

# Basic and natural colours in a Munker White illusion – an art installation

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Humans constantly apply a bilateral system of colour interpretation: that of light and pigment. The objective of these experiments/installations was to verify *White's illusion* in a comparison between three basic colour food colouring in water contrasts and three natural tea colour contrasts. The illusion involves changes in the lightness of a colour test element that interrupts a dark or a light bar of a dark-light square wave grating. In Experiment 1 we used three different basic colours of food colouring in water compared with Experiment 2, where we used natural teas. We proposed a three dimensional structure, composed of glass jars containing the coloured liquids. The transparency of the container allows for a complex pigment light interaction. Typically illusion experiments have been visualised with pigments on paper. The use of coloured liquids in a three dimensional structure created the same effect as the Munker White illusion; lightness or colour assimilation occurred in these multidimensional versions.

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## Introduction

Humans constantly apply a bilateral system of colour interpretation: that of light and pigment. Sandford&Gosti<sup>1</sup> create installations and art works based on basic colour primaries (RGB and RYB) observing the use of colour pigments suspended in water and the duo refraction and reflection of light [1]. They have been using this media – glass jars and coloured liquids – in their art installations since 2002. The meeting theme *Colour and Food: From the Farm to the Table* is illustrated in these comparative experiments of industrially produced food colourings in water and naturally coloured food liquids. The objective of these experiments/installations was to verify the strength of *White's illusion* [2] – also known as the *Munker White illusion* – in a different media through a comparison between food colours and teas. The illusion involves perceived changes in the lightness of a colour test element that interrupts a dark or a light bar of a dark-light square wave grating [2, 3]. This illusion seems to contradict simultaneous contrast, where the test element should look lighter when surrounded by the darker grating, and the opposite, it should seem darker when surrounded by the lighter grating. But instead, when the test elements line up with the lighter grating and are surrounded by darker grating they seem darker than when the test elements line up with the dark bars and are surrounded by light bars. Anchoring (single and double), scission, perceptual transparency, are some theoretical explanations (White [2], Adelson [4], Gilchrist [5], and Bressan and Kramer [6]).

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<sup>1</sup> Sandford&Gosti is the visual art signature used by the two authors to identify their works that have been created together.

The name Munker White illusion [7] – Munker’s coloured version (1970) White’s illusion (1979) [2] – best identifies both the colour and the black and white versions. White’s groundal dotted illusion [8], or Bressan’s dungeon illusion [6], creates the same type of assimilation in both colour and black and white versions, but the geometrics of the pattern are different from the Munker White illusion and therefore would seem to have different theoretical explanations. White’s explanatory approach is a mixture, from the most direct idea of assimilation theory he specifies three types of lightness assimilation. He also points out that Gilchrist’s anchoring theory or Anderson’s scission theory “may provide a more satisfactory explanation” [3]. Other researchers have been working on a theoretical explanation of this illusion and similar ideas [2, 4-6].

In Adelson’s example (as shown in Figure 1), he points out how “some people argue that the T-junctions give evidence that the rectangle should be grouped with the region touching its shorter sides, thus, if the grey rectangle is being compared to the black strips flanking it left and right, it should be seen as lighter, in accord with the illusion” [4].

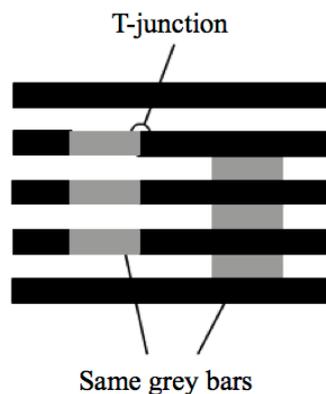
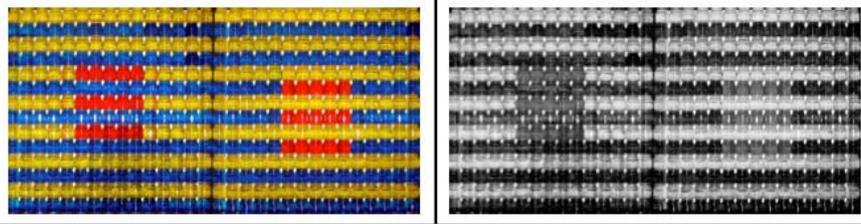
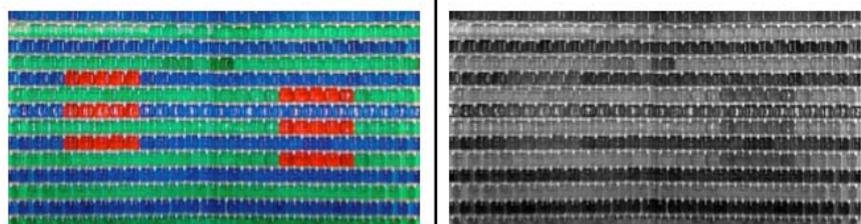
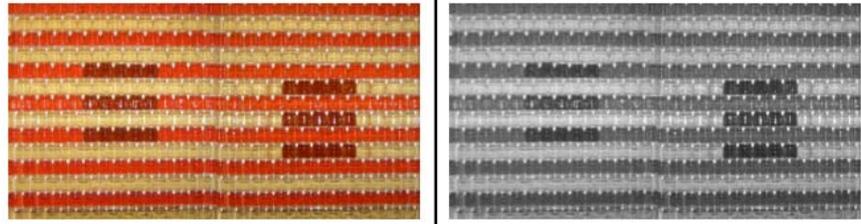
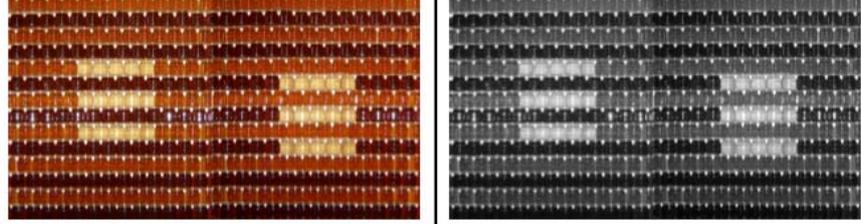
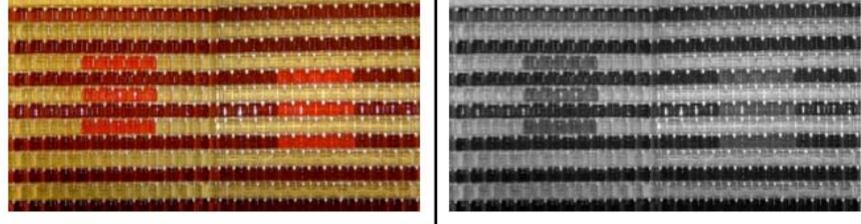


Figure 1: T-junction diagram from White's illusion [9].

Some researchers, including Adelson, have indicated that a mechanism called ‘perceptual transparency’ could be part of the illusion, where we see the lighter test element as being transparent and in front of the bars, making the dark bar seem lighter, and the darker test element as being behind the bars. This would be in keeping with the concept of light is near and dark is far, the implicit conceptual metaphor that guides our gestaltic visual and linguistic interpretations of light and distance [10]. Howe [11], refers to a “circular variant of White's effect in which all the junctions have been removed without significantly affecting the strength of the illusion, suggesting that junctions are not an important consideration in all versions of White's effect”. Corney and Beau Lotto have simulated illusions of lightness by “training synthetic neural networks to recognise surfaces under different lights. [...] These data suggest that “illusions” arise in humans because (i) natural stimuli are ambiguous, and (ii) this ambiguity is resolved empirically by encoding the statistical relationship between images and scenes in past visual experience” [12]. Bressan more recently expresses a different double anchoring theory, which seems particularly relevant. She explains: “the double anchoring theory [...] assumes that any given region (a) belongs to one or more frameworks, created by Gestalt grouping principles, and (b) is independently anchored, within each framework, to both the highest luminance and the surround luminance. The region’s final lightness is a weighted average of the values computed, relative to both anchors, in all frameworks” [13].

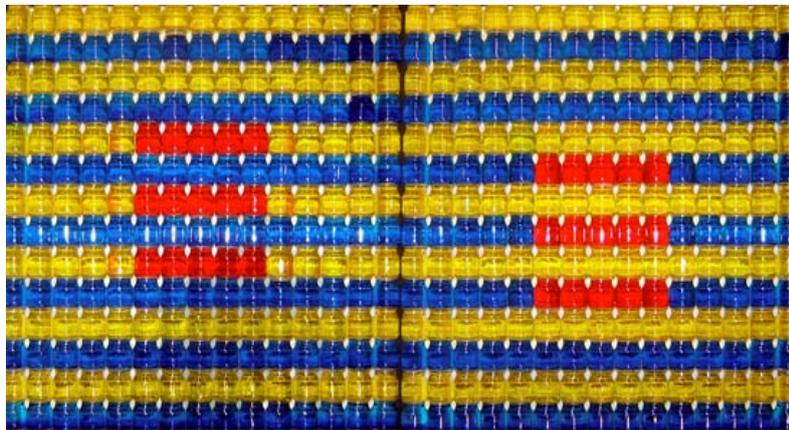
## Methods and Results


<i>Experiment 1a. Food colouring in water, red test element - yellow and blue grating.</i>

<i>Experiment 1b. Food colouring in water, red test element - blue and green grating.</i>

<i>Experiment 2a. Teas, green tea test element - hibiscus and chamomile tea grating.</i>

<i>Experiment 2b. Teas, chamomile tea test element - green and black tea grating.</i>

<i>Experiment 2c. Teas, hibiscus tea test element - chamomile and green tea grating.</i>

*Table 1: The five different combinations of synthetic and natural coloured liquids in colour (left-hand column) and black and white (right-hand column) photographic versions.*

In Experiment 1 (see Table 1) we used four tones of food colouring (red, yellow, blue, green) in water in two combinations (e.g. Test 1a - *red, yellow, blue* in Figure 2) in comparison with Experiment 2 (see Table 1) three combinations of three different colours of natural food liquids (e.g. Test 2c - *hibiscus, chamomile, and green teas* in Figure 3). For Experiment 2 we chose between different tea combinations (hibiscus, chamomile, green, black). Five combinations, two of artificial colours and three of natural colours were tested in a full installation (see Table 1). We experimented placing the jars with the coloured liquids inline (Figure 2) and off-set (Figure 3); we noted no visual difference in assimilation. Sandford&Gosti carried out the direct visual assessment of each of the installations.

The two combinations of food colouring in water in Experiment 1 were: red, yellow, blue, and red, green, blue. The three combinations of teas in Experiment 2 were: green, hibiscus, chamomile; chamomile, green, black; and hibiscus, chamomile, green teas. To make sure that the colour in each jar ( $7 \times 6$  cm) was the same we measured the food colouring for each container in Experiment 1, and used one batch of each tea for each colour type in Experiment 2. Every jar was filled with as much liquid as possible (150 ml) to facilitate the illusion. The glass jars containing the three coloured liquids were placed in a dark gray frame that we constructed for a square installation of the jars.



*Figure 2: Test 1a – Red test elements on yellow and blue grating, white backdrop; 210 in-line jars, 95 × 95 cm. each half; water with red, blue, and yellow food colouring; photomontage of the two settings, image taken at 3 meter distance.*

The anchoring effect, lightness assimilation, was immediately apparent in most of these versions. The photographic images shown here were taken with cross lighting of two incandescent lamps at a distance of three meters with a Sony 4.1 mega pixel, DSC-S60, camera, resulting in a JPEG image of  $2304 \times 1728$  pixels, or 1.7 MB image. The camera was equipped with a Zeiss lens. Each 'frame' consisted in 210 piled jars, measuring  $95 \times 95$ cm. each half. The transparency of the glass, the gaps, the gloss, etc., did not hinder the effect. Each set of colours was photographed with a white backdrop and a black backdrop. The difference in backdrop colour changed the image completely, which made the complex reflected and refracted light interaction more evident. A photo-montage of the two settings was made to compare the change of test element alignment. Munker's colour combination revealed the most robust assimilation illusion, as could be expected by the distinctness of the three colours. The warm natural tea colours, which we expected to react in a similar way to greys, made the illusion less evident, lower saturation and luminance seemed to stimulate a weaker illusion.



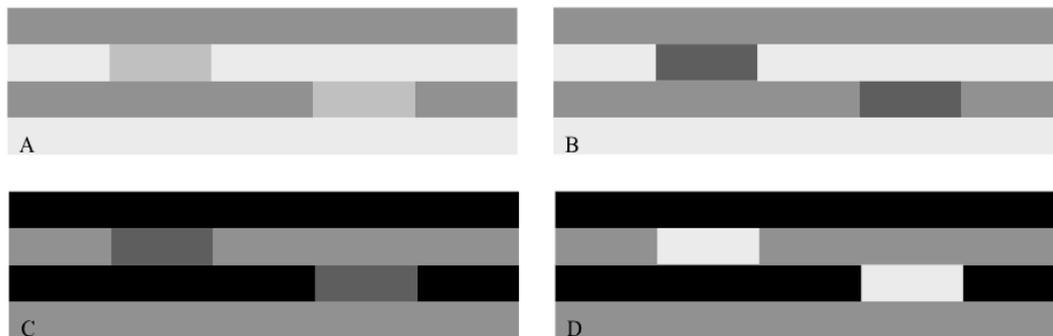
*Figure 3: Test 2c – Red (hibiscus tea) test elements on brown (green tea) and yellow (chamomile tea) grating, white backdrop; 203 off-set jars, 95 × 95 cm. each half; photomontage of the two settings, image taken at 3 meter distance.*

Observing each case the following effects may be distinguished:

- In Experiment 1a the red test element appears notably darker when it lines up with the yellow line of jars and is surrounded by blue, and lighter when it lines up with the blue line of jars and is surrounded by yellow. This is as it should be for the illusion: when the test elements line up with the lighter grating and are surrounded by darker grating they seem darker than when the test elements line up with the dark bars and are surrounded by light bars. In this case, as in the traditional Munker White illusion, red appears to be a medium tone compared to the darker blue and the lighter yellow.
- In Experiment 1b the red test element appears notably darker when it lines up with the green line of jars and is surrounded by blue, and lighter when it lines up with the blue and is surrounded by the green. In these cases blue is perceived as darker than either the red or the green. The green also appears less saturated than the blue or the red. In this case, as in the traditional Munker White illusion, red appears to be a medium tone compared to the darker blue and the lighter green.
- In Experiment 2a the brown test element appears to be slightly darker (yet warmer) when it lines up with yellow lines of jars and is surrounded by red lines of jars, and slightly lighter (yet cooler) when it lines up with the red and is surrounded by yellow. This illusion comes and goes, it seems as if the test element creates simultaneous contrast at times. The test element in this case is the darkest of the three tea colours (brown compared to red and yellow).
- In Experiment 2b the yellow test element appears to be slightly lighter (yet cooler) when it lines up with light brown line of jars and is surrounded by dark brown lines of jars, and slightly darker (yet warmer) when it lines up with the dark brown and is surrounded by light brown. Therefore simultaneous contrast seems to predominate in this test combination. The test element in this case is the lightest colour of the three teas (yellow compared to light brown and dark brown).
- In Experiment 2c the red test element appears to be darker when it lines up with yellow line of jars and is surrounded by brown lines of jars, and lighter when it lines up with the brown and is surrounded by yellow. This illusion seems constant and strong. The test element in this case is a colour that is between the colours of the other two tea colours (red compared to yellow and brown).

The colour contrast in 2a and 2b seem to fit the situation presupposed by Bressan and Krammer [6], “the luminance of the target patch is not a decrement relative to the high-luminance stripes and

an increment relative to the low-luminance stripes (Figures 4A and 4C), but either a decrement (Figure 4B) or an increment (Figure 4D) relative to both the high- and low- luminance stripes. These double-decrement and double-increment displays do not give rise to White's illusion, but instead to a simultaneous contrast effect" reconstructed here in Figure 4.



*Figure 4: In these two versions of White's Illusion (A and C) when the test element interrupts the light grid and is surrounded by the dark grid it seems darker, and when the test element is darker than both the grid lines (B, like our Experiment 2a) (double decrement of luminance) and lighter than both the grid lines (D, like our Experiment 2b) (double increment of luminance) simultaneous contrast is activated instead of White's illusion.*

## Discussion

The transparency of the glass containers creates a complex pigment light interaction. Typically illusion experiments have been visualised with pigments on paper, or illustrations viewed on monitors. This experiment employed a different media that is frequently used by Sandford&Gosti, i.e., coloured liquids in a three dimensional structure. This media was able to create the same effect with the proper colour combination. When the coloured liquid is seen in a clear glass jar all four colour aspects are activated: adaption, constancy, reflection and refraction, yet the Munker White illusion (lightness or colour assimilation) activates clear contextual effects on colour appearance. Perceptual transparency and the interaction of past experience seem to further influence visual interpretation of colour.

These experiments have provided results in keeping with Bressan and Kramer [13]. In order to activate the illusion it appeared necessary to have a specific type of contrast between the test element and the grid colours. In other words, it was necessary that the grid have the maximum contrast in luminance to be able to 'anchor' the test element. In this case the explanation seems to fit Bressan's model, which is "a quantitative model of how the visual system might determine lightness. In this model, target lightness depends on a weighted average of contrasts of the target with other regions. The weights are relative, while their sum remains constant, and each weight is proportional to the grouping strength between the target and non-target regions. In the current research, we manipulate grouping by luminance polarity and luminance similarity, while keeping all other grouping factors constant" [6, 13].

Furthermore, it would seem that lightness assessment is in keeping with the gestalt concepts [3, 13-15], that is the grouping principles that operate in the assessment of lightness (e.g., proximity, similarity, good continuation, closure, smallness, surroundedness and symmetry). In accordance with the Gestalt laws, small elements are grouped together if they belong to the same colour category, if

they are similar to one another in shape or size, if they lead to smooth or closed contours, and if they are adjacent etc. Thus these laws influence how the test elements and grids are grouped according to anchoring or perceptual transparency and the creation of the relation between ground and figure.

## Conclusions

Sandford&Gosti propose a non-conventional setting in this study to demonstrate the White Effect, which is different than those carried out in previous research [2, 3, 6-8, 13]. The setting with jars exhibited gaps, gloss, refraction and reflection of the light and yet it allowed the White Effect. Following these initial experiments, they have also experimented with minced flowers (see Figure 5) [16]. In this case they found that as the flowers dried and pulled up, the greater the gaps in the colour field became – as the white background showed through – the weaker the effect became. Nonetheless, the added colour of a textured background influenced the effect less than one would imagine.

The experiments presented in this paper stem from a visual art point of view; from the idea of creating colour contrasts and colour assimilation with both natural and synthetic liquid colours. We have approached the scientific explanation for the reaction-interaction between these colours in stimulating the illusion. However we have not found an explanation that discusses hue, saturation and luminance (brightness or lightness) together. It seems that in some of these colour combinations the illusion is not necessarily due only to lightness assimilation, but possibly amplified by an aspect of saturation. When photographs of the same experiments were switched into black and white the assimilation (or lack of assimilation) became even more evident, see Table 1, and compare to Figure 4.



*Figure 5: Flower carpet demonstrating the Munker-White Illusion, installed by Sandford&Gosti in June 2012 in the City of Cannara, Italy for the Infiorata celebration; 7000 × 100 cm, red minced carnation element in yellow and purple carnation grating, on white background. Photographed 12 hours after initial installation.*

Contemporary art operates between the conceptual symbol and the predominant sign. In architecture deconstruction represents the on-going realignment of the relationship between art, nature and science. In the ecology of foods today they must be natural, organic, zero mile, 'slow' cooked, or even considered on a molecular basis and the use of natural and synthetic colours. Colour emphasis in the visual arts, architecture, and culinary arts always produces feelings of wonder, curiosity, harmony and well-being. Colour research and understanding is therefore able to give a sense of identity and belonging through experiments and artistic technology. The proposed installation experiment illustrates a perceptual 'medium' variation that engages and communicates with the public. It also represents contemporary scientific endeavour as it is involved in the processing of multiple dimensions and relationships with space, time, and the viewer, and the understanding of visual perception.

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