Pictorial balance is a bottom-up neuro-aesthetic property mediating attention and eye movements. A primitive visual operating system explains the property of balance and a primary visual way of organizing the world.

David Corwin M.D.
dcorwinmd@gmail.com

Abstract
Pictorial balance has been used to explain why some paintings evoke feelings of unity and harmony. The present study shows how the low-level visual system calculates balance in pictures, why it evokes these feelings of unity and harmony and created the earlier perception of balance, and its evolutionary importance in visualizing the world of moving organisms. The concept of pictorial balance as a center of mass effect, i.e. the feeling that somehow a person on the left seems to be balanced by a tree on the right, originated at the beginning of the 20th century. It had never been mentioned in art commentary of the previous 500 years, and yet has become a widely assumed but an unsubstantiated explanation of why some paintings evoke feelings of unity and harmony. Despite this lack of historical documentation, the perception of pictorial balance exists. This study starts with an elusive pictorial effect known to painters evoking these feelings of harmony and unity. In such pictures the image seems to be perceived as a whole without the need to fixate on individually depicted objects. First described by a 17th century critic Roger de Piles and subsequently by a few renowned artists, the author thought that this response was because the picture was 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. A study was conducted in which the identical picture seen sequentially in slightly different frames could seem different to observers because of the change in balance created by the frames. The results indicate that the extent to which the picture pairs were seen as different correlated with a proposed method of calculating balance. This method could be understood as a primitive visual operating system identifying moving organisms as luminous objects and evaluating them in terms of balance. Balanced is determined solely by luminosity as seen in peripheral vision. The more balanced the picture, the more it will be seen as a whole, an object evoking feelings of unity and harmony. It is proposed that in the evolution of vision this luminance pathway using balance is the initial way for organisms to organize the world from luminance and movement.

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

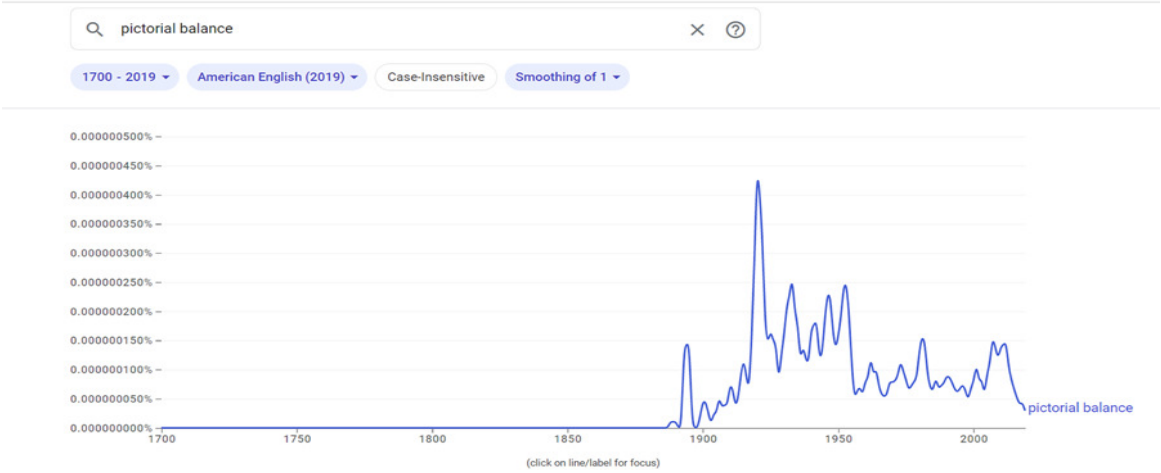
the technology to create flat surfaces, perhaps the fourth millennium BC, and differ from images without borders. Borders evoke the percept of balance: the parts relate to both the center and the border [2]. Balance is both a bottom-up percept and a top-down aesthetic concept taught in schools. This paper is concerned with the bottom-up aesthetic perception – 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," and that 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 initially 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 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 ascribes to the feeling of being balanced.[5] Several studies have unsuccessfully attempted to confirm this method of calculating balance.[7-9] However, both Hubert Locher and Thomas Puttfarken give comprehensive historically discussions of European theories of pictorial aesthetics and composition between the 14th and the 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. Including only 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 it is salience that strongly influences eye movements. The initial sequence of saccades on first viewing a picture can be predicted and correlated with eye tracking through calculations based on the most salient features of surrounding areas [12-14]. There have also been studies that tried to show the more subtle effect of balance on eye movements. Langford could find no difference in these movements between pictures identified as either balanced or unbalanced. Locher and Nodine compared them in pictures that were thought to be balanced with variations of these pictures that were presumed less well balanced. 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 eye tracking, 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]. As will be discussed the effect of balance is subtle and global in nature affecting ease of movement within the picture.

While this hypothesis of balance has been an intellectual interpretation of visual phenomena, the feeling of some sort of balance of visual forces requires an explanation of pictorial balance. To understand and measure low level balance, one must start with a picture that exhibits the sensation of perfect balance. Balance has been used to explain the feelings of pictorial unity and harmony, and this 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 and then in rather vague terms. The unexpected change in a painting from being remarkably luminously unified and harmonious to something less so or the reverse is quite striking. There is the feeling that the whole picture can be seen at one time and that the gaze moves smoothly and seemingly effortlessly without the apparent need

to be fixed on any pictorial element. There is a qualitative difference between perfect balanced where the gaze is looking at the picture as an object and an unbalanced painting where we are looking in the picture fixating on the forms therein.

Because there has been no name for this effect, historical discussion has been limited. Roger de Piles, an early 18th century French critic and painter first described an arrangement 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]. Similarly, Eugene Delacroix in the 19th century wrote 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 [11,20]." Wassily Kandinsky in the 20th century describes an experience also documenting 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." [21] A 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." [22]

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 luminance 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 on white paper that appeared coherent whether framed or cut out. One time due to an error of alignment the framed image appeared unbalanced while the cutout image remained balanced. It was derived from this that with respect to balance, pictures are defined only by luminosity and not borders. For example, 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 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 of its respective quadrant. For simplicity, the picture's geometric center is located at (0,0). L_{TOTAL} is taken as the average total luminance.

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

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. 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 at least 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. This method called the visual method was suggested to me by the need to explain how the eye could divide a picture into such precise quadrants by pure luminance without using the visual cortex. If a moving organism is defined as a collection of luminous points that move together with respect to a ground, it can be divided into two equally luminous parts by a virtual vertical line. Virtual parallel and perpendicular lines are drawn around the organism to create a "picture" while other virtual diagonal lines determine the geometric center. This enables the drawing of a horizontal line bisecting the rectangle dividing it into four quadrants. Originally, I had simply said a virtual horizontal line is drawn bisecting the vertical line to divide the organism into four quadrants, but I do not understand how this can be done using only luminance. 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 but more likely so that the movements of an object appearing to have uniform luminance could be evaluated. The light energy or amount of light within a quadrant is then averaged over the area of the quadrant and its average value is placed at the geometric center of the respective quadrant. This permits calculations using the formula of the geometric method. Since there are two vertical lines dividing the organism, one into geometric halves and the other into two equally luminous parts, this algorithm provides two ways to calculate balance: the geometric method and the visual method.

There are two effects conveyed by perfect balance: the intangible effort for the eye to move across the picture and the feeling that one can see the picture as a whole. that rivets the attention. 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 [23]. Locher et al. made similar observations[24]. 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 increases luminance perception in the fovea and parafovea through structures that transmit polarized light incorporating macula pigments only found there [25]. This would increase the sensitivity of central vision and decrease the sensitivity of peripheral vision. As a result observer preference could not be used to show that the effect was seen. However feelings evoked by the ease of movement in a coherent picture are experienced. This allows a performance based study to show that the effect was perceived in that two identical pictures differing only by balance could be seen as different. LED images had to be used to permit precise luminance determination and reproducibility under the conditions that were feasible. Perfect balance or pictorial coherence will be used as absolute terms whereas balanced or unbalanced will be relative terms

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's ability to distinguish fine degrees of pictorial imbalance correlates with balance as calculated by these definitions.

Materials and Methods

Since a white-framed picture is seen by this low-level visual system as an object in contrast to the top-down view which sees it as a picture in an uninteresting frame, the comparison of a perfectly 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 I did not think that observers could see degrees of relative imbalance within the pairs. Many observers were excluded from the study 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. Painters and those interested in looking at pictures would do this careful inspection. Others had trouble even when

specifically asked although this was not usually done. Two studies were conducted 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 selected for their predominantly neutral content. They were prepared using Photoshop CS2© in the following manner: quadrant image luminance can be changed in an unobtrusive and precise manner using the lasso tool to create an irregular form within a quadrant and changing the luminance with the level command by no more than ±5 percent. This form is then moved around and the operation repeated until the desired quadrant luminance value is reached. The two studies differed only in their use of different sets of white borders. The three possible image and border combinations are in Figure. 2. 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 available) 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 labeled with quadrant luminance data).

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

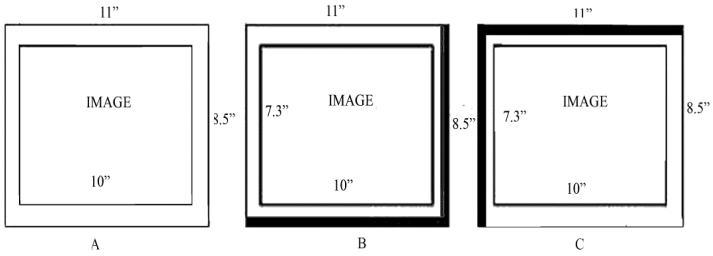


Figure 3 Pictures used in the study pairs

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 also told that it was intended for some pairs to 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 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

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 shows that observers did not perceived the percept of perfect balance. However, a second analysis including the calculations of balance (table 2) shows that either the observers saw the effect of perfect balance and/or the effect of relative balance. Table 1 measures whether they could see intra-pair differences while table 2 shows that they can see inter-pair difference

Table 1 the number of observers correctly answering the same/different question with the 10 pairs

1st study		2nd study	
Observers	Correct Responses	Observers	Correct Responses
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

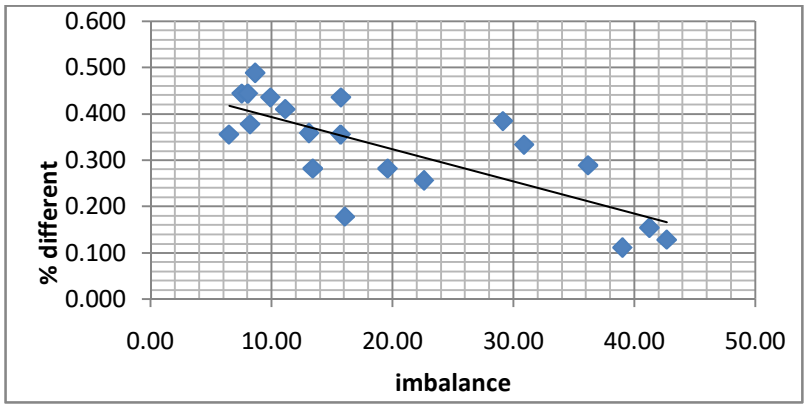
It was noticed to my surprise that subjects saw differences in the unbalanced pairs. At first I thought this was due to guessing, but on further examination it was found that there is an inverse correlation between the percent of pairs seen as different and the pair's average distance (average imbalance) as calculated with the two methods (see table 2). This is seen if the pairs are divided into groups based on their degree of average balance where there is clearly a group in which the average state of imbalance is small (the balanced pairs), and the other where the average imbalance is large.

Table 2 Pair average distance and percent of observers who identified the pairs as different using both methods 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 $r(18) = -0.757$, $p < 0.001$. Figure 3 shows the results graphically.

Figure 3 Graph of the visual balance results of 2



These finding suggest one or both of two interpretations: either the observers are seeing the effect of coherence to distinguish the pictures within the pairs demonstrating that they see the effect, or the observers are seeing pairs according to their average state of balance. The second point is reinforced by the following: 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. This correlation of pair average balance with observations of same or difference is not obviously logical. As I wrote above, I thought that observers would be comparing intra-pair difference in which two unbalanced pictures would seem identical, and I only found a correlation between inter-pair average luminance and observations, Why should the results correspond to different degrees of viewing pairs as different based on average states of balance? An ecological explanation of the study discussed below explains this. As mentioned above it has been thought by several investigators that the effect of balance on eye movements might be objectified with eye tracking using two slightly different pictures, but this lack of intra-pair correlation indicates that this is not likely.

The results are 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 [26-31.] 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 [32, 33]. It was noted that painters become much more involved in the act of looking than non-painters, and that subjects frequently complained that it was tiring to do the study. It is hard work to look carefully at pictures. Moving the eyes to seems effortless, but within pictures it is different because of balance. The reason for this will be discussed below.

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. 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 create states of balance that correspond to the results because observers did the study in many different areas. That observers saw unbalanced pairs as being different was contrary to expectations, and therefore could not have been influenced by the examiner. The methods for calculating balance were determined after the study was done. One could say that they were created so as to determine the desired results disregarding the logic of the formula and algorithm, but one would have to explain how this was done with paradoxical results. The results might be improved by varying the sequence of the pairs. They would certainly be improved by asking the observers to compare the ease of moving their eyes through 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. 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. Changing the illuminating spectrum or the painting's position relative to the viewer destroys the effect. Given that many do not see the effect, and that it is 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. Although the formula for coherence has been defined for viewing a picture directly in front of it at eye level, a given picture can be seen as coherent from another set of conditions. It is possible that given the proper frame many pictures might be seen as coherent when directly in front of the viewer.

Pictures with many equally prominent forms have the same or similar effect as poor 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. However, if the picture is seen from a suitable distance, the forms might coalesce so that the picture appears coherent. Prominent geometric forms enclosed by definite lines and unvarying color will prevent the painting from appearing coherent. However, if the circumscribing line is not precisely defined and the interior surface is variegated they may be part of a coherent painting. For example, the paintings of Mark Rothko often present rectangles laid on a ground. However, in general, all the borders are fuzzy and the surfaces are

all variegated so that paintings in this style can be coherent. It has been noted that binocular vision is necessary to view the percept.

A corresponding condition where a painting cannot exhibit balance is that of 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. If one calculates backwards from the perceived balance i.e. the originally viewed object unmodified by balance calculations, it would be a uniformly luminous object. There has to be some surface quality for this part of the visual system to recognize something as an organism. It has been shown that forms in nature have a fractal quality, that visual systems has evolved to respond to conditions of nature that are fractal, and that fractal images have an aesthetic quality [34-36]. Therefore, it can be inferred that the part of the visual system that calculates balance is also most sensitive to fractal forms. It is thought that 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.

The algorithm used to calculate balance can be seen as a method for identifying and following a moving object by means of a luminance channel. 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 see this. It would seem that the creation of virtual lines has been programmed into our visual system since the beginning [37, 38]. 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 a 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 organisms could be followed simultaneously with minimal computing power, and it guarantees that at any moment either the prey or predator is located within its boundaries. It is proposed that in the evolution of vision this luminance pathway to calculate balance is the initial way for organisms to organize the world from luminance and movement.

An organism is always viewed as if it were a two dimensional object directly in front of the viewer. This explains the phenomenon sometimes called the Mona Lisa effect that has never been adequately explained in which the gaze of a depicted person looking straight at the viewer positioned before the picture seems to follow them as they walk to the side. The painting, *The Mona Lisa*, only imperfectly exhibits this effect, but there is no other name for it [42,43]. To view a picture from the side does create a distortion due to foreshortening such that it should appear to be a trapezoid with the interpupillary distance of Lisa appearing slightly diminished. However,

the low level view fills in the spaces to create a virtual rectangle so that this foreshortened picture with the virtual borders appears like a picture directly in front of us with Ms Lisa staring at us as before (Figure 4).

Figure 4 A simulation of *Mona Lisa* viewed from the side at eye level.

As previously mentioned the results of study are not logically apparent. Why should average pair balance correlate with the degree of appearing different when we are looking at one pair to make the decision, i.e. intra-pair difference? However, an ecological explanation of the study in which the pictures are themselves interpreted as organisms explains this. A bilaterally symmetric organism or its fairly balanced pictorial equivalent would be seen as possibly approaching so that it would require that particular attention be directed at the two different but similar images to evaluate what might seem threatening. However, as the pairs become imbalanced they would be interpreted as the same organism moving somewhat orthogonally with no threatening or other implications.

Looking at a picture in terms of balance means you are looking at it as an object with peripheral vision or that part of the retina which is outside of the para-fovea. Looking in the picture to see what is depicted uses the developmentally advanced central vision's fovea. The more balanced

the picture, the more it will be seen with peripheral vision giving the feeling that we are seeing the entire picture at one time so that it appears unified and harmonious. Whereas normally in viewing scenes and not pictures this is done through cooperation between the peripheral and central vision to determine points of saliency and fixation, in a picture there is competition between the two ways of vision. If peripheral vision is relatively suppressed while looking into an unbalanced picture, saccades become more difficult. Peripheral vision and its corollary covert attention is necessary to determine the next object of fixation [39-41]. Other evidence for this competition is provided by increased fovea sensitivity to polarized light creating an effect similar to imbalance which partially destroys the effect of balance as noted above [25]. The difficulty in making these saccades gives the impression that the forms exert a force on our vision. This explains Poore's observation that "…every item of a picture has a certain positive power, as though each object were a magnet of a given potency.[5]" Correspondingly; Arnheim describes perceptual forces of pictorial objects that he attributed partially to their location[2]. When a picture is balanced and peripheral vision is fully active, these forces are diminished. This is the basis of the 20th century's idea of pictorial balance. Normally we just feel this as fatigue on attentively viewing pictures.

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 which can be riveting in their own way[44, 45]. A "peak artistic experience" in this context is characterized by the work commanding total attention, and as such it can be a dissociative experience as described by Brantley in his review of *Uncle Vanya*[46]. No one is highly sensitive to every art form. Clive Bell in his book *Art* describes his marked aesthetic 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 and its aesthetic percept, to which he can compare responses to other art forms. Without that he might have expected that any aesthetic response is an intellectual one [47]. The distinction between a low level aesthetic percept and higher level intellectual aesthetic responses is fundamental to the understanding of art and is a source of much confusion.

This paper reintroduces the percept of pictorial coherence as first described by Roger de Piles to explain the feelings of unity and harmony evoked by certain pictures. It proposes a calculation of pictorial balance which uses an algorithm that can also be interpreted as a method for a primitive organism to organize their light perception to see other organisms. It further proposes a way for this primitive visual stream to interact with evolutionary later visual streams to enable us to perceive pictures as aesthetic objects. The interpretation of the study and its theoretical conclusions has an internal logic, but further experimental evidence will, of course, determine its

validity and how it affects us in other aspects of vision. A new percept requires a new theory of vision and introduces a different conception of the aesthetic experience. It should be an important neuropsychological objective in other genres to understand what and how an ordered collection of objects, movements, and/or sounds can attract the attention so intensely on a pre-cognitive level in some people as to induce an intense dissociative type of experience. This might not only enable us to understand our experience of and judgments about a work of art but provide greater understanding of how the mind processes sensory experiences.

Summary

1. Pictures create the percept of balance. The more balanced the picture, the more it will be perceived as unified and harmonious, and the more it will draw the attention. This is the low-level neurological aesthetic response.

2. The measurement of balance is determined by an algorithm that can be conceived as being the initial way of organizing the world of living organisms using only luminance and movement.

3. A balanced picture increases attention to peripheral vision so that the picture is seen as a whole decreasing the tendency to use central vision to fixate on what is in the picture.

4. An unbalanced picture decreases attention to peripheral vision and so makes it more difficult for the eye to initiate saccades. This difficulty explains the force fields described by the traditional explanation of balance.

The Matlab code for calculating the visual method of balance was largely provided by the Matlab Mathworks Help community.

Supplemental Information is available for this paper including all documents and information necessary to repeat the study and confirm the results.

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

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