Effects of Alcohol on the Human Vision System

Presented to:
The Alcohol Drug Education Association of Alberta
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Introduction

Alcohol and alcoholism affects us in many ways. It affects the social and economic fabric of our society, the physiology of the human body, and perhaps most importantly, the effectiveness of the mental processing of the human mind.

One of the most important avenues through which the mind receives, analyzes and processes information is through the sense of sight. Vision is often referred to as our "window to the world". When we recognize that over 70% of our learning takes place through the medium of vision we begin to glimpse the significance of vision in our daily lives. There is incontrovertable evidence that the ingestion of alcohol hampers the sense of sight and slows down the visual processes. Realizing the importance of vision, we understand the great threat which agents such as alcohol have upon our ability to perform and to cope effectively in the social, economic and physical arenas of life. That this is an issue which must be of high priority is clear from the large number of adverse ocular affects reported due to ethyl alcohol and due to the fact that the volume of man's consumption of alcoholic beverages is second only to his consumption of water.

Following is a brief outline of the ocular side effects of Acute Intoxication, Chronic Intoxication and Fetal Alcohol Syndrome. Also included is a new visual Sobriety Test, being used in the conviction of motorists who are intoxicated while driving. Immediately following this outline is a more detailed discussion of these ocular side effects with appropriate references to the bibliography.

It is not the purpose of this brief to dwell on the moral, social or economic implications of the distribution and consumption of alcohol. However, as the Association representing the Doctors of Optometry in Alberta, we hope this brief which provides a summary of some of the research on the effect of alcohol on vision, will be a useful resource to those in both the public and private sector who must make decisions or take stands concerning the public availability and distribution of alcoholic beverages.

This brief also contains research data of interest to those responsible for law enforcement, specifically the Alcohol Gaze Nystagmus Test. This is a sobriety test based on visual reaction. As the report indicates, studies identify the nystagmus test as the most valuable index of intoxification. It also has the advantage of requiring relatively involuntary, uncontrollable response and does not require expensive equipment or extensive training.

Ocular Side Effects of Alcohol

A. **Systemic Administration — Acute Intoxication**
(Consumption Over a Short Time Interval)

1. Diplopia
2. Nystagmus
3. Esotropia
4. Impaired Saccadic Eye Movement
5. Impaired Smooth Pursuit Eye Movement
6. Blurred Vision
7. Problems with Color Vision
8. Decreased Dark Adaptation
9. Prolonged Glare Recovery
10. Constriction of Visual Fields
11. Decreased Depth Perception
12. Temporary Blindness

B. **Systemic Administration — Chronic Intoxication**
(Consumption Over a Long Term Interval)

*Chronic intoxication may include any of the side effects listed under Acute Intoxication along with the addition of the following)

1. Central Scotoma
2. Problems with Color Vision
3. Optic Neuritis
4. Alcohol Amblyopia

C. **Fetal Alcohol Syndrome**

1. Narrow Palpebral Fissure
2. Hypertelorism
3. Micro Opthalmia
4. Epicanthus
5. Ptosis
6. Strabismus
7. Retinal Vascular Tortuosity
8. Pseudo Papilledema

Visual Sobriety Test

A. **Alcohol Gaze Nystagmus Test**

Alcohol and Vision

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A Summary of Research

Ethyl alcohol, a central nervous system depressant, can give rise to muscle weakness with diplopia (double vision) and on occasion, blurred vision. In some instances it may aggravate pre-existing ocular defects or cause nystagmus (involuntary oscillating movement of the eyes).[11] In relation to automobile driving there has been considerable interest in the influence of alcohol on the function of the eyes. An investigation and review by *Gramberg-Danielsen* indicated that vision could be effected by alcohol and result in nystagmus, poorly controlled eye movements and diplopia.[7] *Newel and Ernest* report that ethyl alcohol in large amounts causes an esophoria with an accompanying diplopia that the intoxicated individual may not recognize.[11] An unrecognized doubling of the vision by an intoxicated driver or employee working around high speed machinery in the workplace or on the farm could well be a tragedy in the making.

The effect of alcohol upon both saccadic eye movement (movements in which the eyes are moved rapidly from one object of interest to another) and smooth pursuit eye movements (where the eyes follow a relatively slow moving target) is of importance when considering the performances of any skilled task which requires rapid perception of stationary and moving visual objects. *Wilkinson, Kime and Purnell* found an impairment in saccadic eye movement with increasing blood alcohol levels. At blood alcohol levels of 80-100 mg percent, velocity of saccadic eye movement was reduced by 20%.[22] Smooth pursuit eye movements became impaired at relatively low blood alcohol levels. *Bittencourt, Wade and Richens* in a separate study found smooth pursuit eye movement reduced by 25% at BAL's (Blood Alcohol Levels) of 80 mg/dl.[3] This impaired movement reduces the time an object is perceived in the central part of the visual field, with a presumed reduction in clarity of vision. This indeed appears to take place as the subjects in *Wilkinson, Kime and Purnell's* study commented that the target seemed blurred as they tried to follow it.[22]

Color vision may also be effected by alcohol ingestion. Acute ingestion of ethanol has been reported to temporarily cause poor color discrimination in all spectra, but with significantly more errors in the blue-yellow range as reported by *Russell, Carney and Feiock.* Thus ethanol appears to act as a toxin to inner retinal layers, which could account for the higher incidence of tritanopia color blindness found among alcoholics.[17] Chronic alcohol consumption may in some cases result in optic neuritis (inflammation of the optic nerve) with associated red-green color blindness.[10]

Relatively low doses of alcohol significantly slow down recovery time (the time required for the eye to readjust to the detail and illumination level of a previously looked at target) following exposure to a bright light. These changes can be seen for several hours following alcohol ingestion.

The longer glare recovery time and dark adaptation time produced by alcohol intoxication must be viewed as critical from a practical point of view. The period of recovery is a period of relative blindness for the individual and as such is potentially hazardous. Soon after sunrise and just before sunset the sky may act as an extended glare source for the automobile driver. In certain circumstances a driver will intermittently view the bright sky or be subjected briefly to high luminance glare from light scattered by the windshield. Following glare, important features of the driving environment must be seen against average background levels. The possible consequences of an additional 30-50% delay in seeing critical detail in such circumstances is obvious. Alcohol induced delays in glare recovery have been demonstrated at surprisingly low BAL's (approximately one cocktail on an empty stomach) and is dose related.[1]

In Acute Intoxication, constriction of the visual fields and decreased depth perception have been noted. A study by *W.M. Grant* has reported cases of hallucinations and instances of temporary blindness lasting for up to five days.[8]

In Chronic Intoxication, the condition known as alcohol amblyopia may develop. This is a nutritional deficiency secondary to the alcoholics poor general health and debilitated condition. It has an accompanying Optic Neuritis[11] (inflammation of the nerve sending visual information to the brain) that causes reduced vision due to the formation of a Central Scotoma[8] (blind spot). This in turn can lead to defective color vision. If treated soon enough, the condition can be reversed.

Only in recent years have the adverse effects of alcohol on the fetus been widely recognized. It is now generally felt that even two drinks a day can have an undesirable effect and the risk of alcohol related problems increased markedly at higher consumption levels.[16] A study by *Altman* revealed the following eye anomalies associated with alcohol ingestion during pregnancy: Narrow palprebral fissues (narrow eyelid opening); Micro-opthalmia (eye abnormally small in size); Strabismus (one eye or both eyes look in a direction other than where they should be looking); Ptosis (drooping of the upper eyelid); Paleopticdiscs; Retinal Vascular Tortuosity (twisted and wavey blood vessels on the retina of the eye).[2] In a separate study by *Gonzalez* there was also noted epicanthus (a fold of skin cover-

ing the inner angle of the eyelids) in approximately 47% of the subjects studied.[6] In their research on Fetal Alcohol Syndrome, *Miller, Isreal and Cutlone* found low incidence anomalies of corneal opacities and cataracts.[9]

To this point we have dealt only with how the results of excessive alcohol consumption and its associated ocular side effects have affected the intoxicated individual. Unfortunately, the intoxicated individual is not the only person to bear the side affects of his excessive drinking. It is well known that the drunk driver is a source of great misery on the nation's highways.

The latest statistics indicate that in the United States alone during the period from 1975-1985, alcohol related accidents injured 650,000 people per year and caused a total of 250,000 fatalities.[20] In their attempts to identify and arrest drivers who are intoxicated beyond the legal limit, many law enforcement agencies are turning to a new visual sobriety test called the *Alcohol Gaze Nystagmus Test.* Based on reviews of the sobriety test literature and observations of police officers in various locales around the country, certain physiological and behavioral tests were singled out for laboratory evaluation. The initial report of this work was published by the NHTSA (National Highway Traffic Safety Association) in 1977.[4] The report indicated that three psychophysical tests gave data which correlated well a suspect's BAC (Blood Alcohol Concentration). These tests were the walk-and-turn, the one-leg stand and lateral gaze nystagmus.

The nystagmus test, which is sometimes called the alcohol gaze nystagmus test has three components: 1) assessment of the smoothness of lateral pursuit movements; 2) the severity of the nystagmus produced at the end point of gaze (when the eye is turned all the way to the right or left; and 3) the degree of lateral gaze required to produce nystagmoid movements. Smooth pursuits have been shown to deteriorate into saccadic fixations (jerky movements of the eyes) under the influence of alcohol[22] and the severity of end-point nystagmus (a small back and forth oscillating movement of the eye) increases significantly with increasing BAC. The degree of lateral gaze required to produce nystagmus begins at about 40 degrees for a BAC of 0.10% and even earlier for higher BACs.[19] In administering the nystagmus tests, no specific target is required, but the use of a penlight or fingertip is common. Officers are trained to administer the test with the driver's spectacles removed (officers are instructed to ask if the suspect is wearing hard contact lenses and not to perform the test if they are for fear of dislodging a lens) and to hold the target at 12 to 15 inches from the suspect for "ease of focus". Instructions to the suspect are: "I am going to check your eyes . . . keep focusing on this until I tell you to stop".[21]

During training, each officer learns to determine a 45 degree horizontal gaze angle by using a template, but no instrumentation is used in the field. The officer scores the test on a six point scale with three points possible for each eye. The right eye is observed on right gaze for all three signs (smoothness of pursuit, magnitude of nystagmus at end-point and nystagmus onset angle relative to 45 degrees), and then the left eye is observed on left gaze. Any failed test (jerky pursuits, excessive end-point nystagmus or nystagmus onset prior to a 45 degree deviation) for either eye counts as one point. A suspect who scores four or more points can be classified as having a BAC of 0.10% or above with approximately 80% accuracy (plus or minus 3% depending on which NHTSA study is referred to).

Of the three tests recommended by NHTSA for field sobriety testing (walk-and-turn, one-leg stand and nystagmus), each was tested alone in a laboratory setting to determine its ability to predict if a suspect's BAC was above or below 0.10%. The walk-and-turn test provided a correct diagnosis 75.1% of the time, the one-leg stand was correct 75.5% of the time and the nystagmus testing was correct 81.8% of the time. For all three tests administered together, a correct classification was made 83.4% of the time. These results are in agreement with a Finnish Study[15] regarding the importance of the nystagmus testing. Both studies identified the nystagmus test as the most valuable index of intoxication. The importance of this visual test is further heightened because it requires a relatively involuntary, uncontrollable response that suspects cannot practice (as might be possible for the other two tests in the battery).

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