

his visual illusion of the cabin as a fixed frame of reference may be corroborated by false evidence from his semicircular canals and all other physiological means of sensing what is horizontal. With all these senses combining to mislead him, it is no wonder that he may discredit the little glimpses of the ground through these small and distant and apparently stationary windows.

After the wheels touch, the aerodynamic drags weaken gradually, but the wheel brakes take their place and the backward acceleration may not change much. So it is reasonable that the illusion should persist sometimes nearly to the end of the run. Then, when the ship wheels around and the engines start up for taxiing, the acceleration is quickly changed from backward to forward; so in the cases observed by Moore, "the phenomenon abruptly ceased."

To create this illusion, and to maintain it during the change from aerodynamic drags to wheel brakes, the ship must indeed have to be handled very smoothly. But these airline pilots are smooth!

On the practical question of the possibility of a pilot being misled by this illusion, it must be noted that experienced pilots are already disillusioned as to their sense of level, and they are also well trained on how the ground should look in a landing.

This does not mean any lack of use for the sense of level, but only that its use is not what the layman would expect. The principles applied above, to explain Moore's phenomenon, apply also to turns. In them, centripetal acceleration acts like the backward acceleration in a landing, to mislead our sense of level. The only difference is that in the turn it is not through the side windows, but ahead, that the horizon appears not horizontal. If the ship is correctly banked for the turn, however, she seems level to all senses but that of sight. So the pilot uses his internal senses of level to find the correct angle of bank, well knowing that what he senses is not really level, and he uses his eyes to find the true level.

This separation of the internal and visual senses of level, and their concurrent but independent uses for different purposes, is therefore a very important part of piloting. The ability to separate them has to be acquired in learning to fly, because flight is the only activity in which accelerations can grow so smoothly and with so little angular velocity as not to warn us of the difference between acceleration and gravity. Having acquired this ability, however, and having had to put some real effort into its acquisition, the experienced pilot can be counted on to apply it in landing on any airport that he can see. So there is no appreciable chance of his being misled by Moore's illusion.

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SPATIAL DISORIENTATION DURING LANDING FROM AIRPLANE

THE type of spatial disorientation reported by Professor A. D. Moore¹ in connection with the landing of an airplane is by no means unknown to experimental psychologists, although too little attention has been paid to it in the literature on space-perception. The basic principle, as Professor Moore suggests, is that of the conflict of two spatial frames of reference, both of which reside in the visual field of the observer, but one of which is more closely related to the directional system of the observer's body. The ground, as seen through the near window, occupies a sufficiently large visual angle to dominate the perceptual process and consequently to provide a "true" system of horizontal and vertical directions. As seen through the far window it is imbedded in the framework of the interior of the plane, and is consequently seen as tilted. The underlying principles have been discussed, although with different examples, by Koffka,² Wertheimer³ and others, and the phenomenon has even crept into at least one elementary text-book.⁴

Whether or not this is a newly discovered phenomenon is, however, of no importance. What is to be emphasized is that this type of "illusion," and the underlying psychological principles, may too easily be overlooked, not only in aviation but in any field of activity in which the perception of space is an important factor. In seeking for the determinants of our perception of spatial directions we are apt to concentrate on the vestibular functions to the neglect of visual organization. In the example which Professor Moore cites, the problem is essentially visual. I am inclined to think that the solution which he proposes will not prove satisfactory. It might be noted, however, that a sub-committee on problems of perception has recently been organized in connection with the program of the National Defense Research Committee. The problem might well be referred to this committee.

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THE HEAT OF SEROLOGICAL REACTIONS

THE only attempt to measure directly the heat of an antibody-antigen reaction known to us is that of Bayne-Jones.¹ It is generally admitted that his result is much too high.² We have recently completed mea-

¹ A. D. Moore, *SCIENCE*, 92: 477, 1940.

² K. Koffka, "Principles of Gestalt Psychology," 1935.

³ M. Wertheimer, *Zsch. f. Psychol.*, 61: 161-265, 1912.

⁴ E. G. Boring, H. S. Langfeld, H. P. Weld, "Introduction to Psychology," 1939.

¹ S. Bayne-Jones, *Jour. Immunol.*, 10: 663, 1925.

² F. C. Smith and J. Marrack, *Brit. Jour. Exp. Path.*, 11: 494, 1930.