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Colour, vision and ergonomics

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Abstract. This paper is based on a research project - *Visual Communication and Inclusive Design-Colour, Legibility and Aged Vision,* developed at the Faculty of Architecture of Lisbon. The research has the aim of determining specific design principles to be applied to visual communication design (printed) objects, in order to be easily read and perceived by all. This study target group was composed by a selection of socially active individuals, between 55 and 80 years, and we used cultural events posters as objects of study and observation. The main objective is to overlap the study of areas such as colour, vision, older people's colour vision, ergonomics, chromatic contrasts, typography and legibility. In the end we will produce a manual with guidelines and information to apply scientific knowledge into the communication design projectual practice. Within the normal aging process, visual functions gradually decline; the quality of vision worsens, colour vision and contrast sensitivity are also affected. As people's needs change along with age, design should help people and communities, and improve life quality in the present. Applying principles of visually accessible design and ergonomics, the printed design objects, (or interior spaces, urban environments, products, signage and all kinds of visually information) will be effective, easier on everyone's eyes not only for visually impaired people but also *for all of us as we age.*

Keywords: Visual Communication, Colour, Ergonomics, Aged Vision, Sight, Legibility.

1. Introduction

The main objective is to develop the study of aspects related with vision, colour vision, chromatic contrasts and legibility so as to identify the problems related with the decrease of vision in the normal aging process, and to apply that knowledge in the design practice. What is easily perceived by young designers (some colour combinations, colour contrasts, typography), sometimes is difficult to perceive by the majority of people who do not fit this young profile. If designers are aware of these questions, the communication design projects will observe good perceptual conditions, and will be readable by those who have older vision.

With inclusive design solutions, the vast majority of people benefit from having things made easier to see [1]. Designers need to create environments and objects that are easier on everyone's eyes - with or without visual impairments. The visually accessible design is a relevant approach, once the world population is getting older and life expectancy is enlarged.

"Understanding how the relationships between the colours of a chosen palette will affect the final outcome of an overall composition is integral to mastering the use of colour" [2].

2. Colour Vision

With colour deficits, due to normal ageing process, the ability to discriminate colours is reduced. Designers can help to compensate for these deficits by making colours differ more dramatically on the basis of all three characteristics-hue, lightness and saturation. "Two colours that contrast sharply to someone with normal vision may be far less distinguishable to someone with a visual disorder. It is important to appreciate that it is the contrast of colours one against another that makes them more or less discernible rather than the individual colours themselves" [3].

Researchers at the University of Rochester, suggested that our perception of colour is controlled much more in the brain that in the eye. They have found that the number of colour-sensitive cones in the

human retina differs dramatically among people-by up to 40 times-yet people appear to perceive colours the same way. This was possible because they could study living retinas, instead of observing retinas from cadavers; the pigment that allows the cones to react to different colours is very fragile, and doesn´t resist to the light of microscope; and with a death retina they couldn't test colour perception.

They were able to precisely image and count the colour receptive cones in a living human eye for the first time. "We've shown that colour perception goes far beyond the hardware of the eye, and that leads to a lot of interesting questions about how and why we perceive colour". [4]

3. Aged Vision

The aging process is characterized by progressive and multiple acquisitions of minor deficiencies, predominantly related to vision, hearing, dexterity, mobility and cognition. In combination, these can lead to high levels of disability and dependency. The aging process includes physical degeneration; there is a reduction of the overall physical condition, of agility, impaired vision and loss of hearing, memory faculties, and sense of direction. Deficits lead to changes in sensory perception and decreased sense of well-being, which often involves strong feelings of insecurity [5].

Within the aging process, visual functions gradually decline, changes occurs in the eye, retina and visual nervous system, and the quality of vision worsens. Normal aged-related changes in vision occur in the process of ageing and are not diseases.

As a consequence, colour perception is different as showed in Figure 1.

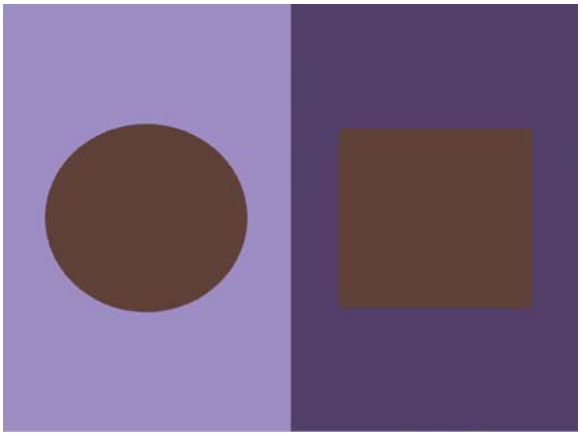

Fig. 1. For a person with colour-deficient partial sight, the left panel might appear like the right-one appears to a person with normal colour vision.
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Anatomic changes **-** The cornea remains clear but becomes thicker, and more likely to scatter light. The lens becomes denser, more yellow and less elastic. The diameter of pupil becomes smaller (*senile miosis*). "Under conditions of dim illumination, the resting diameter of the pupil falls from approximately 7 mm at age 20, to around 4 mm at age 80" [6]. The most functionally changes seem to be this reduction in pupil size and the loss of accommodation or focusing capability. The area of the pupil controls the amount of light that can reach the retina. With age, also decreases the extent to which the pupil dilates, and because of the smaller pupil size, older eyes receive less light at the retina; Most of older adults spend more time adjusting to changes in levels of illumination, and have greater difficulty seeing in dim light.

Accommodation **-** Is the loss of focusing capability (presbyopia), normally incapacity of see correctly near objects, but can be corrected with glasses or lens.

Visual Acuity **-** Is well preserved in older adults. Corrected visual acuity of at least 20/25 in the better eye is retained by 92% of individuals between 65 and 74, and 70% between 75 and 85 years of age. [7]

To other researchers, resolution acuity or the ability to see small detail in stationary targets typically of high contrast, decreases progressively with age and is exacerbated in low light conditions. *Dynamic visual acuity***,** the ability to resolve detail in a moving target also declines with age [8].

Colour and Night Vision **-** The blue and green area of colour spectrum is more difficult to distinguish that the red/ yellow end. Most of older individuals have more difficulty to see in dim light conditions. Colour vision changes cause some reduction of ability to discriminate blues and blue-greens. The yellowing of the lens (that becomes increasingly dense) is believed to be responsible for this effect, and causes a selective absorption of short wavelength light, blues and greens. Blue colour may appear dark and hard to distinguish from green, because the yellowish elderly lens absorbs blue light selectively; The aging lens and cornea causes glare by light scattering, especially for shorter wavelengths; the colour perception improves after cataract surgery. "Two colours that contrast sharply to someone with normal vision may be far less distinguishable to someone with a visual disorder. It is important to appreciate that it is the contrast of colours one against another that makes them more or less discernible rather than the individual colours themselves [9].

Contrast and Glare sensitivity **-** Some loss of contrast sensitivity, means they need sharper contrasts and sharper edges to discriminate between objects. Older adults feel visual discomfort under bright light conditions, or at night with oncoming headlights.

Visual quality and lighting **-** In optimal conditions of light, normal vision is good. Under dim lighting or with changing levels of illumination, some individuals have difficulty to perform visual tasks.

Although these anatomic and physiologic processes are distinct from the aging eye diseases, the vision changes they produce may be similar. Knowledge about these changes is essential to understand the mechanisms underlying age-related changes in visual function. Information about neuroanatomical changes in the visual system helps guide the development of strategies for compensating age-related deficits in visually-guided skills [10]. Most of the age-related weakness in colour discrimination appears to result from reduced retinal illumination and age-differences in colour discrimination performance were minimized with higher levels of target illumination. But, it must be noted that proper lighting is just one approach to deal with these changes in vision. With age, a gradual decline in visual functioning, affects performance on most everyday visual tasks. Much of this deficit is attributable to changes in the ocular media of the eyes, the balance to sensor neural changes in the retina and brain [11].

Although more light is required for the older person to see well, the level, direction and distribution of the light becomes increasingly important. Due to changes in the ocular medium, the senescent eye is more susceptible to the effects of glare and also takes longer to recover from it.

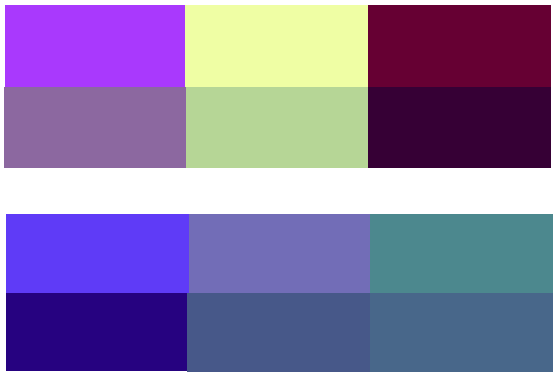
We can summarize the main changes in vision with the aging process:

Presbyopia, senile miosis, decreased visual field, decreased visual acuity, loss of central vision, difficulties with the light-dark adaptation, increased sensitivity to glare and dazzle with the brilliance, the decrease in contrast sensitivity, depth perception and reduced ability to discriminate colors.

As shown in the two sequences of Figure 2, the ageing eye may see the superior range of colors as the inferior one. As a general rule it can be established that strong colour contrasts, more vivid colours, strong differences in contrast brightness more than in contrast of hue, can be a compensation for ageing vision of elderly people.

With aging other problems may interfere with vision and the ability to perceive colors: These are Cataracts, Ageing Related Macular Degeneration, Glaucoma, Diabetic retinopathy and Retinitis pigmentosa, as the most frequent situations among older adults.

So bringing to projectual practice this knowledge, applying principles of visual inclusive design, principles of visual ergonomics, we can help people to improve their quality of life, moving safely in urban environments, living comfortably on interior spaces, and reading all the visual printed information with minimum effort.



Fig, 2 The superior range of colours in these two examples show the difference between colour perception of normal and aged vision.
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References

[1] M. Evamy and L. Roberts, In Sight – a guide to design with low vision in mind, Rotovision, Switzerland 2004.
[2] F. Moreira da Silva, Colour and Inclusivity. A Visual Communication Design Project with Older People. Pdf. Unpublished Research. Salford, 2011.
[3] [9]. A. Arditi, Effective color contrast, Lighthouse International, NY, 1999. Accessed 25 March 2009. <www.lighthouse.org/accessibility >.
[4] D. Williams, Color Perception Is Not in the Eye of the Beholder: It's in the Brain, University of Rochester Press Releases, 25 Oct 2005. Acessed 22 November 2008. < www.rochester.edu/news >.
[5] G. Meerwein, B. Rodeck, F. Mahnke, Color Communication in Architectural Space, Birkhäuser, Basel 2007.
[6] Lowenfeld 1979, cited by F. Schieber, 1993.
[7] C. Stuen and R. Offner, A key to Ageing in Place: Vision rehabilitation for older adults. The Haworth Press, Inc. 1999.
[8] K. Connolly. Legibility and Readability of Small Print: Effects of Font, Observer Age and Spatial Vision. The University of Calgary. Accessed 9 March 2007.

<www.psych.ucalgary.ca/PACE/VA Lab/gkconnol/Introduction.html>

[10]. F. Schieber. Recent Developments in Vision, Aging and Driving: 1988 -1994. Technical Report. Accessed 18 April-2009. http://www.usd.edu/~schieber/pdf/umtri.pdf

[11] Kline & Scialfa, 1996. Cited by K. Connolly.