AGE RELATED COLOUR APPEARANCE DIFFERENCES FOR UNRELATED SELF-LUMINOUS COLOURS

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Abstract

The age related perception of brightness, hue and the amount of white in an unrelated self-luminous colour has been investigated for two groups of observers. A group with an average age of 67 years old and a group with an average age of 27. The older observers rated the most saturated colours as being more bright and as containing a bigger amount of white compared with the younger observers.

Keywords: aging, unrelated colours, appearance, brightness, hue, Helmholtz-Kohlrausch effect

1 Introduction

Due to aging the human perception of colours changes: the light transmittance of the ocular media of the eye changes, the size of the pupil becomes smaller, the number of the photoreceptors, in particular of rods, decreases, the number of neurons responsible for visual information processing in the central part of the brain decreases,… (CIE, 2011) (Goodman, 2006).. Because of the yellowing of the eye lens the spectral luminous efficiency changes with age which makes the bluish colours look relatively darker compared with the perceived brightness for younger people. As the properties of light are generally measured and described using the standard photopic spectral luminous efficiency function *V(λ)*, which was derived mostly from the data of younger observers (Sagawa, 2001), and Colour Appearance Models (CAM) predict the perceptual attributes for young observers, precautions should be made when dealing with older observers.

Coloured stimuli can be categorized into related and unrelated colours. Related colours are colours perceived in relation to other colours, typically reflective colours and displays. Unrelated colours are seen in isolation from any other colours, like self-luminous colours (e.g. coloured light sources) surrounded by a dark background. This research focuses on the age-related differences in perception of unrelated self-luminous colours with a field of view (FOW) of 10°.

2 Experimental setup

An experimental setup and procedure for the evaluation of self-luminous colours viewed against both dark and luminous backgrounds was presented in (Withouck, 2012). For unrelated colours, only a dark background has been used. The room is 3 m x 5 m and has a grey ceiling (see Figure 1 left). The walls are covered by black curtains and there is a black carpet on the floor. One wall has been modified for the experiments. For this experiment a small circular area, acting as the stimulus with a FOV of 10° for the observer, was surrounded by a dark background (see Figure 1 right).

58 stimuli were carefully chosen in order to cover the colour gamut as good as possible. These stimuli are plotted in the u'_{10}, v'_{10} chromaticity diagram in Figure 2. All stimuli have a luminance of51 cd·m^{-2}.

Figure 1 – Left: Experimental room with a dark background. Right: Example of a presented stimulus under dark viewing conditions.

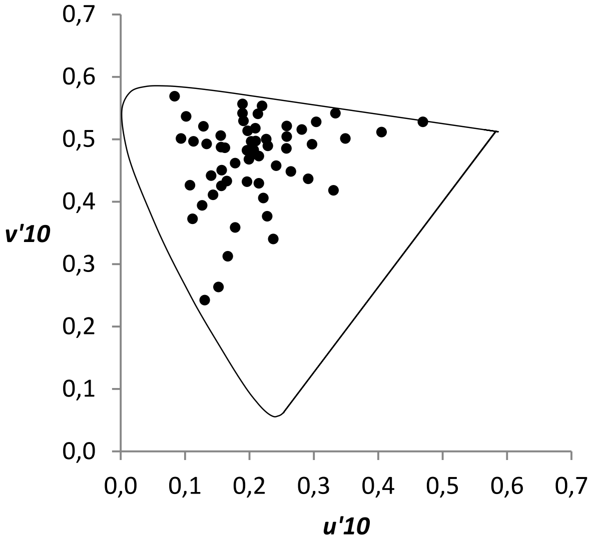

Figure 2 – Chromaticity coordinates of the 58 stimuli plotted in the CIE $u'_{10}v'_{10}$ chromaticity diagram

3 Psychophysical experiments

In a series of psychophysical experiments, young and older observers evaluated the 58 stimuli to obtain values for the perceptual attributes. The perceptual attributes for self-luminous colours are brightness, hue and colourfulness. However, colourfulness is difficult to evaluate without a huge time consuming training because it is not a term people are familiar with. In (Withouck, 2012) a questionnaire has been proposed to evaluate the amount of white instead of the colourfulness. People give a percentage of the amount of white against the amount of non-white they see in a self-luminous stimuli which is related to the colourfulness of the stimulus.

A panel of 18 observers took part at the experiment. The first group, Y, contained 9 young observers between 25 and 30 years old (mean 27 years old - 5 female and 4 male). One of the young observers only did the brightness part of the experiment. The second group, O, contained 9 older observers between 62 and 75 years old (mean 67 years old - 2 female and 7 male). Each observer had normal colour vision according to the Ishihara Test for Colour Blindness and participated a training program of two hours to get familiar with the scaling method. Before starting the experiments, 15 minutes of dark adaptation was implemented.

The perceptual attributes brightness and hue, along with the amount of white, is evaluated using the magnitude estimation method (CIE, 2004) (Gescheider, 1988) (Leloup, 2011). This method is designed to discover functional relationships between the physical properties of a presented stimulus and its perceptual attributes (Torgerson, 1958). For the brightness evaluation, an achromatic reference with value 50 was shown just before and after each stimuli, a value of zero means no brightness. The value for brightness was asked immediately after each stimulus was displayed and switched back to the reference. A value of the amount white and hue was asked without a reference. The amount of white was obtained by asking the percentage of white against non-white presented in the stimulus. The hue was scaled by attributing one, or the proportions of two, of the perceived colours red, yellow, green, and blue. These hue results were transformed into a 0-400 scale: red = 0; yellow = 100; green = 200; blue = 300.

3.1 Data Analysis

The observer agreement was assessed with the coefficient of variation CV (Leloup, 2011), (Luo, 1991).

$$\mathrm{CV} = \frac{100}{\bar{y}}\sqrt{\frac{\sum_{s=1}^{n}(x_s - y_s)^2}{n}}$$

where x_s and y_s both represent a dataset, $\bar{y}$ being the mean value of dataset y_s and n the number of evaluated stimuli, e.g., 58.
The geometric mean was applied because an unconstrained scale was used for the brightness evaluation. The CV values were calculated between each individual observer's results and the mean results for all the observers and it gives a percentage for the variation between this observer and the mean.

For hue and the amount of white the arithmetic mean was used because each observer used the same numerical scale with fixed end points. The observer agreement was again evaluated with the coefficient of variation.

3.2 Results

The mean CV values for the observer agreement of brightness, amount of white and hue are respectively 12, 23 and 9 for young observers and 13, 31 and 14 for older observers (see Table 1). It seems that an older observer has more difficulties in judging the perceptual attributes. During these experiments older observers had particularly more difficulties in answering within this time-limit compared with the young observers. This is why in future experiments older observers should have a longer training in order to make them fully understand the experimentl.
The CV values are similar to those found in earlier experiments for investigating related colours (Luo, 1991) and for investigating unrelated colours (Fu, 2012).

Table 1 – Coefficient of Variation

CV (%)		Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Mean
Bright-ness	Y	11,0	14,9	7,0	6,8	6,9	15,2	12,2	13,5	19,7	11,9
	O	13,3	28,3	9,3	4,5	37,0	8,5	4,2	5,2	7,7	13,1
Amount of white	Y	21,4	23,1	30,4	12,8	15,7	24,3	28,3	25,0		22,6
	O	37,1	22,8	18,1	34,6	30,1	38,4	42,9	38,1	20,6	31,4
Hue	Y	14,5	7,6	7,3	9,0	6,2	11,0	6,8	10,3		9,1
	O	20,0	10,3	15,5	17,8	15,2	11,3	18,2	9,4	9,6	14,1

4 Results and discussions

A comparison between the data obtained by the two groups indicate that there is not a big difference in the hue perception between the young and older observers (see Figure 3 left).

Only the hue of stimuli with a low saturation are more difficult to be recognised for the older group. However it was observed from the individual observer results that older people tend to recognize less mixed colours. While young observers recognized 40% of the time only one of the four primary hue's in the stimulus, older observers saw only one colour in 74% of the stimuli.

The amount of white observed in a self-luminous colour with a very high or a very low saturation seems to be larger for the group of older observers (see Figure 3 right). As young observers give a lower amount of white at the most saturated colours, it seems that they will perceive this colour as containing more colour, i.e. more saturated. The region in between these extremes is however rated as containing a less amount of white by the older observers.

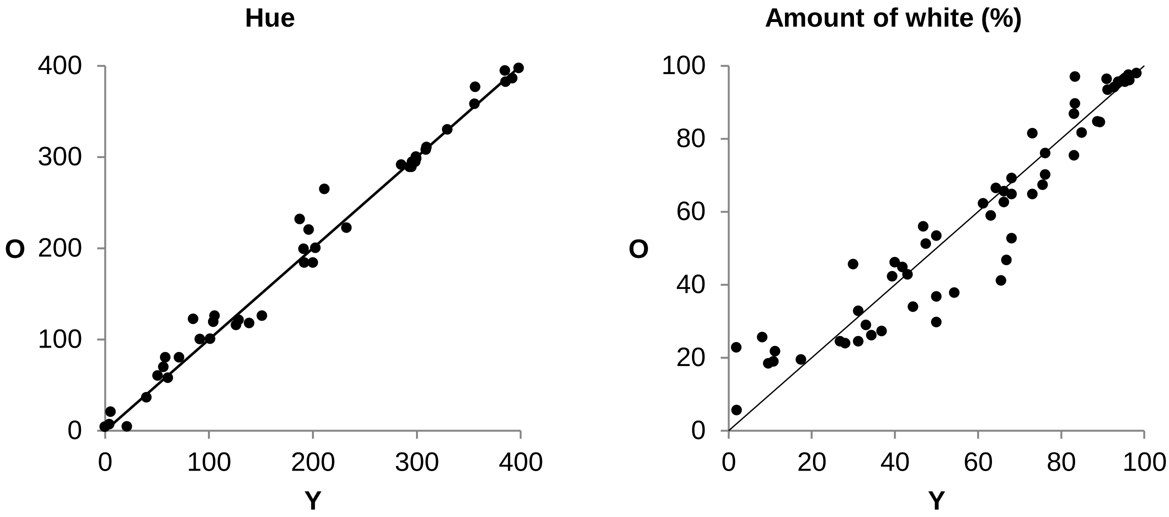

Figure 3 – Comparison of the perceived hue (left) and the perceived amount of white (right) of 58 coloured self-luminous stimuli between older observers (67 year – y axis) and young observers (27 year – x axis)

Although all the stimuli had the same 10°-luminance they were not perceived as being equal bright, both for the young and the older observers. This effect, called the Helmholtz-Kohlraush effect, is initiated because saturated colours are perceived as being brighter than less saturated colours with the same luminance (Hunt, 2011). The stimuli with a high perceived brightness (see Figure 4) are however perceived as being more bright by the older group compared with the young group. Because all these stimuli with a high value for brightness are the colours with a high saturation, the Helmholtz-Kohlrausch effect seems to be bigger for older people.

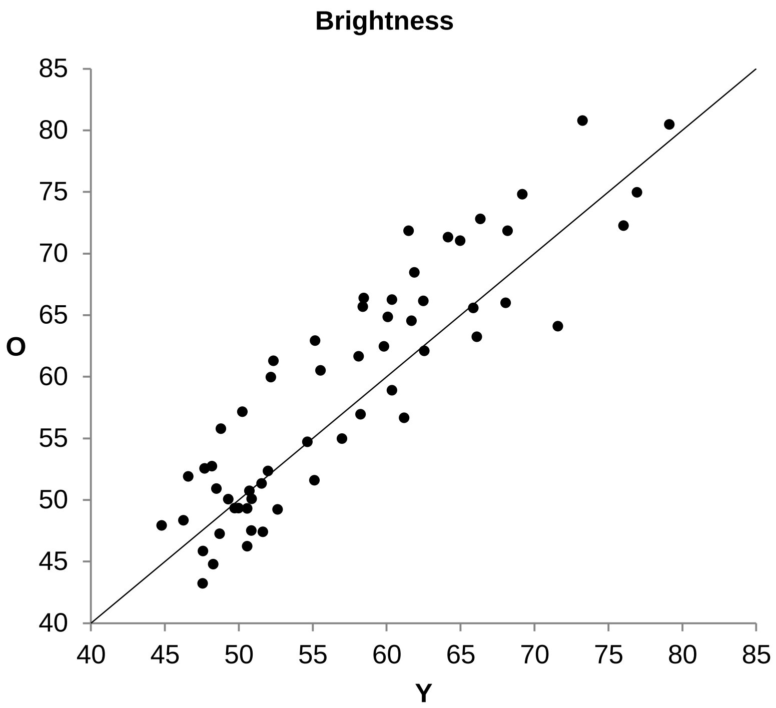

Figure 4 – Comparison of the perceived brightness of 58 coloured self-luminous stimuli between older observers (67 year – y axis) and young observers (27 year – x axis)

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