Pictorial coherence, a special effect of painting, calculated using the luminance of a painting's quadrants explains pictorial balance

Abstract: Painters sometimes see a remarkable visual effect in pictures. First described in the 17th century Roger de Piles, a noted French art theoretician, called it the marvelous effect of the all-together that placed all the pictorial objects in harmony.(p. 105), The "all-together" has had no name or metaphoric description although de Piles uses it to indicate that it unifies the composition and that the eye has the feeling the whole painting can be seen as a whole. Here it is shown that this phenomenon exists and is not an illusion. Analysis of LED pictures indicate that it is seen when the light reflected from both halves of the painting (luminance) is equal with the lower quadrants slightly lighter (1.07 ± 0.3%) than the upper quadrants. Whether it is seen or not is dependent on the ratio of the perceived amount of light reflected. This depends on the spectrum, intensity and evenness of illumination, viewing position and the frame. Because it is frame dependent, a study with painters showed that identical pictures differing only by the frame could appear to be different if one of the images exhibited the effect. Many painters and most non-painters do not observe any difference. The effect is less apparent in LED pictures than in reflected light pictures. This effect is being given a name: pictorial coherence. It is thought to result from a stimulation of the magnocellular visual system allowing the eye to move smoothly through the image. Viewing pictures is not part of man's evolutionary development; because it is located in the magnocellular pathway it must be an incidental effect as a result of a method to follow objects by reducing them to a simple vector.

Keywords: pictorial coherence; quadrant luminance balance; roger de piles; magnocellular; pictorial balance

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Introduction

People who paint sometimes see a visual effect in their pictures that has no name or metaphorical description. It has been called the "marvelous effect of the all-together that places all the pictorial objects in harmony" [1] (p. 40). Since there is no precise description or analogy, the only way to discuss it is to show the painting that exhibits the effect. It might suddenly appear with a small change in a painting eliciting an expression of surprise such as "that's it" or "you've got it." This special visual feeling lasts during the whole viewing time; but, to complicate the discussion, it can disappear with any change or even with no apparent change. On seeing it someone might say to the painter: "stop, don't change a thing." Although it may sound strange, if you want to talk to painters about this effect, you have to use these expressions to be understood. This paper is about this effect, it shows that it is not an illusion, and that it is the basis of what is perceived as pictorial balance. Image 1 can exhibit the effect when seen properly using a **color calibrated monitor** centered at eye level. The effect will disappear if one eye is covered (use a piece of paper). Most people are not likely to see it, which does not mean they will not see it when looking pictures by reflected light. Image 2 does not exhibit the effect and there is no change when one eye is closed. The two pictures are different whereas in the study the two images would be identical and seen against a black screen. For the writer the difference is most obvious when you look at the center and feel as if you are looking at the entire image.

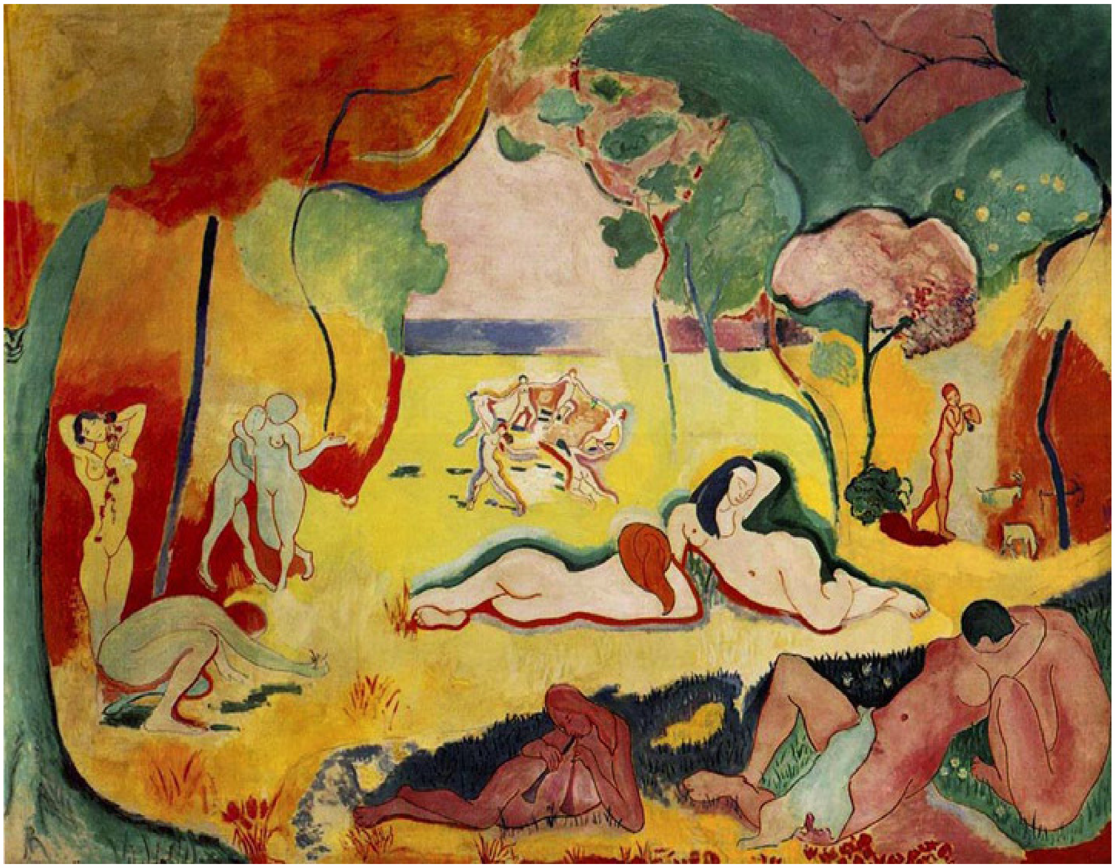

Image 1 A coherent image with luminance values: Upper left quadrant 115.00 Upper right quadrant 114.97 Lower left quadrant 123.08 Lower right quadrant 123.13

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Image 2 An unbalanced image with luminance values: Upper left quadrant 119.11 Upper right quadrant 121.17 Lower left quadrant 123.05 Lower right quadrant 126.5

The traditional idea of pictorial balance has given some investigators the impression of a center of mass type of calculation of the tones, colors and forms so that a tree on one side might seem to "balance" an image of a person on the other side [2](p27) [3] (p.20) [4] (p. 4). However, it has not been shown that pictures are balanced in this way [5,6]. Pictorial coherence is also calculated using a center of mass equation, but the "mass" is quadrant luminance. Coherency is not concerned with how the darks and lights or forms are arranged within a quadrant: only the summation of them in terms of luminance or the amount of light perceived by the eyes from each quadrant as if the picture is seen on a gray scale rather than in color. Both coherency and color balance are purely pictorial phenomena as isolated color or tonal patches do not evoke feelings of weight [7]. Balance is a high level visual and intellectual concept that translates the physical idea and equation of balance to how neurons in the visual system calculate their version of balance. Coherency uses observation to determine how the visual system calculates coherency. Although coherency is a continuous relative state as well as an absolute state, to avoid confusion, a coherent painting will be referring to a perfectly balanced painting. Everything else will be called unbalanced.

We start with a discussion of pictorial coherence, the only clearly definable state – defined on a sensation level as the "that's it" effect. It was first noted by Roger de Piles, a French critic around 1700. He described an assemblage of "lights and darks" in paintings (not chiaroscuro) creating an effect that was spontaneous and intense. He claimed that it permitted the viewer to gaze at ease at the entire painting without focusing on any particular form. He thought it was the primary aesthetic effect of a picture [1,]. Both Delacroix and Cézanne seemed to have noted this [8](p.67), [9](p. 88-89). Wassily Kandinsky describes a typical experience for a painter of seeing the effect unexpectedly, its disappearance without explanation, and in his case as with many others, the attempt to explain it with his preoccupation at the time:

> It was the hour of approaching dusk as I returned home … when suddenly I saw an indescribably beautiful picture, pervaded by an inner glow…I quickly approached this mysterious picture, on which I saw nothing but forms and colors, and the contents of which I could not understand. … It was a picture painted by me, leaning against the wall, standing on its side. The next day, when there was daylight, I tried to recreate this impression of the painting. However, I only half succeeded. Even on its side, I constantly recognized objects, and the fine finish of dusk was lacking. Now I could see clearly that objects harmed my pictures [10] (p. 369).

To understand this phenomenon the writer created computer images that exhibit the "that's it," using observations acquired from his painting. These pictures, visualized as if the colors were on a gray scale, had to have bilateral balance with a somewhat darker upper half. After being created it was found that their CoM as computed with Matlab software (Natick, MA) had no particular location other than being generally close to the center. It did show that the luminance of the these pictures' quadrants were bilaterally balanced with the lower half being slightly lighter than the upper half by a factor of ~1.07 ± ~0.03 (where luminance is measured from 1 to 255 with black equal to 1).

In these pictures, the ratios of quadrant luminance change with the color temperature, evenness and intensity of illumination, viewing position, and framing. Slight changes eliminate the effect. For example, when a perfectly matte rectangular painting is viewed from the side, it appears oblong following the rules of perspective with different ratios destroying the effect. Framing a picture can cause the effect to disappear as it was observed by the author that the eye does not necessarily distinguish between a picture and its frame to calculate these balance ratios. This permits an LED picture on a black ground to become either coherent or unbalanced by switching frames. If the observer concentrates on the image and disregards the frame, the effect could appear to turn on or off. The effect viewed with reflected light is more intense than with LED images: the "that's it' response of surprise is markedly diminished. However, LED images are necessary to guarantee that the images exhibit the stated properties of luminance and that the study be easily reproducible. In the study a coherent framed image is compared sequentially with the identical image rendered unbalanced with a slightly different frame. Any perceived difference would be ascribed to coherence. Although a smaller lower border gives the feeling that the eye can enter the central image easier and a larger lower border gives the feeling that the image is farther away, in the context of the study, this proved to be negligible [11](p. 3,24).

The aim of the study is to prove to the lay observer that there is a special visual effect in some paintings observed by some painters today and has been anecdotally described from the 17th to the 19th century. A second objective is to prove that LED paintings exhibiting this effect have bilateral luminance symmetry with the top half being ~1.07 less luminant than the lower half. The third objective is to justify a probable equation describing pictorial balance as perceived by the visual system. This equation accounts for the feeling of pictorial balance and the historical anecdotal explanation of a center-of-mass effect to explain it.

The following method of the paper will be described:

1. Probable pictorial parameters were established by the author's observations as described above. These parameters would explain its apparent evanescence.
2. The equation used by the visual system is deduced from the pictorial parameters and the perception of some sort of center of mass effect in pictures.
3. A study was done with painters and people interested in painting to confirm that pictures created with the parameters were seen as different from identical pictures not having these parameters. This indicated that the pictures with these parameters were in some way special. Since the effect is the only difference, it proves its existence. This aspect of the study is not a cause and effect study but an ontological study.
4. A statistical association was made between the results of the pairs and their respective imbalance derived from the equation that the visual system uses.

Materials and Methods

Each study consisted of ten pairs of images: Five in which one of the images was coherent as determined by photoshop and the other unbalanced (balanced pairs) and five in which both were unbalanced (unbalanced pairs). The studies differed only in using different sets of borders. Study I compared figure 1a with either figure 1b or 1c. Study 2 compared figure 1b with 1c. The observers see a pair sequentially on a calibrated iPad using the ColorTrue™ app and a Colorite device. The iPad image was verified to have the stated luminance balance through screen shots. The images on the iPad are approximately 5x6.75 inches and subtend visual angles of 19^0 and 23^0 respectively. The observers viewed the iPad parallel to the visual plane at arm's length and were asked whether the two central images appeared to be the same or different. The pictures used for the studies are in figure 2. Images 1,3,5,7, 8 were the balanced pairs.

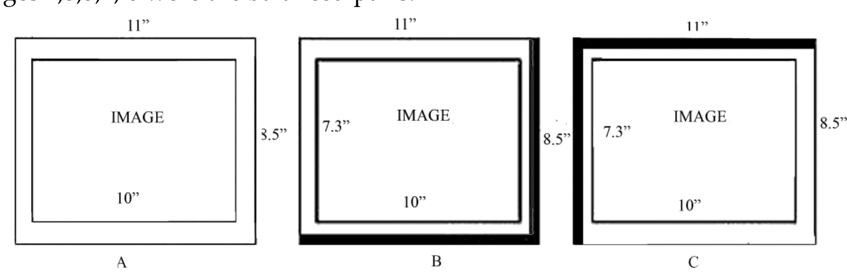

Figure 1. image pair construction, fig.1A has no black borders, fig 1B and 1C have two black borders. When seen against a black ground, only the white borders are see.

Figure 2. Images used in the study pairs.

The observers were predominantly artists or people associated in some way with a traditional art school. There were no requirements other than a willingness to follow the directions to carefully view the central image. There was no attempt to eliminate color deficient observers, individuals who have cataracts, or impaired binocular vision. 45 observers were included in the first study and 39 observers in the second study. Observers were excluded if they rapidly said they could see no difference without careful examination or if they insisted that the frame change was the only difference. There were only four of the latter.

For pairs in which both pictures are unbalanced, it was presumed that observers would find the pictures to be identical as the observers were not thought to be able to distinguish relative states of imbalance. In this case a response of "same" was considered correct. With the balanced pairs a response of "different" would be labeled correct.

The study was conducted in accordance with the Declaration of Helsinki.

Results

Four observers could identify all the balanced pairs as appearing to be different and the unbalanced pairs as being the same. 5 observers made one mistake. (table 1) Although it could not be statistically proven that this was not due to guessing, it is very suggestive that the effect is being seen. One experienced teacher positively identified the effect as corresponding to what was seen in paintings but found the study distressing and refused to cooperate thereafter. Another observer correctly identified the ten pairs as well as two of three additional pairs which were not presented to everyone and not included in this study. Many observers especially those who identified every pair correctly could not describe what the difference was in the balanced pairs. Others described different colors and tones between the pairs whether balanced or unbalanced.

Table 1. The Number of observers for each number of correct responses.

1st study		2nd study	
Correct Responses	Observers	Correct Responses	Observers
10	3	10	1
9	2	9	3
8	2	8	1
7	4	7	6
6	13	6	9
5	12	5	11
4	7	4	5
3	1	3	1
2	1	2	2
Total	45		39

Among observers who perceived differences in any pair, many saw differences in both balanced and unbalanced picture pairs (Table 2). Initially this was thought to be due to guessing. However, there is a strong correlation between the percent of each pair observed to be seen as different and the pair average distance (imbalance).

Pictorial balance was calculated using the standard formula of balance for four connected objects each having a center of luminance balance at their respective geometric centers. If a picture has a geometric center at X=0, Y=0, the upper quadrants are weighted by a factor of 1.07, and X_{**Q},Y_{**Q} are the geometric centers of their respective quadrants, then the quadrant luminance balance of such a picture is:

$$X = (-X_{ULQ}L_{ULQ} + X_{URQ}L_{URQ} - X_{LLQ}L_{LLQ} + X_{LRQ}L_{LRQ})/L_{TOTAL} \quad (1)$$

$$Y = (1.07)Y_{ULQ}L_{ULQ} + (1.07)Y_{URQ}L_{URQ} - Y_{LLQ}L_{LLQ} - Y_{LRQ}L_{LRQ})/L_{TOTAL} \quad (2)$$

$$L_{TOTAL} = (L_{ULQ} + L_{URQ} + L_{LLQ} + L_{LRQ})/4, \qquad \text{Balance} = \sqrt{X^2 + Y^2} \quad \text{or a vector } \vec{L} = X,Y \quad (3)$$

Observers divided the pairs into two groups: one in which the average state of imbalance within the pair was low (the balanced pairs), and the other where the average imbalance was large. (r -0.72, p 0.003). This suggests that observers distinguished the coherent pictures in the balanced pairs from unbalanced pairs. However, given that all balanced pairs also had a smaller average pair balance than the unbalanced pairs, it is possible that for some this was due to average pair imbalance.

Table 2. Pair average distance and fraction of observers that saw them as different.

	BALANCED PAIRS			UNBALANCED PAIRS		
	image pair	distance	% different	image pair	distance	% different
1st Study	1	0.462	0.489	2	0.723	0.356
	3	0.318	0.356	4	1.894	0.289
	5	0.427	0.444	6	1.679	0.333
	7	0.509	0.378	9	0.944	0.178
	8	0.522	0.444	10	2.197	0.111
2nd Study	1	0.608	0.410	2	0.942	0.282
	3	0.652	0.359	4	2.153	0.154
	5	0.473	0.436	6	1.934	0.385
	7	0.658	0.282	9	1.389	0.256
	8	1.026	0.436	10	2.455	0.128
MEAN		0.565	0.403		1.631	0.247
StDev		0.192811	0.060		0.602	0.098

Discussion

Table 1 is created from the simple comparison of the two images to see if they looked different as a result of the effect. Table 2 could also be interpreted this way. However, it is possible to also interpret differently with respect to how imbalanced pairs were seen. Pairs with average low imbalance number were more likely to be seen as different compared to pairs with a average high imbalance number.

It is not clear why the study would show this. One could make an analogy between this study and a situation where people are asked to look at pairs of objects extending into the distance. The closer the object pairss are to the observer the more likely they will be seen as two distinct objects. The farther away they are, the more likely they will be seen as one combined object. This is only an analogy and not an attempt to explain the visual system.

The study did not indicate any correlation between distance and perception of difference in unbalanced pairs. Some unbalanced i.e. images pairs 4, 9 and 10 had varying degrees of internal salient forms which may have influenced this. The ability of the eye to distinguish relative degrees of imbalance could be evaluated with more homogeneous images.

One could say the study only showed by the above described analogy that the eye is able to distinguish relatively balanced images that happened to be coherent from relatively unbalanced images. The writer has some results from an additional study indicating that this seems to not be a factor, as image pairs where one image had a ratio of 1.00 or 1.12 with small degrees of average imbalance were less likely to be seen as different than balanced pairs. This study could not be completed due to a problem finding sufficient subjects.

The use of an iPad in different lighting environments was necessary to bring the study to the observers. This definitely limited the number of responses in those situations where reflections interfered with seeing the effect i.e. false negatives or coherent pictures being seen as unbalanced. This would have also interfered with the relative degree of imbalance in the unbalanced pairs. The images were usually presented in a set order which skews the results to some degree. It was noticed that the first image pair was often seen as different when no difference could be seen in subsequent pairs. In that case the observer was asked again with the images repeated backwards. Observers were in general remarkably consistent with their first impressions when the images were presented again in reverse order. There was a possibility of examiner influence with respect to the results in table 1. However, the results of table 2 would not have been influenced in this way. The results in table 1 were limited by the relative unavailability of teachers and certain well known painters who would have been expected to see the effect.

The phenomenon of coherence is separate from but closely associated with the aesthetic effect of pictures. It has been suggested that the effect should be demonstrated with a study of subject preference. Most subjects that seemed to see it, saw it without attaching an aesthetic meaning and could only say that there seemed to be a difference. Sometimes surprise was elicited in seeing differences in objectively the same image. Because the images in the study differed only by a border, a brief study was done in which viewers, mostly art student, were asked to indicate preference when presented with a coherent LED image and the same one rendered unbalanced with luminance changes. The coherent picture was changed in the same way it was originally created; several small irregular forms in no particular place had their luminance modified by at most 5%. It was found that the image which had the most contrast or brighter color was preferred, either the coherent one or the other. Otherwise, there was no statistical preference between the two. This does not disprove the existence of the effect; it only confirms the previous observation that it is definitely not as pronounced in LED images and that most people cannot or do not directly respond to it. The effect in LED pictures is just an effect while in reflected light pictures it could be an aesthetic effect.

It is understandable that being told of a visual effect that one has not observed and most probably cannot observe (at least in LED images) might be met with skepticism. However, there are many sensory experiences limited to a small group of people i.e the super tasters or perfect pitch, etc. Admittedly, most are not as elusive or as difficult to explain as pictorial coherence, but this has been historically documented, and there are anecdotal everyday observations by painters. There were painters that the writer met who had observed the effect but were skeptical and thought it was an unexplained illusion. Even if viewing conditions remain unchanged the painter often sees the effect inexplicably disappear overnight. There is a visual transformation of drying paint (oil, watercolor and acrylic) which can take twelve hours or much more to reach a final darker or lighter and unequally distributed state.

Any visual effect should have an explanation of how or why it has been evoked. This writer finds that it is possible for his eye to glide smoothly through a coherent painting instead of jumping from form to form. The jumps themselves seem to be done easier. This undoubtedly sounds strange to those who are not in the habit of observing their eye observing a picture, and it evoked a vociferous complaint from one researcher who insisted we cannot be conscious of eye movements. However, artists spend a lot of their time looking at pictures and thinking about how they look at their pictures. While some people can make smooth pursuit movements with training, painters are not trained to do this [12]. They do learn (at least some of them) to follow how their eye moves around a picture to see whether it moves freely or is "weighed down" to determine what might be needed to complete the painting. During the study an observer who was clearly familiar with the effect in his painting but who did not identify the balanced pairs particularly well, was taught to look at his eye movements and to slide his eyes around. He then identified every pair correctly. It was not that he "saw" the image as in "that's it" but learned to recognize its effect on eye movement.

The fluid eye movements could be explained if a coherent picture had a stimulating effect on the magnocellular visual stream, an effect normally only seen with moving forms. This visual gliding is impaired in a picture with prominent tonally salient or geometric forms. It is not impaired by tonally equivalent but contrasting color forms. As a picture becomes progressively unbalanced, these gliding eye movements cease. The writer believes that even when the gliding movements are not possible, there remains an effect on eye movements somewhat proportional to the state of balance. This however is very difficult to show although it would be implied if salient aspects were shown to alter the perceived state of imbalance. For example, if saillant unbalanced paintings were shown to be more unbalanced than the luminance calculations indicate or not be capable of being seen as coherent. This may be what occurred in pairs 4 and 9, 10. The determination of pictorial balance might be an initial part of creating a low level saliency map supported by the observation that observers show a marked tendency to fixate first around the center of a picture [13-15].

In support of the concept of magnocellular stimulation which is suppressed in an environment of red light, the writer has found that an LED image of a balanced red monochromatic image on a black ground is not seen as coherent while a green monochromatic balanced image does appear so [16-18] (fig.3). This cannot be shown using the technique of the study because the white borders interfere with viewing the image as monochromatic red. It might be shown if people who have demonstrated their ability to see the effect can smoothly follow a circle or letter lightly imprinted on a coherent picture and not one which is unbalanced. It should be added as a general observation that the writer cannot see the effect with one eye closed .

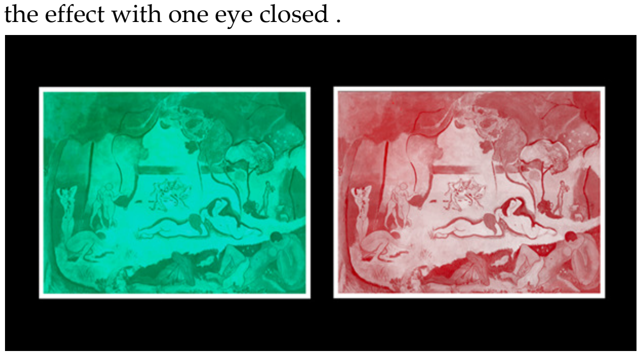

Figure 3. monochromatic images in green and red created to meet the luminance criteria for coherency.

Pictures are not part of the evolutionary development of humans; accordingly, pictorial luminance balance must be incidental to other needs. A low level region in the visual system that can reduce any circumscribed object to a vector - a sensory quality with a size and direction - could facilitate determining the object's direction, speed of movement and distance with binocular vision. It would be part of a primitive visual operating system.

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References

1 Puttfarken, T *Roger de Piles' Theory of Art*, New Haven, Yale University Press 1985

2 Poore HR *Pictorial Composition and the Critical Judgment of Pictures* New York 1903

3 ArnheimR, *Art and Visual Perception* University of California Press, Berkeley, 1974

4 Ross, D *A Theory of Pure Design* Houghton, Mifflin and Co. Boston 1907

5 McManus I C Stover K Kim D Arnheim's Gestalt theory of visual balance *i-Perception* 2011, **2**:615-647

6 Gershoni S, Hauchstein S Measuring pictorial balance perception at first glance using Japanese calligraphy *i-Perception* 2011 2:508–527, doi:10.1068/i0472aap

7 Pinkerton E, Humphrey N The apparent heaviness of colours *Nature* 1974, 250:164-165

8 Delacroix E, Œvres Littéraires. Études Esthétiques 4th ed Paris G. Crés & Cie, Paris 1923

9 Cézanne P, Conversations *with Cézanne*, Doran, M (Ed.) Cochran JL (Trans.) University of California Press Berkeley 2001

10 Kandinsky W. "Point and line to plane" *Complete Writings on Art* Lindsay and Vergo G.K. Hall and Co. Boston 1982

11 Puttfarken, T *The Discovery of Pictorial Composition,* New Haven, Yale University Press 2000

12 Purves D, Augustine GJ, Fitzpatrick D, et al., editors. in *Neuroscience*. 2nd ed. Sunderland (MA): Sinauer Associates 2001. https://www.ncbi.nlm.nih.gov/books/NBK10991

13 Veale R, Hafed ZM, Yoshida M. How is visual salience computed in the brain? *Philos Trans R Soc Lond B Biol Sci*. **2017** 372:1714 doi: 10.1098/rstb.2016.0113

14 Buswell, GT *How people look at pictures: A study of the psychology of perception in art*. Chicago: University of Chicago Press 1935.

15 Tatler B The central fixation bias in scene viewing: Selecting an optimal viewing position independently of motor biases and image feature distributions *Journal of Vision*, **2007** 7: 4 doi:10.1167/7.14.4

16 Livingstone MS, Hubel DH Anatomy and physiology of a color system in the primate visual cortex. *J Neurosci.* 1984, 4-1:309-56

17 Awasthi B, Williams MA, Friedman J. Examining the role of red background in

magnocellular contribution to face perception *PeerJ* , 2016, 4:e1617 https://doi.org/10.7717/peerj.1617

18 Chapman C, Hoag R, Giaschi D The effect of disrupting the human magnocellular pathway on global motion perception *Vision Research,* 2004, 44-2, 2551-2557, https://doi.org/10.1016/j.visres.2004.06.003