Accuracy and variability of simultaneous and memory colour matching

T. Tarczali, J. Csikós, P. Bodrogi
Colour and Multimedia Laboratory, Department of Image Processing and Neurocomputing, University of Veszprém
8200-Veszprém (HUNGARY)
Corresponding author: T. Tarczali (ttarczali@vision.vein.hu)

ABSTRACT

Short-term memory matching was investigated in three experimental series for Caucasian skin, green grass and blue sky colours. Aim of the experiments was to examine the cognitive colour effect in presence and absence of image context and to determine the "distance of emergence" of the effect related to prototypical or long-term memory colours. A further aim was to compare these results with the results of simultaneous colour matching experiments. The image context was realized by showing greyscale photo-realistic images. If the colour centre was far from the prototypical colour then no significant cognitive colour effect was found. Results indicate that the extent of the cognitive colour effect may depend on the distance from the prototypical colour.

1. INTRODUCTION

Colour memory is very important in everyday life as it is often required to compare an original image with its reproduction. In these situations, observers memorize an original colour and then compare this memorized colour with another colour actually being seen. Many recent studies have dealt with colour memory[1-5]. Authors also carried out related experiments in this field in the last years[6]. In the present work, we compare the accuracy and variability of simultaneous and memory colour matching of the same observers and in the same viewing situation, on a self-luminant colour display. We used the so-called "method of deciding" which turned out to be very easy to carry out in numerous repetitions for the observer.

2. METHOD

The most important advantage of the "method of deciding" (described below) is that very similar viewing conditions can be ensured for the "original" colour and the "decision" colour[6]. All visual experiments have been carried out on a well-calibrated and characterised colour monitor in a dark room. Each of our 10 colour normal observers participated in three series called simultaneous (S), geometric (G), and photo (P) series. In the S series, the observer saw two colour patches of 2º viewing angle on a grey background. The observer had to tell a yes or no answer about whether the two patches were of the same perceived colour. One of the two colour patches was called "colour centre" and the other was called "decision colour". In the G series, the observer saw only one colour patch (the "original" colour). He/she had to memorize the original colour in 4 seconds. After a 4 seconds delay he/she saw the "decision" colour for 4 seconds, and had to tell a yes or no answer about whether the original colour and the decision colour were remembered and perceived the same. The P series was similar to the G series except that there was a photo-realistic greyscale image (see in Figure 1) depicting a familiar object around the original colour and the decision colour, which was intended to represent an image context known to influence the performance of human colour memory[6].

Figure 1: Photo-realistic greyscale images used in the P series

Three fixed original colour stimuli (Caucasian skin, green grass and blue sky) were used in all series as colour centres or original colours. They resulted from our previous experiments[6] as colour memory prototypes (in other words: prototypical colours) and thus we expected *no* significant shift between the original colours and the mean memory colours[6]. 50 decision colours per series were randomly selected from the $\Delta E_{ab}^{*}=20$ neighbourhood of the original colours (or colour centres) by ensuring $\Delta L^{*}=0$ between the decision colour and the original colour (or colour centre). The decision colour was allowed to be the same as the original colour (or colour centre).

After the experiments described above, we carried out two further experiments. Aim of these two new experiments was to confirm and extend the results of the first experiment. The procedure of these two new experiments was the same as in the first one. But the original colours (or colour centres) were different: these original colours were derived from the original colours of the first experiment (see above) by the aid of a hue shift first clockwise and then also counter-clockwise with the same amount of CIELAB hue angle (Δh=30° for Caucasian skin and sky, Δh=25° for green grass colour). 11 observers took part in the second experiment and 12 in the third experiment.

3. RESULTS

Figure 2 shows a result of the three experiments described above, for the case of the “green grass” colour, as an example. These CIELAB a^*-b^* diagrams contain all "yes, the same" answers of all observers for green grass colour and for the S, G, and P series. The original colour (or colour centre) is depicted by a large plus sign, the mean decision colour of the "yes, the same" subset of 10(11, 12) observers x 50 decision colours is depicted by a smaller cross sign. The "yes, the same" subset is depicted by small crosses. The variability ellipse of latter subset is also shown.

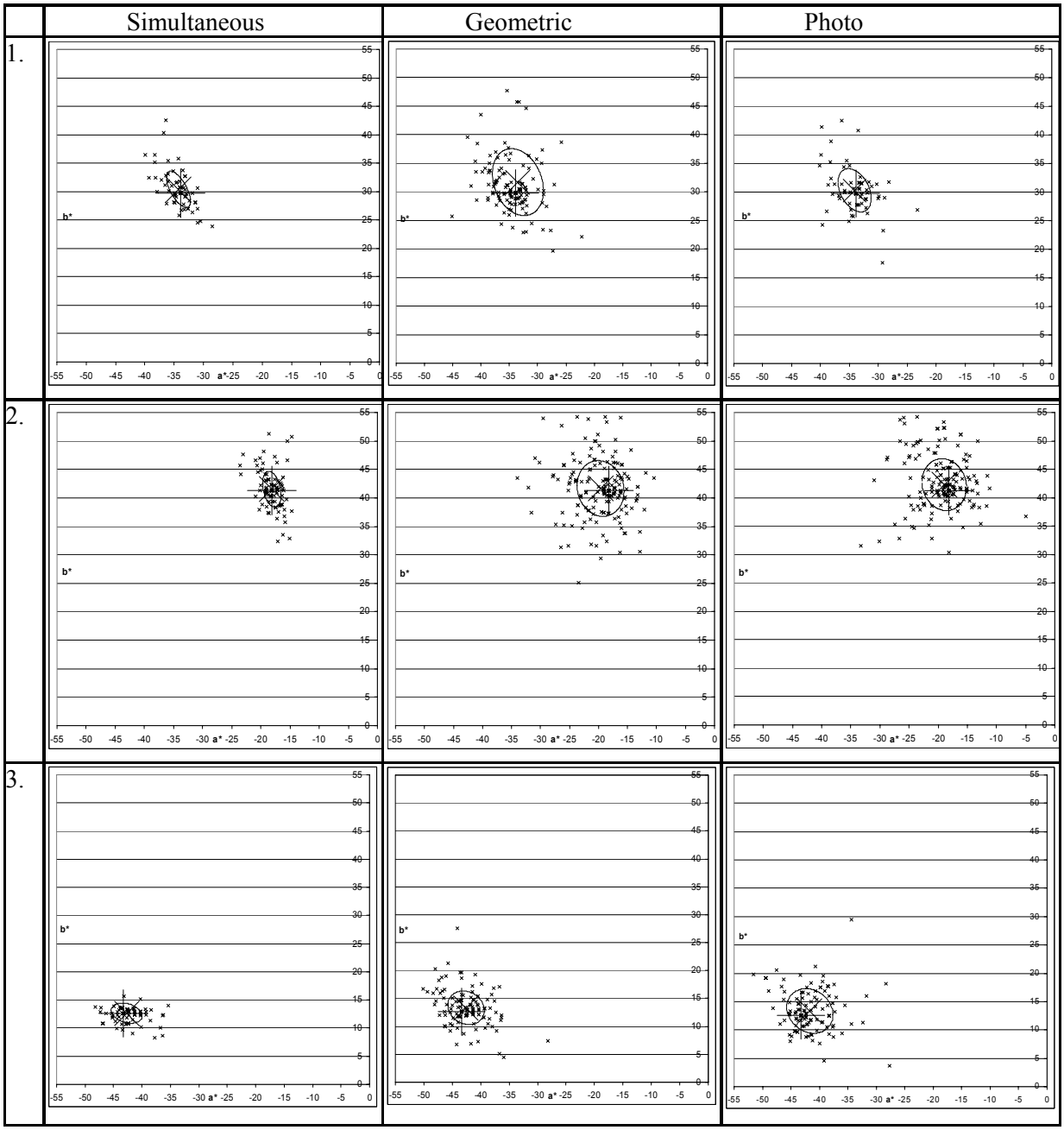

Figure 2: CIELAB *a*-b** diagrams, containing all "yes, the same" answers of all observers for green grass colour and for S, G, and P series for the three series with different colour centres.

As can be seen from Figure 2, in the first row, the scatter of the “yes” answers is largest for the G series, and smallest for the S series. As expected, the scatter was smallest for simultaneous matching. In the P series, in the presence of the photo-realistic greyscale image depicting a familiar object around the original colour and the decision colour, there may be a tendency to categorize the original colour and to remember a colour category only, instead of remembering the perceived colour. Observers may remember the expression “green grass” and accept or not accept the decision colour as “green grass” long-term memory colour. But unfortunately, this effect cannot be seen from the present results. In the first experiment, see row 1, in Figure 2, the original colours were prototypical colours, and therefore, no significant shift of the mean memory colour was expected. In the second and third experiment (see rows 2 and 3 in Figure 2), we expected a significant shift between the original colours

and the mean memory colours[6] confirming the theory of shifting the perceived colour toward memory colour prototypes (prototypical colours) in colour memory[6]. The possible reason for the absence of the memory colour shift is that the colour centres were located so far from the prototypical colours (due to the clockwise and counter-clockwise hue shifts) that the cognitive effects could not have any influence on the memory matching process. Similar result was found for the case of the other original colours, i.e. for Caucasian skin and blue sky.

As can be seen from Figure 2, the standard deviations of the "yes the same" answers of the simultaneous experiment are smaller than the standard deviations of the geometric and photo series for all of the three experiments. The presence of a stronger cognitive effect may cause the smaller scatter of the results in the photo experiment of the first series. This smaller scatter cannot be seen in the results of the second and third experiments. The scatters of the "yes the same" answers of the geometric and photo experiment in the case of the second and third experiments are nearly the same. Obviously, the absence of the greyscale photo-realistic images (context) did not have an influence on memory matching possibly because the colour centres used in these series are located so far from the prototypical colours of the visualized objects that the observers could not identify their perceived colour.

4. CONCLUSIONS

We examined the properties of simultaneous colour matching and memory matching by the aid of the experimental method of decisions. Caucasian skin, blue sky and green grass colours were investigated in simultaneous and successive (memory) matching experiments with and without image context. The aim of the image context was to promote the cognitive colour effect which is important in memory matching. In these experiments, we found no significant difference between the original colour and the short-term memory colour. We hypothesized that it is the *colour difference* of the original colour and the corresponding long-term memory colour that determines if the cognitive effect comes out during the colour memory matching process. We intend to carry out further experiments with other colour differences between the original colour and the prototypical colour. We also compared the scatter of simultaneous matching and memory matching of the present experiments.

References

1. J. Pérez-Carpinell, V. J. Camps, M. D. de Fez, J. Castro, "Color memory matching in normal and red-green anomalous trichromat subjects," Color Res Appl 26, 157-170. (2001).
2. H. H. Epps, N. Kaya, "Color Matching From Memory" in Proceedings of AIC 2004, Color And Paints, Interim Meeting of the International Color Association Porto Alegre, Brazil, November 2-5, (2004).
3. K. Amano, K. Uchikawa, I. Kuriki, "Characteristics of color memory for natural scenes," J Opt Soc Am 19, 1501-1513, (2002).
4. H. H. Selinger, "Measurement of memory of color," Color Res Appl 27, 233-242, (2002).
5. M. D. de Fez, P. Capilla, M. J. Luque, J. Pérez-Carpinell, J. C. del Pozo, "Asymmetric color matching: memory matching versus simultaneous matching," Color Res Appl 26, 458-468, (2001).
6. L. W. MacDOnald, M. R. Luo (editors), Colour Image Science, Exploiting Digital Media, Part 1, Chapter 2, John Wiley & Sons, Ltd, Chichester, England, (2002),