On the color-texture interaction

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ABSTRACT

The psychophysical studies on color-texture interaction [1-5], one of the ingredients of the color-form interaction [6] started in the 1960's, when the test-objects progressively passed from simple and uniform to complex, textured and patterned [7]. The present paper deals with the color appearance of quasi-random textured samples, a), near the detection threshold, b), at suprathreshold levels, by determining the visual balance as referred to the spatially uniform steps of a grey scale. The resistance to melding of colors belonging to different categories and the participation of both color and texture in the sensation of balance are aspects of color-texture interactions, susceptible of being included in the framework of modeling.

1. EXPERIMENT I – APPEARANCES OF NON-UNIFORM STIMULI AS THE DETECTION THRESHOLD APPROACHES

The degradation of the appearance when approaching the detection threshold of a spatially uniform sample, for instance, by increasing the viewing distance, has been codified since long by the traditional visual research. However, the perceptual situation, in the range where vision becomes progressively uncertain, is much more confusing and difficult when the test object is spatially non-uniform and irregular.Qualitative descriptions of the various events met at various eye-target distances are found, for instance, in the recent literature concerning textiles [4], as well as in the history of visual arts [8]. For instance, the Impressionists regarded the resistance to fusion of their brushstrokes, dabs and pointillistic clusters and the related visual effects (shimmering, softness, vibrations, lustre, jittering, transparencies etc.) as responsible of the "alive" appearance of their paintings, as a characteristic of their style.

In our first experiment we used plain and rough knitted samples (squares, 20 cm side), either monochrome, or made by interlacing two wool threads of different colors, illuminated by an incandescent source, on a square, (side of 2 m), middle grey background, 5 cd/sq.m, nearly as that of the test sample placed vertically at the end of a darkened optical tunnel, 18 m long. Three observers devoted several sessions to the qualitative description of the changes in appearance as the viewing distance increased, the minimum step being of 25 cm.The events selected as representative are: the resolution of the fine grain of the knit (the single stitches, or "pixels), followed by a set of broad irregular fuzzy patches. Let us recall that, after Barlow [9], "the cortical neurons do not respond in proportion to the linear sum of the weighted contributions from the paths of their receptive fields. More logical, interesting operations are made, which cannot be modeled by simple summation." By further increasing the eye-test object distance, the image starts being contaminated by speckle-like, boiling dots. Some of them are whitish, others of the same color(s) of the used wool(s).

The main experiment consisted in the quantitative determination of the transition thresholds (T), from one to the other category of appearance, by the constant stimuli method (ten responses per point) and their certainty was rated by the use of a five point subjective scale. Note that such assessments require highly skilled and patient observers.

For the sake of available space one example only is shown in Figure 1. The knits were made by using simultaneously two threads differing in their colors, say: green (S 30 60 – G) and yellow (S 05 50 –Y). The plain knit sample consists of a flat array of stitches, the interdistance between their centers being of about 2.5 mm, whose predominant color is either green or yellow or a mutual interlacing of both. The rice knit is a sort of rough (three-dimensional) checkerboard, the interpeak distance is of about 5 mm, the amplitude of the modulation (perpendicularly to the surface of the sample) is of the order of 3 mm, the brightness distribution is highly irregular, the spatial distribution of the two colors is quasi-random, as if two periodical components, locally variable in spatial frequency and phase, would combine in a complex manner.

In spite of increasing confusion and responses biases, when interpreting the irregularities and the disturbing pulsations and jitter, much more conspicuous for the rice than for the plain knit, an interesting conclusion emerges from our observations : even in the worst conditions, the observer perceives the presence of the two original interlaced colors, green and yellow. The effect is “robust”. When the retinal image is so small that the density of the spatial structures is so large, that the WHAT and WHERE mechanisms fail, a noisy apparrent motion invades the dis-organized image, and various “units” tuned at any retinal location cease to be mutually coordinated, in spite of it, the information about the existence of two different color categories reaches the consciousness, emerging from a struggle with the degraded the spatial structure of the image.

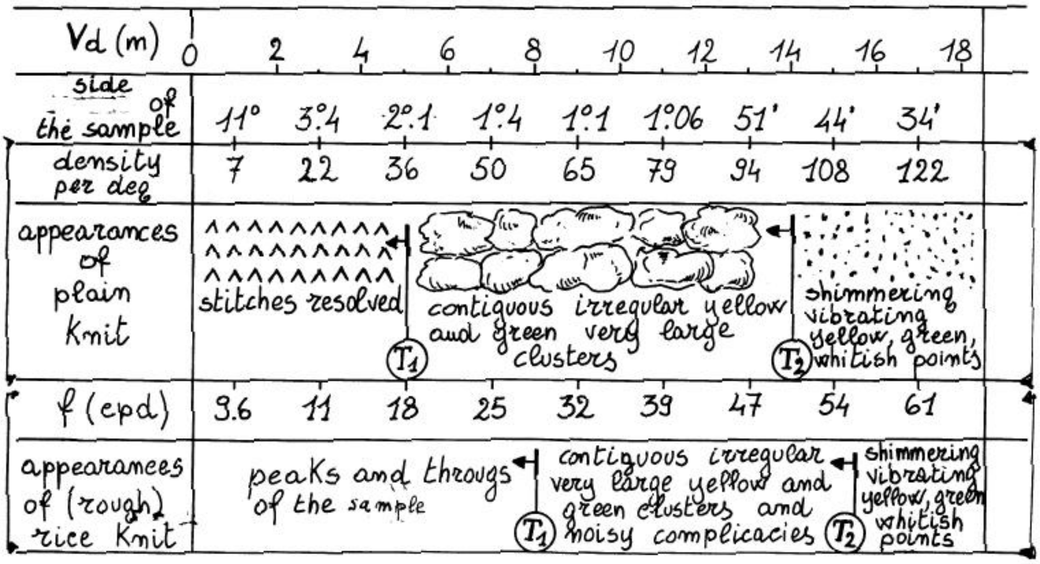

Figure 1 –Selected appearances of plain and rice quasi-random knits (made by interlacing a green and a yellow wool thread), when viewing distance (vd) increases approaching threshold

2. EXPERIMENT II – SUPRATHRESHOLD APPEARANCE OF NON-UNIFORM SAMPLES, AT THE VISUAL BALANCE WITH THE UNIFORM STEPS OF A GREY SCALE

The visual balance is a well known sensation evoked in visual arts (architecture, painting) since ancient times, by properly arranging the sizes, the masses and the colors in the represented spaces, and related to harmony. In the visual laboratories the balance is regarded as a match of the visual weights of two contiguous, paired samples [10-11]. The balance is a global sensation, which, in a multichannel visual modeling, is the outcome of the the combination of various signals, at the output of a number of visual channels. After Munsell’s law (1905), at the balance, for spatially uniform and uniformly lit samples, the equation

$$A1 \times V1 \times C1 = A2 \times V2 \times C2$$

holds, where: A , referred to the geometrical stimulus area, represents the perceived stimulus size; V, the Value, referred to the luminance, represents the lightness; C. the Chroma, represents the interaction between chromatic and achromatic channels, through Hue and Saturation, respectively, and may be specified, for instance, in terms of NCS notations. In the present and previous experiments [e.g., refs.12-13] we use a rectangular test object, of variable length AB, luminance L AB, height 10°, and (variable) area A1, flanked by a reference grey square, side BC =10°, of fixed area A2 made of a uniform cardboard, a step of a grey scale. Its luminance is denoted by L BC, and, from session to session, varies from 5 to 50 cd / sq.m. This display is placed on a desk, at a viewing distance of 59 cm, lit by incandescent sources fitted in the ceiling, and surrounded by a black square paper, (area, one square meter). By varying the length AB of the rectangle, the minimum step being of 1°, the balance condition is obtained by the use of the constant stimuli method (ten responses per points). Each balance condition is represented by a point in the plots shown in Figures 2 and 3, where the data rom three different observers are put together, and the value of AB at the balance (S.E. from 0.05 to 008) is plotted versus log L BC.

Figures 2 a), b), c) were selected from a plethora of data recorded by us. They refer to green-yellowish, uniform cardboard samples of variable m (the NCS stauration). Note the right-left asymmetry, often met in visual experiments when passing from negative to positive intrapair luminance contrasts. Let us consider now the effect of saturation. When m exceeds, say, 30%. The right branch of the plots declines with increasing L BC, but it does not drop below AB = 10° (the same as the side of the square reference BC). This is in qualitative agreement with Munsell's law, by considering that the Value of the saturated colored samples is increased by the so-called extra-brightness, an aspect of the brightness-luminance discrepancy.

The scarcely saturated samples, on the other hand, behave , more-or less, as achromatic samples, as is shown, for instance, in Figure 3 a), which referes to the balance conditions by using pairs of (uniform) grey samples of variable intrapair luminance contrast. The interesting fact, in Figures 2 c) and 3 a) is that the right side of the plots is splitted into two branches , that is, there are two different AB ranges, where the balance can be attained. It may be ascribed [12] to the coexistence of different "units" at the same retinal location. This fact is not expected by minding to Munsells law.

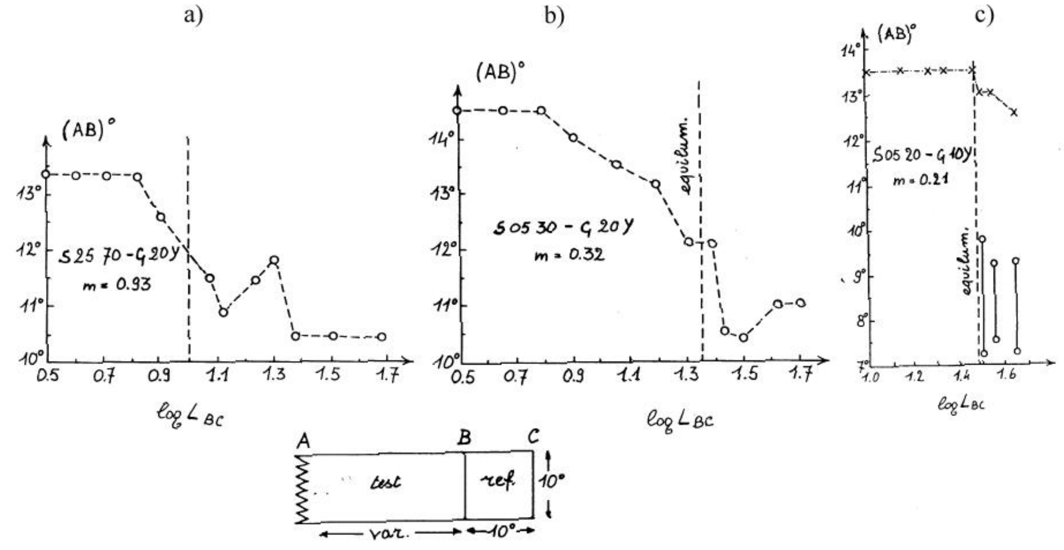

Figure 2. a), b), c) – Balance conditions for spatially uniform green-yellowish cardboards, of decreasing saturation (m) when passing from a) to c). The vertical dotted lines indicate the intrapair euiluminance

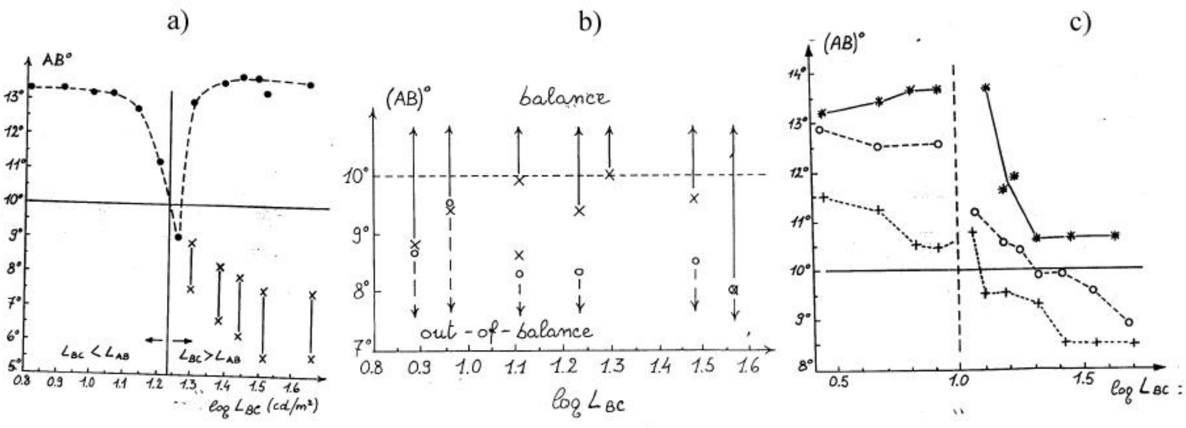

Figure 3. Balance conditions for: a) pairs of grey versus grey uniform cardboards; b) textured ensemble of square random dots (crosses); and a square-wave grating (open circles) c), knits made interlacing green and yellow wools, with different stitches.

Another result not predicted by Munsell is that, in the case of non-spatially uniform samples, the balance condition also depends on the texture of the surface of the test sample. This effect may be quantified by the use of the same technique as above :comparing a non-uniform sample to the (spatially uniform) steps of a gray scale.This is shown, for instance, in figure 3 b) , which refers to test objects consisting of ensembles of square Random Dots (crosses) and of a square wave line grating (open circles), with a thickness of the lines equal to the side of the dots.. The complexity of these patterns minimizes the dependence on the intrapair luminance constrast (which, however, is difficult to be assessed for the textured samples [14]). At last, Figure 3 c) concerns the knitted sample, made by using, jointly, green and yellow wool threads. Note how the plot showing the dependence of the balance condition on log L BC drops when passing from the plain stitch (asterisks), to the wavy grating- like one (open circles), to the rice, checkerboard like (crosses). Accordingly, the presence of the two intermingled colors acts as a noise, rendering increasingly complex the quasi random appearance of the samples. In conclusion, the visual balance is a response index in which both color and texture take part. The nature of this kind of interaction, theme for an investigation now in course, is probably hidden in the fine structure of the above plots.

3. CONCLUDING REMARKS

No exact theory can yet account for the bulk of facts involved by the various color-texture interactions [14]. In particular, our experiment(s) evidence both the resistance to fusion of colors with different categorical names displayed in quasi-random textures even when texture is degraded by noise, and the fact that both color and texture contribute to the sensation of balance. Let us quote an additional kind of interaction evidenced by the color naming experiments: our brain assigns a categorical monolexemic name, or even a hard-to-name color, to irregular and non-uniform textures, provided they coat thesurface of known familiar objects, by virtue of their prototypicality [15-16].But, if this is not the case, the hard-to-name colors become Seurat's indefinable colors [8]. The ingredients of the model we have in preparation include: the multiplicity of "units" coexisting at the same retinal location, vision multiplexing, the coexistence of contradictory percepts, (fused and non-fused), the trading of spatial and temporal dimensions, the fact that electrical brain signals may be evoked by light modulations up to even 20 K Hz and, of course, cognition.

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