DISCUSSION AND REPORTS.

PROFESSOR JUDD'S ILLUSION OF THE DEFLECTED THREADS.

In the number of this REVIEW for May, 1898, Professor Judd described a novel optical illusion, the peculiarities of which he regards as confirmatory of a particular doctrine of space perception. So far as I know, Professor Judd's proposed explanation of the matter has thus far stood unchallenged, for the reason, perhaps, that readers of space literature are more and more well disposed towards the general position that his conclusions represent. The essentials of the illusion and its explanation may be briefly recalled. Two threads, lying in different horizontal planes, are stretched across a box in such a way that their intersection forms an acute angle. The line of sight of the observer should form an acute angle with the planes of the threads. Under these circumstances there are obviously two points of intersection of the threads, one for each eye. Alternately closing either eye will reveal the location of these two monocular points. It is in the region between them that the following illusion occurs. With both eyes open, choose a fixation-point midway between the two threads, in about the middle of the region just mentioned. If this point of fixation be properly chosen, two illusory threads will suddenly appear lying at the right and left respectively in *vertical* planes and thus joining the two actual threads. Their slopes are not identical. One is nearly perpendicular, the other inclines strongly down and away. If viewed from the side they would appear in the form of a somewhat distorted X. The explanation offered is this: Each eye alone sees a pair of intersecting threads without being able to perceive any difference of depth between them. For a single eye the threads appear to lie in one plane and cross at a point peculiar to that eye. Binocularly, however, there are differences of depths perceivable. With both eyes open, therefore, there are two monocular points in the binocular field. Accordingly vision is under the necessity of somehow adjusting itself satisfactorily to both sorts of demands, the monocular as well as the binocular. The result is the two illusory threads running through the third dimension and connecting the mon-

ocular crossing points. The theoretical deductions are wholly along the line of emphasizing the importance of *binocular* factors in all visual perceptions of depth. Impressions that are strictly *monocular* have no definite meaning in terms of distance, whether relative or absolute.

Now while I am in most hearty accord with the general position towards space perception that Professor Judd has expressed both here and in other papers, I cannot see my way clear to accept the connection that he makes between this particular illusion and his theoretical comments. For I have recently become convinced that the experimental analysis of the illusion was, if I understand it, deficient in several critical points. And, unless I am greatly deceived, a much more simple and straightforward explanation than the one originally given must be accepted.

In the first place, inclination of the line of sight to the planes of the threads is not at all necessary. In fact the definiteness of the illusion is perhaps greatest when the line of sight is perpendicular. And, what is vastly more important, *there is absolutely no necessity that the monocular crossing points be in the field of view at all.* Two strips of black cardboard may be so placed upon the edges of the box in which the threads are stretched that the two eyes may clearly see the region between the two monocular crossing points while these points themselves are screened from view. The illusion is now only the more vivid. Yet under these circumstances there can be no thought of a necessary adjustment to two sets of relatively conflicting factors. The cause of the illusion must be sought elsewhere. I find this cause to lie solely in the particular fusions of images which take place when the point midway between the threads is fixated. What happens may perhaps be most clearly described by noting what changes take place in the binocular images as the point of fixation is raised from a position *below* both threads. The following figures represent these successive changes. Let the threads be stretched so that the upper one runs from left to right, the lower from right to left. Let *a* and *b* designate the images of the two threads received by the right eye, *c* and *d* those received by the left eye. Whether the image comes from the upper or the lower thread will be indicated by the letters *u* and *l* respectively. Finally let *R* and *L* be the inclusive or single designations for what is seen by right and left eye respectively.

Fig. 1 presents the case where the point of fixation is below the level of both threads. There is no fusion of double images. The pairs *ab* and *cd* are upon disparate points, and of course four sepa-

rate impressions are received, the double-images being of the 'crossed' variety. In Fig. 2 the fixation-point is on the lower thread. The images *b* and *c* have united. Crossed double-images of the upper thread remain. In Fig. 3 the fixation-point is raised to the upper

FIG. 1. Fixation-point on bottom of box.

FIG. 2. Fixation-point on lower thread.

line, whereupon *a* and *d* fuse. Uncrossed double-images of the lower line remain. In Fig. 4 is depicted the state of things when the fixation-point is *between* the threads.¹ *a* and *d* have not come near enough to fuse, as in Fig. 3, while at the same time *b* and *c* no longer fall upon corresponding points, as in Fig. 2. The entire process due to the successive fixations is, of course, to be pictured first as an approach, then as an over-lapping, and finally as a crossing over of the two monocular fields. Now Fig. 4 gives the stage of most perfect *over-*

FIG. 3. Fixation-point on upper thread.

FIG. 4. Fixation-point between lower and upper thread.

lapping. Each image of one eye falls obliquely upon an image of the other. Consequently the images must fuse at and about the points of intersection, for the simple reason that the latter represent correspond-

¹ A movable fixation-point within this region may be conveniently secured by introducing a wire, or something similar, through an opening in the side of the box.

ing retinal points. And just in this state of partial fusion of two linear images,—such fusion that crossed double-images remain on one side of the point of fusion while uncrossed double-images remain on the opposite side,—just in this state lie the indispensable conditions for the perception of lines running obliquely towards or away from the eyes. Any straight line (*e. g.*, a piece of wire viewed against a uniform background) will, when held so as to slope obliquely *towards* the eye, present the right hand cross of Fig. 4. A line sloping *away from* the eye will appear as the left hand cross of the same figure. The double-images existing on both sides of the fused point of fixation are often hard to see, but they are none the less there. Running the point of sight along the perceived direction of either illusory line brings about their progressive fusion, exactly as when the eyes pass along an objective line of a similar slope. And herein, of course, lies the ground for any and all perceived linear *directions*. For any such perceived direction means neither more nor less than that the point of sight must necessarily take this course in order to bring the various binocular impressions of the line upon corresponding points. If this view of the matter is the correct one, nothing but the universal laws of tri-dimensional vision are here in operation. Vision is not adjusting itself to novel conditions supplied by the experiment. It is simply behaving as it always does in constantly recurring experiences of everyday life.

Several further facts are to my mind entirely confirmatory of the position above taken. It will be remembered that, when two rows of retinal elements are in *complete* fusion, the resulting perception is that of a line perpendicular to the line of sight. The necessity for such perception under these conditions was, as the reader will recall, the explanatory basis of the interesting illusion described by Mrs. Franklin in Vol. I. of the *American Journal of Psychology*. In fact the illusion here in question is at bottom only a complication of that. Both involve identical principles. But to return. By properly adjusting the line of sight to the planes of the threads, one of the illusory threads may be made to lie perpendicular to the line of sight. As things were arranged in my own experiments, this phantom thread could be made to appear at the *right*. Meanwhile the phantom thread at the *left* assumed a marked slope. And at the same time this latter thread possessed neither the solid color nor the spatial stability of the former. While the former remained steadily there, the latter tended to break up into its components and vanish. The double images of the latter were too obtrusive, though a proper movement of the point of

fixation could successively unite them and keep the line alive. With the line of sight perpendicular to the planes of the threads—the position recommended above—the slopes of the illusory threads are the same, though in different directions. And in this case both threads are seen by careful gazing to possess double-images on both sides of the region of fusion. In fact one is reminded of the appearance of the lines in the stereoscopic view of a truncated pyramid. The double-images are essentially the same in the two cases.

A still further observation adds a strong bit of positive evidence. An entirely new form may be given the illusion by supplying a new objective condition. Stretch a third thread along the bottom of the box and parallel with its sides. Let it lie midway, laterally, between the monocular crossing points of the original threads. We have now three threads at different levels. Fixate the middle one at the proper point, and the impressions from the upper and lower will unite to form the perception of two phantom threads, similar to those with which we are already acquainted, but longer and with a greater distance between them. Here, as in the original case, the various monocular crossing points may be entirely screened from view.

In view of these various considerations I cannot refrain from the conclusion that Professor Judd's illusion presents no new visual principle. To say that it is due to the necessity of satisfying demands imposed by the presence of monocular factors in a binocular field is hardly more than to give a general statement of the conditions under which the illusion is to be seen. It is certainly not a true *explanation* that is thus offered. But however that may be, I am convinced that we have before us in this illusion only a particularly interesting case of what is eternally happening whenever we open our eyes to see.

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VOLITION AS A SCIENTIFIC DATUM.¹

The writer would willingly be in error in his apprehension of a certain tendency apparent in recent discussions in psychology, which, if real, is unwholesome in its effects upon the development of the science. In many directions, the effort of listening with obedience to the behest of the age that all knowledge and all doing shall be made 'scientific,' seems to be repeated in as many renewed forms. As psy-

¹ Read before the American Psychological Association, New Haven, December, 1899.