Basic colour categories use in old tritanomalous and non-tritanomalous observers

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ABSTRACT

Two searching tasks evaluated how old people (tritanomalous and non-tritanomalous) use basic colour categories. Both tasks were performed using a sample of 102 simultaneously presented stimuli. Sometimes the observers had to point to "the best example of a category" (prototype searching task), other times to "all the stimuli that could be named with a category" (compatible stimuli searching). The categories considered were the Spanish eleven basics. Old people categories use was influenced by task (better responses for the prototype searching task), observer type (better for the non-tritanomalous) and category (best for yellow, worst for brown-purple).

1. INTRODUCTION

There is an apparent paradox in the results provided by studies related to old people's chromatic categories use. On a hand, some pessimistic information leads to think that they perform in a very distorted way (when compared with young people). The aging of the lens[1,2] and the results provided by aging simulation experiments are examples of this kind of information[3]. More specifically, it is well known that aged lens selectively alters the retina stimulation, reducing the energy of short wavelengths and that, when some procedure is used to mimic such alteration with young people, important alterations in the use of chromatic categories are observed (for example, they use less the blue category, because some blue stimuli are named green[3]). On the other hand, several works have provided more optimistic information, because they have observed in aged people a chromatic categories use very similar to young people[4] (for example, in relation to blue and green), or, in general, that colour perception has the possibility to compensate for the effects of a distorted signal[5].

Research related to old people chromatic categories use, frequently differs in two types of factors: Some are related to stimuli selection, others to old people's visual characteristics.

The results provided by a previous research[6,7] where the Spanish colour categories were identified (how many? Which?) and mapped (where?, in a CIE space) allowed us to create a 102 stimuli set where "good" and "bad" exemplars were sufficiently represented for each category. Using this set the participants in the actual research performed the two following searching tasks: First, to point to the best exemplar of a specific basic category (prototype searching task). Second, to point to all the stimuli that could be named with a category (compatible stimuli searching task).

As it was previously indicated, research papers on categories use can differ in aged people visual characteristics. For example, some works use colour vision tests to exclude people that, according to clinical standards, are pathological observers. In our opinion, this is not the best option, because it excludes aged tritanomalous and, as it is well known, this pathology frequently derives from the normal aging of the eyeball associated with cataracts genesis.

Our research main goal was to study aged people basic chromatic categories use. Therefore, and to compare such use with young people's performance, young observers participated in the first experiment. They did the two searching tasks with and without a yellowish filter that mimicked ocular aging. The comparison between them and old people was possible because two groups of aged observers participated in the second experiment. According to clinical standards one group was formed by tritanomalous. The other included people with normal vision (control group).

2. EXPERIMENT 1

2. 1. METHOD

Participants

Seven subjects (four females and three males) took part in the experiment. They were between 19 and 21 years old (mean = 19.57). All were screened for colour vision by means of the Ishihara Pseudo-Isochromatic colour plates, the City University Color Vision Test (CUCVT), and the Lanthony test. No participant showed evidence of colour blindness.

Stimuli and apparatus

The stimuli set was formed by: (1) The previously[7] identified as Spanish basic prototypes (best exemplars in NCS atlas), (2) the pairs that identified a category transition (for example, in Spanish there is an orange-brown transition because some stimuli are alternatively named with one of these categories), (3) the stimuli half in CIELUV distance between a prototype and a category transition. Each stimulus measured 4 x 4 cm and were binocularly observed at a distance of 50 cm, projecting a visual angle of 4,5 degrees. The full set of stimuli was presented on a medium-grey (N 5000; L*=50) background.

Clinical tests and searching tasks were performed in a booth that allowed a precise illumination (type and quantity) control. Colour temperature and illuminance were 5754K and 250 luxes. All the measurements were performed using a Photoresearch PR-650 connected to a PC computer and a termocolorimeter Gossen Colormaster 3F.

Procedure

All the participants performed every test and every task with and without wearing a yellowish filter attached to a pair of goggles. Half of the observers began the experiment wearing the goggles. A five minutes adaptation time period was used. After it, clinical tests were applied. Later, and for each of the eleven Spanish basic categories (their English equivalents are indicated after hyphen: Blanco-White, Negro-Black, Rojo-Red, Verde-Green, Amarillo-Yellow, Azul-Blue, Marrón-Brown, Naranja-Orange, Rosa-Pink, Morado-Purple, Gris-Gray), the observers performed the two searching tasks. Firstly, they pointed to the best exemplar of each category (prototype searching task). Secondly, they pointed to all the stimuli that could be included in each category (compatible stimuli searching).

2. 2. RESULTS

There were no errors when the observers responded without the yellowish goggles. These were frequent, and very specific, when the filter was used: No protan or deutan errors were made in response to Ishihara and CUCVT. Tritan errors appeared in response to CUCVT (mean = 2.14) and Lanthony (mean = 1). One-tailed Wilcoxon tests significantly showed more tritan-type errors when the pseudoisochromatic plates were seen through the filter for these two tests (CUCVT and Lanthony, $\rho < 0.01$). Results obtained in the searching tasks will be commented in relation to Experiment 2.

3. EXPERIMENT 2

3. 1. METHOD

Everything was identical to Experiment 1, except what explicitly indicated. Twenty-eight aged observers between 68 and 98 years old (mean = 83.5) participated. Tritanomalous group was formed by 14 observers who received such clinic diagnosis from their punctuation in the CUCVT and the Lanthony tests (they had normal vision according to Ishihara test). Control group was formed by 14 observers. They had normal colour vision according to the three tests applied. Old observers were evaluated in their own residence (four institutions collaborated). In all the cases it was possible to arrange a room where, by using incandescent lamps and colour temperature filters, lighting was similar to the one used in Experiment 1.

3.2. RESULTS

To evaluate the relative use of green and blue, we computed a fraction for every observer (Green/Blue) in the compatible searching task. Against what predicted from Lindsay and Brown's hypotheses[3], the following ranking order was obtained for the medians of the groups: Young without filter (2.60), old normal (2.42) old tritanomalous (1.28) and young with filter (0.39). All the statistical comparisons between groups were statistically significant ($\rho < 0.05$), excluding the one concerning the two normal groups (young without filter vs old normal). Figures 1, 2, 3 and 4 inform about the searching tasks results. CIE u´v´ chromaticity diagrams on the left (A) correspond to young people without filter. Central diagrams (B) correspond to non tritanomalous old observers, and right diagrams (C) to old tritanomalous. For all the diagrams, the black triangle indicates the achromatic point, whereas each "+" (plus) sign corresponds to a stimulus that, in our previous research[7], was consistently named with the category indicated by the figure caption.

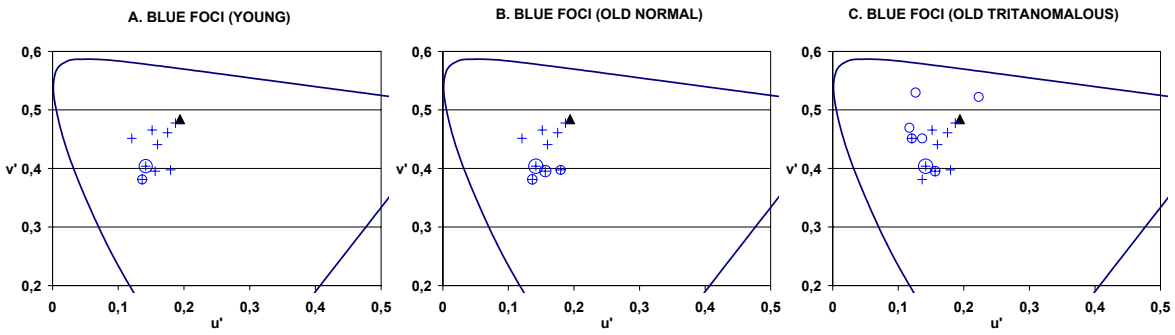

Figure 1. Blue prototype searching task.

Figure 1 informs about the blue prototype searching task. Every circle corresponds to a selected stimulus. Circle size is proportional to the number of selections. Attending to the spatial coincidences between pluses and circles, it can be concluded that young observers (1A) and normal olders (1B) selected, as foci or prototypes for blue, stimuli consistently named as such in our previous research. Even more, their choices were very close in the diagram because were coincident with the standard prototype. On the other hand, for the old tritanomalous group (1C) the stimuli selected as blue spread towards positions without crosses (associated with green in our previous research). Figures 2, 3 and 4 inform about the compatible stimuli searching task. They all show a similar trend: Most of the young people choices (circles in "A" figures) were in positions with plus signs. There are some circles without plus sign for normal olders ("B" figures). Circles without plus sign were very frequent for old tritanomalous ("C" figures). It is interesting to compare category pairs using diagrams corresponding to old tritanomalous ("C" figures). For example, comparing Figures 2C (blue) and 3C (green), it can be observed that the positions occupied by the circles without pluses in a figure are occupied by circles with pluses in the other one. This observation is also valid in relation to brown (Figure 4C) and purple (figure not shown, because of space restrictions).

3.3 DISCUSSION

Our research resolves the paradox about old people chromatic categories use previously mentioned, because it was observed that such use was modulated by three variables: The relation stimulus type-response required, the old people visual characteristics, and the category considered. The high similarity between Figures 1A and 1B indicates that, when excluding tritanomalous observers and the task implicates the use of foci, old people categorisation can be very similar to young people. This similarity can be greater for some categories, like yellow, where errors are infrequent even for old tritanomalous. On the other hand, the differences among "A" and "C" figures indicate that important differences between young and old people can be found using different criteria (tritanomalous included in the old people group, categorisation not centred in prototypes, selections done in relation to categories like brown or purple).

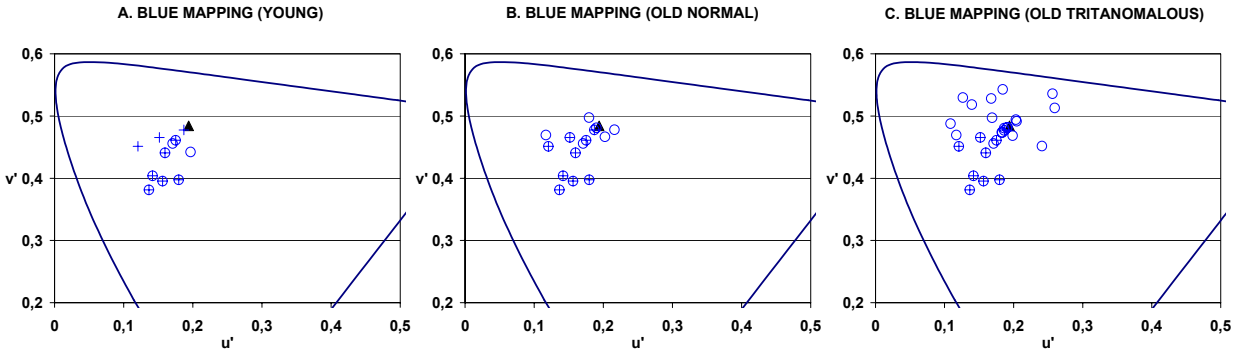

Figure 2. Blue compatible stimuli searching task.

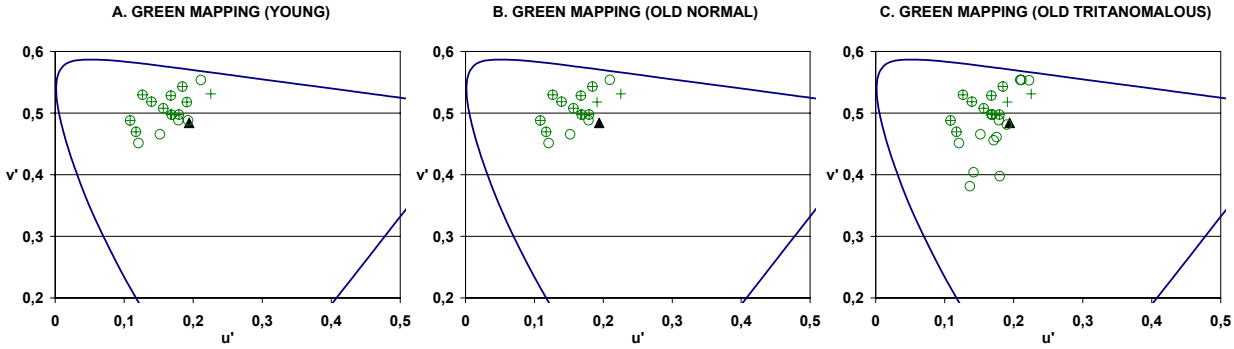

Figure 3. Green compatible stimuli searching task.

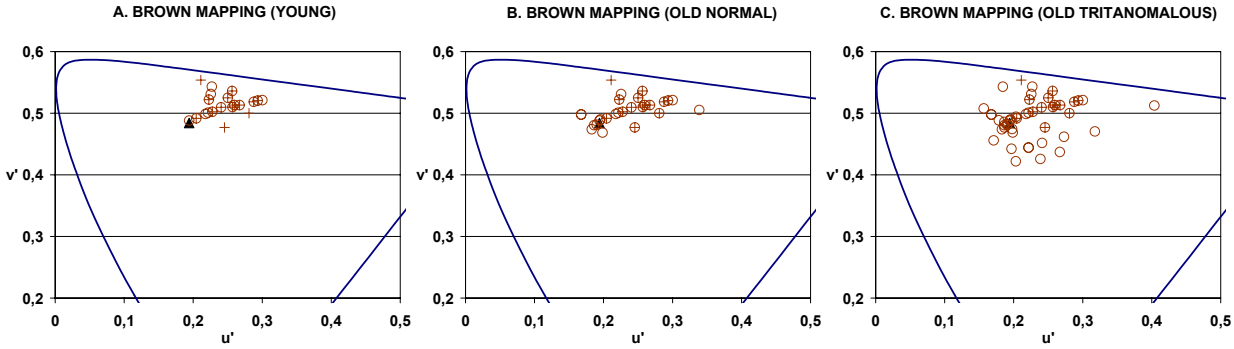

Figure 4 Brown compatible stimuli searching task.

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