Behavior of the deviate observers SDO-CIE-1989, Poza-SDO, and JF-DO in relation to color objects

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ABSTRACT

Recently, in our laboratories, a set of color-matching functions (cmf's) has been formulated for small fields by using two groups of real observers: JAM, MM, CF and AY, JR, MR, JL, JA, FP. These cmf's have been measured using different experimental devices and methods, enabling us to propose a New Deviate Observer for small fields (JF-DO). This new JF-DO was derived from the average observer of our 9 real observers, following the technique used by the CIE to establish the Standard Deviate Observer (CIE-1989-SDO), which was established for fields of 10º. In the present work, we analyze the influence of the cmf's of the deviate observers SDO-CIE-1989, POZA-SDO and JF-DO on color differences of a size greater than threshold. It is deduced from the study that there is a great variability between observers considered here, with the observer JF-DO being more different than the other two, POZA-SDO and CIE-1989-SDO.

1. INTRODUCTION

Studies on inherent variability in color-matching functions (cmf's) of the groups of observers with normal color vision have led to the establishment of deviate observers (DO). Consequently, the CIE in 1989 proposed a Standard Deviate Observer (CIE-1989-SDO) taking as a basis the cmf's of 20 actual observers for 10º field from the research of Stiles-Burch.

A DO, which enables us the evaluation of differences caused by the variability between observers, is derived changing actual cmf's taken as the average of those of several observers. The objective is to establish an observer whose cmf's are more consistent with the cmf's of real observers than with the cmf's of their average value, all this from the standpoint of metamerism.

The CIE[1] assumes that the deviate observers proposed for fields of 10º (SDO-CIE-1989) are also applicable to smaller fields, based on the physiological causes of the variability of the cmf's of real observers. Our research group has recently proposed two new deviate observers for small fields[2,3]: Poza-SDO and JF-DO, both obtained for small fields. Here, we present a study of the influence that the cmf's of the deviate observers SDO-CIE-1989, Poza-SDO, and JF-DO exert on suprathreshold color differences. For this, we have followed the guidelines of the CIE[5], using Munsell[6] chips with a glossy finish. Also, all the cmf's of the observers used here are referred to the new system of unreal primaries X'Y'Z' with the use of the new transformation matrix T[7].

2. METHOD

The CIE has recognized the value of studying the variability of cmf's in relation to judgments on color differences among different normal observers.

In addition, any modification of the standard observers proposed by the CIE—that is, the proposal of other cmf's that characterize better the average behavior of the human visual system would involve an immediate change in the basic specification of the color given by the tristimulus values. Undoubtedly, these changes must be taken with caution and, though a specification of color or of color differences which is more in accord with visual perception is currently desirable, it is no less true that any modification would also entail various problems related to colorimetric instrumentation and the industrial applications of colorimetry. This demands that these modifications present a statistically significant improvement.

In this regard, we have studied the behavior of the new observer JF-DO and have made comparisons with other SDO's.

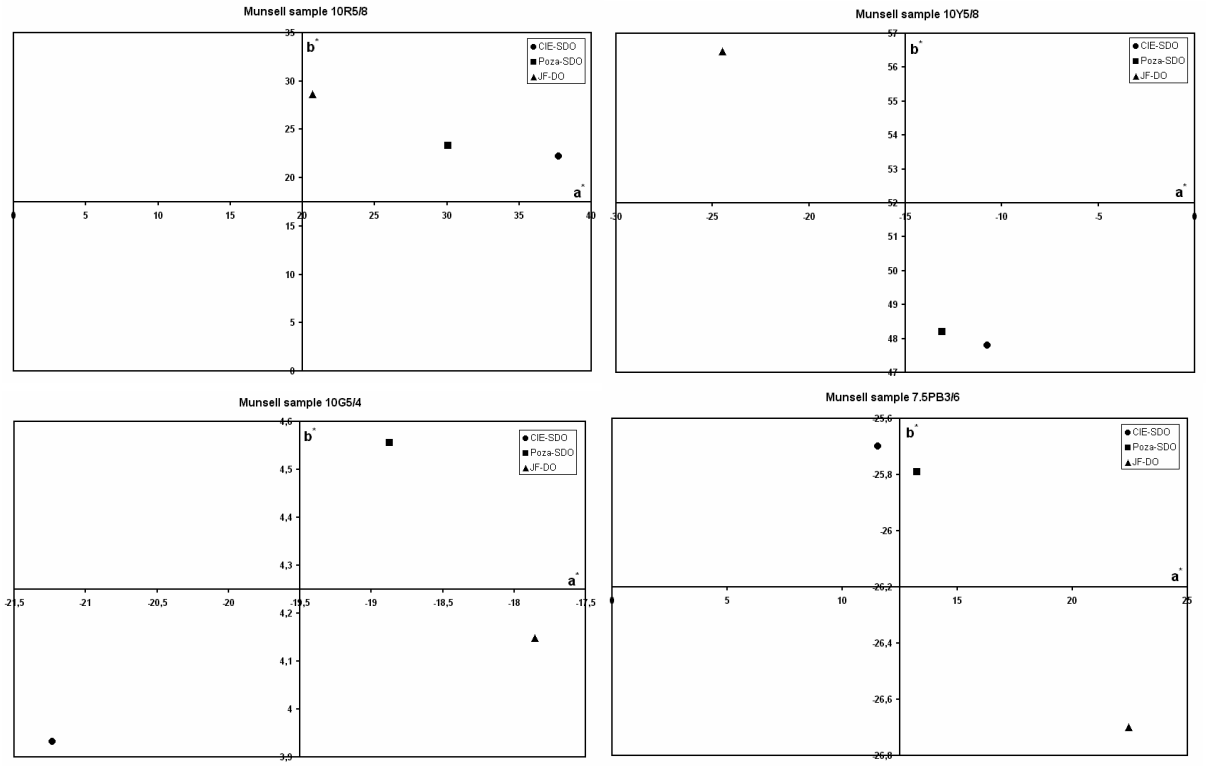

Figure 1: CIELAB coordinates for each of the four selected Munsell samples obtained with the CMF's of the observersCIE-1989-SDO, POZA-SDO, and JF-DO

One of the 10 parameters that the CIE[5] proposes to coordinate research on color differences is observer variability (related in large part to SDO's), highlighting moreover the interest of studying the variability of the cmf's on the judgments of color differences among normal observers. Here we study the behavior of DO's with respect to color objects. For this, we have selected four chips from the Munsell[6] system with a glossy finish and, to calculate the color differences, we have used the CIELAB formula recommended by the CIE for color objects[8]. We have considered an achromatic reference and the simulated D65 illuminant. The four Munsell chips close to the CIE[5] centers were: 10R5/8, 10Y5/8, 10G5/4 and 7.5PB3/6. The reflectances of these samples were measured with the spectroradiometer Hunterlab PR-107, within the wavelength interval 400-700 nm. Each observer used (JF-DO, POZA-SDO, and CIE-1989-SDO) was presented with each of the four Munsell samples selected, resulting in different CIELAB coordinates for each observer. For a general characterization of the differences between the three observers used here when observing the same Munsell chip, we considered the observers by pair combinations—that is, each observer was combined with the remaining: SDO-CIE-1989 with JF-DO; Poza-SDO with JF-DO; SDO-CIE-1989 with Poza-SDO. The CIELAB color differences corresponding to the three pairs of observers were calculated for each Munsell chip.

3. RESULTS AND CONCLUSIONS

Figure 1 present the CIELAB coordinates for each of the four selected Munsell samples obtained with the CMF's of the observersCIE-1989-SDO, POZA-SDO, and JF-DO. In these, we distinguish the points corresponding to the three observers (SDO's) used. The analysis of these indicate a strong variability between the different observers.

Figure 2 shows CIELAB color differences observed by the pairs of the deviate observers for each Munsell used. The analysis indicated that the least CIELAB color differences resulted with the observer pair SDO-CIE-1989 and Poza-SDO, while the greatest differences were found with the pair SDO-CIE-1989 and JF-DO. However, marked differences were also found for the pair Poza-SDO and JF-DO. Furthermore, it was noted that in general the smallest CIELAB color differences resulted in each case for the sample 10G5/4, followed by 7.5PB3/6, whereas the largest differences corresponded to 10R5/8.

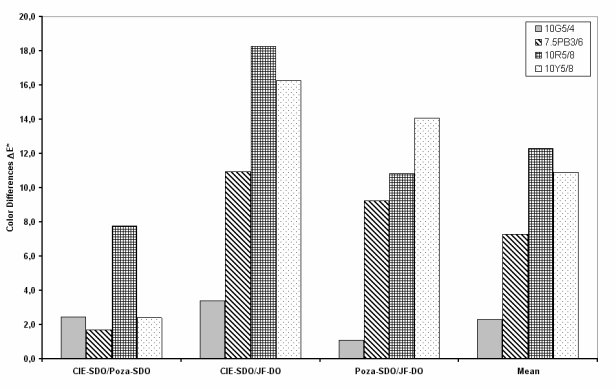

Figure 2: CIELAB colour differences observed by the pairs of the deviate observes for each Munsell chip used.

All this may indicate not only great variability among the three observers, but a greater difference in observer JF-DO than in the other two, although the former is closer to Poza-SDO than to SDO-CIE-1989, while Poza-SDO is closer to SDO-CIE-1989.

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