III.—THE PHYSIOLOGICAL FACTORS OF THE ATTENTION-PROCESS (III.).

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MUSCULAR ACTIVITY AS A FACTOR OF THE ATTENTION-PROCESS.

THAT motor activities play a part of some importance in the attention-process is now pretty generally admitted, and this general statement needs no further proof. But I have to report in this section some observations that seem to afford more direct evidence of this influence than has yet been produced and to throw some light upon the way in which this influence is exerted. Most of the experiments to be described in this and the following sections deal (1) with the phenomenon described by me in a former paper¹ and there called 'the complete fading of visual images'; (2) with the fadings and reappearances of after-images; (3) with the alternations of colours and contours in the struggle of two different visual fields presented to the two eyes; (4) with the alternations of different modes of perception of ambiguous figures such as those reproduced in figures 7 and 8 on pages 482 and 483 and in figure 2 of the first part of this paper.²

It will probably be said by any reader, who may have had the patience to follow my disquisition up to this point, that these phenomena, with the exception of those of the last group, have little or nothing to do with Attention. I will therefore indicate at once the general purpose of my observations and the line of the argument that I found upon them. These four groups of phenomena have one striking feature in common, namely, that while the physical stimuli affecting the sense-organ remain unchanged or undergo only slow and gradual changes, the affections of consciousness to which they give rise undergo very marked and rapid changes. My

¹ MIND, No. 37.

² MIND, No. 43, p. 335.

aim is therefore, in the first place, to show that the physiological changes underlying these abrupt changes of consciousness are essentially similar in character in all these groups of cases, for to do this is to justify the scheme of the physiological processes underlying the states and the movements of attention that was outlined in part i. of this paper. Secondly, assuming the essential similarity of the physiological processes in all these varieties of phenomena, I have studied the simpler varieties because it seems probable that, if we can gain insight into the physiological processes in these simpler cases, we shall at the same time gain insight into those underlying the true states and movements of Attention, and in fact into the physiology of mental activity in general. I have studied especially the effects upon these allied processes (1) of activity of the muscles of the sense-organs, (2) of fatigue, (3) of reinforcement by the idea (including under this vague phrase the effects of voluntary preperception or expectation), and (4) the evidences of reciprocal inhibitions.

As regards the influence of activity of the eye-muscles upon the complete fading of a steadily fixated image, I have not been able to devise any form of experiment that will unfailingly demonstrate the effect, because it is impossible altogether to avoid slight waverings of fixation save for very brief periods. I can only assert with a confidence drawn from a considerable experience that though complete fading may occur while both intrinsic and extrinsic eye-muscles are contracted as in convergence with accommodation, yet it occurs far more readily when all the muscles are as far as possible relaxed and at rest.

In the case of after-images the disturbing effects of waverings of fixation are absent, but in all other respects the conditions of the after-sensation are similar to those of the sensation itself (as I have endeavoured to prove¹), namely a continuous excitation of nerve-endings in the retina by chemical substances. That after-images, besides undergoing changes of brightness and colour, are apt suddenly to disappear and reappear is a familiar fact and the causes of these changes have been discussed by many authors. It has been frequently asserted that movements of the eyeballs tend to cause disappearance of an after-image, and this is certainly true in the case of after-images projected upon surfaces that present any appreciable details of texture. Prof. Exner² argues that in such cases the disappearance of the after-image is due to the attention being diverted from it and

¹ MIND, vol. x.

² *Zeitschrift f. Psychologie*, Bd. i., S. 47.

reflexly or habitually drawn to those features of the visual field that move relatively to the retina, because those that are due to objects or stimuli residing wholly within the eye and moving with it, such as *musca volitantes* and after-images, have no value as signs of objective existences and are therefore habitually neglected. This view of the matter is borne out by the fact that as one accustoms oneself to pay attention to these appearances they assume a much more stable character. Herr Wirth¹ takes a similar view of the sudden comings and goings of after-images and argues that the chief determining influences are 'Apperceptive Momente'. Prof. Hering² too maintains that the disappearance of a projected after-image on movement of the eyes is due to the attention being drawn to new features of the background, and he shows that when an after-image is observed in complete darkness eye-movements do not cause it to disappear, and that the more homogeneous the surface upon which an after-image is projected the less does the after-image tend to disappear on movement of the eyes.

My own observations on the influence of the surface of projection are entirely in agreement with Prof. Hering's, and it is therefore not necessary to describe them here, but in regard to the influence of eye-movements upon after-images I think we may go farther than Hering, and say that, so long as after-images are observed in total darkness, eye-movements not only do not tend to cause them to disappear, but tend rather to maintain them and to restore them to consciousness when they have disappeared. Lateral movements of the eyes in the dark will frequently cause the reappearance of an after-image, but the effect is feeble and inconstant. A movement of convergence with accommodation exerts a much more powerful and unmistakable influence of this sort, and it is possible to restore an after-image several times by making repeated efforts of convergence, the after-image reappearing at each effort and persisting for some few seconds. I find that the form of after-image best suited for this kind of experiment is that last stage of the after-image of a bright light which appears, as noted in a previous paper,³ as a fuzzy ill-defined grey or dull white, and which, as I there suggested (a suggestion which further experience has confirmed), is due to the apparatus for vision in a dim light (the rod-apparatus or *Dunkel-Aparat* of v. Kries).

¹ *Philosoph. Stud.*, Bd. xvi.

² *Von Graefe's Archiven*, Bd. xxxvii, and *Zeitschrift f. Psychologie*, Bd. i.

³ *MIND*, vol. x., p. 242.

But the following experiment demonstrates this re-enforcing effect of activity of the eye-muscles more satisfactorily than the observation of a simple after-image, and at the same time it shows that the intrinsic muscles of the eye play the chief part. By two successive applications of $\frac{1}{100}$ grain of atropine sulphate to the left eye I completely paralysed the ciliary muscle and the iris.¹ I then held a slip of white card (about 20 mm. by 50 mm.) in the path

FIG. 4.

of a ray of direct sunlight entering the dark room. I first held it in the vertical position and fixated a point at the middle of the bright surface for 30" with the left eye alone, and then held it in the horizontal position and fixated the same point for 30" with the right eye alone. With head covered and eyes closed and in the primary position of rest I then observed the after-images. The two bright positive after-images struggle for predominance just like

FIG. 5.

vertical and horizontal white strips combined in a stereoscope, appearing alternately like figure 4, *a* and *b*, the vertical strip predominating on the whole because the larger pupil of the left eye has admitted the more light. On then making an effort of accommodation the horizontal after-image always predominates at once, usually to the total exclusion of the vertical after-image of the left eye, and

¹ The atropine paralyses the motor nerve-endings in the muscles, and so prevents impulses passing down the nerves from affecting the muscles.

continues to predominate so long as the accommodation of the right eye is maintained, so that save for momentary appearances of the whole of the vertical image, I see only images of the forms of figure 5, *a* and *b*. I have made many varieties of observations of this kind, using various patterns of bright light (e.g., parallel bars of light forming a square area and presented in different positions successively to the two eyes), and always with similar results.¹

This observation seems to prove indisputably that contraction of the intrinsic muscles of one eye sends up to the brain, presumably through afferent nerves of the muscles, an influence that directly re-enforces the activity of the cerebro-retinal tract of that eye, while it exerts no such effect upon the corresponding tract of the other eye, or exerts it in a minor degree only.²

This re-enforcing effect of the activity of the intrinsic muscles of the eye may be demonstrated unmistakably in the case of direct visual sensations by studying the struggle of two visual fields of different colours. In studying the durations and rate of alternation of the states of consciousness during the struggle of two different visual fields and the changes of mode of apperception of ambiguous figures, it is necessary to make some objective record of the changes at the moment of their occurrence, because the general impression retained by the subject as to the relative frequency and duration of the different states of consciousness is altogether unreliable. So far as I am aware, two observers only have attempted systematically to record such changes, namely Dr. N. Lange³ in the case of ambiguous figures, and Mr. Breese⁴ in the case of the struggle of two different visual fields. Both these observers worked with two contact keys, the subject being instructed to press one key or the other according as

¹ This observation seems to me to afford the most conclusive evidence of the separateness of the visual cortical areas for the two eyes, a fact of great importance for the theory of vision, because as I have pointed out in a previous paper (*MIND*, vol. x., p. 222) it seems to present an insuperable difficulty to the theory of "Gegenfarben".

² In the recently published *Monograph Supplement* (vol. iv.) of the *Psychological Review*, Mr. E. B. Holt describes experiments which seem to show that, during voluntary movements of the eyes, visual sensations are interrupted or inhibited for a brief moment. I find in my notebook the following note: "It is noteworthy that in all cases the re-enforcing effect of activity of the eye-muscles does not seem to manifest itself until an appreciable period after the beginning of the effort". There is therefore nothing contradictory in my observations to those of Mr. Holt.

³ *Phil. Stud.*, Bd. iv.

⁴ *Psycholog. Review, Monograph Supplement*, No. 11, 1899.

one or other of two states of consciousness predominates. Now, I find that, in the case of myself and of several other subjects, the periods of complete predominance of one or other form do not make up the whole period of observation, but that between these periods there come others, in the case of two differently coloured fields, periods during which the two colours appear fused or mixed as irregular patches, and in the case of ambiguous figures, such as those of figure 6, periods during which the figure does not assume either of the dominant forms, but appears as a number of lines in one plane of which some may or may not group themselves in consciousness apart from the rest. It seems necessary therefore to use a form of apparatus that will enable the subject to register the duration of these intervening periods as well as of the periods of distinct dominance, and I have devised for this purpose the apparatus described in the note below.¹

¹ A brass cylinder 590 mm. in circumference is made to rotate on a horizontal axis by clockwork driven by a heavy weight. The motion is kept regular by a delicate pair of wind-sails and can be set to any required speed of a considerable range by adjusting the driving weight and the size of the wind-sails. For these experiments the speed was adjusted to give one complete rotation in 118 seconds, which means a translation of any point on the surface of the drum at the rate of 5 mm. per sec. The drum is sheathed in a sheet of smooth white paper of such a length that its two ends united by gummed slips do not quite meet, but leave exposed a slip of the brass cylinder about 4 mm. in breadth. The writing apparatus consists of a tubular glass pen or ink-holder drawn to a point capped with brass. This is clamped in a penholder which forms one arm of a two-armed lever, the other arm carrying an adjustable counterweight. The fulcrum of this lever consists of a piece of small brass tube about 20 mm. in length which slides smoothly upon a steel rod held by adjustable clamps in the horizontal position between two metal upright supports which are carried by a strong iron base-plate. This is placed so that the horizontal steel rod lies parallel to the surface of the drum and at such a distance that the point of the pen lies lightly upon the paper. As the drum rotates the pen then traces a continuous line and after each complete rotation it slips off the edge of the paper on to the narrow strip of exposed metal surface, and in so doing causes the drum to give out a bell-like note which signals to the operator the completion of the rotation. A second pair of uprights fixed in a separate base-plate carries a second horizontal steel rod on which also slides a short piece of brass tubing encased in india-rubber; this is the finger-piece. This second rod carrying the sliding finger-piece is placed parallel to the first and at any distance from it that is most convenient. Attached to one of the supports of the rod carrying the penholder is a small brass pulley, and a silk thread attached to the finger-piece is carried from it round this pulley and tied to the axis of the penholder. This sliding axis is also attached to the support of the other end of the rod on which it slides by a light india-rubber band. The range of movement of the finger-piece is limited to about 25 mm. by a pair of stops on the steel rod, and the length of the silk thread joining

In studying the struggle of two differently coloured visual fields with the aid of the apparatus described in the note I sit before a prism-stereoscope of the ordinary form, fixed in a horizontal position over an aperture in the window-shutter of the dark-room, the two fields being patches of light transmitted through coloured paper or gelatine, and I hold between the finger and thumb of the left hand the finger-piece of the apparatus described in the note. During complete predominance of one coloured field I hold the finger-piece against one stop and on predominance of the other I slide it over and hold it against the other stop and when the two colour-fields appear fused or mixed in patches I hold it in a position midway between the stops. In this way a line of the form of figure 6 is traced on the paper and it constitutes a record of the number of changes of colour and of the duration of each phase of the struggle during the 118 secs. of rotation of the drum.

FIG. 6.

In this way I have made a considerable number of series of observations, but since I do not think that the average of the results of a large number of such series will give a truer picture than the records of a single one of the most satisfactory and representative series, I will present the record of one such series, merely stating that it is in harmony in all important points with the other records obtained in similar experiments. In this series the competing fields were two small squares (2 mm. wide but slightly magnified by the stereoscope), either one occupying the centre of a white square of about equal brightness and 10 mm. in width. These two fields were mounted on separate black cards, the light of the two square fields being transmitted through holes in the cards, and the rest of the aperture in the shutter

the two sliders is so adjusted that the finger-piece is held against the one stop by the tension of the rubber band. The pen-holder then accurately reproduces every sliding movement of the finger-piece between its two stops, and the pen records these movements upon the moving paper. This apparatus is very simple and constant in the working, it involves neither electrical connexions nor smoked surfaces, both of which are apt to prove unmitigated nuisances, and it can easily be worked by the subject without the aid of an assistant.

being filled by the opaque cards; the two cards overlapped and the distance between the two coloured fields could be adjusted by sliding the one card behind the other. The white borders aid in maintaining perfect coincidence of the two coloured fields. The one square was orange, the other blue. Each observation lasted during one complete rotation of the drum, *i.e.*, 118 seconds, and each was repeated with the cards transposed, so that in the one observation orange was presented to the left eye and blue to the right eye, and then in a second observation, under otherwise similar conditions, blue was presented to the left eye and orange to the right eye. The results of these parallel observations are presented side by side in the following table. The muscles for accommodation of lens and pupil of the left eye were completely paralysed through previous application of atropine, the right eye was normal.

In the pairs of observations I., II. and III. the two fields were at such a distance apart that they appeared combined when the visual axes were approximately parallel.

I. *Passive.*

	a.	b.
Left eye .	14 O = 36"	17 B = 20"
Right eye.	16 B = 37"	29 O = 45"
	N = 45"	N = 53"

II. *Holding B.*

	a.	b.
Left eye .	26 O = 17"	17 B = 81"
Right eye.	27 B = 52"	29 O = 29"
	N = 49"	N = 58"

III. *Holding O.*

	a.	b.
Left eye .	22 O = 45"	14 B = 11"
Right eye.	20 B = 16"	29 O = 59"
	N = 57"	N = 48"

In the case of the following pair of observations the two fields were 20 mm. nearer together than in preceding cases, so that their binocular combination involved a moderate degree of convergence of the two eyes.

IV. *Passive.*

	a.	b.
Left eye .	12 O = 8"	9 B = 9"
Right eye.	19 B = 32"	24 O = 26"
	N = 78"	N = 83"

In this table 'Passive' means that throughout the observation my attitude was as far as possible that of a passive

spectator of the series of changes; 'Holding B' means that I attempted to favour the predominance of the blue square by a voluntary effort, that is when the blue predominated I concentrated my attention upon it and when orange predominated, or the two were fused to a neutral tone, I made efforts to recall the blue square. N in the table stands for the periods of neutral or mixed colour, and the figure standing after N is the sum of these periods expressed in seconds during one rotation of the drum. The figure standing before O or B is the number of appearances of this colour during the rotation, and the figure standing after O or B is the sum of the periods of those appearances expressed in seconds. The latter are the significant figures, the number of appearances being of little importance. These figures appear at first sight somewhat chaotic but on consideration of them the following points appear very distinctly under equally favourable conditions. O tends to predominate over B, and this tendency is obscured in I. *a* and exaggerated in I. *b*, because the field of the normal right eye is favoured, as against the field of the atropinised left eye, presumably through a slight activity of the intrinsic muscles of the normal eye. II. *a* and III. *b* show that a voluntary effort to favour the predominance of one colour-field is very successful when that colour is presented to the normal eye, the gain being 15" in the case of B and 14" in the case of O. II. *b* and III. *a* show that the sensation excited in the retino-cerebral tract of the atropinised eye can also be favoured by voluntary effort but to a less degree than that excited in the normal eye, the gain being 11" and 9" for B and O respectively. IV. *a* and *b* show that the effect of convergence is twofold; firstly the neutral periods are much prolonged at the expense of the periods of predominance of the pure colours; this effect must be ascribed to the activity of the extrinsic muscles of both eyes which, maintaining the convergence of both eyes, re-enforces or supports the excitement of both cerebro-retinal tracts. Secondly, the field of the normal eye is favoured relatively to that of the atropinised eye and to a greater extent than when the visual axes are parallel; this must be due to the increased activity of the intrinsic muscles of the normal eye that accompanies convergence.

I will quote briefly the similar results of one other series of observations made by a different method. This series too was one of several made by the same method and giving similar results.

A plate of milk-glass, 3 cm. square, let into window-shutter

of the dark room, was lit by an evenly grey sky. The centre of this bright square was fixated by both eyes at a distance of 50 cm. The left eye was completely atropinised, the right eye was normal, and an artificial pupil of 2 mm. diameter was worn before either eye. Then with a blue glass before the left eye and a red glass before the right eye a record of the struggle of the blue and red fields was made with the help of the apparatus described above. The resulting figures were :—

Sum of B periods	=	21" (left eye)
" R "	=	33" (right eye)

and on repeating—

Sum of B periods	=	19" (left eye)
" R "	=	26" (right eye).

Then with the glasses transposed, *i.e.* with red glass before

FIG. 7.

the left eye and blue glass before the right eye, the figures were :—

Sum of R periods	=	8" (left eye)
" B "	=	37" (right eye)

and on repeating—

Sum of R periods	=	7" (left eye)
" B "	=	41" (right eye).

The asymmetrical character of the figures is due to the tendency of the blue field to predominate under equally favourable conditions, but in spite of this the re-enforcement by activity of the intrinsic muscles of the normal eye is very clearly marked.

These observations seem to prove in a more direct and conclusive manner than any others with which I am acquainted two important points, (1) that the whole cerebro-retinal tract in which colour-sensations are excited is double, *i.e.*, that the tract of either eye is separate and distinct from

that of the other eye; (2) that the excitement of the tract of either eye is directly and powerfully re-enforced during activity of the intrinsic muscles of the eye through impulses carried up to the brain by afferent nerves from those muscles.

The effects of contractions of the eye-muscles in determining the modes of ambiguous figures are well known. Prof. Titchener points out¹ that in the case of the staircase-figure reproduced in figure 7, a movement of the point of fixation of the eyes from *b* to *a* favours predominance of the step-mode, while movement from *a* to *b* favours the broken-wall mode of perception. I find that it is possible after a little practice to associate the reverse change with either of these movements, nevertheless it remains true that the

FIG. 8.

changes occur most readily in association with movements of the directions pointed out by Titchener.

Prof. Leob² has pointed out the influence of movements of accommodation in determining the mode of perception of such figures as Necker's cube (fig. 8). If one of the central angles, *a* or *b*, is fixated with one eye only, and then accommodation be slightly increased, that angle tends to appear convex and as the nearest point of the obliquely lying cube; and if then accommodation be a little relaxed, the angle fixated suddenly recedes and appears as a concave solid angle and the farthest point of the cube. These movements of accommodation render these changes of the mode of perception easy and are, as it were, natural to them, but I shall have occasion in a later section to point out that they are by

¹ *Experimental Psychology*, vol. I., pt. ii., p. 812.

² *Pflüger's Arch.*, Bd. xl.

no means indissolubly associated with, or necessary to, the voluntary determination of the changes.

The influence of eye-movements on the mode of perception of such objects as figure 2 is very marked. It may be studied most conveniently and in its purest form in the after-images of such figures. When a clear after-image of figure 2 is obtained (in positive and negative after-images the effects are alike) movements of the eyes along the direction of any one of the three possible linear groupings greatly facilitate the appearance of that grouping, and by such movements the three linear groupings or any two of them may be made to alternate with one another regularly, or one grouping may be made to persist to the exclusion of all others for several seconds.

We may note lastly in this connexion that activity of the eye-muscles favours the return to consciousness of the primary memory-image; as Prof. Ward¹ writes, after a momentary glance at an object, "the object is imaged for a moment very vividly and distinctly, and can be so recovered several times in succession by an effort of attention. Such reinstatement is materially helped by rapidly opening and closing the eyes, or by suddenly moving them in any way." And he adds, "In this respect a primary memory-image resembles an after-sensation, which can be repeatedly revived in this manner when it would otherwise have disappeared".

My own experience bears out this statement entirely, and I would only add that the movement that has the most marked effect of this kind is a movement of convergence with accommodation.

I turn now to the consideration of the physiological adjustments in virtue of which the muscular activities are able to produce these effects. In this connexion I have no novel suggestion to make. I would merely attempt to render a little more definite and concrete the view of the process adopted by Dr. Maudsley, by Profs. Wundt, Ribot, James and others. This view may be stated shortly in Ribot's words: "As a motor organ the brain plays a complex rôle. In the first place, it inaugurates the movements that accompany perceptions, images or ideas; afterwards, these movements, which frequently are intense, return to the brain by way of the muscular sense as sensations of movement; the latter increase the quantity of available energy,"² which on

¹ Art. "Psychology," *Encyclop. Brit.*, p. 59.

² We see here that Ribot uses the conception of a common store of free energy in the afferent side of the nervous system, in much the same way as I have used it above.

the one hand serves to maintain or to reinforce consciousness, and, on the other, returns to its original starting-point in the form of a fresh movement."¹ Allowing for a certain looseness of the phrasing, this sentence seems to me to represent the process correctly. Ribot distinguishes two parts of the effect produced by the inflow of neurin by the nerves of the muscular sense, (1) part of it at once re-enters the motor tract to maintain the contraction; (2) part serves to re-enforce consciousness. The former process, the return of the excitement to the motor tract, implies the existence of the 'motor circle' as it has been called by James. The principle of the motor circle is now pretty well established as obtaining very generally, if not universally, throughout the cord and subcortical levels. It may be schematically represented as follows (fig. 9): A stimulus at S excites the sensory neurone *a*, which discharges through a central neurone *b* into motor neurone *c*, thus bringing about a reflex contraction of some muscle *m*; the contraction of the muscle stimulates its afferent neurone *d*, and this then discharges into the central neurone *b*, and so re-enforces the excitement of this reflex path and maintains the contraction.² And this arrangement seems to be repeated in the second or sensory-reflex level, for, as Ebbinghaus puts it,³ "Those parts of the cerebral cortex, which centrifugally are connected with the cells of origin of a particular movement-complex in the subcortical centres, contain also the end-station for the kinæsthetic excitations arising from the execution of just this movement and passing centripetally to the cortex". So that this path (*k* in fig. 9) in the Rolandic cortex, whose activity determines the sensation of movement, constitutes a loop upon the motor-circle, leading off from the afferent neurone *d*, and returning to the motor neurone *c* of that circle.

The motor effects of a sensory, say a visual, stimulus thus tend to maintain themselves and the corresponding kinæsthetic sensation by a circular activity, and they also support and maintain sensation in general by contributing to the influx of neurin to the afferent side of the nervous system. They do not however re-enforce in this way all sensations equally,

¹ *Psychology of Attention*, p. 20.

² For the evidence of the prevalence of this arrangement see Chaveau, "On the Sensorimotor Nerve-circuit of Muscles," *Brain*, vol. xiv.; Sherrington, Marshall Hall Address, 1899, 'The Spinal Animal,' *Medico-Chirurgical Trans.*, vol. lxxxii.; James, *Princ. of Psychology*, vol. II, p. 588.

³ *Grundzüge d. Psychologie*, Bd. I., S. 692.

but chiefly those of the sense organ whose excitement has initiated these motor effects, for, as we have seen above in the case of the two eyes, the afferent influx from the intrinsic muscles of one eye re-enforces the sensations of that eye much more strongly than those of the other eye. We must assume then that the afferent tract from the intrinsic muscles of

FIG. 9.

either eye is specially connected with the tract leading from the retina of that eye, so that the excitation process initiated in it by contraction of the muscles discharges not only through the motor-circle but in part through the retino-cerebral tract, augmenting in the latter the excitement which is directly due to the visual stimulus. How exactly the two

tracts are connected, whether on the afferent side, as seems probable, or only on the motor side, we cannot yet say.

But the contractions of the muscles of one eye, not only re-enforce the visual sensations of that eye and in so doing tend to make those sensations the objects of Attention, they exert a still more complex effect, for, as we have seen in studying figure 2 and the other ambiguous figures, the contractions tend to determine one or other mode of Attention to the sensations according to the character of the contractions and the kinæsthetic impressions initiated by them. And the relation is a reciprocal one, each mode of Attention to figure 2 tends to determine a certain mode of activity of the eye-muscles and this mode of activity of the eye-muscles, when otherwise determined (accidentally or voluntarily), tends to bring about that particular mode of Attention. Here the central connexions between the kinæsthetic and the visual tracts are still more intricate and complex than in the case of simple re-enforcement of sensation, and it would be premature to attempt to define them otherwise than very roughly and in general terms. Let us take the case of the perception of figure 2 as horizontal rows of discs. The upper-level path, whose excitement converts the undiscriminated sensation of patches of light into the perception of patches regularly grouped in horizontal rows, is a path leading from the visual cortex to the Rolandic or kinæsthetic cortex and there making connexion with a group of neurones whose excitement determines a to and fro movement of the eyes in the horizontal direction. If, on glancing at figure 2, I see it at once as horizontal rows of discs, it is because the sensory excitation discharges in part at once through this upper-level path. If, on the other hand, I voluntarily move my eyes to and fro horizontally and so determine the onset of this mode of Attention the order of events is as follows,—I call up the kinæsthetic idea of lateral movements, which, physiologically expressed, is to excite the group of neurones of the kinæsthetic cortex which lead to the subcortical centres for lateral movements; and these neurones are the paths of efferent discharge of that upper-level path which comes from the visual cortex; their excitement therefore throws open this path by lowering the resistance of its efferent outlet, and the excitation-process of the visual cortex then discharges in part through it to the kinæsthetic neurones. For each mode of perception of figure 2 we must assume an upper-level path of this kind, a path leading from the visual cortex to a group of kinæsthetic neurones whose excitement issues through the motor neu-

rones that bring about the corresponding eye-movement and which are in turn excited by such eye-movements.

In some such way as this we must seek to explain the effects of motor-activities in determining the mode of attention. In the following section I propose to bring forward experimental evidence that the motor-effects or accompaniments of sensory perception have not that predominant or exclusive importance with which they have been credited by several authors.