also corroborate Miss Gamble's findings that the perception of distance depends mainly, if not entirely, upon intensity.

The most extensive experiments are those of Ferree and Collins (2). Their object was to demonstrate three arguments for the binaural ratio of intensity. (a) Observers naturally more sensitive in one ear should show a constant tendency of displacement toward that ear. (b) Observers in whom a difference in acuity is produced artificially should manifest the same tendency. (c) A natural tendency toward right or left displacement should be subject to correction by making the proper change in the ratio of acuity.

The experiments were conducted by means of Titchener's sound perimeter. The stimulus was a 20,000 vibration Galton whistle tone. The acuity of the ears was determined by the watch test. Ten observers were employed, but the records of only three are given.

One observer whose ears were equally sensitive showed a slight displacement of 2.1 degrees toward the right side. Another observer in whom the ratio of natural sensitivity of the right to the left ear was as 4 to 1 showed an average displacement of 20.3 degrees toward the stronger ear. The third observer in whom the ratio of sensitivity of the right to the left ear was as 3 to 1 showed a displacement of 10.7 degrees toward the stronger ear. Differences in acuity produced artificially yielded similar results.

Individual differences indicated by Dunlap were also found in these tests, but they seemed to be permanent in the same individuals.

A valuable part of this article is the historical survey of the field since the appearance of Pierce's work in 1901.

REFERENCES

1. DUNLAP, K. The Localization of Sound. *PSYCHOL. MONOG.*, No. 40, 1909, 1-16.
2. FERREE, C. E. and COLLINS, R. An Experimental Demonstration of the Binaural Ratio as a Factor in Auditory Localization. *Amer. J. of Psych.*, 1911, 250-297.
3. GAMBLE, E. A. McC. Intensity as a Criterion in Estimating the Distance of Sounds. *PSYCH. REV.*, 1909, 16, 416-426.
4. STARCH, D. and CRAWFORD, A. L. The Perception of the Distance of Sound. *PSYCH. REV.*, 1909, 16, 427-430.

TACTUAL AND KINAESTHETIC SPACE

BY ROSWELL P. ANGIER

Yale University

In his first paper (1) Basler investigates the problem, — how great must a movement of a stimulating point along the skin be in order, first, that the movement as such and, second, that its direction be

tactually just perceived? The apparatus consisted of a pencil of hard rubber tapering to a point about 1 mm. in diameter; this was inserted vertically near the fulcrum of a one-armed lever, moving horizontally, the free end of which moved along a scale. The magnification on this scale of the movement of the point was about 50. The part of the skin to be investigated was placed on a support over and in contact with the point which was then given various extents of movement along the skin. On the cushion of the forefinger movements of from .02 to .03 mm. were just perceived, with a pressure of from 3g. to 10g. The sensitivity of the forefinger is as good, concludes the author, as that of the retina at a distance from a moving object of 30 cm., at which distance a movement of .02 mm. is just perceptible.¹ The results were unchanged when, instead of a point, a straight edge, or a disc, 4 mm. in diameter, with a rough surface, was used on the skin. On the forearm, about 4 cm. (proximally) from the hump of the scaphoid bone, the threshold was from .5 to 1 mm. These results are smaller than those of Hall and Donaldson,² doubtless because the movement of the point was oscillatory (about 10 back and forth movements for each observation) while Hall and Donaldson made for each only one movement.

The perception of direction was not so accurate, the threshold being about .05 mm. for the finger—a smaller sensitivity than for the eye.

Since the thresholds obtained in these experiments were much smaller than those obtained by v. Frey for successive touch, the explanation doubtless is that the moving point occasions slight displacements of the skin which in turn stimulate the sensory touch endings.

In the second paper (2) Basler studies the minimal speed of a distinguishable movement on a touch area. The finger rested on a fixed cork surface with the finger cushion over a hole 1 cm. in diameter; from below an ebonite point (1 mm. across) just touched the finger. This point was fixed vertically to a horizontal rod movable at any desired speed by a clockwork. The end of the rod was provided with a marker recording on a kymograph. A Jaquet chronograph was used for the time line. After the clockwork had been started (the

¹ BASLER, A. Über das Sehen von Bewegungen. II. Mitt. Die Wahrnehmung kleinster Bewegungen bei Ausschluss aller Vergleichsgegenstände. *Arch. f. d. ges. Physiol.*, 1908, 124, 313-325.

² HALL, G. ST. AND DONALDSON, H. Motor sensations on the skin. *Mind*, 1885, 10, 557-563.

kymograph having already been set going) the subject was to state whether he felt a movement. The movement of the point was transverse to the finger axis. After practice the threshold was (for the left forefinger) .05 or .06 mm. At the threshold a movement would often not be felt for several seconds. For the ball of the thumb the threshold was about double, a line of hard rubber, 4 mm. long and moved at right angles to its length, being used, however, instead of a point. For the forefinger the *direction* of movement was always distinguishable at a speed of .15 mm. per second. A subsidiary experiment concerned the rapidity with which voluntary movements for the purpose of tactual estimations (*tastende Bewegungen*) of objects are made. A wire arch was placed over the dorsal side of the forefinger and attached to a movable horizontal rod which recorded on a drum. The volar side of the finger tip could thus be moved back and forth transversely over wires of various diameters wound closely about pieces of cardboard. The subject was simply asked to feel the presented surface and decide whether it was smooth or rough. The average normal speed of such movements, in different subjects, was 30 to 40 mm. per second, the slowest being 17 mm. and the fastest 100 mm.

Treves (3) reports a series of experiments on blind children of different ages testing the accuracy with which they could reproduce positions of the limbs, execute movements of given directions and extents, draw lines and figures (verticals, horizontals, squares, right angles), etc. They were designed chiefly to suggest practical exercises in educating the blind.

REFERENCES

1. BASLER, A. Über die Grösse der mit der Haut eben wahrnehmbaren Bewegungen. *Arch. f. d. ges. Physiol.*, 1910, **132**, 494-510.
2. BASLER, A. Über das Erkennen von Bewegungen mittelst des Tastgefühls. *Arch. f. d. ges. Physiol.*, 1910, **136**, 368-401.
3. TREVES, Z. Beobachtungen über den Muskelsinn bei Blinden. *Arch. f. d. ges. Psychol.*, 1910, **16**, 279-306.

SPACE ILLUSIONS

BY PROFESSOR HARVEY CARR

University of Chicago

Foucault (10) contributes a critical digest of the literature on the paradoxical illusion and the two point threshold. He is able to suppress or produce the illusion at will mainly by a manipulation of