

## VISUAL PERCEPTION OF RADIAL SINE-WAVE GRATING AFTER THE ALCOHOL CONSUMPTION<sup>1</sup>

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**Abstract:** The aim of this study was to compare the visual perception of contrast in adults with no alcohol intake, and after moderate consumption of alcohol by them – 0.09% Blood Alcohol Concentration (BAC), through the Contrast Sensitivity Function (CSF). Participated in the experiments five volunteers, aged 21-30 years, with normal or corrected visual acuity. To measure the CSF, we used radial sine-wave grating stimuli of frequencies of 0.25; 2 e 8 cycles per degree of visual angle. We used an experimental design or sketch, with repeated measures, and a forced-choice psychophysical method. The results showed significant effect of subjects ( $F_{4,55} = 25,518; p < 0,001$ ), of frequencies ( $F_{2,110} = 172,288; p < 0,001$ ), and of the interaction

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between frequencies versus conditions versus subjects ( $F_{8,110} = 26,806$ ;  $p < 0,001$ ). This preliminary study suggests changes in CSF, related to moderate alcohol consumption.

**Keywords:** Visual perception. Contrast sensitivity. Alcohol consumption. Radial sine-wave grating. Psychophysical method.

A stimulus complex as a visual scene can be decomposed into various light intensities. This is the theoretical assumption of linear system analysis that relies on a theorem of Fourier and has been applied to study the response of the human visual system (De Valois & De Valois, 1990). This theorem is useful to try to understand how the visual system analyzes and processes a complex spatial distribution of light that make up a scene, separating it into components of simple sine waves.

Fourier analysis provides the theoretical foundation for the use of visual stimuli defined by distribution of sine waves in space to study the neurophysiologic mechanisms that respond selectively to these distributions of waves (Sachs, Nachmias, & Robson, 1971; Schwartz, 2004). Psychophysical and neurophysiological researches have offered support for the application and importance of this type of model object in visual processing (De Valois & De Valois, 1990). And one of the most used tools to describe and evaluate the response of these mechanisms that respond selectively to patterns of sine waves is the Contrast Sensitivity Function (CSF).

The CSF is defined as the inverse of contrast threshold curve,  $1/FSC$  (Cornsweet, 1970). The contrast threshold corresponds to the lowest amount of brightness that the visual system needs to detect an object in a particular spatial frequency. This is the number of cycles (or ranges of maximum and minimum luminance) per degree of visual angle or the number of cycles per unit of space (Schwartz, 2004). For example, a spatial frequency of 2 cycles per degree of visual angle (cpd) has two light and two dark stripes on a given space.

The CSF is one technique used to assess visual perception in various conditions (Nicholson, Andre, Tyrrell, Wang, & Leibowitz, 1995; Pearson & Timney, 1998; Quintyn, Massy, & Brausser, 1999; Wegner, Günthner, & Fahle, 2001), for example, to evaluate the visual impairment caused by various neuropathological disorders and substance use, such as schizophrenia (Slaghuis, 1998), multiple sclerosis (Vleugels van Nunem, Lafoose, Ketelaer, & Vandenbussche, 1998), mercury poisoning (Ventura et al., 2005), nicotine use (Fine & Kobrick, 1987) and marijuana (Flom, Brown, Adams, & Jones, 1976).

Research involving the moderate consumption of alcohol and the CSF are rare, and yet were found only with elementary stimuli like sinusoidal vertical grid. For example, Roquelaure et al. (1995) measured the CSF in 30 alcoholic patients and 52 healthy volunteers, using spatial frequencies of 0.1, 0.3, 0.5, 1, 2.6 and 6 cpd. The results demonstrated a reduction in the perception of alcoholics participating in all spatial frequencies tested.

Andre (1996) investigated the effects of alcohol with a blood alcohol level of 0.073% BAC (Blood Alcohol Concentration) in two conditions of luminance of the monitor screen – 12.9 cd/m<sup>2</sup> (candelas per square meter) and 0.129 cd/m<sup>2</sup> – mobile and static stimuli, using the CSF to spatial frequencies of 1.5, 3 and 6 cpd. The results revealed a significant reduction in contrast sensitivity at higher frequency (6 cpd). Pearson and Timney (1998) measured the CSF to six volunteers to spatial frequencies of 0.75, 1.5, 3, 5, 7.5 and 10 cpd, with a blood alcohol level of 0.077% BAC and found that alcohol decreased contrast sensitivity in the perception of high spatial frequencies (7.5 and 10 cpd). On the other hand, Quintyn et al. (1999), in a study with six participants under the influence of 0.57 g / kg intake of alcohol, noticed no significant change in contrast sensitivity.

To date, no studies were found with CSF related to alcohol intake using circularly symmetric radial sinusoidal gratings. The first proposal to study these patterns described in polar coordinates came from Kelly (1960), who suggested the use of circularly symmetrical stimuli modulated by cylindrical Bessel function of order zero ( $J_0$ ). This class presents the basic stimulus modulation contrast varying sinusoidally in the radial direction, the very center of the circle as the origin of the polar coordinate system. According to Kelly (1960), patterns modulated by cylindrical Bessel function appear to be more natural considering the roughly circular and symmetrical of the retina. In addition, such stimuli provide a clear center attachment (Magnuski & Kelly, 1975). Not so with parallel patterns such as sinusoidal gratings.

This study sought to characterize the typical responses of the visual system to sinusoidal radial patterns in five volunteers under the effect of moderate alcohol intake and no alcohol intake. Thus, the main objective was to describe the effects of moderate alcohol intake in the detection of radial sinusoidal grating using the psychophysical forced-choice method. Research of this kind are unprecedented in the literature and part of the proposition that the polar coordinate stimuli are processed by higher visual areas like V4 and IT (inferior temporal) (Gallant, Connor, Rakshit, Lewis & van Essen, 1996; Merigan, 1996).

## Method

### Participants

Five females participated in the experiments, aged 21-30 years. They passed in two conditions: Moderate intake of alcohol (BAC.09) and no alcohol intake. The alcohol volume was calculated taking into account the mass, the formula proposed by Drummer and Odell (2001):  $C_{max} (g / l) = 0.02 \times \text{dose} (g \text{ per } 70 \text{ kg body weight})$ . The volunteers were healthy, had normal visual acuity with correction and were free of visual pathologies. The participants who had personal or family history of alcoholism were excluded from the sample.

Participation in the survey was by signing a term of informed consent, according to Resolution No. 196/96 of the National Health Council. This work was recorded by the Ethics Committee in Research of the Center for Health Sciences at this university.

### Equipment and Visual Stimuli

We used a program created by our laboratories to generate visual stimuli. These were presented on a video monitor LG, CRT (cathodic ray tube) 19-inch, connected to a computer and a BITS ++ (Cambridge Research System). BITS ++ extends the luminance of the monitor voltage of 8 to 14 bits, allowing the generation of stimuli with the largest gain in contrast. The average luminance of the screen was  $42.6 \text{ cd} / \text{m}^2$  LightScan evaluated by a program and an Optical photometer (Cambridge Research Systems). We also used a model Alcoscan etilômetro Sentech AL-6000, which determines the amount of alcohol in the blood in % BAC, and a mechanical balance model TEC20 (Techline).

In the measurement of CSF, we used visual stimuli elementary sinusoidal radial grating of static and achromatic spatial frequencies of 0.25, 2 and 08 cpd and a neutral stimulus with the luminance homogeneous (Figure 1). The stimuli were presented with a diameter of about 7 degrees of visual angle at 150 cm from the monitor. Further information on elementary stimuli can be found in the literature (Kelly, 1960; Santos, Simas, & Nogueira, 2004; Simas & Santos, 2002).

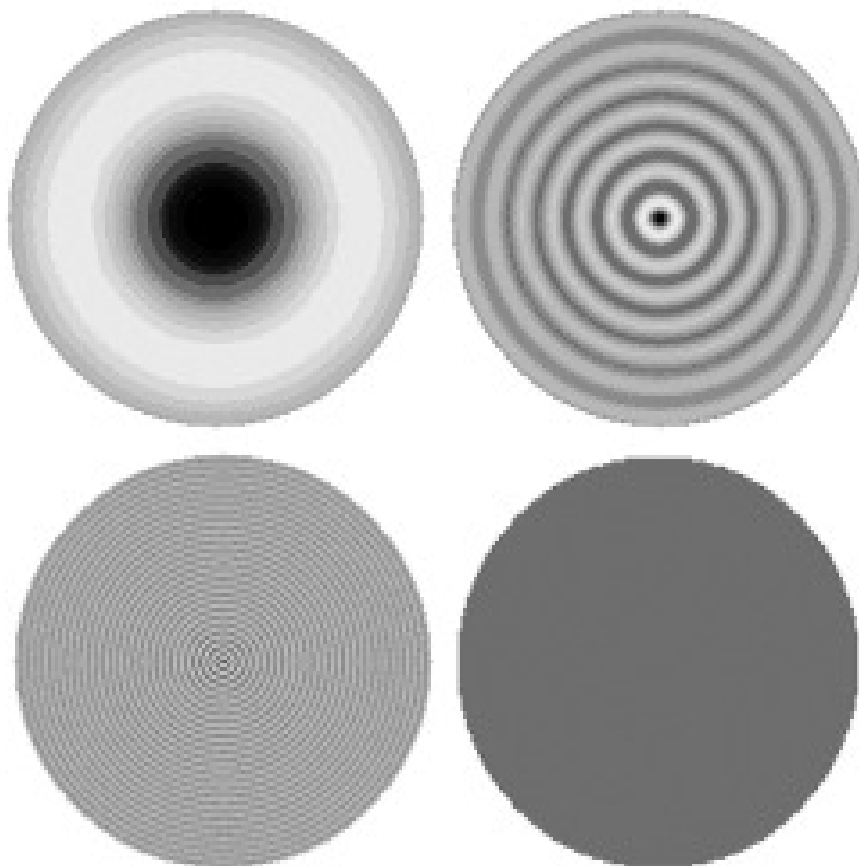


Figure 1. Examples of stimuli sinusoidal radial gratings (above, left to right, and 0.25 cpd and 2; below, from left to right, 8 cpd and neutral stimulus with luminance homogeneous). Stimuli originally calibrated to be seen at 150 cm.

## Procedure

We used an experimental design with repeated measures, where all participants were tested at all frequencies and in two conditions: placebo (control condition – CC) and after alcohol intake (Experimental Condition – EC), on different days. The order in which each subject underwent each of the two conditions was controlled by counterbalancing technique.

The administration of alcohol was made with vodka “Stolichinaya” at a concentration of 40%, diluted in natural orange juice with beet and sugar in the proportion of 1 / 1. In the placebo condition, the vodka was replaced by lemon juice. The instruction to the intake of the drink or the placebo was that content should be taken in five minutes, so the peak

blood alcohol content could be achieved on average 30 minutes (Drummer & Odell, 2001).

The tests were performed in the morning, between 9 am and 12 noon. All participants had a light breakfast and standard (200 ml of orange groove with soy, one banana, two loaf sandwich bread and two slices of mozzarella cheese). After breakfast, the volunteers were asked not to consume food for two hours before the experiments. The volunteers were also asked not to drink alcohol in the 24 hours preceding the experimental session. The blood alcohol concentration was measured with the etilometro before the start of the experiment, 15, 30, 45 minutes after ingestion of alcohol or placebo. The average alcohol content was 0.09% BAC. This value refers to the limit of alcohol allowed by U.S. law traffic (Patel, Modig, Magnusson, & Fransson, 2010).

To measure visual perception, the estimates were made with the psychophysical forced-choice method (Wetherill & Levitt, 1965). This method is based on calculating the probability of consecutive hits by the volunteer, i.e., in about 100 presentations of choices between two stimuli (test stimulus and neutral stimulus), the test stimulus is perceived by 79% of the time volunteer.

The procedure for measuring the threshold was the frequency of each successive presentation of pairs of simple stimuli and voluntary would have to choose among them which contained the spatial frequency. The volunteers were instructed to press the left mouse button when they felt the test stimulus (spatial frequency) was presented first and right when they felt it had been presented in the second place, i.e., after the neutral stimulus.

The criterion used to measure the CS for each spatial frequency was three consecutive hits to decrease 20% of the remaining contrast, and an error to increase contrast by the same percentage.

## Results

After each experimental session, the software produced a record sheet with the threshold contrast values, six in the test and six in the re-test. The values of maximum and minimum contrasts obtained for each spatial frequency (0.25, 2:08 cpd) were grouped into spreadsheets for any particular condition (EC and CC). The grand average was used as an estimate of contrast sensitivity as a function of spatial frequency.

Figure 2 shows the curves of contrast sensitivity for circular sinusoidal gratings with spatial frequency of 0.25, 2 and 8 cpd for the volunteers with and without moderate intake of alcohol. In both conditions, participants showed greater sensitivity at the lowest frequency (0.25 cpd) and lower sensitivity at higher frequency (8 cpd). However, it was observed

that the EC was more sensitive than CC in the frequency 0.25 cpd. On the other hand, the CSF by CC was 1.11 times more sensitive than the EC at frequencies radial of 2 and 8 cpd, respectively.

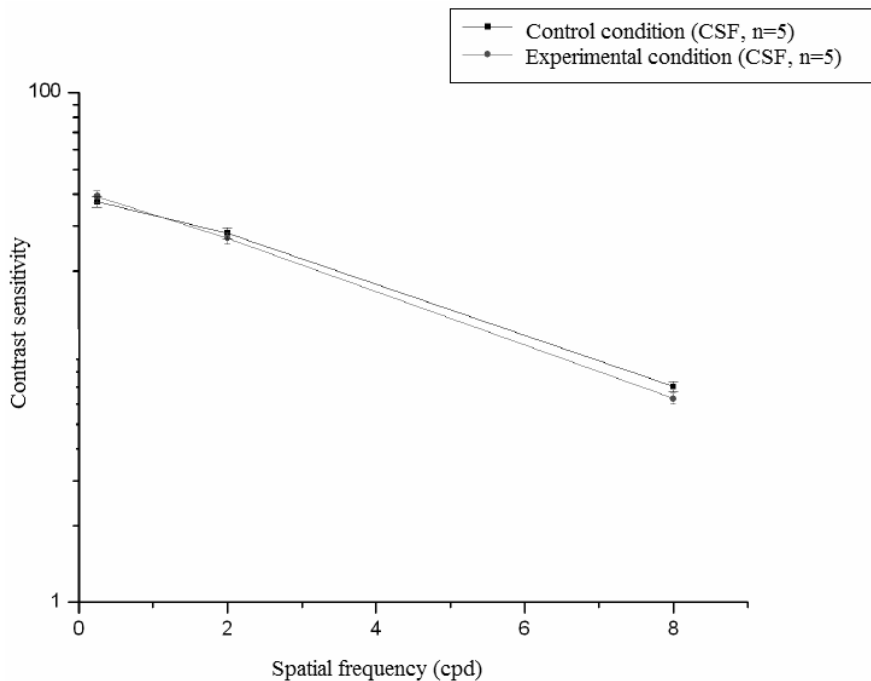


Figure 2. Contrast sensitivity curves for vertical sine-wave gratings in women without alcohol ingestion, control condition (—□—) and after alcohol ingestion, experimental condition (—○—). Vertical lines show the standard error of the mean for each spatial frequency (0.25, 2 and 8 cpd).

Statistical analysis with ANOVA for repeated measures showed significant effect among the participants ( $F_{4, 55} = 25.518, p < 0.001$ ), frequency ( $F_{2, 110} = 172.288, p < 0.001$ ), participants x frequency interaction ( $F_{8, 110} = 15.532, p < 0.001$ ), frequency x condition interaction ( $F_{2, 110} = 412.506, p < 0.001$ ) and frequency x condition x participants interaction ( $F_{8, 110} = 26.806, p < 0.001$ ). There was no significant effect between conditions ( $F_{1, 55} = 1.926, p = 0.170844$ ) and participants x conditions interaction ( $F_{4, 55} = 2.045, p = 0.100677$ ). Analyses with the post hoc Newman-Keuls test (significance level  $\alpha = 0.05$ ) showed significant differences at all frequencies tested ( $p > 0.001$ ). The results indicate that a moderate intake of alcohol can change the CSF.

## Discussion

The objective of this research was to determine whether moderate alcohol intake (0.09% BAC) changes the visual processing of contrast in the adult female. The results suggested changes in visual perception of circular sinusoidal grating patterns before and after drinking alcohol. After alcohol intake was possible to observe an increased sensitivity in the frequency 0.25 cpd and a decreased sensitivity in spatial frequencies 2 and 08 cpd.

Statistical analysis with the Newman-Keuls test indicates interactions between the channels that process spatial frequencies and alcohol intake. Analyzing the interaction frequencies x participants noted that after the intake of alcohol (EC) the five participants showed impairment in all frequencies tested, especially in the frequency 2 cpd ( $p < 0.001$ ), indicating that the change was greater in channels that process medium frequency.

On the other hand, the results showed that the maximum contrast sensitivity occurred in the frequency range of 0.25 cpd. What characterizes a displacement of the zone of maximum sensitivity to the left, in relation to the general pattern found in the literature for adults (no alcohol intake) in the same age group. That is, a peak in the low mid frequencies, with reduced sensitivity to values below or above this range. This is because levels of above 9 cd/m<sup>2</sup> luminance, the range of maximum sensitivity occurs around 0.5 to 2 cpd for radial frequencies (Kelly, 1982; Magnuski & Kelly, 1975; Simas, Santos, & Thiers, 1997). The displacement of the maximum sensitivity to lower frequencies can be related to the functioning of the magnocellular visual pathway, which is specialized in processing low spatial frequencies (Benedek, Benedek, Keri, & Janáky, 2003; Elleberg, Lewis, Liu, & Maurer, 1999). Visual processing of form and contrast involves at least two systems: the parvocellular visual pathway, which is specialized in processing medium and high spatial frequencies or fine detail and operates at high levels or photopic luminance, and the magnocellular visual pathway, which specializes in processing low spatial frequencies and operates at low or scotopic luminance.

The results were similar to previous study by Cavalcanti and Santos (2008) showed that the FSC to stimuli like sinusoidal vertical gratings (0.25, 1 and 4 cpd) in low luminance (0.7 cd/m<sup>2</sup>) and exclusively with women, is amended by moderate alcohol intake (0.06% BAC). The sinusoidal vertical grating results revealed significant losses in visual processing of higher spatial frequency (4 cpd) and a nonsignificant improvement in visual processing of lower spatial frequency (0.25 cpd).



The results also corroborate with other reports in the literature, which found no decline in contrast sensitivity at higher frequencies in men and women after consumption of alcohol, under conditions of luminance of 21 cd/m<sup>2</sup> (Pearson 1997, Pearson & Timney, 1998). However, this study used a different methodology (average luminance of 42.6 cd/m<sup>2</sup>, concentric circular sine wave grating and female participants only). Still, we observed significant changes in all the frequencies used.

These findings were expected, considering that the luminance of the monitor screen is an important factor in assessing the visual pathways. Among the studies of alcohol and CSF, few have made it clear luminance used. The research mentioned that this information reported significant changes in low and medium luminance, e.g., 0.129 and 12.9 cd/m<sup>2</sup> (Andre 1996). As this study used a luminance of 42.6 cd/m<sup>2</sup> and found changes at all frequencies, it reinforces the hypothesis proposed by Pearson (1997) that the magnocellular and parvocellular visual pathways are affected differently by moderate alcohol intake.

Most studies that relate visual perception of contrast and alcohol intake was performed with spatial patterns of sinusoidal vertical grid type. It was not found to date no study using spatial patterns of concentric sinusoidal grating type. In this sense, the use of concentric spatial frequencies in studies of this nature provides an assessment of the effect of moderate alcohol intake on brain areas that had not yet been assessed by CSF. This hypothesis may be reinforced by psychophysical studies (Santos & Simas, 2002; Simas & Santos, 2002, Simas et al., 1997; Wilson & Wilkinson, 1998; Wilson, Wilkinson & Asaad, 1997) and neurophysiological (Gallant et al., 1996; Heywood, Gadotti & Cowey, 1992; Merigan, 1996, Wilkinson et al., 2000) suggesting that vertical sinusoidal gratings and concentric sinusoidal gratings are processed by distinct mechanisms and visual areas. While the stimuli of sinusoidal vertical grating type are processed in V1, concentric sinusoidal gratings are processed by cortical visual areas V2, V4 and IT (Gallant et al. 1996; Merigan, 1996, Wilkinson et al., 2000).

Regarding the sample, the interest in conducting this study exclusively with female participants from the premise that in women, blood alcohol concentrations are generally higher than in men, whereas the same amount consumed. This is due to the smaller volume of water per body weight, the greater amount of fat and lower activity of ADH (alcohol dehydrogenase Gastric) – an enzyme important for metabolism of ethanol (Edwards, Marschall, & Cook, 2005; Ramchandani, Bosron, & Li, 2001). In women, this enzyme is only present in the liver, unlike men, they are the same in the liver and stomach. These characteristics result in a greater physiological effect of the changes promoted by the ingestion of alcohol in women compared to men.

Studies with repeated measures and psychophysical method, commonly used to assess the perception involve a small number of subjects in each condition. This is due to the fact that the difference or variance between subjects to be great. In this sense, preference was given to the procedure with repeated measures with a high number of measures at different times of the same phenomenon with an observer, where the statistic is obtained with N the number of intra-individual (Blakemore & Campbell, 1969; Campbell & Robson, 1968).

The fact of the changes found are different between the subjects indicates that alcohol alters the CSF in a heterogeneous and idiosyncratic conditions of the subjects are relevant to such changes. This statement also suggests that some variables interact with the effects of drinking alcohol in the body. In this study, some of these were controlled, such as standardization of the breakfast, the period between the last meal and the experiment, sex, how often the person drinks alcohol (the sample consisted of women who drank rarely), smoke and time of completion experiments. Yet changes were observed in individual alcohol in the blood.

Some studies discuss the interaction of these and other variables and the effects of alcohol on the body (Drummer & Odell, 2001, Edwards et al., 2005; Figueira, 2002). In this context, the equation of Drummer and Odell (2001) was used as a parameter to calculate the percentage of vodka that each participant had to drink to achieve the same concentration of alcohol. Although the formula developed by these authors to be based mainly on body mass, it excludes other important variables such as body water content, height, age and gender, which interact with alcohol consumption.

On the other hand, this is a preliminary study and further research must be conducted to discuss more thoroughly the possible changes in visual perception related to alcohol intake and visual processing of object and contrast and even the influence of effects caused by alcohol appear to vary greatly between volunteers. It is within this perspective that we chose initially to study only the effect of alcohol intake in young healthy females. New experiments involving other mathematical equations that quantify the concentration of alcohol intake, different visual stimuli and luminance must be conducted to investigate the knowledge about the possible effects of moderate alcohol intake on visual perception.

## Conclusion

The results obtained here suggest that a moderate intake of alcohol alters the ability of the visual system has to detect concentric sinusoi-

dal gratings. These characteristics, in turn, may be related to the peculiar behavioral characteristics of subjects related to alcohol intake and the neural processing of stimuli. In general, taking into account the results of this study and others found in the literature, one can infer that the visual system is affected by alcohol and using different mechanisms or pathways for processing visual spatial patterns defined in polar coordinates (grids sinusoidal concentric). From this perspective, we will proceed with investigations, including new variables including, for example, males and other levels of luminance.

### **Percepção visual de grade senoidal radial após o consumo de álcool**

**Resumo:** O objetivo deste trabalho foi comparar a percepção visual de contraste de adultos sem a ingestão de álcool e após a ingestão moderada de álcool – 0,09% Blood Alcohol Concentration (BAC), através da Função de Sensibilidade ao Contraste (FSC). Participaram dos experimentos cinco voluntárias, na faixa etária de 21 a 30 anos, com acuidade visual normal ou corrigida. Para medir a FSC, foram usados estímulos de grade senoidal radial de frequências de 0,25; 2 e 8 ciclos por grau de ângulo visual. Utilizou-se um delineamento experimental com medidas repetidas e o método psicofísico da escolha forçada. Os resultados demonstraram efeito significativo de participantes ( $F_{4,55} = 25,518$ ;  $p < 0,001$ ), de frequências ( $F_{2,110} = 172,288$ ;  $p < 0,001$ ) e de interação entre frequências x condições x participantes ( $F_{8,110} = 26,806$ ;  $p < 0,001$ ). Este estudo preliminar sugere alterações na FSC relacionadas à ingestão moderada de álcool.

**Palavras-chave:** Percepção visual. Sensibilidades de contraste. Consumo de álcool. Grade senoidal radial.

## Sur la perception visuelle de la grille sinusoïdale radiale après la consommation d'alcool

**Résumé:** L'objectif de cette étude était de comparer la perception visuelle de contraste chez des adultes sans consommation d'alcool et, dans le cas contraire, après une consommation modérée d'alcool – 0,09% taux d'alcoolémie (TA), grâce à la fonction de sensibilité au contraste (FSC). Cinq volontaires – âgés de 21-30 ans et avec d'acuité visuelle normale ou corrigée – ont participé aux expériences. Pour mesurer la FSC, nous avons utilisé la grille sinusoïdale radiale de 0,25; 2 et 8 cycles par degré de l'angle visuel. Nous avons utilisé aussi un modèle expérimental, avec des mesures répétées, et une méthode psychophysique de choix forcé. Les résultats ont montré d'effet significatif dans les sujets ( $F_{4,55} = 25,518; p < 0,001$ ), dans les fréquences ( $F_{2,110} = 172,288; p < 0,001$ ) et dans l'interaction entre les fréquences, les conditions et les sujets ( $F_{8,110} = 26,806; p < 0,001$ ). Cette étude préliminaire suggère des changements dans la FSC, liés à la consommation modérée d'alcool.

**Mots-clés:** Perception visuelle. Sensibilité au contraste. Consommation d'alcool. Grille sinusoïdale radiale.

## Percepción visual de una reja de una onda senoidal radial después del consumo de alcohol

**Resumen:** El objetivo de este estudio fue comparar la percepción visual de contraste en los adultos, sin consumo de alcohol y después de un consumo moderado de alcohol por parte de ellos – 0,09% de concentración de alcohol en sangre (BAC), a través de la función de sensibilidad al contraste (CSF). Participaron en los experimentos cinco voluntarios, con edades entre 21 y 30 años, con valores normales de agudeza visual. Para medir la CSF, se utilizaron radiales de onda sinusoidal rejilla de estímulos de frecuencias de 0,25, 2 e 8 ciclos por grado de ángulo visual. Se utilizó un diseño experimental o croquis, con medidas repetidas y un método psicofísico de la elección forzada. Los resultados mostraron efecto significativo de sujetos ( $F_{4,55} = 25,518, p < 0,001$ ), de las frecuencias ( $F_{2,110} = 172,288, p < 0,001$ ) y de la interacción entre las frecuencias en comparación con las condiciones en comparación con sujetos ( $F_{8,110} = 26,806; p < 0,001$ ). Este estudio preliminar sugiere cambios en el LCR, relacionados con el consumo moderado de alcohol.

**Palabras claves:** Percepción visual. Sensibilidad de contraste. El consumo de alcohol. Rejilla radial de onda senoidal.

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