Pictorial balance is a bottom-up aesthetic property mediated by eye movements. A model of a primitive visual operating system explains the property of balance.

David Corwin M.D.
dcorwinmd@gmail.com

Abstract

The concept of pictorial balance as a visual center-of-mass effect originated at the beginning of the 20th century to explain why some paintings evoke feelings of unity and harmony. It had never been mentioned in art commentary of the previous 500 years and is an unsubstantiated but widely assumed illusion. However, the visual basis for this illusion exists, and it is the object of this paper to show what balance is, how it is calculated and what it says about the visual system by means of the study of an unnamed pictorial effect. This is known by painters to give a picture a feeling of being remarkably unified and harmonious and enables the eye to move smoothly and easily around the picture so that every part has equal importance. This was first described by a 17th century critic Roger de Piles and subsequently by a few renowned artists. The author thought that this was due to the painting being in a state of perfect balance. Computer modeling found that such a picture must have bilateral luminance symmetry with a lighter lower half by ~1.07 and that a picture with a white frame on a black ground is seen as one object. A study was done in which the identical picture in two slightly different frames could seem different to subjects who viewed them in sequence, the sole difference being the balance of the two images, some of which were perfectly balanced. It showed that subjects could see relative states of balance according to an algorithm and strongly suggested that the effect was seen.

The algorithm is derived from an idea as to how a primitive organismu could organize its visual experience to see other organisms. These are defined as collections of lights moving together against a ground. It divides the organism into two equally luminous parts which are further bisected. A virtual rectangle is drawn around the four parts to form a picture. Balance is calculated by a center of quadrant luminance equation analogous to a center-of-mass calculation. This defines the organism as an ever changing vector or rectangular halo and shows why a picture viewed from any angle is seen as if it were directly in front of the viewer.

Introduction

Pictures are flat bounded images that correspond to nothing found in nature or mental imagery including the borderless images in prehistoric caves[1]. They are a very recent invention requiring the technology to create flat surfaces (perhaps the fourth millennium BC). They differ from images without borders in that borders evoke the percept of balance: the parts relate to both the center and the border[2]. Balance is both a bottom-up percept and a top-down aesthetic concept taught in schools. This paper is concerned with the bottom up aesthetic perception of balance –

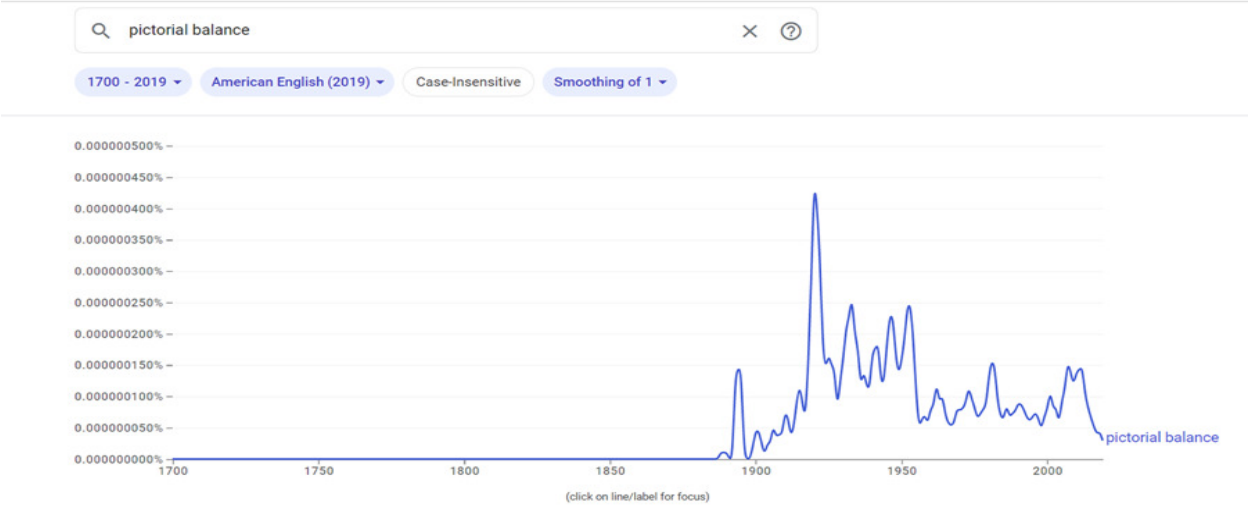
the pre-emotional, pre-cognitive pathway from the retina to the primary visual cortex as Molnar postulated [3].

It has been stated that: "for centuries artists and writers on Western art have asserted that balance is the primary design principle for unifying structural elements of a composition into a cohesive narrative statement." A picture is considered balanced "if all its elements are arranged in such a way that their perceptual forces are in equilibrium about a fulcrum and if the fulcrum coincides with the center of the picture[4]." Objects, size, color, intrinsic interest, positions and apparent depth have been proposed as contributing to this balance and the aesthetic qualities of unity and harmony if they are balanced around the geometric center as calculated by a center of mass type of equation[2,4-6]. Rather than being a timeless observation, it is an early 20th century concept promoted by Henry Rankin Poore, a painter. However, he was most likely trying to explain the effect of low level balance that I discuss in this paper in that he wrote:

> The whole of the pictorial interest may be on one side of a picture and the other side be practically useless as far as picturesqueness (sic) or story-telling opportunity is concerned, but which finds its reason for existing in the balance, and that alone.

Nothing in this "useless" side has the pictorial qualities described above, but for him they create in a particular picture a feeling that he calls balance[5]. There have been a number of recent studies that have tried to confirm this as being how balance is calculated without success[7-9]. Both H. Locher and Puttfarken give comprehensive discussions of European theories of pictorial aesthetics and composition between the 14th and late 19th century in which balance is not mentioned[10,11]. This judgment of balance is inherently a modern top-down idea taught in schools. A Google ngram search for "pictorial balance" gives a good idea of this. While it only includes books scanned by Google, it exemplifies the above (see figure 1).

Figure 1. The frequency per year that "pictorial balance" was mentioned in books as scanned by Google



Balance has been thought to direct the eye, but the force that strongly influences eye movement is salience. The initial sequence of saccades on viewing a picture can be predicted through calculations based on the most salient features of surrounding areas that correlate with eye tracking[12-14]. There have also been studies that tried to show the more subtle effect of balance. Locher and Nodine compared eye movements in pictures that were thought to be balanced with variations of these pictures. They found that trained observers had more diverse and fewer specific exploratory movements in the more balanced compositions than untrained observers. On the other hand, in his extensive study of tracking eye movements, Buswell could find no difference between the two groups. The duration of fixations and the length of saccades are usually discussed in top-down cognitive terms of subject comprehension or artistic judgment unrelated to balance[15-19]. Eye movements have three components: direction, duration and ease of movement. The effect of balance is subtle, global in nature and affects ease of movement.

While this hypothesis of balance has been an intellectual exercise, the feeling of some sort of balance of forces could not exist without some basis in reality. To understand and measure low level balance one must start with a picture that exhibits the sensation of perfect balance, this feeling of pictorial unity and harmony, and it corresponds to an obscure effect observed by painters that does just that. There is no name or metaphorical description for the percept evoked by these pictures other than to say that they exhibit the aforementioned unnamed effect. It is usually only discussed in art schools when standing before such a picture. To those who perceive it, the unexpected change in a painting from being remarkably unified and harmonious to something less so or the reverse is quite striking. Peripheral attention increases creating the feeling that the whole picture can be seen at one time; the gaze moves smoothly around without the need to be fixed on any pictorial element. This effect of a perfectly balanced picture is being called pictorial coherence.

Because there has been no name for this, historical discussion has been limited. Roger de Piles, an 18th century French critic and painter described arrangements of “lights and darks” creating an effect that is spontaneous and intense, riveting the attention and giving the impression that the viewer could gaze at the entire painting without focusing on any particular form. He thought this was the primary aesthetic effect of a painting[11]. Both Delacroix and Kandinsky give vivid descriptions of seeing paintings that exhibit this:

Eugene Delacroix writes that "there is a kind of emotion which is entirely particular to painting: nothing [in a work of literature] gives an idea of it. There is an impression which results from the arrangement of colours, of lights, of shadows, etc. This is what one might call the music of the picture...you find yourself at too great a distance from it to know what it represents; and you are often caught by this magic accord[11,21].” Wassily Kandinsky also describes the effect: “It was the hour of approaching dusk. As I was returning home … when suddenly I saw an indescribably beautiful picture, imbibed by an inner glow. First I hesitated, then I quickly approached this mysterious picture, on which I saw nothing but shapes and colors, and the contents of which I could not understand. I immediately found the key to the puzzle: 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 get yesterday's impression of the painting. However, I only succeeded half-ways: even on its side, I constantly recognized the objects and the fine finish of dusk was lacking [22].” A fine contemporary description is provided by Brock: "some of [the photographers'] best work seemed to radiate a combined sense of balance, order, harmony and energy. The viewer's eye seems to be held in the image in an almost hypnotic way, dancing around the picture." [23]

To study this effect, I created computer models that evoke it using experience from many years of painting. Image analysis indicated that it was perceived when a picture, centered at eye level and parallel to the plane of vision, has bilateral quadrant symmetry with the lower half being slightly more luminous by a factor of 1.07 ± ~0.03. A perfectly balanced painting will be described as coherent; all others will be called unbalanced for the study’s first objective. With respect to balance it was discovered by accident that the visual system cannot distinguish a picture from its white frame. I had printed black and white pictures that appeared coherent whether framed or cut out. One time due to an error of alignment the framed image appeared unbalanced while the cut-gout image remained balanced. It was derived from this that with respect to balance, pictures are defined only by luminosity and not lines. This is not true for an LED picture framed in black on a white ground where black marks the end of the picture.

There is a theoretical formula for balance which explains observations of a center-of-mass like effect using a slightly modified variation of a standard center-of-mass calculation: if a rectangular picture with bilateral quadrant luminance symmetry and a darker upper half is said to be perfectly balanced around the geometric center, then the standard formula for the center of mass of four connected objects can be used. In this formula quadrant luminance L_{xxQ} replaces the mass of each object and is located at the geometric center but not the center-of-mass of the respective quadrant. For simplicity, the picture's geometric center is located at (0,0). $L_{\mathbf{TOTAL}}$ is taken as the average total luminance.

$$X = (X_{ULQ}L_{ULQ} + X_{URQ}L_{URQ} + X_{LLQ}L_{LLQ} + X_{LRQ}L_{LRQ})/L_{TOTAL}$$
$$Y = ((1.07)Y_{ULQ}L_{ULQ} + (1.07)Y_{URQ}L_{URQ} + Y_{LLQ}L_{LLQ} + Y_{LRQ}L_{LRQ})/L_{TOTAL}$$
$$L_{\mathbf{TOTAL}} = (L_{ULQ} + L_{URQ} + L_{LLQ} + L_{LRQ})/4,$$
$$\text{Balance} = \sqrt{X^2 + Y^2} \text{ or a vector } \vec{L}\ (X,Y)$$

Y values of the upper quadrants are modified by 1.07 to account for the increased visual weight of the upper half. X_{XXQ} and Y_{XXQ} are the coordinates of the center of their respective quadrants, and L_{xxQ} is a quadrant's luminance. The equation can be expressed as an addition of four vectors $\vec{L} = (X,Y)$. Although this equation is precise for defining perfect balance, it is not clear whether it is true for states of imbalance. This will be called the geometric method of determining balance.

There is another way of calculating balance derived from the idea that it could be an early method for identifying and following moving organisms based solely on luminance. If organisms are defined as collections of luminous points that move together with respect to a ground and one were to divide this into two equally luminous parts by a virtual vertical line which is itself bisected horizontally by another virtual line, the organism is divided into four parts. Virtual lines parallel to the preceding ones are drawn enclosing it to create a "picture." The luminance of the upper half would be arbitrarily decreased by a factor possibly to account for light coming from above so as to render the organism more balanced. The light energy or amount of light is then averaged over the area of its respective quadrant permitting calculations using the formula of the geometric method. This second method is called the visual method of balance.

There are two effects conveyed by balance in a perfectly balanced picture: the intangible effort for the eye to move across the picture and an attention riveting effect. Both contribute to feelings of unity and harmony. When seen by reflected light, the two seem inseparable. However, it was observed that an LED picture is a poor conveyer of the attention riveting effect while maintaining the effect on eye movements. This would explain the study of Bertamini et al. who noted that observers preferred a print reproduction to the same picture as seen in a mirror or on a monitor

and that they preferred the mirror view of the actual image to the monitor image[24]. Locher et al. made similar observations[25]. The only difference between these three situations is that the light emitted from an LED screen is polarized. Misson and Anderson showed that polarized light alters luminance contrast perception[26]. This in some unknown manner interferes with the attention riveting aesthetic effect of a coherent picture so that contrasting it with the identical non-coherent picture cannot be measured using observer preference. However feelings evoked by the ease of movement are experienced allowing a performance based study to determine whether two identical pictures were the same or different with balance being the only difference. LED images had to be used to permit precise luminance determination and reproducibility under the conditions that were feasible. Printed pictures could not be shown to have the stated luminance properties under the conditions available.

The first object of this study was to show that some people are able to see this state of pictorial coherence, by showing that they perceive a difference in two identical pictures differing only in that one is perfectly balanced. The second later objective was to show that one or both calculations of pictorial balance are valid by showing that the study group is able to distinguish fine degrees of pictorial imbalance using these definitions.

Materials and Methods

Since a white framed picture is seen by this low level visual system as one object while the top-down view sees it as a picture in an uninteresting frame, the comparison of a balanced picture with the identical but unbalanced picture can be done by a slight change of frame. If an observer compares carefully the two images and is able to disregard the frame change, any perceived difference would be ascribed to the effect. It was presumed that the pairs of unbalanced pictures would be indistinguishable because initially I did not think that observers could see degrees of relative imbalance within the pairs. Many observers were eliminated because they did not pay full attention to the pairs. They would glance at the pictures rapidly and decide that there were no differences. Observers were included in the analysis if they carefully inspected the pictures whether they saw any difference or not. It was noticed that painters and those interested in looking at pictures could do this. Others had trouble even when specifically asked. Two studies were done using different frames.

Each study consisted of the same ten pairs of images: five, in which one of the images was perfectly balanced (balanced pairs), and five in which both were unbalanced (unbalanced pairs). Images were chosen because they seemed to have predominantly neutral content. They were prepared using Photoshop©. Quadrant image luminance can be changed in an unobtrusive and precise manner through the use of the level command on an irregular form in which the

luminance is usually changed by no more than ±5 percent. The form is then moved around until the desired quadrant value is reached. The two studies differed only in using different sets of white borders. The three possible image and border combinations are in Fig. 1. Study I compared figure 2a with either 2b or 2c. Study 2 compared figures 2b with 2c. The observer viewed sequentially a picture with different frames on a color-calibrated iPad3 using the ColorTrue™ app (which is no longer extant) and a Colorite™ calibration device. The observer viewed the iPad centered and parallel to the plane of vision at arm's length. The images on the iPad were approximately 5 x 6.75 inches. The pictures used for the studies are shown Fig. 3, and this is the order in which they were seen. Images 1,3,5,7, 8 were the balanced pairs. (all images are in the supplemental files with accompanying quadrant luminance data).

Fig. 2 The three possible image and border combinations: the solid black lines would not be seen on a black ground.

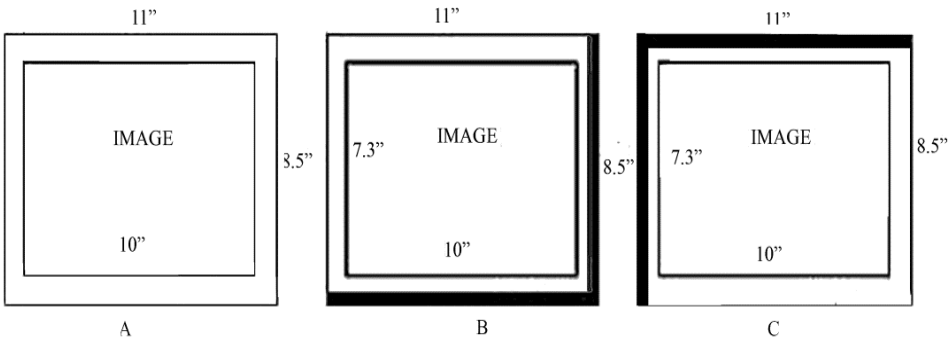


Figure 3 Pictures used in the study pairs

The observers gave their verbal consent to participate anonymously in a study about how people look at pictures. They were told that it would consist of looking carefully at ten pairs of pictures and being asked whether the central images appeared to be the same or different while disregarding the frames. They were told that it was intended for some pairs be seen as the same while others as different. No identifying information or medical history was obtained, and there was no attempt to eliminate observers who were color deficient, had cataracts or had impaired binocular vision. 45 observers were included in the first study and 39 observers in the second study. Observers were excluded if they did not follow the directions by either rapidly saying without careful examination that they could see no difference or by insisting that the frame change was the only difference. There were only four of the latter. For the unbalanced pairs it was presumed that because of slight differences of imbalance, observers would find the pictures

to be identical so that the response of “same” was considered correct. With the balanced pairs a response of “different” would be labeled correct indicating they had seen the effect.

Observers viewed the pictures sequentially on an iPad at arm’s length while I sat slightly behind them. They were permitted, indeed encouraged, to hold the iPad themselves as long as it was maintained correctly centered and parallel to the plane of vision. There were no restrictions on the length of observation, and they could return to a previous image as much as they wanted. However, subjects were told that the difference if any was more in the way of a feeling and were discouraged from making point by point comparisons. The difference was described as analogous to that between monophonic and stereophonic music: same music but seems different.

Results and discussion

Four observers could identify all the balanced pairs correctly, and 5 observers made one error. (Table 1). Some subjects thought they saw differences in color while one thought the depth of field was different, and many felt there were differences but could not describe them. A simple analysis (table 1) does not show that observers perceived the percept of perfect balance. However, a second analysis based on table 2 which includes the calculations of balance shows that either the observers saw the effect of perfect balance and/or that they saw the effect of relative balance.

Table 1 the number of observers answering correctly the 10 pairs in the study g

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

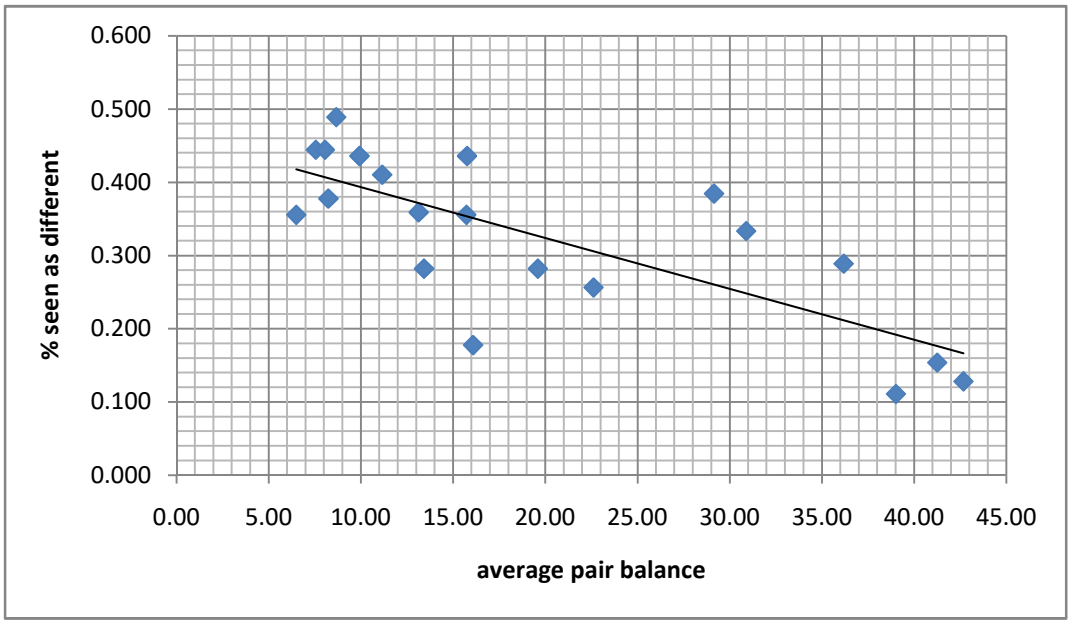
It was noticed to my surprise that subjects saw differences in the unbalanced pairs. At first I thought this was due to guessing, but on further examination it indicated that there is an inverse correlation between the percent of pairs observed as different and the pair average distance (average imbalance) as calculated with the two methods (see table 2). As well as dividing the pairs into groups, the balanced and the unbalanced ones, they can also be divided into groups based on their degree of balance. Here again one sees clearly a group in which the average state of imbalance is small (the balanced pairs), and the other where the average imbalance is large as in Table 2).

Table 2 Pair average distance and percent of observers who identified the pairs as different using both the geometric method and visual method of balance. The MATLAB™ code used to determine visual balance and files of the corresponding pictures without black borders are in the supplemental files.

		BALANCED PAIRS				UNBALANCED PAIRS		
		geometric distance average	visual average distance	% Seen as different		geometric average distance	visual average distance	% Seen as different
1st Study	1	8.81	8.66	0.49	2	11.39	15.72	0.36
	3	5.00	6.50	0.36	4	29.70	36.18	0.29
	5	6.97	11.06	0.44	6	26.36	30.90	0.33
	7	7.97	8.24	0.38	9	14.88	16.08	0.18
	8	8.08	8.05	0.44	10	25.98	39.02	0.11
2nd Study	1	2.92	11.15	0.41	2	14.67	19.60	0.28
	3	10.15	13.13	0.36	4	33.50	41.25	0.15
	5	7.35	9.92	0.44	6	30.09	29.15	0.38
	7	10.24	13.42	0.28	9	21.62	22.62	0.26
	8	15.96	15.76	0.44	10	38.19	42.68	0.13
average		8.34	10.59	0.40		24.64	29.32	0.25
StDev		3.48	2.88	0.06		8.83	10.35	0.10

The correlation for the geometric determination between average pair imbalance and the percent identified as different is: $r(18) = -0.676$, $p = 0.001$. The same correlation for the visual determination is $r(18) = -0.757$, $p < 0.001$. The graph of the visual balance results is in Figure 3.

Figure 3 Graph of the Visual balance results of 2



This leads to one of two interpretations or both: either the observers are seeing the effect of coherence to distinguish the pictures within the pairs, or the observers are seeing pairs according to how they are balanced. The second point is reinforced if the average of the balanced pairs is used as one data point so as to avoid the statistical influence of their relatively large number and the ten unbalanced pairs as other data points, the visual method has a correlation of $r(11) = -0.64$ $p = 0.046$. Thus subjects most likely perceived relative average balance across the pictures and not just between pairs with low and high average balance. The correlation of pair average balance with observations of same or difference is not obviously logical. As I said originally, I thought that observers would be comparing intra-pair difference in which two unbalanced pictures would seem identical. However, there was found to be no correlation; an ecological explanation of the study as discussed below is an explanation of this. It has been thought my several investigators that the effect of balance on eye movements might be objectified with eye tracking as mentioned above, but this lack of intra-pair correlation indicates that any difference in eye movements within two identical but unbalanced paintings as in the study is not likely to be significant.

The ability to see either pictorial coherence or the pairs as different as a function of their average balance is true for the observers selected for their ability to follow the rules who were mostly painters. This correlates with studies showing that painters view pictures differently than untrained individuals [27-33]. Antes showed that fixation patterns distinguish painters from non-painters, and Koide et al. using a prediction model of a saliency map showed that artists are less guided by local saliency than non-artists [33]. Painters become much more involved in the act of looking than non-painters. Subjects frequently complained that it was tiring to do the study. It is hard work to look carefully at pictures. Many painters are either trained to or instinctually do follow their eye as it moves around a picture. Moving our eyes in viewing the world especially the world of nature with its fractal forms seems effortless, but witthehin pictures it is different because of balance. Attentive examination exerts an unaccustomed force on the eye muscles causing fatigue. The earlier traditional analysis of balance interpreted this force as being localized to pictorial objects and so arrived at a global theory of a balance of forces, but as this paper postulates, the force is caused by the varying difficulty of making eye movements – a resistance to the effect of salience.

Although a few non-painters were found to discriminate between the pictures, any study is limited by the need to find large numbers of painters. I found anecdotally that sculptors and print makers are not among this group. There were also a small number of subjects who I was pretty sure could see the effect in pictures seen by reflected light but unable to see it in polarized pictures. The use of an iPad in different lighting environments was necessary to bring the study to the observers as no laboratory was available. Reflections from the iPad screen increased the number of false negatives, i.e. coherent pictures being seen as unbalanced as the reflections change quadrant luminance. It is highly unlikely that the reverse would be true. That observers saw unbalanced pairs as being different was contrary to expectations, and therefore could not have been influenced by the examiner. Results might be improved by varying the sequence of the pairs. A MacNemar test shows data validity $p < 001$.

Observations

Pictorial coherence is extremely sensitive to small differences of quadrant luminance which explains its fugacity without precise viewing conditions. Changing the illuminating light spectrum or the painting's position relative to the viewer destroys the effect. With pictures in a studio even the drying of paint in the following hours creates a tonal change that is sufficiently to cause the effect to disappear. Given that many do not see the effect normally created through chance and even then is fleeting, and that there is no name for it, one can understand why it is not discussed in 20th century literature. De Pile's observations were known to Delacroix but he is known only to art historians today[11].

A flat surface with no marks, i.e. one coated with an opaque layer of paint gradually modified so that the upper half is slightly darker, cannot be seen as coherent. If one calculates backwards from the perceived balance i.e. the originally viewed object unmodified by the visual system, it would present itself as a uniformly luminous object. There has to be some surface quality for this part of the visual system to recognize something as an object. It has been shown that forms in nature have a fractal quality, that fractal images have an aesthetic quality and that the visual system has evolved to respond to conditions of nature that are fractal[34- 36]. Therefore, it can be inferred that the part of the visual system that calculates balance is also most sensitive to fractal forms. The visual system is designed to work best in this fractal environment and not the world of manmade objects that are linear and uniform, causing the eye to jump from one form to another. Pictures with uniformly colored geometric forms having no fractal qualities or those with many equally prominent forms detract from balance. Pair 2 is a good example of this. The eye is forced to go from form to form with perhaps slightly greater ease as balance improves. Geometric forms are usually solid unvarying in color that strongly attract the eye and do not exist in nature. They may be seen as pictures within the picture. It has been noted that binocular vision is necessary to view the percept.

As previously mentioned the algorithm used to calculate balance can be seen as a method for identifying and following a moving object in the early visual system operating by means of a luminance channel which corresponds to the color spectrum sensitivity of the parvocellular system to be later superseded by the parvocellular and magnocellular system. The object would be identified by a vector and its virtual rectangle. The ability of the visual system to create virtual lines has been shown through the Kanizsa illusion. Insects and birds as well as sharks have been shown to be able to perceive this. It would seem that the creation of virtual lines has been programmed into our visual system since the beginning[36,37]. Once the measurement of balance is done, the visual system has identified the organism and can follow its changes. A complex object of whatever size is reduced to an ever changing vector and rectangular halo. Even if it stops moving, the vector and halo would remain visible where it might otherwise blend in with the ground. Many different moving forms can be followed simultaneously with minimal computing power, and it guarantees that at any moment either the prey or predator is located within its boundaries. This leads to an ecological explanation of the study in which the pictures are interpreted as organisms. A bilaterally symmetric organism or its fairly balanced pictorial equivalent could be seen as an approaching organism requiring that particular attention be directed at the two different but similar images. However, as the pairs become imbalanced they would be interpreted as an organism moving somewhat orthogonally with no threatening or other implications. The two images would then be seen as inconsequential variations of the same organism and identified as being the same.

There is a illusion sometimes called the Mona Lisa effect which has never been adequately explained where the gaze of a depicted person looking straight at the viewer in front of a picture seems to follow the viewer as the their position changes. This occurs with other directional images such as a barrel of a gun or a road. The painting, *The Mona Lisa*, only imperfectly exhibits this effect, but there is no other name for it[38-40]. Viewing a picture from the side does create a distortion due to foreshortening such that it should appear to be a trapezoid. However, the low level view fills in the spaces with a virtual rectangle. Although there is a perspective change, this "other" picture with the virtual borders does not change much from the original so that the picture seems as if it is in front of the viewer.

With the polarized light of LED pictures there is a decoupling of two low level aesthetic effects. One, relating to the ease of making eye movements, is not inhibited or less inhibited while the other which rivets the attention in an involuntary way when perfectly balanced and in varying degrees as the picture becomes unbalanced is inhibited. The anatomical location for neurons that perceive balance and the pathway that rivets the attention might be found by using various imaging techniques with a suitable subject viewing a projected balanced picture through both a polarizing filter and a neutral density filter or by using a technique similar to that used in this study. Based on work by Wu et al. and Duchemin et al, the calculation of balance and its effect on eye movements might be located in the pretectal area of the midbrain. This has been shown to be a major center of global motion processing[41, 42]. On a higher visual pathway level, Thakral et al showed that the sensation of movement in a picture is shown to be reflected by activity in the sensory motion processing region MF+[43]. Presumably the more balanced the picture, the more it should show activity in the MF+.

The attention riveting effect is, as so eloquently described by Delacroix, an artistic peak effect different but similar to the peak effects in other art forms. These can be riveting in their own way and so may have a common pathway [44,45]. A "peak artistic experience" in this context is characterized by the work commanding total attention to the exclusion of everything else, and as such it is a dissociative experience as described by Brantley in his review of *Uncle Vanya* [45]. While the response to different artistic mediums may have a common pathway, no one is highly sensitive in this manner to every art form. For example, Clive Bell in his book ***Art*** describes his marked emotional sensitivity to painting and compares this to his relative lack of sensitivity to music. He can enjoy and intellectually understand why a musical composition or performance is excellent, but it is not the same as his response to painting. He can make this distinction only because he had this acute sensitivity to painting to which he can compare other responses. Without that he might have expected that any aesthetic response is an intellectual one [47]. This

distinction between emotional and intellectual response is fundamental to the understanding of art and is a source of much confusion.

The author would like to thank the Matlab Mathworks Help community for writing the code calculating the visual method of balance.

Supplemental Information is available for this paper with the study results, pictures both with and without black bars, calculations of balance and statistical studies.

Correspondence should be addressed to David Corwin dcorwinmd@gmail.com

References

1. Schapiro, M. On Some Problems in the Semiotics of Visual Art Semiotica 1969 1:225-242
2. Arnheim, R. Art and Visual Perception Berkeley: University of California Press; 1974 p.10
3. Molnar F A Science of Vision for Visual Art (1997) Leonardo 30:3 pp. 225-232
4. Locher, P & Martindale, C Dorfman, L. (2006). New directions in aesthetics, creativity and the arts. Foundations and Frontiers in Aesthetics. pp 19-32.
5. Poore, H.R. Pictorial Composition and the Critical Judgment of Pictures. New York:G.P Putnam Sons 1903
6. Ross, D.A. Theory of Pure Design. Boston: Houghton, Mifflin and Co.; 1907
7. Gershoni S, Measuring pictorial balance perception at first glance using Japanese calligraphy 2011 i-Perception 2, p 508 – 527 doi.org/10.1068/i0472
8. Hübner R, Thömmes K (2019) Symmetry and Balance as Factors of Aesthetic Appreciation: Ethel Puffer's (1903) "Studies in Symmetry," Symmetry 11(12), 1468
9. McManus IC, Stöver K, Kim D. Arnheim's Gestalt theory of visual balance: Examining the compositional structure of art photographs and abstract images. Iperception. 2011;2(6):615-47. doi: 10.1068/i0445aap.
10. Locher H Towards a Science of art: the Concept of 'Pure Composition' in Nineteen and Twentieth century Art Theory. Pictorial Composition from Medieval to Modern Art, Warburg Institute, London 2000 p. 323
11. Puttfarken, T. The Discovery of Pictorial Composition, New Haven: Yale University; Press; 2000
12. Itti, . Koch, C, Niebur, E. A Model of Saliency-Based Visual Attention for Rapid Scene Analysis IEEE Trans Pattern Anal Mach Intell. 1998 20(11);9 doi:10.1109/34.730558
13. Kowler, E. Review of Eye movements: The past 25 years Vision Research. 2011 51(13), 1457-1483 doi.org/10.1016/j.visres.2010.12.014
14. Krasovskaya, S, MacInnes, W.J.. Salience Models: A Computational Cognitive Neuroscience Review. Vision 2019 3(4). doi: 10.3390/vision3040056.
15. Locher, P, Gray. S, Nodine, C.F. The structural framework of pictorial balance Perception 1996 25: 1419-1436 doi: 10.1068/i0472aap
16. Nodine, C.F. Locher, P. Krupinski, E.A. The Role of Formal Training on Perception and Aesthetic Judgment of Art Composition Leonardo 1993 26(3), 219-227 doi: 10.2307/1575815
17. Langford 1935 Ocular behavior and the principle of pictorial balance Journal of General Psychology
18. F. Molnar, "About the role of visual exploration in aesthetics," Advances in Intrinsic Motivation and Aesthetics,H.I. Day, pp. 385-413, New York, Plenum Press, 1981.
19. G. T. Buswell, How People Look at Pictures: A Study of The Psychology of Perception in Art, The University of Chicago Press, Chicago, 1935.
20. Doran, M (Ed.) Cochran JL (Trans.).Conversations with Cézanne. Berkeley; University of California Press ;2001 , p.88-89, 110-111
21. Delacroix, E. Œvres Littéraires. Études Esthétiques 4th ed Paris :G. Crés & Cie ;1923 p.63 http://classiques.uqac.ca/classiques/delacroix_eugene/etudes_esthetiques/etudes_esthetiques.pdf
22. Kandinsky "Rückblicke" in Weiss, P. Kandinsky in Munich. Princeton University Press; Princeton, 1979 p.68
23. Brock Jon The Art of Composition - Dynamic Balance Updated: Jun 11, 2023

24. Bertamini, M. Blakemore, C. Seeing a work of art indirectly: When a reproduction is better than an indirect view, and a mirror better than a live monitor. Front Psychol, 2019 10, Article 2033. doi.org/10.3389/fpsyg.2019.02033
25. Locher, P. Smith, J.K. Smith L.F.. The influence of presentation format and viewer training in the visual arts on the perception of pictorial and aesthetic qualities of paintings Perception. 2011 30,449-465 doi: 10.1068/p3008.
26. Mission, G.P. Anderson, D.J. The spectral, spatial and contrast sensitivity of human polarization pattern perception (2017) Scientific reports 7:16571. doi:10.1038/s41598-017-16873-6
27. Chen, K. Jin, Z. Yao, L. Neural substrates in color processing: A comparison between painting majors and non-majors. Neurosci Lett, 2011 487: 191-195.
28. Antes, J.R. Kristjanson, A.F. Discriminating Artists from Nonartists by Their Eye-Fixation Patterns. Percept Mot Skills.1991;73(3):893-4. doi.org/10.2466/pms.1991.73.3.893
29. Antes, J.R. Kristjanson, A.F The impact of level of expertise on the evaluation of original and altered versions of post-impressionistic paintings Acta Psychologica. 1996 94(2),117-131 doi.org/10.1016/0001-6918(95)00055-0
30. Zangemeister, W.H. Sherman, K .Stark, L. Evidence for a global scan path strategy in viewing abstract compared with realistic images. Neuropsych 1995 33(8):1009-1025 doi: 10.1016/0028-3932(95)00014-t
31. Park, S., Wiliams, L., & Chamberlain, R. (2022) Global Saccadic Eye Movements Characterise Artists' Visual Attention While Drawing. Empirical Studies of the Arts, 40(2), 228–244. https://doi.org/10.1177/02762374211001811
32. Nodine CF, Locher P, Krupinski EA 1993The Role of formal Training on Perception and Aesthetic Judgement of Art Composition Leonardo 26(3):219-227
33. Koide, N. Kubo, T. Nishida, S. Shibata, T. Ikeda, K. 2015 Art Expertise Reduces Influence of Visual Salience on Fixation in Viewing Abstract-Paintings. PONE; 10(2): e0117696. doi: 10.1371/journal.pone.0117696 doi:10.2307/1575815
34. Mandelbrot, B. The Fractal Geometry of Nature; W. H. Freeman and Co: San Francisco, 1982
35. Spehar, B. Clifford, C, Newell, B. Taylor, R.P. 2003 Universal aesthetic of fractals. Comput. Graph 37, 813–820. doi:10.1016/s0097-8493(03) 00154-7
36. Gibaldi, A. Banks, M.S. (2019) Binocular Eye Movements Are Adapted to the Natural Environment J Neurosci 39 (15) 2877-2888; doi:10.1523/ JNeurosci .2591-18.2018
37. Fuss, T. Bleckmann, H. Schluessel, V. The brain creates illusions not just for us: sharks (Chiloscyllium griseum) can "see the magic" as well 2014 Frontiers in Neural Circuits, 8 DOI 10.3389/fncir.2014.00024
38. Horstmann G, Loth S (2019). The Mona Lisa Illusion—Scientists See Her Looking at Them Though She Isn't. i-Perception, 10(1). https://doi.org/10.1177/2041669518821702
39. Schott, G.D. (2018). Gombrich and 'Pictures That Follow with Their Eyes'. The Journal of Art Historiography, https://arthistoriography.wordpress.com/wp-content/uploads/2018/11/schott.pdf
40. Boyarskaya E, Sebastian A, Bauermann T, Hecht H, Tüscher O (2015) The Mona Lisa effect: neural correlates of centered and off-centered gaze. Hum Brain Mapp. Feb;36(2):619-32. doi: 10.1002/hbm.22651.
41. Wu Y, Dal Maschio M, Kubo F, Baier H. (2020) An Optical Illusion Pinpoints an Essential Circuit Node for Global Motion Processing. Neuron.108(4):722-734.e5. doi: 10.1016/j.neuron.2020.08.027.

42. Duchemin A, Privat M, Sumbre G. 2022 Fourier Motion Processing in the Optic Tectum and Pretectum of the Zebrafish Larva. Front Neural Circuits (15:8):14128.
43. Thakral PP, Moob LR Slotnicka SD 2012 A neural mechanism for aesthetic experience Neuroreport 23(5):310-3 doi: 10.1097/WNR.0b013e328351759f.
44. Grewe O, Nagel F, Kopiez R, Altenmüller E. 2005 How does music arouse "chills"? Investigating strong emotions, combining psychological, physiological, and psychoacoustical methods. Ann NY Acad Sci. 1060:446-9. doi:/10.1196/annals.1360.041. PMID: 16597800.
45. Wassiliwizky, E. Koelsch, S. Wagner, V. Jacobsen, T. Menninghaus, W (2017) The emotional power of poetry: neural circuitry, psychophysiology and compositional principles. Soc Cogn Affect Neurosci. 12(8):1229-1240. doi:10.1093/scan/nsx069.
46. Brantley, B. (2018 Sept 16). Review: Listening to 'Uncle Vanya' With Virgin Ears, New York Times https://www.nytimes.com/2018/09/16/theater/review-uncle-vanya-richard-nelson.html .
47. Bell, C *ART* New York Frederick Stokes and Co. 1913