

# Eye-Movements and the Aesthetics of Visual Form.

By

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With 31 figures in the text.

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In current theories of our enjoyment of form by the eye, an important role is often assigned to the sensations coming from the optic muscles. Grant Allen, for instance, tells us that »Beauty of Form is chiefly concerned with the muscular sweep of the eye in cognizing adjacent points. . . . The agreeable feeling derived from all graceful forms is due to the easy and unimpeded action of the muscles and other tissues concerned«<sup>1</sup>). And similarly Dr. Santayana writes that »In the curves we call flowing and graceful, we have . . . a more natural and rhythmical set of movements of the optic muscles«<sup>2</sup>).

Such quotations could be multiplied in favor of the view that grace of curve and symmetry of composition are mainly muscular matters, and that our pleasure here is in the facility of the eye's motion as it glides over the contour of the figure. The eye's movements themselves by their ease and balance, make the form grateful to us; while ugliness of outline springs from a certain friction and weariness in these same organs. It is true that even those writers who insist most strongly on the importance of this muscular element usually introduce later an »intellectual« factor as contributing to the total result. But they put little heart into this concession, and the impression remains that, for them, our appreciation of line and

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1) *Physiological Aesthetics*, p. 168 et seq.

2) *The Sense of Beauty*, p. 90.

shape is chiefly a sensuous pleasure derived from the parts bordering on the socket of the eye.

Introspection, it must be granted, seems to support such a view. It does feel as though the eye itself moved gracefully over graceful curves, translating into a pleasing cadence of its own the varied arrangements in the figure presented. But, so far as I am aware, no records have ever been taken of the actual character of the eye's motion in looking at these forms. As a check upon the introspective evidence, consequently, some tracings of the eye's free action were obtained, and I shall try to give an account of what they seem to me to indicate.

In attempting to record the eye's movements for this study, a method was first tried which was similar to that devised and used by Prof. Delabarre<sup>1)</sup> for studying space illusions, and also used by Huey<sup>2)</sup> for investigating the eye's action in reading. A plaster-of-paris attachment was placed upon the eye-ball, and trials were made to obtain records on smoked paper by its means. But the necessity of using cocaine, and the doubt as to the reliability of such records after all, since the eye is in an abnormal condition and its records are certain to be influenced by the momentum of the external apparatus, made it seem best to use some entirely different method.

Photography was finally hit upon as offering an escape from the worst of these difficulties. Anyone may observe that when the eye moves hither and thither, it causes a movement of any small image that may happen to be reflected upon the smooth surface of the cornea. And a photographic record of the movement of such a minute image would, to some extent, give an account of the course taken by the eye in running over characteristic curves and figures, a record, too, that would in no way inconvenience the eye nor add anything like a foreign momentum to its normal swing.

One need recount but briefly the difficulties met with in putting into practice even so simple a plan. The suitable method, of course, is not to take an instantaneous photograph, for this would give only

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1) A Method of Recording Eye-Movements. Amer. Journ. of Psych., vol. IX p. 572.

2) Preliminary Experiments in the Physiology and Psychology of Reading. Amer. Journ. of Psych., vol. IX, p. 575.

a single position of the eye. A »time exposure« is necessary, during which the eye freely travels over the object to be observed. During this time, a single point of light on the pupil of the eye — in the present case, the reflection of an arclight at some distance, in an otherwise darkened room — is focussed upon the sensitive plate in a camera and moves around upon this plate as the eye moves. But the amount of motion of such a point of light on the cornea during a comfortable movement of the eye is small; and when reduced in size, as in the usual photograph, it makes but an indistinguishable blur upon the plate. Or if the apparatus is adjusted to produce an enlarged record of the course of this beam, one at first finds in his developed negative only a series of irregular and disconnected dots that represent the various points of rest of the eye as it looked over the figure, and no record at all of the path taken by the eye as it darts from one of these resting-places to another. But the records of the path taken by the eye during its passage from rest to rest is one of the most essential parts of the experiment, and yet I fear that the attempt to obtain them might have seemed hopeless if in the midst of our trials, Dodge and Cline of Wesleyan University had not published an account of their valuable experiments on the »Angle-Velocity of Eye-Movements«<sup>1</sup>). They had overcome many of the same difficulties while working with a different problem, and encouraged by their results it seemed possible to obtain the finer features that were still missing in our own records. I wish also to acknowledge my indebtedness to my friend and colleague Mr. J. N. LeConte whose knowledge and skill in photography gave us the first really successful plates, showing not only the various points of rest of the eye during its complicated course, but also the continuous path connecting these points. My students, Miss Nelson and Mr. Baruch, and my assistant, Mr. Brand, have also rendered invaluable service in many ways.

The arrangement of apparatus which in the end worked best was as follows. A camera that could be extended a meter and more, was fitted with a fine Goerz double anastigmatic lens whose focal length was 8 or 16 inches, according as both, or only one, of the

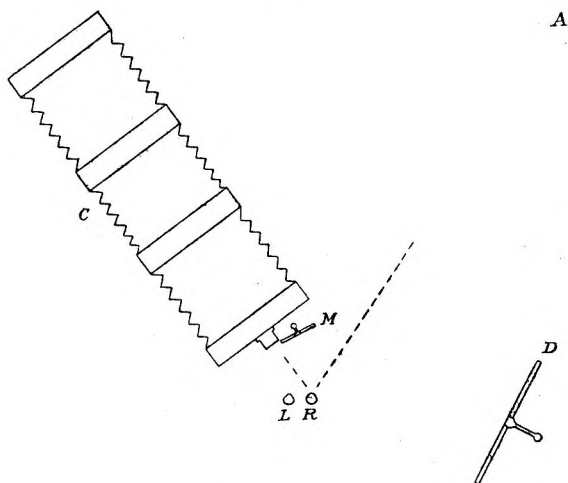
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1) The Psychological Review, vol. VII (March 1901), p. 145.

subsidiary systems of lenses was employed. The camera, upon a firm table, was placed about 25 cm from the right eye and directed toward it, although in all except a few cases to be mentioned later, the curves and figures were observed binocularly. The light whose reflection in the cornea was to give the record was in every case placed at about the height of the eye to the right at a distance of about 3.5 m.

Many of the earlier photographs were taken with the eye reflecting the arc-light direct, the figure to be observed being placed midway

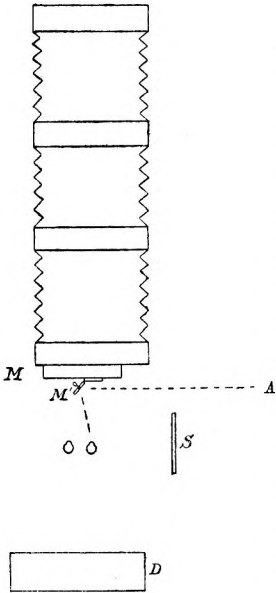
Fig. 1.



in the right angle between light and eye and camera. But with much of an excursion of the eye the plate catches not only the corneal reflection but troublesome moving »high lights« from the conjunctiva. Subsequently a set of mirrors was used to avoid this trouble; but the photographs without mirrors were clear enough to be used in confirmation of the later results. This new arrangement with which all the records here reproduced (unless otherwise expressly indicated) were taken, is shown in Fig. 1, where a mirror *M*, placed in front of the camera *c*, and to the right, brings the diagram *D* apparently close to the lens and yet far enough away from the eyes, *R* and *L*, to permit an easy accommodation. For reasons that I shall speak

of directly in referring to the distortion which the corneal record always suffers, check experiments were also made with an arrangement shown in Fig. 2, where the mirror  $M$  was placed above the lens and sloping upwards, reflecting the diagram,  $D$ , placed higher than the head and sloping downwards; a small silver-faced mirror  $M'$  in front and to the left of the lens reflected the arc-light to the cornea. The direct light from arc to eye was in this case cut off by a screen  $S$ . Great care was of course taken throughout to prevent, by suitable

Fig. 2.



rests and guards, any movement of the head during the experiments. And only those persons were used as subjects whose vision required no corrective glasses.

In all, over one hundred records have been obtained. More than three photographs with any one subject were never taken on the same day; and since a considerable pause was made between even these three, I cannot feel that the movements here recorded depart in any essential measure from the natural behaviour of the eye.

The records thus obtained must not be understood, however, as an exact picture of the eye's movement, but only as permitting us to understand, after making certain allowances, the general character of its action. For in the first place, the image seen in the cornea does not have a motion exactly the same as that of the cornea itself. Its motion is a »function« of the corneal movement, but not identical with it. The movement of a corneal reflection lags behind that of the eye, and so presents a diminished copy of the original; and moreover this diminution is greater in some instances than in others, according to the direction of the eye's movement, the position of the object reflected in the cornea, and the direction from which the reflected image is observed. So that the moving reflection not only reduces the actual movement of the eye, but to some degree distorts its form. But in spite of these shortcomings, there are many things

that a record of these movements can show indubitably. A sudden stop in the motion of the reflection, for instance, cannot be ascribed to anything but a stop in the motion of the eye. And likewise, a sudden and marked change of direction in the path taken by the reflection indicates that the eye itself made a somewhat similar change in its movement. By means also of check experiments, with the apparatus in different positions, one may know the character of the distortion in any given set of records and make allowance for it. Thus with the apparatus in the position shown in Fig. 2, the careful fixation of a series of points arranged in a horizontal line gives a record showing a slight curve, convex upward. An exactly similar curve in the record during free movement of the eye must therefore be read not as a curved motion, but as a straight horizontal motion. On the other hand, the arrangement of apparatus shown in Fig. 1 gives no appreciable distortion of horizontal movements, but a slight ogee curve to vertical lines. With these means of check, then, the records become significant for at least certain grosser features of the eye's action, and we need not at the present time lay stress on their minutest details.

The first records here presented have to do with the course taken by the eye when the subject was expressly instructed to follow specific outlines. The figures given in the text are from drawings made from the photographic negatives. It would in many ways be more satisfactory if a direct »process« reproduction of the photographs could be given. These records are small, however, and while the points of rest might be mechanically reproduced, the intermediate paths of movement, even when they are quite distinct in the negatives, are nevertheless so faint that it is improbable that these connecting lines would be distinguishable in a half-tone. Care has been taken, however, not to make the drawings misleading, and where the connecting line was obscure and the course of the eye was conjectural, such conjectures are indicated by dotted lines. In the drawings there is an enlargement of from two to four times the size of the records; and these themselves, as was said, enlarged the image about four times. There is no attempt to reproduce in the drawings the size of the points of rest or the thickness of the intermediate lines. In several instances, however, a marked thickening of the line as it

approaches a point of rest is copied from the photographs, and seems to indicate a slowing up of the motion in immediate anticipation of the stop.

Fig. 3 is the record of subject *N* in running the eyes around a circle 38.5 cm in diameter and about 80 cm from the eyes, starting from the top and taking the direction of the clock. The heavier points, of course, show the pauses in the eye's course, as it seemed to swing around the curve. Figs. 4 and 5 are similar records from the same subject, but with other diagrams. In the one case the

Fig. 3.

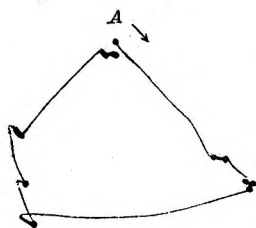


Fig. 4.

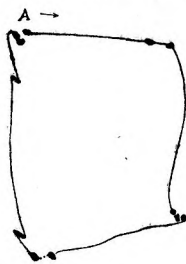


Fig. 5.



Fig. 6.



drawing observed was an outlined rectangle having the golden proportion ( $25 \times 40.5$  cm) placed perpendicularly; the other drawing was a combination of two segments of circles as shown in Fig. 6 (extreme dimensions 60 cm). The point of beginning of the record is in each instance indicated by the letter *A*, and the direction of movement by an arrow. The records are to be read from the point of view of the subject — the direction  $\rightarrow$  means a movement of the eye to the subject's right —  $\leftarrow$  to the left, etc.

Figs. 7, 8 and 9 show records from subject *B* for the same drawings, respectively. In all of these cases the time occupied by the movement was in the neighborhood of three seconds. This was

considered a happy mean between a movement that would be too slow, and so lose anything like a sweep of the eye, and a movement so rapid as to lose all sense of security in following the contour. They were more deliberate than was absolutely necessary to take in the character of the line, without, however, being over-deliberate.

An examination of the records of which those here given may serve as samples, brings out the fact that the eye moves far less accurately over an outline than has usually been supposed; it takes a course which is but a rough approximation of the form which we perceive<sup>1</sup>). The eye darts from point to point, interrupting its rapid

Fig. 7.

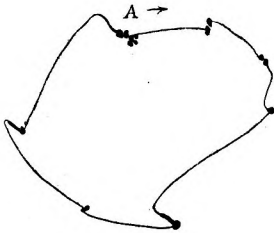


Fig. 8.

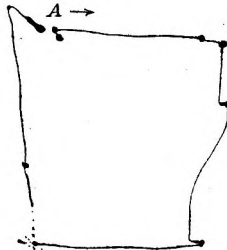


Fig. 9.



motion by instants of rest. And the path by which the eye passes from one to another of these resting places does not seem to depend very nicely upon the exact form of the line observed. The eye may take a short cut that is nearly or quite a straight line while »following« the segment of a circle, as in some portions of Fig. 3. Or it may take a graceful swing which is, however, entirely unlike the curve which is the object of perception; as in the final sweep in Fig. 9, where the objective line and the eye's path bend in the very opposite directions. So that we cannot say that the eye invariably takes the most direct route to its destination — that it moves in straight lines, or on an unchanging axis<sup>2</sup>). Nor even when taking a curved course

1) The discussion of many interesting features in these and other records is postponed until a later paper. Only those marks that have the most important bearing on the aesthetics of simple lines are here considered.

2) The records thus confirm the observations of Wundt, made long ago, that the axis of rotation changes during movement. Cf. his *Beiträge zur Theorie der Sinneswahrnehmung*, pp. 140 et seqq., and 201 et seq.



does there seem to be any single and invariable curve that it follows. It takes both simple and more complicated curves, making at times even an almost angular change in its direction (see Figs. 7 and 8). Or finally it may take an uncertain and tremulous course, as in Fig. 23, to be shown farther on.

Even the points of rest do not seem to be points of absolute rest at all times. The line of motion as it enters and as it leaves many of these points shows that in the mean time it has made a slight shift, as in Figs. 3, 4 and 5. Nor are these points very accurately gauged to fall exactly on the outline observed. Very often the eye leaps off to some point in the neighborhood of the line, and then corrects its position by a slight shift, as in the lower right hand corner of Fig. 4, the central groups of Fig. 5 and in Fig. 3. So that the series of these points, disregarding the connecting paths, do no more, at best, than roughly suggest the form which the eye is taking in; while often, as in Fig. 3, it bears not even a distant resemblance to the form.

In general, the correction of the eye's position seems to be initiated after the eye has come to a momentary standstill. During this pause there is time to note the error of its position, and a fresh and corrective shift is then introduced. At times, however, the character of its path strongly suggests that the motion is corrected *en route*, without any actual interruption of its motion, as in the approach to the final two resting-points in Fig. 7, the left of the two points below the letter *A*, and the point next below and to the left of this one. But the fact that perception during the motion itself is so exceedingly vague, as shown by the experiments of Prof. Dodge<sup>1)</sup>, makes it doubtful whether such changes are not quite independent of any perception of the error of its position obtained in transit. They may be due to a certain incoördination of the external muscles of the eye, or possibly to the delayed introduction and use of perceptual data obtained during the stop immediately preceding. The character of many of the negatives, of which Figs. 31 and 7 may serve as samples, seems to show that there is sometimes

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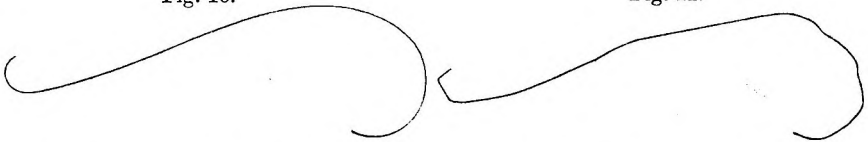
1) Visual Perception during Eye-Movements. Psychological Review, vol. VII, p. 454.

a decided retarding of the motion as the point of rest is approached, a slow glide into the point, indicated by the sudden thickening of the line in several places due to a longer exposure just before it comes to rest. A careful examination of the negatives does not indicate that this apparent thickening of the line is really due to a close series of stops.

The eye's movement during the observation of a line or figure is thus signally unlike the form which we perceive during these movements. The general course of the ocular movement over a graceful line is itself usually far from graceful. But it may at once occur to the reader that while the swing of the eye in connection with a flowing curve might indeed be lacking in absolute grace, yet the ocular motions induced by a graceless form might be so much more irregular and harsh as to make the other movement seem by contrast

Fig. 10.

Fig. 11.



distinctly and positively pleasant. With the query in mind whether this might not be so, I took a series of photographs while the eye passed along the curve shown in Fig. 10, from left to right, with the apparatus as shown in Fig. 2; and another series for comparison, substituting the form shown in Fig. 11, under the same conditions. The latter figure is clearly a decided variant, aesthetically, of the preceding form, surrendering whatever of grace the other may possess. The photographs were taken in alternate pairs on different days, now the one and now the other form coming first, so that no particular advantage should accrue to either of the sets. A set of records for subject *N* with the form in Fig. 10 is given in Figs. 12 to 16, and with the form in Fig. 11, in Figs. 17 to 21. It is interesting to note that subject *N* who was allowed to see her records at the completion of the experiments, was greatly surprised at their irregularity. She had felt sure, she said, that she had followed the lines with the greatest exactness. A corresponding set of experiments with another subject gave results similar to those shown above.

It is at once seen that the records for the graceful line are not identical with those for the ungainly one. But we may certainly say that the contrasting groups of records are immeasurably more alike than are the two original curves as regards their *aesthetic* character. The lines themselves are polar opposites aesthetically. Yet the paths of the eye in the two cases seem to offer but little ground for choice. In both cases there is the same broken, spas-

Fig. 12.



Fig. 13.



Fig. 14.



Fig. 15.



Fig. 16.



Fig. 17.



Fig. 18.



Fig. 19.

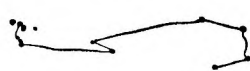


Fig. 20.

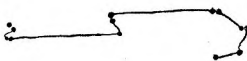
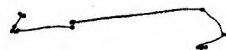


Fig. 21.



modic action, the same blunders in the course, the same hasty efforts at recovery. If these marks are possibly more pronounced in the case of the ugly form, it is at most but slightly so, and by no means sufficient to account, by contrast, for the marked psychological antithesis in which the two forms stand. From this it would seem far-fetched to insist that the enormous emotional difference in the two forms is due to such slight variations of muscular sensation, when

the latter at best are apparently so colorless that they can utterly belie the form we enjoy, without interfering with that enjoyment.

It may perhaps be well to speak briefly of certain experiments in check and control of the results already given. The suspicion readily occurs that the experimental conditions might make it peculiarly difficult for the eyes to follow a set line, and that the irregularities in the records might be due either to these unusual difficulties or possibly to some over-anxiety on the part of the subjects of the ex-

Fig. 22.



Fig. 24.



Fig. 26.

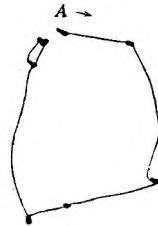


Fig. 23.

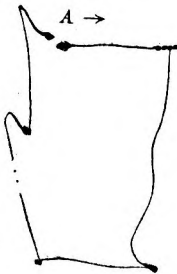


Fig. 27.



Fig. 25.



periment. Some additional records were taken to throw light on a natural question of this kind. In the first place, if the subject were bidden to run his eye rapidly over an imaginary form, then he would, to a considerable extent, be free from any constraint that a set, objective line might impose upon the free action of the eye. And some photographs were accordingly taken of such movements. In place of the usual white ground on which the diagrams were given in India ink, a sheet of dead-black German *Tuchpapier* was placed so that the person would have as little as possible in the field of view to serve as attractive points of fixation. He was then told to

describe by a sweep of the eye the forms, respectively, which had before appeared in diagram — the circle, the rectangle, and the curve of Fig. 6. Characteristic records of these imaginary forms in the order just named are given for subject *B* in Figs. 22, 23 and 24; for subject *N* in Figs. 25, 26, and 27.

It is clear that such objectively unconstrained movements of the eye bear but a crude resemblance to the figures conceived by the subjects and which they felt they were more or less successfully reproducing. The same jerky interruptions of the sweep, the same angular junction of movements that were intended to compose a smooth curve, appear here as in those records where there was an attempt to follow the set line of a diagram. It would seem from these records that a given outline is hardly an impediment to the eye, is no hindrance to the free expression of the idea behind it, but is really a help and guide. The eye's sweep through an imaginary circle, for instance, is less like a circle than when the figure is drawn out for it to follow. It would appear, too, from all of these records that the curve is the most difficult of all for the eye to describe and that it finds much greater freedom in the straight line. This is contrary to all our usual conceptions by which the preference for curves has been explained.

That the awkward action of the eye is not due to some over-scrupulousness of the subject to repeat accurately the prescribed copy is evidenced in still another way. It was difficult to make the close of the exposure of the plate correspond exactly with the end of the ocular movement which we wished to record, and at first the subject was instructed to rest the eye, at the completion of its course, on the terminal point of the line observed. But the »resting« proved at once to be in reality a roving of the eye over a considerable area, and often seriously obscured a portion of the main record. The subject was then instructed to move his eye away carelessly, at the completion of the desired record, toward the lens of the camera, or in some other direction; and it was explained that the motion was simply to get the eye out of the way. These careless, irresponsible movements were of course recorded on the plate, and show the same general character as those performed in the body of the experiment, — sometimes free and graceful sweeps such as appear at times in

the main record between two successive points of rest; sometimes violent changes of direction, and even a tremulous uncertainty that would have suggested, were the conditions of the movement unknown, that the subject had painfully striven to keep to a difficult prescribed course.

And as a final check to prove whether with monocular fixation the eye's action would be decidedly more accurate, the left eye was covered and photographs taken of the right alone. Here of course the feeling that one has accurately followed the curve, could only come from the eye which gave the record. The results show certainly no characteristic improvement of accuracy. On the contrary the records give the impression of even greater waywardness, owing, no doubt, to the fact that binocular vision is the more normal, and leaves the subject more at ease.

The main conclusions to be drawn from the present set of experiments seem plain enough. In the first place, they give evidence of a most striking introspective illusion. From the mere feeling, one would never suspect that the eye took so irregular a course. Introspectively it seems as if the eye's movements were smooth and continuous, while the records show convincingly that its course is wild and broken. The illusion, I believe, arises from our confusing the point of attention with the point of ocular fixation. The vivid suggestion of motion which lines, and especially curves, convey produces, as its psychical result, a continuous and smooth passage of the attention as if we were following the flight of some imaginary point in process of generating a line; and this movement of attention reacts in its turn and vivifies the suggestion of objective motion. In the quick darts of the eye from resting place to resting place, the attention is not resting all the while the eye is at rest, but occupies this time partly in coming up to the point of ocular fixation and partly in running on beyond the point. This continuous passage of attention, moving uniformly over the line, seems like a uniform movement of the fixation point, and consequently, as an unbroken movement of the eye itself. The doctrine that the fixation point and the point of attention are normally identical and can be separated only by careful training, is thus seen to be only an approximation, rather than an absolutely exact state-

ment, of the truth. They are normally, in all probability, somewhat apart.

In the second place it would seem as if the preference for curves as against straight lines must be explained in some other way than that curves are more readily followed by the eye, — that they conform more closely to the eye's own normal path of movement. While it is true that between two adjacent points of rest the eye frequently moves in a graceful sweep, yet this would hardly seem to be a more typical form of its motion than is the straight line. And it is certain that in regard to following a given contour, the eye has much less difficulty with a straight line than with a curve. In fact it would appear that a curve is just the form to which it cannot possibly conform its own motion. If the curve of its own movement and the curve of the objective line coincide, it is due to sheer chance, rather than to purposive conformity. In all my records there is not a single case where a combination of several leaps of the eye make a uniform curve. When the extent is such as to invite an interruption of the eye's movement, the total path of the eye never conforms to a regular curve set before it. The records with the rectangles show often a close resemblance to the figures observed. The records with the circles are more suggestive of irregular polygons than of regular curves. Since we cannot control the eye's movement so as to make it conform to an objective curve, while it is often possible to make it move along straight lines, we cannot attribute our preference for curves to the eye's adaptation to them. As the facts stand, if mere *ease* of ocular movement were the controlling principle in our enjoyment of forms, we should enjoy straight lines and angles rather than curves.

But apart from ease or difficulty of movement, there are still farther grounds for believing that the importance of eye-movements for the aesthetics of form has been exaggerated. Since the eye's movement during the observation of a line or figure is so unlike the form which we perceive and enjoy, it seems illogical to ascribe this enjoyment to the character of the eye's movements and to the sensations which arise in this way. For the motion of the eye is, even in more ways than appear at once from these records, a libel on the figure we perceive. From what has already been said it is

of course clear that spatially the two are quite unlike. The ocular path is irregular, varying and even angular, while the line perceived during this movement may be continuous and smooth. But in addition to this, the eye's movement is, in its temporal character, also at striking variance with the movement suggested by a graceful curve. A pleasing curve suggests temporal continuity of movement, as well as spatial; but it seems absolutely impossible for the eye to follow a given curve without a series of jerks and pauses, of short rapid flights and sudden interruptions which have no likeness whatever to the uninterrupted movement we attribute to a graceful curve. In so far as there is any justice in Spencer's claim that grace of line is enjoyable because of the sense it gives of economy in the expenditure of force<sup>1</sup>), the economy here felt is certainly not found in the eye's own motion. The real feeling of the character of a visual form thus seems to be developed in opposition to what the muscular sensations, alone and unaided, would suggest. And of course the same statement, *mutatis mutandis*, applies to whatever tactual sensations come from the contact and friction of the ball and socket of the eye. Since the records of the eye's movements and positions tell us of the tactual sensations in so far as they arise in consciousness at all, these tactual sensations too must give an exceedingly misleading account of an aesthetic form as actually perceived and appreciated.

The records also offer what seem to me insuperable objections to a modified view that has often been taken in the past. In explanation of the fact that a form may be seen with eyes at rest, it has been urged that the perception here is due to the suggestion of previous eye-movements which it is no longer necessary to carry out. Likewise in regard to the enjoyment of a pleasing curve, it would be in keeping with this thought to say that we enjoy the graceful eye-movements which the curve suggests, even when the eye is in repose. So long as the graceful movements of the eye stood in opposition merely to an actual repose of the eye, such a theory would offer little difficulty. But in view of the present records it seems no

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1) See his article on »Gracefulness« in his *Essays: Moral, Political and Aesthetic*.



longer satisfactory. For it would now require us to suppose that suggested movements, for some reason, could retain a much greater psychological weight than the actual and present movements of the same organ. We should expect, however, that mere suggestions would seem tenuous and unreal in the presence of an actuality which flatly contradicted them. Even supposing that such suggestions had all the vividness of reality, the pleasure so derived would at most be offset by the unpleasantness of the actual movements that were ugly. Such a supposition is probably over-generous, however, to the suggestion theory, and it is improbable that suggested movements under such circumstances could normally have this vividness and feeling-tone. And, moreover, if the graceful following of a curve cannot now by any possibility be carried out by the eye, it is unlikely that it occurred in the past. The absence of any previous experience of such eye-movements would therefore be a most serious difficulty in the way of our supposing that their ideal revival is an important source of pleasure.

So that, on the whole, it seems probable that the motor and tactual sensations obtained during the vision of a beautiful outline are no more intimately connected with the final aesthetic effect than are the sensations from our leg-muscles with our pleasure as we walk through the gallery at Dresden. The external apparatus of the eye merely brings the retina to such points of vantage as will permit various views of the more significant details, and out of the series of snapshots obtained during these stops in the eye's course the mind constructs its object into a clearer whole. The part played by the external muscles of the eye is thus a menial one aesthetically. They are not the star-actors of the performance; they are mere scene-shifters.

Shall we say then that the chief part must now be assigned to the retina? This would seem almost as far from the truth, although perhaps not quite so far, as when we ascribe the main effect to the muscles. For it would seem as if one might justly attribute a certain primacy to the retina as against the eye-muscles in this connection. There is no opportunity here to discuss at length so intricate a problem as this. But it may not be out of place to recall some observations during my experience with inverting lenses, showing that, as regards the direction of movement, the retinal impression is able to dominate

the muscular one and give it an entirely different feeling. With such lenses fastened to the face, a movement of the head to the right, by a purely optical law, causes objects to pass into the field of view on the left side and move through the field rapidly toward the right — the very reverse of what we ordinarily experience by a head-movement of this kind. Instead of passing through the field of vision in a direction opposite to the movement of the head, they rush through in the same direction, and by their more rapid course seem to outstrip the motion of the head. Now the more one grows accustomed to such behaviour of visual objects, the more one tends to accept the direction of the passage of images through the field as indicating that the head is being turned counter to their motion. The head seems to move to the left because its motion causes objects to swing to the right. Thus the false retinal impression is able to brow-beat the muscular perception into complete submission, even when the latter has all the right on its side. And the same holds true of the movements of the eye, apart from head-movements. Movements of the eyes that were really toward the forehead came in time to feel like movements toward the feet, simply because they brought the feet and objects in that neighborhood into clearer vision<sup>1</sup>). The muscles thus seem unable to hold their own when it comes to a direct and continued conflict with retinal experience.

But admitting this domination of the retina in the perception of movement, it is not just to say, in the present connection, that the appreciation of curves is to be attributed to the retina as against the muscles. For the retinal impression, here, is in its own way almost as far removed from the form which we enjoy as is the muscular one. The retinal image during such a perception, it must be remembered, is not a single flash-light image having the form that gives us pleasure. It is rather a *series* of more or less disjoined impressions gained by moving the central region of the retina into a limited number of favorable points of view. Such a series of impressions during the simplest of the eye-movements recorded, for instance in Fig. 15, might be represented in diagram. Assuming that

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1) See my *Vision without Inversion of the Retinal Image*. Psychological Review, vol. IV, p. 480, et passim.

the point now marked by capitals in this record, Fig. 28, represent successive fixations of the eye upon the points of the curve marked by corresponding small letters in Fig. 29, and also that the retinal

Fig. 28.



Fig. 29.

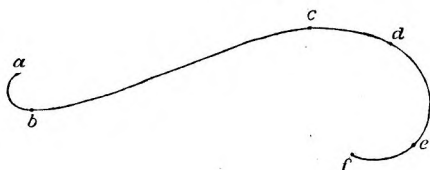


Fig. 30.

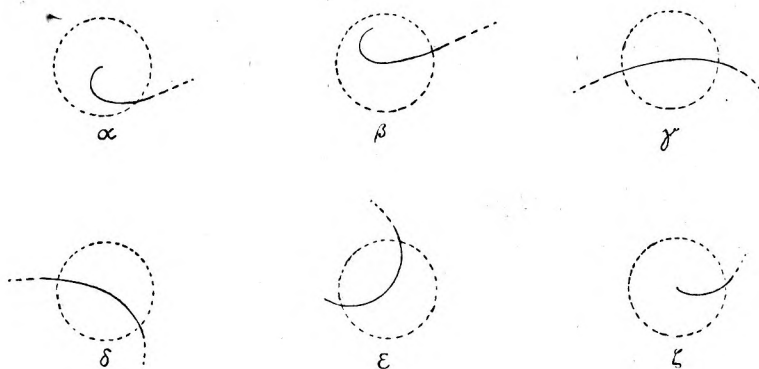
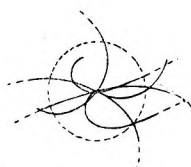


Fig. 31.



perception is obtained well-nigh exclusively during the moments of rest, then we should have a series of impressions as shown in Fig. 30

where the circles represent the retinal area of clearer vision — somewhat larger than the fovea.

Here, if we may neglect the inversion of the retinal image,  $\alpha$  would represent the impression while the eye was resting at point  $A$  of the record,  $\beta$  at  $B$ , and so on. The series represented as superposed upon one another on the same region of the eye would be somewhat as

shown in Fig. 31. But even apart from this latter composite, and assuming (which is improbable) that each impression is gone before the other appears, it is readily seen that the retinal impressions

in Fig. 30 viewed in rapid succession seem very unlike the object which the mind appreciates. The object shows ease and continuity. The impressions in succession seem restless and disjointed; each breaks with its neighbor and the whole together, as shown in Fig. 31, irregularly overlap and are confused. The aesthetic enjoyment can hardly be conceived, therefore, as a sensuous retinal pleasure, in opposition to a sensuous pleasure from the motor apparatus of the eye. Neither the one nor the other portion of the organ furnishes an impression which would seem to be very pleasurable, nor can we well say that the mere mixture of the two would account for the final aesthetic effect. Together they appear merely to furnish the crude materials, and some farther activity — a »central« process in both a physiological and a psychological sense — is needed before anything is obtained that would seem capable of affording us aesthetic enjoyment.

The form we enjoy is therefore not a simple sensuous impression, nor is it a series of such impressions, either muscular or retinal. For the series alone and of itself in either case is radically unlike the simple and harmonious object that gives us pleasure. The enjoyable form seems to be due to nothing short of an elaborate mental act of selection and recomposition of the data furnished by the eye. The *dissecta membra* gathered in by the retina with the aid of the motor apparatus require skilful articulation before they can appear beautiful. The aesthetic object is not furnished ready-made by the sense organs; so far as it is an experience of ours it is a spiritual creation.

But this, of course, does not as yet explain why the form gives us pleasure. An ugly line is also, in a similar way, a spiritual creation. And we have still to ask what there is in the character of a graceful form that makes it the source of aesthetic enjoyment.

No simple formula, I feel sure, will here suffice. The facts themselves are complicated, and arise from complicated causes. Certain pleasurable sensations from the body<sup>1)</sup>, as will be pointed out later,

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1) For an interesting development — one might almost say, an over-development — of this side of the matter, see the articles in the *Contemporary Review*,

are no doubt a contributing cause to the total effect. But the enjoyment seems much more closely connected with movements of the attention and imagination, and with the activity of comprehension and sympathy, than with the stream of organic sensations, important though these are.

In the first place, there is a wealth of pleasurable association in a graceful line. If it is not regarded in some dim fashion as itself a living thing, it is at least felt as coming fresh from living things; as if it were the direct outcome of that kind of conscious action which we most deeply admire. For it suggests action guided by a single thought or aim, and which carries out or expresses that aim in a masterful manner. The flight of birds or of insects, the evolutions of the skater, the movements of a well-trained hand — these have made us most familiar with beautiful lines. So that the thought of unconstrained activity, if not distinctly in mind when flowing curves are seen, is doubtless vaguely present as a kind of undertone affecting our attitude toward the object.

A similar connection with life, although of the very opposite character, appears in the ugly line. It is expressive of power not under control, or, if under control, at least not guided by a purpose that is constant and simple. Broken and wayward lines, the conjunction of curves that display no common guiding law — these, in our experience, are often the work of inefficient creatures, of beings not masters of their situation, or of a hand not entirely subject to the will, so that it does not carry out completely the mind's purpose. There is here an offensive hindrance, a thwarting of the evident purpose; the life seems unable to cope with its body or with its environment. Or if the irregular line seems to be the result of no inefficiency of the organs of movement or of expression, it is apt to suggest a defect of purpose. The aim is no sooner taken than it is changed. Such instability of will may be familiar, but it is normally unpleasant.

A kind of social, if not moral, approval is thus hovering in the background of our perception of graceful lines. But somewhat distinct

from any enjoyment of this almost ethical kind, is the intellectual pleasure of *comprehension* which such lines give us, and which ugly forms often lack. Just as a person's action when guided by a stable aim is more intelligible to us than the behaviour of the flighty or the insane, so a line which is ordered throughout by law may be *understood*, we may see what its intention<sup>\*</sup> is; whereas the lawless line is meaningless and baffling. And this feeling of intellectual grasp is distinctly satisfactory, the more so in this case since there is the feeling that the comprehension is easy. For the attention is less taxed by regular lines, including straight ones, than by their opposites. The successive parts, while arousing a modicum of surprise, more or less fulfill the expectation aroused by the preceding parts. The mental formula or conception gained early in our perception of the line is found to apply throughout. As the mathematician can express even the longest line, if it is regular, by a simple algebraic equation, so the lay mind, when viewing a well-ordered curve, feels able to retain it in the form of a single and easily remembered conception. The ugly line, on the other hand, seems to have in it a confusion of laws; we can perhaps comprehend its isolated parts, but together they do not fall under any single idea. *Economy of attention* is consequently one of the chief sources of our enjoyment of graceful lines. They furnish a special instance of that more general enjoyment of facile comprehension, — the pleasure we take in having an object fit easily into our ready form of space and time perception, which Wundt has emphasized as an important part of our aesthetic feeling<sup>1</sup>).

An additional factor to which I have already alluded, is the organic reaction to which the line gently stimulates us. As we imaginatively endow it with movement and life, so by a kind of sympathy and imitation we undoubtedly reproduce in some degree the action of the body which would naturally occur were we ourselves performing the movement which the line suggests. Some alteration of breathing and circulation, but probably more important a rhythmic change of tension of various groups of voluntary muscles of the limbs and of the neck and trunk, keeping time with the swing of the

1) Physiologische Psychologie, 4. Aufl., II, S. 251.

imaginary point, — the sensations from these changes vivify our representation of the motion, and give us the dim feeling that we ourselves are participating in it. And since the thought of such a movement in another is already pleasurable, this pleasure is farther heightened by this ideal participation, vague and indiscernible though it may often be.

The faint bodily reaction which accompanies the perception of a line is therefore of importance. It helps us realize and appropriate the imagined movement in the object, so that it thereby becomes, in some literal sense, flesh of our flesh. But it would be an error to regard the feeling of this muscular adjustment as the sole cause of our enjoyment of graceful forms. The organic reverberation is but one of many factors, and a secondary factor at best, coming as it does in response to an incipient interest and appreciation and sympathy already there, which the form directly calls forth. But the organic sensations, as I have said, doubtless react upon the complex mental state, reinforcing it and giving it »body«. In this respect their function is not unlike the drums and cymbals in an orchestra, which emphasize the beat, and serve for filling and fire, but which have slight aesthetic value in themselves.

Like all states that are tinged with emotion, the enjoyment of Form is a complex of sensations, of feelings coupled with these, conjoined with intellectual and volitional processes. The activity of the intellect and the will would of themselves be empty; the sensations and feelings alone would be blind. None of these factors consequently may be urged to the exclusion of the others. The present experiments thus assist us to maintain the proper proportion and balance in the theory of visual form. They help to free us from the thought that our aesthetic feeling here is a purely sensuous affair. For, as the experiments show us, the object of our enjoyment is not given, but is a spiritual construction out of materials that are in many respects its very opposite. And, moreover, even the elementary aesthetic pleasure in this object, is found upon careful analysis to have, in little, the self-same marks that appear more clear and distinct in our highest enjoyment. For as the higher aesthetic effects depend, as Wundt has said<sup>1)</sup>, upon the awakening of intellectual, ethical and religious

1) *Physiologische Psychologie*, 4. Aufl., II, S. 251.

ideas; so it is, in a measure, even on the plane of mere abstract line. A graceful contour, too, arouses intellectual ideas; and if its enjoyment does not arise directly from our ethical and religious nature, it at least comes from something akin to this — arises from our sympathy with well-ordered action and from our love of participation in such action — qualities in us that are at the foundation of morality and worship itself.

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