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VISION WITHOUT INVERSION OF THE RETINAL IMAGE.

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In the November number of this REVIEW, I gave a short account of some preliminary experiments on vision without inversion of the retinal image. Brief as the experiments were, they gave certain definite results and hinted at others which would probably be obtained if the artificial conditions were continued for a longer time. The course of the experience also showed that problems much wider than that of upright vision were involved, and that a careful record of a longer test might throw light on these also. I was strengthened in this view that the experiment bore on other problems at least as important as that of upright vision, by the remarks of Professor Titchener when the paper was publicly read; while the questions of Professor Münsterberg, on the same occasion, suggested the need of more careful observations in regard to dizziness and the localization of sounds.[1]

The earlier paper was thus necessarily vague or silent on a number of questions in regard to which a more careful and extended experiment could hardly fail to produce something of interest—on such questions as, for instance, whether the reconstruction of the directions, right and left, proceeded exactly parallel to that of the directions up and down; what the connection of visual and tactual localization really is, which enables the one

[1] See the *Berichte* of the Third International Congress for Psychology. Munich, 1897, p. 194.

to influence the other; and, finally, what were the more definite conditions under which the harmonious accommodation to the abnormal sight-perceptions waxed and waned. It was also necessary that a nicer distinction should constantly be observed between acts or ideas arising as a result of deliberate volition and those which arose effortless and unpremeditated. In other words, the account should clearly distinguish at any given stage of the experiment between processes which occurred spontaneously and those which could be called up only by force of will.

The present experiment was conducted under almost the same conditions as those of the preliminary experiment. I myself was again the observer, and the apparatus was the one described in the earlier article, except that a thin cloth-lined plaster cast of the region about the eyes was substituted for the padded paste-board case which before had held the tube of lenses. In making the cast a small mass of non-adhesive material was placed directly over each eye, and afterwards removed from the cast; so that during the experiment the inner lining of the case did not press on the eyes, nor interfere in the least with their free movement. In front of the right eye there was an opening in the cast, into which the tube of four lenses before described fitted exactly. This tube was carefully focussed and set at such a distance from the eye as to give a clear visual field of about 45° compass. The cast could then be bound to the head by a set of tapes, and although somewhat heavier than the paste-board case, was nevertheless much more comfortable, because it pressed evenly over a large surface of the face. By this device all light was excluded, except such as came through the lenses into the right eye.

The time was not spent, as before, entirely indoors. Besides the free range of the house, I could walk in a secluded garden; and since the experiment fell at a time of bright moonlight, I took, every evening but the first, a long walk through the village, accompanied and, when there was need, guided by a companion. The experiment lasted, this time, from noon of the first day until noon of the eighth day—a net period in all (after subtracting the time during which the eyes were blindfolded),

of about 87 hours, as against 21½ for the previous experiment. The actual record for the eight days is as follows:

Day.	Hour of Putting Glasses on.	Hour of Taking Glasses off.	Length of Time Glasses were Worn.
16t	12 m.	9 p. m.	9 hrs.
2d	9 a. m,	9 p. m.	12 hrs.
3d	9 a. m.	9 p. m.	12 hrs.
4th	9 a. m.	9:45 p. m.	12 hrs., 45 mins.
5th	9:50 a. m.	10:30 p. m.	12 hrs., 40 mins.
6th	9:50 a. m	9:45 p. m.	11 hrs., 55 mins.
7th	9:15 a m.	9:45 p. m.	12 hrs., 30 mins.
8th	8 a. m.	12:10 p. m.	4 hrs , 10 mins.
			Total, 87 hrs.

At all times when the glasses were not worn, the eyes were thoroughly blindfolded. Careful notes were made every day, to record as exactly as possible the actual state of the experience at that time.

Before I attempt a narrative of the experience under the experimental conditions, a word or two as to the terminology will be necessary. One has constantly to make a distinction between the appearance of an object as seen through the reversing lenses, and either the appearance it had before the lenses were put on, or the appearance it would have had if the lenses were removed and normal vision restored. This appearance just described is called in the narrative the 'older,' the 'normal,' often the 'pre-experimental' appearance of the object; while the appearance through the lenses is called its 'newer' or 'later' appearance. Similar distinguishing terms have also to be used with reference to the mere representation or idea of an object, as contrasted with its actual perception.

It is perhaps unnecessary to state that the accommodation to the artificial conditions was, in my case, probably more rapid than it would have been, had I not retained some of the effects of the practice gained in the earlier experiment, about five months before.

The experience from day to day was as follows:

First Day.—The entire scene appeared upside down. When I moved my head or body so that my sight swept over the scene, the movement was not felt to be solely in the observer,

as in normal vision, but was referred both to the observer and to objects beyond. The visual picture seemed to move through the field of view faster than the accompanying movement of my body, although in the same direction. It did not feel as if I were visually ranging over a set of motionless objects, but the whole field of things swept and swung before my eyes.

Almost all movements performed under the direct guidance of sight were laborious and embarrassed. Inappropriate movements were constantly made; for instance, in order to move my hand from a place in the visual field to some other place which I had selected, the muscular contraction which would have accomplished this if the normal visual arrangement had existed, now carried my hand to an entirely different place. The movement was then checked, started off in another direction, and finally, by a series of approximations and corrections, brought to the chosen point. At table the simplest acts of serving myself had to be cautiously worked out. The wrong hand was constantly used to seize anything that lay to one side. In pouring some milk into a glass, I must by careful trial and correction bring the surface of the milk to the spout of the pitcher, and then see to it that the surface of the milk in the glass remained everywhere equally distant from the glass's rim.

The unusual strain of attention in these cases, and the difficulty of finally getting a movement to its goal, made all but the simplest movements extremely fatiguing. The observer was thus tempted to omit all those which required nice guidance, or which included a series of changes or of rapid adaptations to untried visual circumstances. Relief was sometimes sought by shutting out of consideration the actual visual data, and by depending solely on tactual or motor perception and on the older visual representations suggested by these. But for the most part this tendency was resisted, and movements were performed with full attention to what was visually before me. Even then, I was frequently aware that the opposite, the merely represented, arrangement was serving as a secondary guide along with the actual sight perceptions, and that now the one factor and now the other came to the foreground and was put in control. In order to write my notes, the

formation of the letters and words had to be left to automatic muscular sequence, using sight only as a guide to the general position and direction on my paper. When hesitation occurred in my writing, as it often did, there was no resort but to picture the next stroke or two in pre-experimental terms, and when the movement was once under way, control it visually as little as possible.

The scene before me was often reconstructed in the form it would have had in normal vision; and yet this translation was not carried to such an extent as at the beginning of the first experiment. The scene was now accepted more as it was immediately presented. Objects of sight had more reality in them—had more the character of 'things,' and less that of phantasms—than when the earlier trial began. Objects were, however, taken more or less isolatedly; so that inappropriateness of place with reference to other objects even in the same visual field was often, in the general upheaval of the experience, passed by unnoticed. I sat for some time watching a blazing open fire, without seeing that one of the logs had rolled far out on the hearth and was filling the room with smoke. Not until I caught the odor of the smoke, and cast about for the cause, did I notice what had occurred.

Similarly, the actual visual field was, for the most part, taken by itself and not supplemented, as in normal vision, by a system of objects gathered and held from the preceding visual experience. Sporadic cases occurred, in which some object out of sight was represented as it had just been seen; but in general all things not actually in view returned to their older arrangement and were represented, if at all, as in normal sight. Usually this was the case also in picturing an unseen movement of some part of my body. At times, however, both the normal and the later representation of the moving part spontaneously arose in the mind, like an object and its mirrored reflection. But such cases occurred only when actual sight had just before revivified the later memory-image.

As regards the parts of the body, their pre-experimental representation often invaded the region directly in sight. Arms and legs in full view were given a double position. Beside the

position and relation in which they were actually seen, there was always in the mental background, in intimate connection with muscular and tactual sensations, the older represention of these parts. As soon as my eyes were closed or directed elsewhere, this older representation gathered strength and was the dominant image. But other objects did not usually have this double localization while I looked at them, unless non-visual sensations came from the objects. Touch, temperature, or sounds, brought up a visual image of the source in pre-experimental form.

Anticipations of contact from bodies seen to be approaching, arose as if particular places and directions in the visual field had the same meaning as in normal experience. When one side of my body approached an object in view, the actual feeling of contact came from the side opposite to that from which I had expected it. And likewise in passing under a hanging lamp, the lamp, in moving toward what in normal experience had been the lower part of the visual field, produced a distinct anticipatory shrinking in the region of the chin and neck, although the light really hung several inches above the top of my head.

Whether as a result of the embarassment under which nearly all visually guided movements were performed, or as a consequence of the swinging of the scene, described above, there were signs of nervous disturbance, of which perhaps the most marked was a feeling of depression in the upper abdominal region, akin to mild nausea. This disappeared, however, toward evening; so that by half-past seven it was no longer perceptible.

Second Day.—This feeling of nervous depression, just mentioned, returned the next forenoon. Movements, though, had in many respects grown less laborious, and were performed more on the basis of the actual sight-experiences, and less by excluding these as a means of guidance. Once at least, in the afternoon, I noticed that in washing my hands I had given myself up completely to the actual scene; but at the next instant inappropriate movements occurred, and with the consciousness that I had thus given myself up the old pre-experimental translation of things returned.

Unseen objects could, by force of will, be represented in harmony with things in view, more easily than on the preceding day. I could, for instance, voluntarily bring before me, in consistent relation to the visual field, the general outline of the room in which I was sitting. My own body, however, was much less tractable; at best I could get only my legs and arms appropriately represented, and this only by an effort not required by other objects. And even an unseen object of this latter sort, when felt in intimate connection with some part of the body which stubbornly held its old ground, could not by effort of will be vividly represented in terms of the newer sight.

There was much evidence of a rigid interconnection of experiences, by which the place or reality of one thing decided the place or reality of something else. The vividness with which a part of the body could be localized by visual representation, was influenced to some extent by the consistency of this representation with the actual perceptions of sight. Thus in swinging my clasped hands above my head, although I was aware of the direction of such a movement in the pre-experimental visual field, yet the actual disappearance of my hands *below* the lower border of the field, and the free continuance there of the movement, involuntarily made the region seem, for the time, visually vague and empty where I had hitherto represented my chest and shoulders. Likewise, in walking through the room, the disappearance of a low-hanging electric globe toward the space in which my chin and neck were represented, and the immediately following contact of the globe with the top of my head, tended to disturb the place of representation of both my chin and scalp; while attention to the ceiling disappearing, as I walked along, in what was normally the lower part of the visual field, weakened the connection of the image of my feet with this place in the field. There was thus a suggestion of more than one way of appropriately knitting some item into the body of experience. This not infrequently led to two representations of a single thing, both of which had a sort of reality; although not to such an extent as to give an actual illusion of two objects where there was really only one. The unseen fire-place in the room where I was sitting could be viv-

idly represented according to the new set of visual relations, but the crackling of the fire was involuntarily referred to another direction, and in that direction there was also a dim image of the fire-place. And even when I looked directly at some part of my body, there was an acceptance of the seen thing as the real thing, and yet there was an accompanying transposed representation of it which also possessed a certain reality of its own.

As to the uprightness or inversion of things, the general feeling was that the seen room was upside down; the body of the observer, represented in pre-experimental terms, was felt as standard and as having an upright position. But different circumstances produced a different shade of feeling. When I looked out over a wide landscape, the position in which I felt my body to be and the position of the scene before me were surely discordant and unnatural. Yet I could not, as I had the day before, take either the one or the other unreservedly as standard. It seemed as if an abnormal position of my body in viewing things might just as well account for the facts as would an inversion of the scene. The very expanse of the landscape in comparison with the size of my body no doubt tended to subordinate the latter and render it less unreservedly a norm for judging of correctness of position. But even when, indoors, the view was almost completely filled with the dining-table and its furnishings, there was no striking and obvious feeling that the scene was upside down.

During a rather long walk in the evening I was unable to recognize my surroundings most of the time, although normally they were quite familiar. Recognition evidently depended largely on external relations of position and direction, and, with a disturbance of these, the objects themselves seemed strange. I could voluntarily feel my feet strike on the ground seen in the upper part of the visual field. But my companion, who held my arm, I could not represent on that side of me which, I knew, a harmonious construction of the visual field would require.

On being blindfolded for the night, there was an immediate and involuntary recurrence to the older way of picturing things. Only rarely could anything be represented in terms of the later sight.

Third Day.—I was now beginning to feel more at home in the new experience. At no time during the day did any signs of nervous distress appear, and the hours passed more rapidly than on either of the preceding days.

Walking through the narrow spaces between pieces of furniture required much less care than hitherto. I could watch my hands as I wrote, without hesitating or becoming embarrassed thereby. Yet I often stretched out the wrong hand to grasp a visible object lying to one side; right and left were felt to be by far the most persistently troublesome relations when it came to translating visual into tactual or motor localization. An involuntary feeling of dissatisfaction with the new visual perceptions in some cases produced movements which, although intended to be corrective, were really the contrary. For instance, while holding my hands in water running from the customary faucet, in the wash-bowl, I had repeatedly to suppress involuntary movements of the hands toward the wrong faucet which now occupied a visual position identical with that formerly held by the right one in the normal experience. The visual hands were not in the visual place approved of by the older experience; spontaneous efforts to rectify the misplacement followed, although the motor perceptions were entirely appropriate to the scene, had this been translated into pre-experimental terms. The corrective movements were therefore evidence that a translative reconstruction of the scene had not taken place. And yet the older criteria of inappropriateness of visual position were still active in the new experience. Instead of a reconstruction or translation of this new experience into terms of the old, I now occasionally became aware of an opposite process—a spontaneous translation of some pre-experimental memory-image into the form of the later vision.

Head-movements were still accompanied by a slight swinging of the scene, although in a markedly less degree than on the first day. The movement was referred more to the observer, so that it seemed to be more a moving survey of stationary objects.

It is difficult to describe my attitude of mind toward the inverted scene. Little more can be said than that there was clearly an abnormal relation between the general localization of

my body and the position of the scene as a whole; but, as when looking at the landscape the day before, it was not clear which of the terms was standard and normal and which was thereby condemned. I had, however, a distinct consciousness that the feelings connected with certain positions in the visual field were by no means what they had been in the normal experience. What had been the old 'upper' position in the field was beginning to have much of the feeling formerly connected with the old 'lower' position, and *vice versa*. Once as I stood before the fire-place, watching the fire, an odd sensation came over me, as if I were looking at the fire out of the back of my head.

Contacts in walking past objects had hitherto for the most part been surprising, because the contact was felt in a different place from the one anticipated. But to-day I noticed that expectation was coming more into harmony with the actual experience. It was also evident that this expectation, when joined with a vivid representation of the region of the body in question, had a perceptible influence upon the direction in which the contact was actually felt. If, for example, I walked up to a low railing which came against my abdomen, the sensations of pressure seemed to come from the new visual position of the abdomen if I called up a vivid image of this part of my body in its new position and expected the sensations to come from there. But the unexpected contact of the railing with my arms (then out of sight), which had not been represented in their new position, was referred only in the old way, until these too were distinctly imaged as the abdomen had been. But even when the localization was in accord with the new visual experience, there was still a subordinate, background localization after the old manner.

Other factors besides volition or even recency of visual perception were observed to have an effect on the direction in which unseen objects were represented. The position of the shadow of my body in the visual field, for instance, involuntarily strengthened the new representation of my body. Shadows had also a marked influence in determining where I must think the window or the sun to be. And movements of my hands in front of my eyes to some part of my body which I could not see, gave the clue to the new visual position of the part.

In this way and from other influences, there was coming to be a more vital connection between my actual perceptions and the larger visual system of merely represented objects. It was becoming easier to follow a line in the field of sight and, continuing the line into this larger system of things, to know what it would lead to. The rooms beyond the one I was in, together with the scene out of doors, could be represented in harmonious relation with what I was actually looking at. Such representations, however, were more or less a matter of voluntary effort; the spontaneous pictures were usually on the pre-experimental basis. But I was now able for the first time to produce even voluntarily a vivid representation of those parts of my body which could not be brought to view, in proper relation to my sight-perceptions. This was much easier when my legs and arms were in sight, but even otherwise the new representation could still be made. The representation in the old way, though, was the spontaneous one, and doubtless was always at least in the background. But in this older representation there was an unusual paling and weakening of the image of those parts which had most often been seen during the course of the experiment. By bringing my legs and arms into view, the older representation became a sort of torso, the filling in of the seen parts refusing to appear, except in the vaguest way, even by an effort of will. When objects other than the body were in sight, they were not accompanied by any background representation of them on the older basis, unless they gave some sound. In such a case, the sound was localized according to pre-experimental relations, and its source was dimly pictured in accord with this localization.

That the new experience was getting a more stable place in my mind, was perhaps shown by the involuntary recurrence of scenes in their new visual relations, after actual perception had ceased—when I closed my eyes, for instance, or in the evening when my glasses were removed and my eyes were blindfolded.

Fourth Day.—By the fourth day the new experience had become even less trying. There was no sign of bodily discomfort, and for the first time during the experiment, when nine o'clock in the evening came I preferred to keep the glasses on,

rather than sit blindfolded—which had hitherto been chosen as a welcome relief.

During the day, actions appropriate to the new visual perceptions frequently occurred without any conflict or apparent tendency to react by a misinterpretation of visual positions. My hands, in washing, often moved to the soap or to the proper position in the basin, without premeditation or any need of correcting the movement. At one time in the morning, before the bandage was removed from my eyes, I pictured the basin and its appurtenances before me in pre-experimental terms. But my actions were the opposite to those which would have been appropriate to this image. Here I reacted in the new way on an old system of relations, instead of reacting in the old way on a new system of relations— a mode of reaction frequent in the earlier part of the experiment, and by no means fully suppressed even yet. But the more common form of inappropriate reaction now was a movement of one hand when the circumstances really required a movement of the other; as when I reached with my right hand to pick up a book on the floor to my left. I happened to discover, however, a simple means of obtaining without calculation the use of the proper hand in picking up things on the floor —a means which I used thereafter with almost invariable success. If, with one of my feet near the object, I gave a tap or two on the floor before I stooped to pick it up, the proper hand immediately came into play. Curiously enough, it was easier at this time to start the proper foot than to start the proper hand. But there had also been great progress in the suitable use of my hands, shown particularly in the lessened difficulty in serving myself at table, although this was still far from easy.

The sight of objects other than my body, was not accompanied by a representation in the form of the normal experience. The character of the representation of things not actually in sight was influenced by the recency of their visual perception and by the closeness of their relation to things in sight. Objects in sight called up the ideas of neighboring objects in harmonious spatial relation with the things I saw. When I looked down the room in which I was sitting, the ideas of the other rooms of the house were apt to arise in appropriate rela-

tion to my sight perceptions. But if I tried to represent the other rooms without first surveying the room before me and obtaining afresh a powerful 'apperceptive mass,' the spontaneous image of the other rooms was more frequently in terms of pre-experimental vision. And yet the spontaneous representation of things when all sight-perceptions were shut out by closing or blindfolding my eyes, or by darkness, was far from being an inevitable return to the older form of vision. More than once on shutting my eyes, for instance, the room was involuntarily represented as it had just been seen; or in walking after dark into an unlighted room, its general arrangement and more prominent objects rose of themselves before me in the later form of sight. And even in the morning, before I had put on the lenses and refreshed the new experience, the flow of ideas was not purely in the form of the older experience but was strongly mixed with forms of the new. This was also the case on removing the lenses in the evening.

The mode of representing the parts of my body differed with circumstances. On entering the unlighted rooms spoken of above, the movements of my legs and arms were, without my willing it, imaged in terms of the newer sight. As far as I could make out, this quite obscured the older form. At other times, the older representation of my legs striking against the floor was apparent, but seemed dim and unreal as compared with the new. Thus not only was the spontaneous visualization of these parts becoming a mirror of the new visual experience, but the spatial reference of the touch-perceptions was following with greater vividness the direction given by the new visualization. The feeling of contact of things on one side of my body was likewise becoming more spontaneously referred to the proper place in the new visual representation. Hitherto the proper lateral reference had probably always been an afterthought, or reflective reconstruction; the wrong localization was first suggested and then rejected. Now the wrong localization, it is true, still came, but often no sooner than the correct one, and in subordination to this. At other times the older reference alone was suggested. For instance, it occurred that two objects of different shape, one in each hand, when brought into

view, had just the transposed position, as regards right and left, from what I had expected to see them have in the visual field. The touch sensations were here localized in incorrect visual terms.

Sounds coming from objects out of sight were localized as of old, except when the object was vividly represented in the new way. In the latter case, the old localization of the sound was not the exclusive one, but was accompanied by a distinct solicitation to refer the sound to the place where the object was visualized. When the object was in plain sight, the sound seemed to come from the direction in which the object was seen.

The feeling of the inversion or uprightness of things was found to vary considerably with the strength and character of the representation of my body. When I looked at my legs and arms, or even when I reinforced by effort of attention their new visual representation, then what I saw seemed rather upright than inverted. But, if I looked away from my body and gave exclusive force to its pre-experimental image, then everything in sight seemed upside down. Especially was it noticeable that during active movements of the body, as in brisk walking or in coping with objects whose arrangement was relatively unfamiliar, the feeling of the uprightness of the scene was much more vivid than when the body was quiet. During such active operations there was at times a surprising absence of incongruity in the appearance of things. In the evening, during my outdoor walk, I called up a picture of my body in its old visual position, outside the field of view; I had the distinct feeling that such a position was upside down. The outer scene and the new arrangement were clearly at this time the standard.

The swinging of the scene during movements of my body seemed greater or less, according to the way in which I represented to myself this movement of my body. When I pictured the movement in terms of the new visual experience, the movement seemed to be a survey of stable objects. But when I lapsed into the older way of visualizing the movement, then the scene itself seemed to shift before my eyes.

Fifth Day.—At the thought of putting on the lenses, in the

morning, there was an influx of ideas in the new visual form. I even noticed in many cases that there was a reconstruction, in the new terms, of objects which I had just before been thinking of in the old way.

At breakfast, with the lenses on, the inappropriate hand was rarely used to pick up something to one side. The movement itself also was easier and less wayward; seldom was it in an entirely wrong direction. When hand and object were both in sight I did not, as a rule, have to calculate or try to find the direction and extent of movement necessary to reach the object, but merely fixed my attention on the thing, and the hand was laid upon it without more ado, except for an occasional slight correction of the direction.

In walking I did not so often run into obstacles in the very effort to avoid them. I usually took the right direction without reflecting and without the need any longer of constantly watching my feet. When the doors were open I could walk through the entire house by visual guidance alone, without holding out my hands in front of me to warn in case of a misinterpretation of the sight-perception. For the first time, I dared to turn and sit down on a chair without beforehand assuring myself with my hands that I had placed myself aright. My movements were of course still cautious and awkward. And often the question of right and left was troublesome; for example, I wished to grasp the handle of the door beside me, and must hesitate a moment before it was clear which hand to use. But I found that the appropriate hand often came to the appropriate side of the visual field directly and without the thought (frequently necessary before) that *that* visual side meant the *other* side in motor or older visual terms. An evidence of the growing ease with which simple movements were coming to be done is given by the fact that I took a sheet of my notes and laid it upon a shelf in another part of the room, all the while intent on something entirely foreign to the matter in hand.

When I rocked myself in a chair the downward and forward movement of my body was primarily and spontaneously felt as a movement toward the actual visual floor; that is, toward the *upper* region of the visual field, to express the direction in terms

of normal vision. And the backward, upward movement was likewise felt entirely in accordance with the actual visual experience. In this way the rhythmic variation of the visual field during the rocking seemed a harmonious and natural result of the rocking itself, and not, as formerly, a shifting of the scene, unnatural, and therefore suggestive of illusion. And on other occasions, there often was no immediate feeling that the position of the object seen—the position of a person, for instance, with whom I was talking—was incongruous; only after reflection was I aware that the scene was reversed from what it had been before the experiment began.

But in general the most harmonious experiences were obtained during active operations on the scene before me. In rapid, complicated, yet practiced movements, the harmony of the localization by sight and that by touch or motor perception—the actual identity of the positions reported in these various ways—came out with much greater force than when I sat down and passively observed the scene. During such a passive observation I still involuntarily represented my head, shoulders, and chest in the old pre-experimental relation to the actual things in sight. I could, however, by an effort of will fill out the entire form of my body upon the foundation of the parts then seen, but such a visualization was felt to be forced; the spontaneous image of the unseen parts of my body as I sat quiet was thus what it had been during the older experience, and did not at all fit the actual localization of the parts I saw. For these latter were felt to be where they appeared in sight. But even they, when no longer actually in view, often lapsed into the older mode of representation; so that with my two feet pointing in the same direction, but with one in sight and the other outside the visual field, they sometimes felt as though pointing in diametrically opposite directions; the seen foot pointing forward while the unseen one pointed backward, to express the directions in terms of the new visual experience. If I took a fresh look at the hidden foot, however, and then let it pass out of sight, its image remained for some time in accord with the recent perception. But that the older way of representing my body was losing ground, even in the case of the unseen parts,

was evidenced by the disappearance of that anticipatory "drawing in" of chin and chest when a solid object passed through the visual field in the direction which in normal vision would have meant a blow in the chest, but which now suggested a free passage overhead. The clear knowledge that the object would not strike me, had been of no avail on former days to prevent some sign of practical distrust.

Localization in cases of unseen contact often went astray, mainly in that the wrong visual side was first suggested, but corrected before I turned my eyes on the thing touching me. Localization of sounds was various, and at times gave a sudden and surprising turn to the experience. Thus, as I sat in the garden, a friend who was talking with me began to throw some pebbles into the distance to one side of my actual view. The sound of the stones striking the ground came, oddly enough, from the opposite direction from that in which I had seen them pass out of my sight, and from which I involuntarily expected to catch the sound. I unhesitatingly accepted the visual directions of throwing and of the stones' movement, but the auditory spatial suggestion was in complete discord with these.

During the usual moonlight walk it was evident that differences of light and shade could not so readily as in normal vision be translated into differences of elevation of the ground.

When blindfolded, after the glasses had been taken off, representations in the form of the new vision were a more vivid constituent of my train of ideas than on any previous night. After I went to bed, while still awake, they came in concrete and colored scenes.

Sixth Day.—In walking about the room blindfolded for a few moments in the morning, images in form of the pre-experimental vision were almost exclusively present. Once or twice at this time a strange indecision and confusion came over me when I did not immediately lay hands on an object which I knew was within reach. I doubted whether I was not using the opposite hand from the one intended. A moment's hesitation, the bewilderment for some reason gave way to assurance, and the movement went on its way. In putting on my shoes—the lenses were now in place—the problem of right and left, which

had hitherto rendered this operation difficult, was unreflectingly solved by making a direct visual comparison of the contours of foot and shoe and seeing whether they matched.

Movements of the head or of the body, which shifted the field of view, seemed now to be in entire keeping with the visual changes thus produced; the motion seemed to be toward that side on which objects entered the visual field, and not toward the opposite side, as the pre-experimental representation of the movement would have required. And when, with closed eyes, I rocked in my chair, the merely represented changes in the visual field persisted with the same rhythmic variation of direction which they would have shown had I opened my eyes. I tried to *make* the imagined objects take the opposite course—the course they would have taken in the older vision during such movements of the body; but only after some moments of effort could I get even a faint suggestion of such changes, and these were immediately supplanted by those in accord with the new visual experience, the instant I ceased my attempt to reinstate the old by force.

When I sat passive, either the old or the new position of my unseen body could be brought prominently forward by act of will. When the old representation was thus reinforced, the actual scene seemed inverted. But when the new representation of my body was emphasized, then the scene felt right side up. During active operations on the visual surroundings, however, the older image of my body became, in many cases without my willing it, weaker than the new, and at times faded completely away.

Variations of touch-localization under different conditions of sight were clearly observable. I felt that my legs were where I saw them, or where they were vividly represented, if they were out of sight. If I tapped upon my knee in plain sight, the contact was localized only where sight reported it to be. But if I tapped while not looking at my knee, the contact was referred to both the old and the new visual positions, the reference according to the older visual experience being probably the stronger. I then placed my two index fingers in view before me, at equal distances from my body, and resting on a paper

tablet in my lap. The right finger now was in that position in the visual field, which in normal sight would have been occupied by the left and *vice versa;* though, of course, the direction in which the fingers pointed in the visual field did not similarly correspond with the old. In many cases, now, a contact (the touch of a pencil point, for instance, by an assistant) on one of the fingers could at will be felt in either of them; at times, indeed, the contact could be referred to both fingers at once. When there actually was a contact with both fingers at once (for instance, a pencil point on one, and the assistant's finger tip on the other), the voluntary transfer of the localization of the pencil's contact from one finger to the other was much easier. And in this case, the contacts, although qualitatively distinguished with ease, and spontaneously referred to their distinct and proper places in the actual field of sight, could nevertheless voluntarily be felt as coming from the same finger at the same time. A movement of one of the fingers, such as a slight bending and straightening of it, while the other remained passive, produced a marked difference between the two fingers, both as to their visual appearance and as to the character of the tactual sensations just mentioned; and this movement rendered the arbitrary reference of the two contacts impossible. Each contact could then be felt only in the place where it was seen to be.

Likewise the substitution of a thumb for one of the fingers (the right thumb for the right index, or the left for the left) prevented a voluntary control of the localization. In the case of the two fingers, however, such a control was still possible when the positions of the fingers in the visual field did not exactly correspond each to that of the opposite finger in pre-experimental sight, or when the contacts fell on relatively different spots on the two fingers, that is, on spots which did not mutually correspond. With the thumb and forefinger, as above described, it is true that, when attention was somewhat withdrawn from vision and given more to touch, I could voluntarily feel my thumb on the opposite visual side from the one on which I saw it; yet there was no reference of the two sensations of contact to the same member, or an identification of the felt thumb with

the seen finger, as was usually possible with the two index fingers. In several cases, though, the visual perception of the source of the peculiar sensation of contact kept also the touch-sensation fixedly on that side where its source was seen to be; or even gave a sudden and surprising reversal to the whole localization, when this had been based on only a vague and partial report from sight. This reversal of localization occurred several times when I was not directly experimenting on the matter, and furnishes an interesting parallel to the results more deliberately obtained. More than once, as I sat with both hands in sight, holding a tablet of writing-paper, a sensation coming from one hand—the feeling of a single loose sheet projecting beyond the others—was involuntarily referred to the visual perception of the *other* hand. But as soon as I saw where the cause of the sensation visually lay, then the touch sensations immediately went over to this latter position, changed hands, in other words, and could not even by effort of will be felt as at first.

Localization of sounds, when the source of the sound was in sight, followed in most cases the visual position of the source, provided I did not voluntarily recall the older position of the object. And since the compass of the visual field was about 45°, the actual divergence from the older localization of the sound could thus be about as great as the diameter of the field of view. For when the source of sound was seen at the border of this field, its older localization would have been on the opposite side of the field and at an equal distance from the center. When the source of the sound was out of sight, a much greater divergence of localization was possible. For in walking I actually felt my feet striking against the floor which I saw extending into the (old) upper side of the field of view before me; and the sound of my steps seemed to come from the place where I felt my feet strike—in this case a divergence of 180° from the old direction of the sound. But when I felt my feet in the old place, the sound too seemed to come from that direction.

In the evening, after I was blindfolded, the play of imagination was almost exclusively in terms of pre-experimental vision.

(To be concluded.)