Pictorial balance is a bottom-up neuro-aesthetic property mediating attention and eye movements. A model of a primitive visual operating system explains the property of balance and some visual properties of pictures

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Abstract
Pictorial balance has been used to explain why some paintings evoke feelings of unity and harmony. This study shows how it is calculated and proposes an evolutionary reason for its existence. 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 unsubstantiated explanation of why some paintings evoke feelings of unity and harmony. Despite the lack of historical documentation, the perception of pictorial balance exists. This study shows how the low-level visual system calculates balance, how it evokes feelings of unity and harmony, and its evolutionary importance in visualizing the world of moving organisms. It is done by means of a study of an elusive pictorial effect known to painters, in which these feelings are evoked. In such pictures the image seems to be perceived as a whole without the need to fixate on individual depicted objects. The effect was first described by a 17th century critic Roger de Piles and subsequently by a few renowned artists. The author hypothesized that this response 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. 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 pairs were seen as different correlated with two methods of calculating balance. One of them could be understood as a possible primitive visual operating system for identifying other moving organisms as ever-changing vectors of balance. The more balanced the painting, the more it will be seen as a whole object by emphasizing peripheral vision and decreasing the tendency to fixate on what is in the picture, causing the painting to be perceived as unified and harmonious. It is proposed that in the evolution of vision there is a luminance pathway that was later superseded by other pathways using color vision. This explains the percept of balance and other visual phenomena.

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

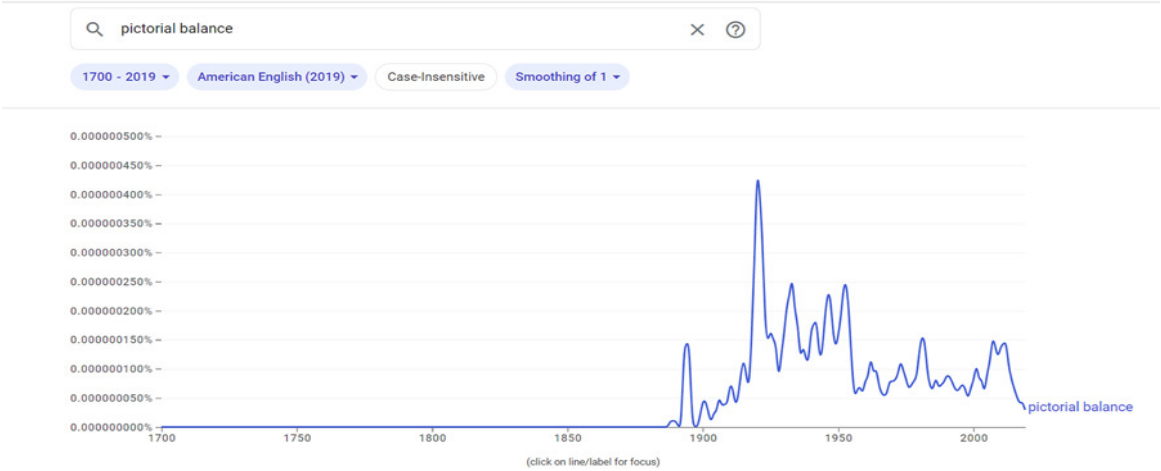
the technology to create flat surfaces, perhaps the fourth millennium BC, and differ from images without borders. Borders evoke the percept of balance: the parts relate to both the center and the border.[2] Balance is both a bottom-up percept and a top-down aesthetic concept taught in schools. This paper 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." It has also been asserted 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 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 calls balance.[5] Several studies have unsuccessfully attempted to confirm this method of calculating balance.[7-9] Historically, both Hubert Locher and Thomas Puttfarken give comprehensive 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 the force that strongly influences eye movement is salience The initial sequence of saccades on 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].

While this hypothesis of balance has been an intellectual interpretation of sensory phenomena, the feeling of some sort of balance of visual forces requires an explanation. To understand and measure low level balance one must start with a picture that exhibits the sensation of perfect balanced. 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 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 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, historical discussion has been limited. Roger de Piles, an 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] 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." [11,20] Wassily Kandinsky also describes an experience 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 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." [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 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-luminance mass of the 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. To do this one conceives of a moving organism as a collection of luminous points that move together with respect to a ground. Divide this into two equally luminous parts with a virtual vertical line and bisected this horizontally by another virtual line to create an organism 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 but more likely so that an object appearing to have uniform luminance could still be seen as unbalanced. The light energy or amount of light within a quadrant is then averaged over the area of the quadrant and is arbitrarily situating it at the geometric center of the respective quadrant permitting calculations using the formula of the geometric method. This second method is being 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 the prominence of peripheral vision so that the picture is seen as a whole which 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 incorporating macula

pigment only found there that transmit polarized light.[25] This would increase macula sensitivity and decrease peripheral vision sensitivity. 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 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.

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 the balance 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 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 excluded from the study because they did not pay full attention to the pairs. These observers 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©. Quadrant image luminance can be changed in an unobtrusive and precise manner. Using the lasso tool to create an irregular form within a quadrant, the luminance is usually changed 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 with accompanying quadrant luminance data).

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

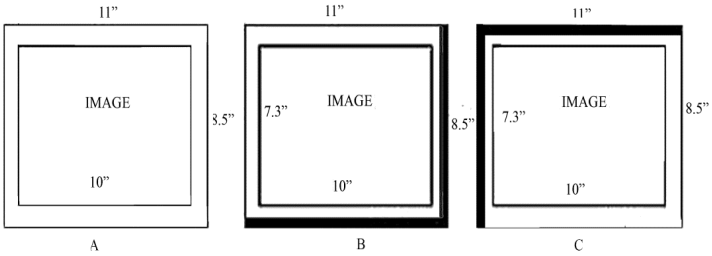


Figure 3 Pictures used in the study pairs

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 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 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

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 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

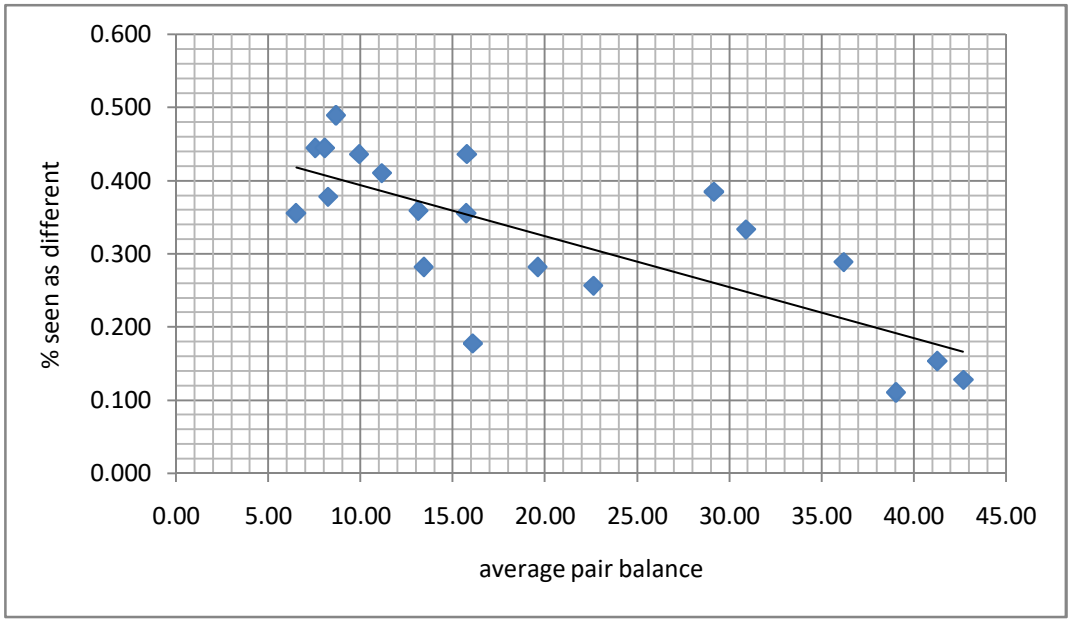
It was noticed to my surprise that subjects saw differences in the unbalanced pairs. At first I thought this was due to guessing, but on further examination it was found that there is an inverse correlation between the percent of pairs seen as different and the pair's average distance (average imbalance) 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 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 $r(18) = -0.757$, $p < 0.001$. 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. The correlation of pair average balance with observations of same or difference is not obviously logical. Originally 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 is an explanation of this. It has been thought by several investigators that the effect of balance on eye movements might be objectified with eye tracking as mentioned above using two slightly different pictures, but this lack of intra-pair correlation indicates that this is not possible.

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. [26-32] 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 the eyes in viewing the world especially the world of nature seems effortless, but within pictures it is different because of balance. Attentive examination exerts an unaccustomed force on the eye muscles causing fatigue. This is experienced by anyone in museums of art. The 20th century 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 that sculptors and print makers did not seem to be among this group. I was also fairly sure that there were a small number of subjects who could see the effect in pictures when seen by reflected light but unable to see it in the study's 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. Results 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. 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.

Pictures with many equally prominent forms have the same 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. This is also true for geometric forms which by definition are enclosed by straight lines and usually solid unvarying in color 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. Anything that encourages the eye to look in the picture and not at the picture contributes to the feeling of poor balance.

As previously mentioned 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.[34,35] 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. This would not require precision vision. 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. On the same theoretical grounds one can postulate that every part of the retina contributes to this.

This explains the observation that 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 this visual pathway, it would present itself as a uniformly luminous object, something virtually unknown under natural conditions. 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 fractal images have an aesthetic quality and that the visual system has evolved to respond to conditions of nature that are fractal [36-38]. 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.

It also correlates with the observation that irregular motion resembling that of animate creatures is more salient and induces faster reaction times than motion resembling that of inanimate objects with constant velocity or acceleration.[39] The importance of animate beings is also demonstrated with static pictures. Subjects more rapidly initiated saccades to and detected changes within it if the pictures depict animals rather than inanimate objects.[40,41] Although one can argue that this is caused by a higher level evaluation, there are no special neurons dedicated to recognizing an animal, any animal, such as there are with faces [42]. It would be consistent with a primitive system that just responds to moving organisms.

This leads to an ecological explanation of the study in which the pictures are themselves 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 for evaluation. 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 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.[43-45] 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 Lisa's interpupillary distance 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 the Mona Lisa viewed from the side at eye level.

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[46,47]. A "peak artistic experience" in this context is characterized by the work commanding total attention, and as such it is a dissociative experience such as described by Brantley in his review of *Uncle Vanya*.[48] 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 other responses. Without that he might have expected that any aesthetic response is an intellectual one.[49] 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. While the response to balance in pictures is directly related to the primitive visual system, it was discovered by accident and has no evolutionary significance such as Darwin has suggested for musical sounds [50].

An important aesthetic neuropsychological objective is to understand in the arts what and how an ordered collection of objects, movements, and/or sounds can attract the attention so intensely on a pre-cognitive level so as to induce an intense dissociative experience. This might not only satisfy our curiosity about the arts but provide greater understanding of how the mind processes sensory experiences.

Summary

1. Pictures create the percept of balance. The more balanced the painting, the more it will be perceived as unified and harmonious.
2. This is caused by increased attention to peripheral vision and decreased tendency to fixate on what is in the picture.
3. Perfect balance occurs when there is bilateral luminance symmetry and the luminance of the lower quadrants is equal and higher (slightly brighter) by a factor of ~1.07.
4. It is proposed that pictorial balance is determined by an algorithm involving solely the reflected luminance of the picture
5. It is proposed that pictorial balance a manifestation of an early evolutionary way of perceiving and determining the direction of moving organisms.
6. It is further proposed that in the evolution of vision there is a primary luminance pathway that was later superseded by other pathways using color vision.

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 with the study results, pictures constructed so that it is easy to repeat the study, and calculations of balance and statistical studies.

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References

1. Schapiro M, (1969) On Some Problems in the Semiotics of Visual Art *Semiotica* **1**, 225-242
2. Arnheim, R. **Art and Visual Perception** Berkeley: University of California Press; 1974 p.10
3. Molnar F (1997) A Science of Vision for Visual Art *Leonardo* **30:3,** . 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, (2011) Measuring pictorial balance perception at first glance using Japanese calligraphy *i-Perception* **2,** 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. 2011Arnheim's Gestalt theory of visual balance: Examining the compositional structure of art photographs and abstract images. *iPerception* **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. in **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 L Koch C Niebur E (1998) A Model of Saliency-Based Visual Attention for Rapid Scene Analysis IEEE Trans Pattern Anal Mach Intell. **20(11);** 9 doi:10.1109/34.730558
13. Kowler E (2011) Review of Eye movements: The past 25 years *Vision Research*. 51(13), 1457-1483 doi.org/10.1016/j.visres.2010.12.014
14. Krasovskaya S MacInnes WJ (2019) Salience Models A Computational Cognitive Neuroscience Review *Vision* 3(4). DOI: 10.3390/vision3040056.
15. Langford RC (1936) Ocular Behavior and the Principle of Pictorial Balance, J Gen Psych, 15:2, 293-325, DOI: 10.1080/00221309.1936.9917924
16. Locher P Gray S Nodine CF (1996) The structural framework of pictorial balance *Perception* **25**: 1419-1436 doi: 10.1068/i0472aap
17. Nodine CF Locher P Krupinski EA (1993) The Role of Formal Training on Perception and Aesthetic Judgment of Art Composition *Leonardo* 26(3), 219-227 doi: 10.2307/1575815

18. Molnar F "About the role of visual exploration in aesthetics," **Advances in Intrinsic Motivation and Aesthetics**, H.I. Day, , New York, Plenum Press, 1981. pp. 385-413
19. GT Buswell, **How People Look at Pictures: A Study of The Psychology of Perception in Art**, The University of Chicago Press, Chicago, 1935.
20. 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
21. Kandinsky W "Rückblicke" in Weiss, P. **Kandinsky in Munich**. Princeton University Press; Princeton, 1979 p.68
22. Brock J *The Art of Composition - Dynamic Balance* Updated: Jun 11, 2023 https://www.jonbrockphoto.com/post/the-art-of-composition-part-i-dynamic-balance
23. Bertamini M Blakemore C (2019) Seeing a Work of Art Indirectly: When a Reproduction Is Better Than an Indirect View, and a Mirror Better Than a Live Monitor, *Frontiers in Psychology*, 10:1-12 doi.org/10.3389/fpsyg.2019.02033
24. Locher P Smith JK Smith LF (2011) The influence of presentation format and viewer training in the visual arts on the perception of pictorial and aesthetic qualities of paintings *Perception*. 30,449-465 doi: 10.1068/p3008.
25. Mission G.P Anderson DJ (2017) The spectral, spatial and contrast sensitivity of human polarization pattern perception *Scientific Reports* 7:16571. doi:10.1038/s41598-017-16873-6
26. Chen K Jin Z Yao L (2011) Neural substrates in color processing: A comparison between painting majors and non-majors. *Neurosci Lett*, 487: 191-195.

28 Antes, JR Kristjanson, AF (1991) Discriminating Artists from Nonartists by Their Eye-Fixation Patterns. *Percept Mot Skills*.**73(3)**: 893-4. doi.org/10.2466/pms.1991.73.3.893

29 Antes JR Kristjanson, A.F (1996) The impact of level of expertise on the evaluation of original and altered versions of post-impressionistic paintings *Acta Psychologica* **94(2)**,117-131 doi.org/10.1016/0001-6918(95)00055-0

30 Zangemeister WH, Sherman K, .Stark L (1995) Evidence for a global scan path strategy in viewing abstract compared with realistic images. Neuropsych 33(8):1009-1025 doi: 10.1016/0028-3932(95)00014-t

31 Park S, Williams 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 (1993) The 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 RP (2003) Universal aesthetic of fractals. *Comput. Graph* **37**, 813–820. doi:10.1016/s0097-8493(03) 00154-7

36 Gibaldi A, Banks MS (2019) Binocular Eye Movements Are Adapted to the Natural Environment *J Neurosci* 39 (15) 2877-2888; doi:10.1523/ JNeurosci .2591-18.2018
37 Nieder A (2002) Seeing more than meets the eye: processing of illusory contours in animals J Comp Physiol A 188: 249–260 DOI 10.1007/s00359-002-0306-x
38 Fuss T, Bleckmann H, Schluessel V. (2014)The brain creates illusions not just for us: sharks (Chiloscyllium griseum) can "see the magic" as well Frontiers in Neural Circuits, 8 DOI 10.3389/fncir.2014.00024
39 Pratt J, Radulescu1 PV, Guo RM, Abrams RA (2011) It's Alive! Animate Motion Captures Visual Attention *Psychological Science* **21(11)** 1724–1730, doi: 10.1177/095679761038744
40 Kirchner H, Thorpe SJ (2006) Ultra-rapid object detection with saccadic eye movements: Visual processing speed revisited. *Vis Res*, **46**, 1762–1776.
41 New J Cosmides L Tooby J. (2007). Category-specific attention to animals reflects ancestral priorities, not expertise. *Proceedings of the National Academy of Sciences, USA*, **104**, 16598–16603 https://doi.org/10.1073/pnas.0703913104
42 Cao R Li X Brandmeir NJ Wang S. (2021) Encoding of facial features by single neurons in the human amygdala and hippocampus. *Commun Biol*. Dec **14;4(1)**:1394. doi: 10.1038/s42003-021-02917-1.
43 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
44 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
45 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*. **36(2)**:619-32. doi: 10.1002/hbm.22651.
46 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.
47 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.
48 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
49 Bell, C **ART** New York Frederick Stokes and Co. 1913
50 Darwin, C. R. 1874. **The descent of man, and selection in relation to sex**. London: John Murray. 2d ed. p.572 https://darwin-online.org.uk/content/frameset?itemID=F944&viewtype=side&pageseq=595