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LUMINANCE ADJUSTMENT: NEVER FEAR AGAIN

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Abstract

The control of experimental variables is a crucial step in methodological research planning. In experimental psychology one can use stimuli to promote behavioral and physiological responses. The analysis of the physiological responses implies that the generation of the stimuli must be particularly careful. Certain physical properties of stimuli can override the psychological properties that are being evaluated, for that reason it is important to ensure their constancy. In particular, the measurement of the pupil diameter of the human eye under a visual stimulus gives an indicator of the sympathetic nervous system activation. To carry out such measurements it is necessary to guarantee that the luminance level of the visual stimulus must be kept constant. In general, a large set of visual stimuli has to be considered and the procedure for the luminance adjustments is a real time consuming task since the luminance level of the final stimulus is important for the activity of the pupil. In this paper is presented and described the developed methodology to make such luminance adjustments easier.

Keywords: *visual stimuli, luminance level, contrast.*

1. Introduction

The control of experimental variables is a crucial step in methodological research planning. In experimental psychology one can use stimuli to promote behavioral and physiological responses. The analysis of the physiological responses implies that the generation of the stimuli must be particularly careful (Christensen & Waraczynski, 1988; Sowden, Rose, & Davies, 2002; Johannes, Münte, Heinze, & Mangun, 1995). Certain physical properties of stimuli can override the psychological properties that are being evaluated, for that reason it is important to ensure their constancy (Sowden et al., 2002; Johannes et al., 1995). In this paper is presented and described the developed methodology to control the luminance adjustments of the visual stimuli that will be used to monitor the activation of the human sympathetic nervous system through the measurement of the pupil diameter of the eye to identify false memories.

2. Objective

The main objective of this work was the development of a methodology to easily control the luminance adjustments of visual stimuli for later use to monitor the pupil diameter of the human eye to identify false memories. The measurement of the pupil diameter of the eye under a visual stimulus gives an indicator of the sympathetic nervous system activation. To carry out such measurements it is necessary to guarantee that the luminance level of the visual stimulus must be kept constant. In general, a large set of visual stimuli has to be considered and the procedure for the luminance adjustments is a real time consuming task since the luminance level of the final stimulus is important for the activity of the pupil.

3. Methods

The set of visual stimuli is composed by 34 gray scale images (format bitmap 8 bits) where a gray centered circle (Lipsman & Rosenberg, 2006; Hecht, 1987) (intensity level 100) is displayed on a black background (intensity level 0). On each circle was typed in white a single word (intensity level 255). The size of the circle covers a 4.3 degrees field of view, which corresponds to the parafoveal area of the retina in the human eye, to be visualized at a distance of 1.0 meter. In such way it is ensured a retina stimulation spanning the foveal region (Osterberg, 1935; Hecht, 1987).

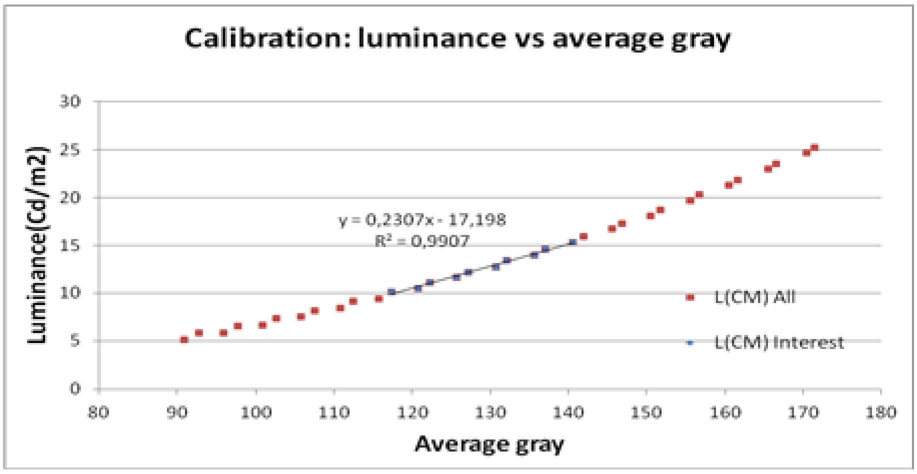
Those images were then displayed on a calibrated and stabilized CRT monitor (Sony GDM-F520) driven by a visual stimulus generator card (Cambridge Research System ViSaGe) installed on a computer. The measurements of the luminance level over the area of the entire circle of the stimulus were then carried out using a spectroradiometer (PhotoResearch Inc. PR650 SpectraScan). Within the list of the 34 words, which have been chosen from a DRM experimental paradigm, 2 words were selected that correspond to the smallest and biggest number of character in order to establish the luminance calibration curves. For each of the 34 images the average gray level (*agl*), the number of pixels in the circle (*nopc*), the number of pixels in the words (*nopw*), the total number of pixels (*tnop*) in interest were calculated, and the corresponding luminance level (*ll*) was also measured.

Assuming the linearity of the calibration curves within the range of interest when those were computed, a model predicts the optimal relationship between the gray and white intensities in order to achieve the intended luminance (*l*) keeping the contrast. The gray circle with different words varied in intensity from 90 to 170 in the range [0-255]. The characters of the words had their intensity level corrected in order to maintain contrast constant at a defined value of 110 in the range [0-255]. The luminance level to be produced by all the images was set to 13.3 cdm^{-2}, to accomplish the photopic condition ensuring the stimulation of photoreceptors (cones) in the retina. The maximum measured difference between the luminance of the target and the luminance of the stimuli was fixed to 1.0 cdm^{-2}, which is within the limits of the measurement error of the system used. An application written in MATLAB performed all the calculations to create a new set of 34 images that, when displayed on the monitor, exhibit the same luminance level.

4. Discussion and Conclusions

The average gray level in a particular image, which is expressed by Equation 1, represents the overall intensity of the stimulus that is being evaluated. From the graph depicted in Figure 1 one can observe that when the average gray level increases the luminance level increases. Considering the desired luminance of 13.3 cdm^2 a linear calibration function in the range [10,15] cdm^{-2} was established based on the obtained curve. The function can be expressed by a straight line according the Equation 2 with $R^2 = 0.99$. From that, 72 images have been adjusted and the corresponding luminance level measurements shown an average value of 13.0 ± 0.1 cdm^{-2}, which is also within the error of the equipment.

Figure 1. Variation of the luminance level as a function of average gray level measured for the displayed images. The red dots represent the totality of the data collected. The blue dots represent the region that was considered relevant for desired setting.



The luminance level adjustment can be carried out in an automated manner ensuring that the viewing conditions are defined for the desired experimental setting, being computed the background gray level (*bggl*) using Equation 3, and the intensity of the word pixels (*iowp*) using Equation 4.

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$$agl = \frac{\sum_{k=level} k \times (nopc - nopw)}{nopc} \quad (1)$$

$$l = 0.2307 \times agl - 17.198 \quad (2)$$

$$bggl = \frac{13.3 \times tnop + 17.198 \times tnop - 0.2307 \times npow \times 110}{0.2307 \times tnop} \quad (3)$$

$$iowp = 110 - bggl \quad (4)$$

The measurement of all the images after these adjustments stated that the mean luminance was 13.02 cdm^{-2} with a standard deviation of 0.107. Factoring the experimental error of the equipment one could say that all stimuli had the same luminance and the same contrast.

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