. Kalaiyarasan R** for his support and encouragement throughout.

I would also like to thank my dearest friend **Ms. Sundareswari Pon** for backing me always.

I extend my deep sense of thanks to all the members of the **Faculty** of AIISH , for sharing their knowledge and making us more privileged..

I am very much grateful to **Mr. Mugunthan** for his timely help and efforts.

It will be a grievous lapse on my part if I do not thank the participants and authorities of rehabilitation centre who enthusiastically participated in the study, without whose co-operation the whole study has been difficult.

I would extend my thanks to **Mr. Raghul Ponnappan** and his friends for their help; without them, my data collection wouldn't be possible.

I would like to express my gratitude to **staffs** of my parental institute **Madras Medical College** for their encouragement and support.

I would like to thank my **UG (TUERENTURZ' 14)**and **PG (BRAINIACS)** batchmates for tolerating me for these many years.

I thank my roomies **(Uma, Soundarya, Jenni, Sundu, Gracia)** for being there for me in my hard and happy times and lend their shoulders at difficult times.

I also thank my hostel mates **(Roja, Siva ranjini, Jasper, Sana di, Augustina, Mohana, Manju, Krupa)** for their care and affection towards me.

I would like to thank my seniors **Ms. Saranya Mahendran, Ms. Abhinaya and Ms. Roshini** for their valuable input and extended support.

Last but not least, I would like to thank **Mrs. Snekha Rao, Ms. Suruti, Ms. Sridevi and Mr. Balayogi** for their constant support and encouragement.

Abstract

Chronic alcohol intake is one of the most popular abused substance to affect the hearing mechanism. Abusive consumption of alcohol has been shown by a variety of techniques to cause alteration in both the function and the structure of the nervous system. Several studies were carried to see the effect of chronic alcoholism in electrophysiological measures. However, none of the studies has extensively explored whether there is any change in difference limen for frequency (DLF), intensity (DLI) and duration (DLT) in abstinent alcoholics.The aim of the study was to measure and compare differential sensitivity measures for frequency, intensity, duration between abstinent alcoholics (Group I) and non-alcoholics (Group II). A total of 80 ears were included in the study. DLF, DLI and DLT were assessed for different frequencies (500 Hz, 1 kHz, 2 kHz, 4 kHz and 6 kHz). Maximum likelihood procedure toolbox was used to measure psychoacoustical abilities which implement a maximum likelihood procedure in MATLAB software. The results of the study indicate that there was a significant difference between both the groups except at 1 kHz and 4 kHz in DLI. This could be due to cochlear damage or demyelination / neurochemical changes in auditory pathways or auditory processing deficits as a result of excessive alcohol consumption.

***Key words**: Abstinent alcoholics, DLF, DLI and DLT*

Table of contents

List of Tables

Chapter 1

Introduction

The widespread use of alcohol has become a major public health concern for the majority of countries all over the world. About 5.3% of all deaths happenings around the world (3 million) results from the abusive use of alcohol (World Health Organisation [WHO], 2018). Consumption of alcohol is ranked as the global third most causal factor for diseases and disability and as the greatest risk in the middle-income country (WHO, 2011).

Alcohol is one of the two psychoactive substances most widely used (excluding caffeine, the use of which is relatively unproblematic) with an estimated three billion consumers of alcoholic beverages. Alcohol per capita consumption increased in southeast Asia regions, in that India accounts for an increase in consumption of 2.4 liters, 4.3 liters, 5.7 liters in 2005, 2010, 2016 respectively (WHO, 2018).

Total alcohol intake per capita is anticipated to rise in half of the WHO region by 2025. The greatest rise is anticipated with a rise of 2.2 liters in India alone, representing a big percentage of the total population in southeast Asia region. Prevalence of present drinker's heavy episodic drinking by gender and age: males – 34.9%; females – 14.4%; both sexes – 25.2% of the total population (WHO, 2018).

Alcohol use disorder is defined by a cluster of behavioral and physical symptoms, which can include withdrawal, tolerance, and craving. Individuals with an alcohol use disorder may continue to consume alcohol despite the knowledge that continued intake cause significant physical (e.g., blackouts, liver disease), psychological (e.g., depression), social, or interpersonal problems (e.g., violent arguments with spouse while intoxicated, child abuse) (American Psychiatric Association [APA], 2013).

Repeated intake of high doses of alcohol can affect nearly every organ system, especially the gastrointestinal tract, cardiovascular system, and the central and peripheral nervous systems. Peripheral neuropathy may be evidenced by muscular weakness, paresthesia, and decreased peripheral sensation. Memory impairment, cognitive deficits and degenerative changes in cerebellum are the most persistent central nervous system effects seen due to repeated intake of alcohol. These effects are related to the direct effects of alcohol or due to trauma and to vitamin deficiencies (particularly of the B vitamins, including thiamine). Alcohol induced amnestic disorder or Wernicke-Korsakoff syndrome (in which the ability to encode new memory is severely impaired) is relatively rare destructive central nervous system effect caused by high intake of alcohol (APA 2013).

In India, 60 percent live in rural areas with the most fundamental level of education. India's urban slums are inhabited by a rural migrated population. Literature reports that the dependence on alcohol in this population is three times higher than in the rural population (Chavan, Arun, Bhargava & Singh, 2007).

Abstinence is the total avoidance of an activity. In the United states, abstinence is used as a major approach to overcome chronic alcoholism and drug abuse. Abstinence can also be used as a treatment-outcome measure, as an indicator of its effectiveness. Abstinence is defined as the number of drug free days or weeks during treatment. The effectiveness of treatment can be measured by level of a drug in urine during treatment as an objective indicator (Peele, 1995). Three time periods of abstinence are acute detoxification period, intermediate-term abstinence period and long-term abstinence period. Acute detoxification period lasts as long as the first two weeks of abstinence. Following detoxification, first two months of abstinence is called an intermediate-term abstinence period. Abstinence extends from two months to five year is called the long-term abstinence period (Fein, Bachman, Fisher, & Davenport, 1990). There is a significant proof in terms of mental health that cognitive impairment remains after alcohol withdrawal in individuals with long-standing and extreme use of alcohol (Eckardt, Stapleton, Rawlings, Davis & Gordon, 1995; Grant, 1987; Yohman, Parsons, & Leber, 1985). Abstract thinking, cognitive flexibility and persistence, and inhibition of competing responses often seem to be impaired after years of heavy alcohol consumption (Noel et al., 2001; Ratti, Giardini, & Soragna, 2002). Alcohol use disorders identification tool (AUDIT) is a 10 item screening tool developed by WHO to assess alcohol consumption, drinking behaviors and alcohol related problem. A person who scored zero in AUDIT be categorized as non alcoholics.

Chronic alcohol intake is one of the most popular abused substance to affect the hearing mechanism. Alteration in both the function and the structure of the nervous system caused by excessive alcohol consumption has been shown by a variety of techniques. Research suggests the presence of abnormalities in Information processing abilities of alcoholics on task that assess detection (Polich et al., 1994) and orientation (Fein et al., 1995). Studies on electrophysiological measures of signal processing abilities in alcoholics revealed abnormalities in inhibitory function (Ahveninen et al., 2000), and behavioural disinhibition (LeMarquand et al., 1999). According to Begleiter et al. (1984), these abnormalities in information processing might be due to chronic alcohol consumption or genetic biological vulnerabilities which inturn increase alcohol abuse risk.

The presence of neuropsychological deficits in alcoholic individuals after abstinence is not a trivial issue; atleast some deficits are present in a majority of abstinent alcoholic individuals after acute detoxification (Fein et al., 1990). Hence, there is a need to study deficits in psychoacoustic abilities as a consequence due to excessive use of alcohol which may facilitate an understanding of the effects of alcoholism and also primary, secondary or tertiary prevention accordingly.

Need for the study

Studies found that frequency discrimination dependent on both frequency and sensation level (SL) (Wier, Jesteadt, & Green, 1977). Abel (1972) reported that two mechanisms play a role in frequency discrimination, one based on changes in the excitation pattern (a "place" mechanism) and one based on phase locking in the auditory nerve(a "temporal" mechanism). In end-organ lesions, the DLF increases in contrast to the DLI, which often diminishes. For the discrimination of temporal gaps, a just noticeable difference in duration (ΔT) depends on the stimulus marker, decreasing as its amplitude increases. For the discrimination of noise or tone burst, ΔT is independent of the magnitude of the stimulus.

Reviews of the article showed that discrimination is more affected than detection because of alcohol consumption (Jellinck & McFarland, 1940; Wallgren & Barry, 1970). Studies on differential limen intensity

(DLI) in alcoholics showed the increased threshold for DLI (Hansen, 1925 & Specht, 1907, as cited in Schneider & Carpenter, 1969; Schwab & Ey, 1955, as cited in Wallgren & Barry, 1970). Pearson, Dawe, and Timney (1999) conducted the frequency discrimination task on six alcoholics. Frequency discrimination threshold were measured for six carrier frequency(100,200,400,800,1600 and 3200 Hz). This study revealed the significant effect of alcohol on frequency discrimination especially at higher frequencies (> 1000Hz). The frequency discrimination scores were < 1Hz at frequencies < 1000Hz, at frequencies >1000Hz scores were 3 fold greater than at lower frequencies .The studies so far conducted evaluate the effect of alcoholism on the differential sensitivity of frequency and intensity. Since none of the studies have extensively explored whether there is any change in difference limen for frequency, intensity, and duration in abstinence alcoholics, it is crucial to measure the abstinence effect of alcohol on differential sensitivity using behavioral measures.

Aim

The study aimed to measure and compare differential sensitivity measures for frequency, intensity, duration between abstinent alcoholics and non-alcoholics.

Objectives

- To study the effect of alcohol in abstinence alcoholics using frequency difference limen (DLF), intensity difference limen (DLI) and duration discrimination test (DDT).
- To compare frequency difference limen (DLF), intensity difference limen (DLI) and duration discrimination test (DDT) in abstinent alcoholics with non-alcoholic individuals.

Null hypothesis

The null hypothesis is framed for each main objectives of the study. They are

- There is no effect of alcohol abuse in frequency difference limen, intensity difference limen and duration discrimination test of alcoholics in abstinence.

- There is no significant difference in frequency difference limen between abstinent alcoholics and non alcoholics.
- There is no significant difference in intensity difference limen between abstinent alcoholics and non alcoholics.
- There is no significant difference in duration discrimination test between abstinent alcoholics and non alcoholics.

Chapter 2

Review of literature

The major concern for public health in developed countries is the widespread use of alcohol. According to International Classification of Diseases (ICH), it is considered as disease (WHO, 1999). The harmful use of alcohol is one of the leading risk factors for population health worldwide and has a direct impact on many health-related targets (WHO, 2018).

2.1 Differential sensitivity measures

Differential sensitivity is the ability of our ear to differentiate between two signals. This ability is measured as a difference limen (DL) also known as just noticeable difference (JND). Difference limen is the minimum perceivable difference in dB between two signal differ in intensity, frequency or duration.

2.2 Auditory effects in alcoholics

2.2.1 Peripheral auditory effects

2.2.1.1 Acute effects of alcohol

Impairment in outer hair cell (OHC) functions have been reported due to intake of alcohol (Hwang, Tan, Chiang, & Liu, 2003). The authors evaluated pure tone thresholds (PTA) and distortion product oto acoustic emission (DPOAE) in eight subjects (3 males, 5 females; mean age 25.6 years; range 22- 29 years) before and after alcohol consumption. All the individuals were non abusive alcoholics. The results showed no significant changes in pure tone thresholds and decrease in (DPOAE) amplitude after alcohol consumption. Significant decreases in DPOAE amplitude was observed at 30 minutes and 1 hour after alcohol consumption at frequencies 5500Hz and 6562 Hz. However, mean changes in DPOAE amplitude measured at various times was not statistically significant. No changes in DPOAE amplitude was reported for frequencies below 4375 Hz.

Hence authors concluded that acute alcohol consumption may cause temporary reduction in DPOAE amplitude especially at high frequencies without affecting hearing thresholds.

Upile et al. (2007) conducted a study on thirty normal hearing individuals with a mean age of 27 ± 5 years. The authors measured hearing thresholds before and after alcohol intake. Participants had consumed alcohol until the breath alcohol concentration reached upto 30 u/l. Significant increase in hearing thresholds after alcohol intake was seen in all subjects with a mean change of 7dB with 90% of subjects having 3 or more frequencies affected. Low frequencies were more affected including 1000 Hz than high frequencies. Positive correlation was seen between elevated hearing thresholds and breath alcohol concentration (p = 0.6). It was concluded that low frequencies mostly 1000 Hz was affected due to alcohol consumption. Thus auditory threshold and DPOAE amplitude altered after alcohol consumption which signifies temporary peripheral auditory system damage imposed by acute alcohol intake.

2.2.1.2 Chronic effects of alcohol

Long term effect of alcohol consumption on hearing threshold was studied by Belle, Sartori, and Rossi (2007). The experiment group with 37 individuals was further divided into two groups based on their age with age range of 33-49 years in Experimental A (EA) group and 50-70 years in Experimental B (EB) group. Thirty seven age matched non alcoholic individuals were also included in this study. The mean alcohol intake duration was 19.5 years and 29.45 years for EA and EB respectively. Pure tone audiometry was done to find out alteration in hearing thresholds. The results showed 67.5% alcoholic individuals showed abnormalities in audiometry. Among them 55% (N=11) of the individuals in EA group and 82.5 % (N=14) of them in EB group had altered hearing threshold. For the control group A, 20% of the individuals (N=4) and 35.29% in control group B (N=6) had hearing threshold alteration. Since alcohol is considered as an ototoxic agent, long term intake of alcohol caused deleterious effect on cochlea. As considering age factor, alteration in hearing threshold was not solely due to chronic alcohol intake in EB group. But in EA group chronic alcoholism leads to increased hearing thresholds than controls. Thus, authors concluded that abused alcohol usage interferes with hearing and balancing system leads to deleterious effect of the human body.

2.2.2 Central effects

2.2.2.1 Auditory brainstem response

Chu, Squires, and Starr (1982) aimed to study prevalence of brainstem abnormalities in chronic alcoholics. This study included 66 chronic alcoholics (mean age - 44.8 years) with (n=17) and without (n=49) alcohol related neurological problems. The mean duration of alcohol intake was 25 years. Auditory brainstem response (ABR) was recorded from 66 subjects using click stimulus presented at 65 dBnHL. The results showed prolonged inter-peak latencies of I-V, I-III,III-V in 41% (i.e.21 out of 66) of the study group. The mean interval of wave I-V was 4.36 + 0.35ms. The incidence of abnormal ABR for chronic alcoholics without neurological problems was 12 %. Among subjects with neurological disorder, cerebellar degeneration had the highest incidence of abnormal ABR (83%) followed by wernicke karsakoff syndrome (50%), hepatic encephalopathy (50%), dementia (50%) and deilrium tremens (25%). Thus the study reported that chronic alcoholics even without any clinical history of brainstem involvement may have brainstem disorders.

2.2.1.2 Cortical potentials

Effect of low dose of ethanol (0.5 g/kg) on mismatch negativity (MMN) was investigated by Jaaskelainen et al. (1995). A study was conducted on 10 alcoholics using a single-blind, placebo-controlled cross over design. A low dose of ethanol was given and MMN was measured for dichotic stimuli in which subjects were instructed to attend to stimuli in one ear while ignoring the stimuli in other ear. The results of the study revealed both amplitude and latency were significantly affected after alcohol consumption. The amplitude of N1,P2 and MMN were diminished and latencies of N2b and MMN were prolonged after alcohol consumption. The amplitude of MMN were significantly reduced by 60% of its amplitude after the dose of ethanol. The authors concluded that reduction in amplitude might be due to disturbed preconscious detection of acoustic changes .

Hence the authors suggested that automatic information processing systems are more sensitive to alcohol intake than controlled, attentional functions. From the above studies, it has been revealed that chronic alcohol intake not only affects peripheral auditory system but also the central auditory system.

2.3 Auditory effects in abstinent alcoholics

2.3.1 Peripheral effects

Ribeiro et al. (2007) analyzed the effect of alcohol abuse in auditory system in their period of abstinence. 75 subjects were divided into two experimental groups (GE1 & GE2) and two control groups (GC1 & GC2). The mean age of GE1, GE2, GC1, GC2 groups were 46.3 years, 45.7 years, 45.4 years and 45.5 years respectively. The experimental group is further divided into two groups based on history of noise exposure. 18 subjects were in GE1 with no history of noise exposure and 22 subjects in GE2 with history of noise exposure. The mean duration of abstinence was 14.3 years and 1.4 years for GE1 and GE2 respectively. Pure tone audiometry (PTA) and Transient evoked oto acoustic emission (TEOAE) results were compared between control group 1 and experimental group 1 (GC1/GE1) and between control group 2 and experimental group 2 (GC2/GE2) and also between experimental group 1 and 2 (GE1/GE2). The study results revealed statistical significant difference in PTA between GC1 and GE1 at 3kHz ($p = 0.028$) and 6kHz ($p = 0.040$) in the right ear, and 3kHz ($p = 0.048$) and 4kHz ($p = 0.038$) in the left ear. The comparison between groups which exposed to noise (GC2 & GE2), showed a statistical significant difference in PTA only at 0.5 kHz ($p = 0.029$) in right ear.No significant difference in PTA and TEOAE responses were found between groups GE1 and GE2. Thus study results revealed higher rate of hearing loss and absence of TEOAE in alcoholic group than control group. The combined exposure to alcohol and noise was not synergic on the auditory system. Hence the authors concluded that cochlear damage, especially OHC are more prone to damage due to long term alcohol abuse. From this study, we can interpret that chronic alcoholism caused more permanent damages to peripheral auditory system even after abstinence than noise exposure.

2.3.2 Central effects

Diaz, Cadaveira, and Grau (1990) recorded short and middle latency auditory evoked response in 15 chronic alcoholics after one month of abstinence with the age range of 23-51 years. All the subjects had histories of alcohol abuse for atleast 8 years. Brainstem auditory evoked potential (BEAP) results showed significant delayed in peak V latency and III-V and I-V interpeak latencies. The latencies of the middle auditory evoked potential (MAEP) components Na and Pa, on the other hand, were significantly shortened. These findings suggest that chronic abusive consumption of alcohol may bring about structural and /or neurochemical alterations at various levels in the auditory pathway.

Cadaveira et al. (1994) studied changes in ABR in 34 chronic alcoholics who had been abstinent for 1 year. ABR was recorded at 1 month, 5month and 1 year of abstinence period. After 1 month of abstinence, subjects showed significant difference in peak V latency and in III-V and I-V interpeak latency differences with respect to controls. In the first 5 month shortening of III-V interval and in the 5-12 month period, shortening of latency and in the V-I interval was seen. After 1 year of abstinence, a significant improvement in the V, III–V and I–V parameters was recorded. The author concluded that the recovery of the functions impaired by chronic alcohol consumption after 1 year of abstinence was incomplete, although the tendency was towards normalization

Singh, Kaur, Kaur, Walia, and Sharma (2016) recorded ABR in 26 chronic alcoholics who were abstinence for 10 days before testing and 26 non alcoholics. Individuals with normal hearing who were taking alcohols for more than 8 years were included in experimental group. ABR was recorded and wave V latency was compared between control and experimental group. The result of this study revealed significant increase in wave V latency (5.874 ± 0.2969 ms) in alcoholics as compared to non alcoholics (5.678 ± 0.2271 ms). Significant increase in Inter peak latency I-V, III-V (4.199 ± 0.4225ms , 2.495 ± 0.3892 ms) in alcoholics than non alcoholics (3.883 ± 0.2579ms, 2.228 ± 0.348ms). The authors concluded that increase in wave V latency and interpeak latencies could be due to demyelination in auditory pathway.

From the above studies, we conclude that chronic alcoholism leads to damage in auditory pathways which inturn delays the conduction of signals and the damages sustain even after 1 year of abstinence.

2.3.2.1 Cortical potentials

Realmuto, Begleiter, Odencrant, and Porjesz (1993) recorded MMN in 63 alcoholics with average abstinence period of 31.4 days and 27 non alcoholics . The mean age of abstinent alcoholics was 34.65 years. MMN was recorded at three different sites (Fz,Cz and Pz)using odd ball paradigm with 1000 Hz tone as frequent stimulus and 750 Hz as infrequent stimulus. The tones were presented binaurally with 1.5 msec as fixed interstimulus interval.The study results showed a significant decrease in amplitude of N2,P3 and N2-P3 complex in alcoholics than controls. No significant difference was seen in latency between groups. The authors suggested that decrease amplitude might reflect a deficit of preperceptual, automatic and subsequent mismatch processes.

Fein, Whitlow, and Finn (2004) assessed the effects of chronic alcoholism abuse and abstinence duration on MMN amplitude. 38 subjects (mean age 45.9 $\pm$ 6.3 years) who met DSM IV criteria with minimum of 6 months of abstinence from alcohol were included in the experimental group and 38 social drinkers (mean age 41.5 $\pm$ 9.1 years) whose lifetime average drinking was less than 30 drinks/month were included in the control group. MMN was recorded by presenting 350 standard tones (1000 Hz) and 50 mismatch tones (500 Hz /2000 Hz) at a level of 60 dB. The results showed no significant difference in MMN amplitude and latency between groups. Hence , the authors concluded that chronic alcoholism had no effect on MMN. The difference in results between two studies might be due to methodological difference wherein first study the comparison was between abstinence alcoholics and non alcoholics whereas in second study the comparison was between abstinence alcoholics and social drinkers. But in both studies MMN was not completely absent thus unveil that chronic alcoholism following abstinence has little or no effects on MMN. This inturn indirectly indicate that higher level of auditory processing recover after withdrawal from alcohol. Research have shown increased MMN amplitude than controls after withdrawal of alcohol. This might be due to CNS hyperexcitability post withdrawal of alcohol which has been detectable at 3–8 weeks after alcohol detoxification (Ahveninen et al., 2000; Alling et al., 1982; Kathmann et al., 1995).

2.4 Abstinent alcoholism and its Psychophysical correlates of Hearing

Pitch, loudness, and duration play an important role in the perception of speech, language, and music. In general, the talker's information will be carried by the pitch, duration and loudness of the stimuli basically speech. When considering human discrimination abilities, conventional pure tones been used to judge the difference in sound with that of standard sound and usually tested by using psychophysical tests which involves the entire auditory system (Shofner, 2008). Abstinent chronic alcoholism, can lead to cochlear and neural damage . Hence, when the cochlea is damaged the functioning abilities such as coding, differentiation and temporal processing abilities will be affected. Previous studies have also reported sensory and neural damage in abstinent alcoholics. Therefore, there might be deficits in differential sensitivity in abstinent alcoholics. There is a need to study the effect of abstinent alcoholism on differential sensitivity as there is limited literature in this area.

Chapter 3

Method

3.1 Participants:

Forty (eighty ears) normal hearing individuals within the age range of 20-50 years participated in the study. These individuals were divided into two groups, with group I (mean years = 31.0, SD = 6.9) and group II (mean years = 21.15, SD = 1.8) based on the study inclusion criteria.

3.1.1 Inclusion criteria:

Abstinent alcoholics (Group I)

- Individuals with a clinical diagnosis of alcohol use disorder according to DSM 5 criteria (APA, 2013) with abstinence of 21 days or more (Díaz, Cadaveira & Grau, 1990)
- Individuals with normal hearing sensitivity. Hearing threshold: Air conduction hearing thresholds should be within -10 dBHL to 15 dBHL at octave frequencies between 250Hz to 8000Hz
- No history or presence of any external or middle ear problem
- No history or presence of any neurological problem
- No history of diabetes mellitus and hypertension.
- No history or presence of any medical related problems
- No history of head injury
- No history of frequent use of opiate, inhalant or smoking
- No history of psychiatric disorders
- Abstinent alcoholic individuals, those who scored greater than or equal to 24 points in Mini Mental State Examination (MMSE) (Folstein, 1975).

Non-alcoholics (Group II)

- Non-alcoholic individuals who were willing to participate in this study was interviewed for any substance abuse and exclusionary medical conditions
- Individuals who scored zero in AUDIT.
- Individuals with normal hearing sensitivity. Hearing threshold: Air conduction hearing thresholds should be within -10 dBHL to 15 dBHL at octave frequencies between 250Hz to 8000Hz
- No history of major depression, untreated sleep apnea, polypharmacy
- No history of severe head injury, stroke
- No history of any chronic neurological condition (Alzheimer’s or Parkinson’s disease), chronic psychosis or schizophrenia

3.2 Equipment:

The following equipments were used in the study

- Screening audiometer and middle ear analyser were used for evaluation.
- A laptop loaded with following software: MATLAB software [MATLAB 7.12.0 (R2011a)]

3.3 Testing environment:

All audiological tests was carried out in a sound treated double room where the noise levels were within permissible limits (American National Standards Institute [ANSI], 1999).

3.4 Stimuli & Procedure:

Written informed consent was taken from all the participants for willingly participating in the investigation.

a) Detailed case history

A detailed case history was taken as a closed set interview on the clinical symptoms of auditory and vestibular disorders, the presence of tinnitus, ototoxic drugs, and general health conditions.

b) Otoscopy

Otoscopy was carried out before the testing. It was done to visually inspect the status of the external ear canal and tympanic membrane.

c) Obtaining thresholds

For each test ear, hearing thresholds had been estimated for both air conduction and bone conduction at octave frequencies using Modified Hughson and Westlake procedure (Carhart & Jerger, 1959)

d) Acoustic Immittance audiometry

Tympanometry for 226 Hz probe tone was obtained to assess middle ear status. Acoustic reflex thresholds for octave frequencies ranging from 0.5 KHz to 4KHz were also obtained.

e) **Assessment of difference limen abilities**

All differential sensitivity tests were carried out using “Maximum Likelihood Procedure” toolbox which applies maximum likelihood procedure in MATLAB (Grassi & Sorano, 2009). The maximum likelihood procedure uses a large number of candidate psychometric functions, and after each trial, calculates the probability (or likelihood) of obtained the listener’s response to all of the stimuli that have been presented given each psychometric function. The psychometric function yielding the highest probability is used to determine the stimulus to be presented in the next trial. Within about 12 trials, the maximum likelihood procedure usually converges on a reasonably stable estimate of the most likely psychometric function, which then can be used to estimate threshold (Grassi & Soranzo, 2009; Green, 1990, 1993). This procedure has been widely used to assess psychophysical abilities and found to have good reliability and validity (Kumar & Sangamanatha, 2011).

Stimuli for all psychophysical tests were reproduced at 44,100 Hz sampling rate. All the tests were performed using a three-interval alternate forced-choice technique to track a 79.4% correct response criterion (Levitt, 1971). Each trial consisted of three blocks, wherein, two blocks had the standard stimulus and the other block had the variable stimulus. The participant's task was to identify the block containing the variable stimulus. All the psychophysical tests was performed as per the procedure stated above and the presentation of the stimulus and acquisition of the response was controlled by the mlp toolbox. Before the beginning of each test 5 -6 practice items were given. The tests had been performed in a randomized order across participants to avoid potential order effects. The stimulus for all difference limen tests was presented at 85 dB SPL. Headphone was calibrated to produce the desired output using Bruel and Kjaer 2270 sound level meter in a 6 cc coupler Stimulus duration was kept at 250 ms for most of the tests as it avoids temporal integration.

The difference equivalent to the 79.4% psychometric function was estimated by using a three down, one up rule (Levitt, 1971). Details of the stimuli and procedure used for individual tests are provided below:

3.4.1 Frequency difference limen (DLF): In this, the minimum frequency difference necessary to discriminate two closely spaced frequencies were assessed. Frequency difference limen (FDL) was measured at octave frequencies ranging from 0.5-6 KHz (500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz). Both the standard and variable stimuli was of 250 ms long pure tones gated with the onset and offsets of 10 ms raised cosine ramp (Grassi & Soranzo, 2009; Jain, Mohamed, & Kumar, 2014). Each trail consisted of three blocks, of which two blocks had identical frequency pure tones (standard) and another block contained pure tone of frequency higher than standard frequency (variable). The minimum and maximum frequency deviation of the variable stimulus were 0.1 Hz and 200 Hz respectively. The listener’s task was to detect the variable block.

3.4.2 Intensity difference limen (DLI): In this, the minimum intensity difference necessary to discriminate two otherwise same sounds was assessed. Intensity difference limen (IDL) was measured at octave frequencies ranging from 0.5 – 6 KHz (500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz). The standard and variable stimuli were pure tones of 250 ms gated with 10 ms raised cosine ramps (Grassi & Soranzo, 2009; Jain et al., 2014). The minimum and maximum intensity deviation were used at 0.99 dB and 10 dB. Each trail consisted of three blocks, of which two blocks had identical intensity pure tones (standard) and another block had pure tone of duration higher than the standard tone (variable). The listener's task was to detect the variable block.

3.4.3 Duration discrimination test (DLT): The minimum time difference necessary to discriminate between two otherwise same sounds was assessed. Time difference limen (TDL) was measured at octave frequencies ranging from 0.5Hz - 6KHz (500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz). The standard and variable stimuli were pure tones of 250 ms gated with 10 ms raised cosine ramps (Grassi & Soranzo, 2009; Jain et al., 2014).The variable stimuli changed in its duration randomly from 0.1 msec to 200.1 msec**.** Each trail consisted of three blocks, of which two blocks had identical duration pure tones (standard) and another block had pure tone of duration longer than the standard tone (variable). The listener’s task was to detect the variable block.

3.5 Statistical Analyses

The data obtained from the study was subjected to statistical analyses using the statistical package for the social science (version 21). Descriptive statistics was carried out to estimate the mean and standard deviation for all the parameters. Following this test of normality and other assumptions of non parametric tests like Wilcoxon signed rank test for within group comparisons of right and left ear scores and Mann whitney U test for between group comparisons of scores were carried out.

Chapter 4

Results

The present study, included two groups of participants. The group I included abstinent alcoholics and the group II included non alcoholics. In each group, 20 participants (40 ears) participated in the study. Differential limen for frequency (DLF), intensity (DLI) and duration (DLT) were assessed for all the participants using "mlp" toolbox which implements a maximum likelihood procedure in MATLAB 7.12.0 (R2011a). The data obtained were analyzed using Statistical Package of Social Science (SPSS) software version 20.0.

The results of the study are explained under following headings:

1. Comparison of the differential limen for frequency between abstinent alcoholics and non alcoholics
2. Comparison of the differential limen for intensity between abstinent alcoholics and non alcoholics
3. Comparison of the differential limen for duration between abstinent alcoholics and non alcoholics

Shapiro Wilk test of normality was administered to check whether the data was normally distributed or not and was found to be not normally distributed ($p < 0.05$). Hence, non-parametric tests were carried out for further statistical analysis.

4.1 Comparison of differential limen for frequency between abstinent alcoholics and non alcoholics.

The data was collected separately for right ear and left ear. Wilcoxon signed rank test was carried out to check if there is significant difference in results between ears. The results of Wilcoxon signed rank test comparing right and left ear DLF for all frequencies of differential limen scores are depicted in Table 4.1.

Table 4.1.

Results of wilcoxon signed rank test comparing right and left ear for scores of DLF at all frequencies

DLF	Group I Z values ('p' value of significance)	Group II Z values ('p' value of significance)
DLF 500 Hz	-1.9 ($p > 0.05$)	-1.1 ($p > 0.05$)
DLF 1000 Hz	-2.7 ($p < 0.05$)	-1.2 ($p > 0.05$)
DLF 2000 Hz	-.37 ($p > 0.05$)	-.03 ($p > 0.05$)
DLF 4000 Hz	-.07 ($p > 0.05$)	-.07 ($p > 0.05$)
DLF 6000 Hz	-2.6 ($p < 0.05$)	-1.7 ($p > 0.05$)

From Table 4.1 it can be seen that there is no significant differences for DLF of group I between ears at 500 Hz, 2000Hz, 4000 Hz and in group II for all the test frequencies. Hence, for further analyses the data of left ear and right ear were combined. Descriptive analysis was done with the combined data to find the mean, median, and standard deviation (SD) scores for differential limen across frequencies such as 500Hz, 1000 Hz, 2000 Hz ,4000 Hz and 6000 Hz for group I and group II participants as shown in Table 4.2.

Table 4.2

Mean, Median and Standard deviation (SD) scores of DLF across frequencies such as 500Hz, 1000 Hz, 2000 Hz, 4000 Hz and 6000 Hz for group I and II

DLF	GROUP	MEAN in Hz (SD)	MEDIAN in Hz
500 Hz	Group I	10.8 (± 1.5)	10.9
	Group II	8.7 (± 2.5)	8.8
1000 Hz	Group I	33.9 (±23.9)	26.3
	Group II	14.7 (±10.1)	12.5
2000 Hz	Group I	50.2 (±27.3)	46.2
	Group II	31.3 (±18.3)	27.2
4000Hz	Group I	77.6 (±20.9)	80.9
	Group II	48.5 (±24.5)	47.0
6000Hz	Group I	78.7 (±26.2)	95.8
	Group II	54.7 (±25.5)	48.1

The data of Table 4.2 reveal that there is difference in scores between both the groups, which indicated high differential limen for frequency for abstinent alcoholics compared to non alcoholics. Further, Mann-Whitney U test was administered for between group comparisons. The results of Mann Whitney U test are shown in the Table 4.3 for differential limen across frequencies.

Table 4.3

The results of Mann Whitney U test for DLF between groups

FREQUENCY	*U* **values**	***p –value***
500 Hz	-4.505	$p < 0.05$
1000 Hz	-4.901	$p < 0.05$
2000 Hz	-3.320	$p < 0.05$
4000 Hz	-4.836	$p < 0.05$
6000 Hz	-3.864	$p < 0.05$

The results of Table 4.3 showed that DLF were significantly different between abstinent alcoholics and non alcoholics at all frequencies.

4.2 Comparison of differential limen for intensity between abstinent alcoholics and non alcoholics

The data was collected separately for right ear and left ear. Wilcoxon signed rank test was carried out to check if there is significant difference in results between ears. The results of Wilcoxon signed rank test comparing right and left ear DLI for all frequencies of differential limen scores are depicted in Table 4.4

Table 4.4

Results of Wilcoxon signed rank test comparing right and left ear for scores of DLI at all frequencies

DLI	**Group I Z values (‘p’ value of significance)**	**Group II Z values (‘p’ value of significance)**
DLI 500 Hz	-0.1 ($p > 0.05$)	-1.2 ($p > 0.05$)
DLI 1000 Hz	-1.5 ($p >0.05$)	-0.9 ($p > 0.05$)
DLI 2000 Hz	-1.1 ($p > 0.05$)	-0..4 ($p > 0.05$)
DLI 4000 Hz	-1.3 ($p > 0.05$)	-1.5 ($p > 0.05$)
DLI 6000 Hz	-0.9 ($p > 0.05$)	-0.6 ($p > 0.05$)

From Table 4.4, it can be seen that there is no significant difference between right and left ear DLI in both groups. Hence, for further analyses the data of left ear and right ear were combined. Descriptive analysis was done with the combined data to find the mean, median, and standard deviation (SD) scores for differential limen intensity across frequencies such as 500Hz, 1000 Hz, 2000 Hz ,4000 Hz and 6000 Hz for group I and group II participants as shown in Table 4.5.

Table 4.5

Mean, Median and Standard deviation (SD) scores of DLI across frequencies such as 500Hz, 1000 Hz, 2000 Hz, 4000 Hz and 6000 Hz for group I and group II

DLI	**GROUP**	**MEAN in Hz (SD)**	**MEDIAN in Hz**
500 Hz	Group I	3.8 (± 2.1)	3.3
	Group II	2.4 (± 1.4)	2.1
1000 Hz	Group I	4.1 (± 1.9)	3.6
	Group II	3.4 (± 1.7)	2.9
2000 Hz	Group I	4.7 (± 2.5)	4.6
	Group II	2.9 (± 1.3)	2.7
4000Hz	Group I	4.7 (± 2	4.7
	Group II	3.6 (± 1.7)	3.9
6000Hz	Group I	5.5 (± 2.4)	5.0
	Group II	3.8 (± 2.0)	3.9

The data of Table 4.5 showed that there is difference between both the groups, which indicated high differential limen for intensity in abstinent alcoholics compared to non alcoholics. Further, Mann-Whitney U test was administered for between group comparisons. The results of Mann-Whitney U test are shown in the Table 4.6 for differential limen across frequencies.

Table 4.6

The results of Mann-Whitney U test for DLI between groups

FREQUENCY	U **values**	***p –value***
500 Hz	-3.372	$p < 0.05$
1000 Hz	-1.800	$p > 0.05$
2000 Hz	-3.566	$p < 0.05$
4000 Hz	-2.244	$p > 0.05$
6000 Hz	-3.225	$p < 0.05$

The result of Table 4.6 shows significant difference in DLI between abstinent alcoholics and non alcoholics at all frequencies except 1000 Hz and 4000 Hz.

4.3 Comparison of differential limen for duration between abstinent alcoholics and non alcoholics

The data was collected separately for right ear and left ear. Wilcoxon signed rank test was carried out to check if there is significant difference in results between ears. The results of Wilcoxon signed rank test comparing right and left ear DLT for all frequencies of differential limen scores are depicted in Table 4.7.

Table 4.7

Results of Wilcoxon signed rank test comparing right and left ear DLT at all frequencies

DLT	**Group I Z values ('p' value of significance)**	**Group II Z values ('p' value of significance)**
DLT 500 Hz	-0.3 ($p > 0.05$)	-0.9 ($p > 0.05$)
DLT 1000 Hz	-1.8 ($p >0.05$)	-0.6 ($p > 0.05$)
DLT 2000 Hz	-0.6 ($p > 0.05$)	-1.1 ($p > 0.05$)
DLT 4000 Hz	-0.3 ($p > 0.05$)	-0.3 ($p > 0.05$)
DLT 6000 Hz	-0.2 ($p > 0.05$)	-0.4 ($p > 0.05$)

From Table 4.7, it can be seen that there is no significant difference between right ear and left ear DLT scores in both groups. Hence, for further analyses the data of left ear and right ear were combined. Descriptive analysis was done with the combined data to find the mean, median, and standard deviation (SD) scores for differential limen duration across frequencies such as 500Hz, 1000 Hz, 2000 Hz ,4000 Hz and 6000 Hz for group I and group II participants as shown in Table 4.8.

Table 4.8

Mean, Median and Standard deviation (SD) scores of DLT across frequencies such as 500Hz, 1000 Hz, 2000 Hz, 4000 Hz and 6000 Hz in group I and group II

DLT	**GROUP**	**MEAN in Hz (SD)**	**MEDIAN in Hz**
500 Hz	Group I	76.8 (± 31.3)	81.4
	Group II	43.1 (± 19.0)	37.1
1000 Hz	Group I	72.7 (± 31.4)	64.3
	Group II	34.4 (± 14.3)	34.7
2000 Hz	Group I	78.7 (± 36.1)	79.3
	Group II	38.4 (± 21.7)	34.1
4000Hz	Group I	92.0 (± 63.6)	82.9
	Group II	38.8 (± 21.2)	36.2
6000Hz	Group I	91.7 (± 40.6)	92.9
	Group II	46.9 (± 22.5)	47.3

The data of Table 4.8 showed difference between both the groups, which indicated high differential limen for duration in abstinent alcoholics compared to non alcoholics. Further, Mann-Whitney U test was administered for between group comparison .The results of Mann-Whitney U test are shown in Table 4.9 for differential limen across frequencies.

Table 4.9

The results of Mann Whitney U test for DLT between groups

FREQUENCY	*U* **values**	***p* –*value***
500 Hz	-4.967	$p < 0.05$
1000 Hz	-6.180	$p < 0.05$
2000 Hz	-5.362	$p < 0.05$
4000 Hz	-5.559	$p < 0.05$
6000 Hz	-5.158	$p < 0.05$

The results of Table 4.9 showed significant difference in DLT between abstinent alcoholics and non alcoholics at all frequencies.

Chapter 5

Discussion

Our objectives of the study is to find the effect of alcohol in abstinence alcoholics using frequency difference limen (DLF), intensity difference limen (DLI) and duration discrimination test (DDT) and to compare DLF, DLI, DLD in abstinent alcoholics with non-alcoholic individuals.

The findings obtained are elaborately discussed under the following sections:

5.1. Comparison of DLF on abstinent alcoholics and non-alcoholics:

The present study result revealed significantly higher frequency discrimination scores in abstinent alcoholics than non-alcoholics. The result supports earlier findings stating that increased frequency discrimination scores in alcoholics (Pearson et al.,1999) and decreased amplitude of MMN for tones differ in the frequency in abstinent alcoholics (Realmuto et al., 1993).The auditory processing is a fundamental component of most auditory tasks, which is seen at different stages, starting from the effect of the onset of stimulus processes by neurons and response to speech which is a higher level function controlled by the cortex. Hence, when the cochlea is damaged, the functioning abilities such as coding, differentiation, and temporal processing abilities would be affected. It is well known that normal cochlear/neural functioning is important for differential sensitivity or limen, which plays a vital role in the perception of speech. Since, there are cochlear or neural damage reported in chronic alcoholics even after abstinence (Ribeiro et al.,2007 ; Belle et al.,2007;), this could have lead to poor performance in differential sensitivity in the present study.

5.2 Comparison of DLI on abstinent alcoholics and non-alcoholics:

In our study, we found significant difference in intensity discrimination between abstinent alcoholics and non alcoholics in all frequencies except 1000 Hz and 4000 Hz. The difference in DLI between abstinent alcoholics and non alcoholics might be due to demyelination or neuro chemical alteration in auditory pathway due to chronic alcoholism. This assumption is in agreement with Ylikoski et al. (1981) description, where studies on the temporal bones and the brainstem of alcoholic subjects have shown that loss of cochlear neurons are usually accompanied by advanced loss of hair cells.These damages sustain even after one year of abstinence (Cadaveira et al.,1994).

No significant difference was found at 1000 Hz and 4000 Hz frequencies. One possible reason could be post withdrawal CNS hyperexcitability as reported in abstinent alcoholics (Ahveninen et al., 2000; Kathmann et al., 1995 ; Alling et al., 1982).According to Alling et al. (1982), post withdrawal brain hyperexcitability effect remains as long as 8 weeks after cessation of alcohol intake.

5.3 Comparison of DLT on abstinent alcoholics and non-alcoholics:

The duration discrimination was poorer in abstinent alcoholics compared to non-alcoholics. One of the possibilities was long stimulus processing time in abstinent alcoholics. Thus in alcoholics, even easy discrimination task requires more time to process as of difficult ones. Thus inturn reflected in poorer discrimination scores due to memory deficit or deficit of preperceptual, automatic and subsequent mismatch processes (Porjesz et al ., 1986; Realmuto et al., 1993). Chronic alcoholism is accompanied by “frontal” neuropsychological deficits that include an inability to maintain focus of attention. Attentional deficits in abstinent alcoholics are indicated by increased distractibility by irrelevant sound changes, which are interpreted to reflect impaired inhibition of task-irrelevant processing (Cohen et al., 1997).The loss of this task-relevant inhibition could explain the pronounced distractibility by task irrelevant sound changes in alcoholics. This was indicated by increased reaction time lag for trials that succeeded frequency deviants in study done by Azhveninen et al. (2000). Thus poorer duration discrimination might be attributed to attentional deficits in abstinent alcoholics.

Thus in our study, reduced discrimination ability even in the period of abstinence might be due to demyelination in auditory pathways, which could progress towards normalization. Subclinical brainstem abnormalities in chronic alcoholics were reported by Chu et al. (1982), this could be the reason for no significant hearing complaints reported by participants of our study.

Chapter 6

Summary and conclusion

The present study showed the adverse of chronic alcoholism on differential sensitivity of frequency, intensity and duration in alcoholics even in the period of abstinence. Since none of the studies have explored whether there is any change in differential sensitivity measures due to excessive alcohol intake in abstinent alcoholics, the present study aimed to measure and compare differential sensitivity measures for frequency, intensity, duration between abstinent alcoholics (Group I) and non-alcoholics (Group II). A total of 40 participants were included in the study. DLF, DLI and DLT were assessed across frequencies (500 Hz, 1000 Hz, 2000Hz, 4000Hz & 6000Hz).

The result of the study revealed that here was a significant difference between Group I and Group II on measurement of DLF, DLI and DLT at all frequencies except at 1 kHz and 4 kHz in DLI. Individuals with history of chronic alcoholism scored poorer in discrimination tasks than non alcoholics. This could be due to cochlear damage or demyelination / neurochemical changes in auditory pathways or auditory processing deficits as a result of excessive alcohol consumption. Thus reveals decreased sensitivity to acoustic signals in chronic alcoholics even in the period of abstinence.

6.1 Implications of the study

- The study helps to understand the effect of chronic alcoholism in differential sensitivity measures.
- This would help in counselling the patients regarding the deleterious effect of alcohol on auditory structures and functions even in the period of abstinence.
- This study helps us to understand that even in young adults, differential limen abilities are affected, especially between the age group 20-50 years before the presbycusis effects are seen.

6.2 Future directions

- To study the relationship between the quantity of alcohol ingested, duration of abstinence and audiological measures.

- Correlation of differential sensitivity deficits with quality of life could have been done.
- The results of the psychophysical (behavioral) measures could be correlated with the electrophysiological measures for better validation.
- Studies could be carried out to determine the combined effect of alcohol with other systemic diseases.

6.3 Limitation of the study

The results of the study are valid only for adults. The study should be carried out on other age groups too for better generalization of the results.

References

Abel, S. M. (1972). Duration discrimination of noise and tone bursts. *The Journal of the Acoustical Society of America*, *51*(4B), 1219-1223.

Ahveninen, J., Escera, C., Polo, M. D., Grau, C., & Jääskeläinen, I. P. (2000). Acute and chronic effects of alcohol on preattentive auditory processing as reflected by mismatch negativity. *Audiology and Neurotology*, *5*(6), 303-311.

Alling, C., Balldin, J., Bokström, K., Gottfries, C. G., Karlsson, I., & Långström, G. (1982). Studies on duration of a late recovery period after chronic abuse of ethanol: a cross-sectional study of biochemical and psychiatric indicators. *Acta Psychiatrica Scandinavica*, *66*(5), 384-397.

American National Standards Institute. (1999). Maximum permissible ambient noise levels for audiometric test rooms. *New York: Author.*

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. *BMC Med, 17, 133-137.*

Bechara A, Dolan S, Denburg N, Hindes A, Anderson SW, Nathan PE (2001) Decision-making deficits, linked to a dysfunctional ventromedial prefrontal cortex, revealed in alcohol and stimulant abusers. *Neuropsychologia 39*(4)*:*376–389.

Begleiter H, Porjesz B, Bihari B (1984) Event-related brain potentials in boys at risk for alcoholism. *Science 225:*1493–1496.

Begleiter, H. E. N. R. I., & Porjesz, B. E. R. N. I. C. E. (1986). The P300 component of the event-related brain potential in psychiatric patients. *Evoked Potentials. New York, NY: Alan R Liss Inc*, 529-535.

Bellé, M., do Amaral Sartori, S., & Rossi, A. G. (2007). Alcoholism: effects on the cochleo-vestibular apparatus. *Brazilian journal of otorhinolaryngology*, *73*(1), 110-116.

Cadaveira, F., Corominas, M., Holguín, S. R., Sánchez-Turet, M., & Grau, C. (1994). Reversibility of brain-stem evoked potential abnormalities in abstinent chronic alcoholics: one year follow-up. *Electroencephalography and clinical Neurophysiology*, *90*(6), 450-455.

Carhart, R., & Jerger, J. F. (1959). Preferred method for clinical determination of pure-tone thresholds. *Journal of speech and hearing disorders*, *24*(4), 330-345.

Chavan, B. S., Arun, P., Bhargava, R., & Singh, G. P. (2007). Prevalence of alcohol and drug dependence in rural and slum population of Chandigarh: A community survey. *Indian journal of Psychiatry*, *49*(1), 44.

Chu, N. S., Squires, K. C., & Starr, A. (1982). Auditory brain stem responses in chronic alcoholic patients. *Electroencephalography and clinical Neurophysiology*, *54*(4), 418-425.

Chu, N. S., Squires, K. C., & Starr, A. (1982). Auditory brain stem responses in chronic alcoholic patients. *Electroencephalography and clinical Neurophysiology, 54(4)*, 418-425.

Cohen, H. L., Porjesz, B., Begleiter, H., & Wang, W. (1997). Neuroelectric correlates of response production and inhibition in individuals at risk to develop alcoholism. *Biological psychiatry*, *42*(1), 57-67.

Díaz, F., Cadaveira, F., & Grau, C. (1990). Short-and middle-latency auditory evoked potentials in abstinent chronic alcoholics: preliminary findings. *Electroencephalography and Clinical Neurophysiology/Evoked Potentials Section*, *77*(2), 145-150.

Eckardt, M. J., Stapleton, J. M., Rawlings, R. R., & Davis, E. Z. (1995). Neuropsychological functioning in detoxified alcoholics between 18 and 35 years of age. *The American journal of psychiatry*.

Fein G, Biggins CA, MacKay S (1995) Delayed latency of the eventrelated brain potential P3A component in HIV disease. Progressive effects with increasing cognitive impairment. *Archives of Neurology 52*(11):1109–1118.

Fein, G. E. O. R. G. E., Bachman, L., Fisher, S., & Davenport, L. (1990). Cognitive impairments in abstinent alcoholics. *Western Journal of Medicine*, *152*(5), 531.

Fein, G., Whitlow, B., & Finn, P. (2004). Mismatch negativity: no difference between controls and abstinent alcoholics. *Alcoholism: Clinical and Experimental Research*, *28*(1), 137-142.

Finn PR, Mazas CA, Justus AN, Steinmetz J (2002) Early-onset alcoholism with conduct disorder: go/no go learning deficits, working memory capacity, and personality. *Alcoholism: Clinical and Experimental Research 26*(2):186–206.

Finn PR, Sharkansky EJ, Brandt KM, Turcotte N (2000) The effects of familial risk, personality, and expectancies on alcohol use and abuse. *Journal of Abnormal Psychology 109*(1):122–133.

Folstein, M. (1975). Folstein SE, McHugh PR:" Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12,* 189-198.

Grant, I. (1987). Alcohol and the brain: Neuropsychological correlates. *Journal of consulting and clinical psychology*, *55*(3), 310.

Grassi, M., & Soranzo, A. (2009). MLP: a MATLAB toolbox for rapid and reliable auditory threshold estimation. *Behavior research methods, 41*(1), 20-28.

Green, D. M. (1990). Stimulus selection in adaptive psychophysical procedures. *The Journal of the Acoustical Society of America*, *87*(6), 2662-2674.

Green, D. M. (1993). A maximum-likelihood method for estimating thresholds in a yes–no task. *The Journal of the Acoustical Society of America, 93*(4), 2096-2105.

Hwang, J. H., Tan, C. T., Chiang, C. W., & Liu, T. C. (2003). Acute effects of alcohol on auditory thresholds and distortion product otoacoustic emissions in humans. *Acta oto-laryngologica, 123*(8), 936-940.

Jääskeläinen, I. P., Lehtokoski, A., Alho, K., Kujala, T., Pekkonen, E., Sinclair, J. D., ... & Sillanaukee, P. (1995). Low dose of ethanol suppresses mismatch negativity of auditory event-related potentials. *Alcoholism: Clinical and Experimental Research*, *19*(3), 607-610.

Jain, C., Mohamed, H., & Kumar, A. U. (2014). Short-term musical training and pyschoacoustical abilities. *Audiology research, 4*(1).

Jellinek, E. M., & McFarland, R. A. (1940). Analysis of psychological experiments on the effects of alcohol. *Quarterly Journal of Studies on Alcohol.*

Kathmann, N., Wagner, M., Rendtorff, N., & Engel, R. R. (1995). Delayed peak latency of the mismatch negativity in schizophrenics and alcoholics. *Biological psychiatry*, *37*(10), 754-757.

Kumar, U., & AV, S. (2011). Temporal processing abilities across different age groups. *Journal of the American Academy of Audiology*, *22*(1), 5-12.

Lejoyeux M, Feuche N, Loi S, Solomon J, Ades J (1998) Impulse-control disorders in alcoholics are related to sensation seeking and not to impulsivity. *Psychiatry Res 81*(2):149–155.

Lejoyeux M, Feuche N, Loi S, Solomon J, Ades J (1999) Study of impulse control disorders among alcohol-dependent patients. *J Clin Psychiatry 60*(5)*:*302–305.

LeMarquand DG, Benkelfat C, Pihl RO, Palmour RM, Young SN (1999) Behavioral disinhibition induced by tryptophan depletion in nonalcoholic young men with multigenerational family histories of paternal alcoholism. *Am J Psychiatry 156*(11):1771–1779.

Levitt, H. C. C. H. (1971). Transformed up-down methods in psychoacoustics. *The Journal of the Acoustical society of America, 49*(2B), 467-477.

Noël, X., Van der Linden, M., Schmidt, N., Sferrazza, R., Hanak, C., Le Bon, O., ... & Verbanck, P. (2001). Supervisory attentional system in nonamnesic alcoholic men. *Archives of general psychiatry, 58*(12), 1152-1158.

Pearson, P., Dawe, L. A., & Timney, B. (1999). Frequency selective effects of alcohol on auditory detection and frequency discrimination thresholds. *Alcohol and alcoholism*, *34*(5), 741-749.

Peele, S. (1995). Abstinence/Controlled drinking versus abstinence. *Encyclopedia of Drugs and Alcohol, New York: Macmillan,* 92-97.

Polich J, Pollock V, Bloom F (1994) Meta-analysis of P300 amplitude from males at risk for alcoholism. *Psychological Bulletin 115*(1):55–73.

Ratti, M. T., Bo, P., Giardini, A., & Soragna, D. (2002). Chronic alcoholism and the frontal lobe: which executive functions are imparied?. *Acta Neurologica Scandinavica*, *105*(4), 276-281.

Realmuto, G., Begleiter, H., Odencrantz, J., & Porjesz, B. (1993). Event-related potential evidence of dysfunction in automatic processing in abstinent alcoholics. *Biological Psychiatry, 33*(8-9), 594-601.

Ribeiro, S. B. A., Jacob, L. C. B., de Freitas Alvarenga, K., Marques, J. M., Campêlo, R. M., & Tschoeke, S. N. (2007). Auditory assessment of alcoholics in abstinence. *Brazilian Journal of Otorhinolaryngology, 73*(4), 452-462.

Schneider, E. W., & Carpenter, J. A. (1969). The influence of ethanol on auditory signal detection. *Quarterly Journal of Studies on Alcohol, 30*(2), 357-370.

Shofner, W. P. (2008). Representation of the spectral dominance region of pitch in the steady-state temporal discharge patterns of cochlear nucleus units. *The Journal of the Acoustical Society of America, 124*(5), 3038-3052.

Singh, H. J., Kaur, S., Kaur, A., Walia, L., & Sharma, A. (2016). Effect of chronic alcohol intake on auditory system with changes in auditory brainstem evoked responses. *National Journal of Medical Research, 9.*

Upile, T., Sipaul, F., Jerjes, W., Singh, S., Nouraei, S. A. R., El Maaytah, M., ... & Wright, A. (2007). The acute effects of alcohol on auditory thresholds. *BMC Ear, Nose and Throat Disorders, 7*(1), 4.

Wallgren, H., Barry, H., III: Actions of Alcohol, vol. 1. Biochemical, physiological and psychological aspects. Amsterdam: Elsevier 1970.

Wier, C. C., Jesteadt, W., & Green, D. M. (1977). Frequency discrimination as a function of frequency and sensation level. *The Journal of the Acoustical Society of America, 61*(1), 178-184.

World Health Organisation (2011). Global status report: Alcohol policy. Geneva, Department of Mental Health and Substance Abuse.

World Health Organization (2018). Global Status Report on Alcohol and Health. WHO, Geneva, Switzerland.

Ylikoski, J. S., House, J. W., & Hernandez, I. (1981). Eighth nerve alcoholic neuropathy: a case report with light and electron microscopic findings. *The Journal of Laryngology & Otology*, *95*(6), 631-642.

Yohman, J. R., Parsons, O. A., & Leber, W. R. (1985). Lack of recovery in male alcoholics' neuropsychological performance one year after treatment. *Alcoholism: Clinical and Experimental Research*, *9*(2), 114-117.