why the hyoid bones do not articulate at all with the skull, why the malleus is outside the ear, and why there is apparently but one ossicle in the tympanum, of the particular shape shown in fig. 3.

(To be continued.)

THE PSYCHOLOGICAL MECHANISM OF DIRECTION.

Were it admissible that one person should add to the work of a living author, I might call this paper a supplement to Mr. Francis Galton's Human faculty. My object is to explain the subjective mechanism by which I preserve the consciousness of direction. How far others adopt the same mechanism, I am not fully aware, but am inclined to think that what is fundamentally the same system is employed by nearly every one; but I doubt whether the details are always the same, and the matter appears of sufficient interest to be discussed.

To be conscious which way he is going, one must keep in mind some system of directions. It is true, that, so far as finding one's way about in a place with which he is fully acquainted is concerned, no attention to direction is necessary. One knows that he must turn here to the right, and there to the left, and must follow certain familiar paths, all of which he can do without attending to direction. It is probable that most animals, and possible that some men, have no system except this. Regarding such a limitation as exceptional, we must suppose that in general, men, in going about, have constantly in mind an idea that they are going in a certain definable direction. A direction can, however, be defined only by reference to the direction of some line taken as a standard of reference; and it is this standard of reference, as I have always employed it, which I shall now describe.

I. I continually carry around with me a conception of four horizontal lines, which I shall call co-ordinates, going out in four cardinal directions. I shall call these directions east, west, north, and south; but it must be understood that they have no necessary relation to the actual points of the compass, being purely subjective. This system of co-ordinates is employed, I think, by most or all men.

II. These four cardinal directions are conceived of as *absolute* directions, and not as defined relatively to any particular line on the earth's surface. They have remained unchanged since the earliest memories of childhood. To be more explicit, the ideal or subjective west is the direction in which I was facing, when, as a child, my father explained to me which was the right hand, and which the left; the ideal north is the direction towards which my right side was then turned; the ideal south, that towards which the left side was turned; while east was behind my back.

I have always since imagined myself as conscious of these four absolute directions, and therefore at any moment can face as I imagine myself to have been facing on the occasion referred to. I do not know whether the co-ordinates have the same absolute character with other men, but think it highly probable that they do, since absolute directions must be more easily thought of than relative ones.

III. With some limitations, to be soon referred to, the system of directions is quite independent of the will. Once fixed in a place, a street, or a house, they are an inseparable component of the situation, and forever unalterable so long as the identity of the place is recognized. Once in a room of which I conceive a certain side to be the absolute west, by no act of the will, and by no consciousness that some other side is the west, can I change the subjective impression. Of course, however, one is liable on going into a strange place, or on walking about without sufficient attention, to be mistaken as to his direction; and thus I am subject to a kind of trouble or confusion which I never heard any one else describe, and which, therefore, I can hardly suppose to be universal. Some instances will illustrate the matter better than general statements.

I recently went to a hotel in Paris, where I had stopped eight years before. While driving into the court, and just as the carriage was stopping, my attention was momentarily occupied in speaking to one of the attendants. Getting out of the carriage, I remarked, as I supposed, that the offices of the hotel had all been moved from the north to the west side of the court. I may anticipate by saying that this was an illusion arising from the very minute circumstance that the carriage, during the moment that I was speaking to the attendant, had turned at a right angle from facing north to facing east; but being unconscious of this change, and not looking around the court, I supposed that the carriage was still directed towards the ideal north. I entered the elevator, was carried to an upper story, shown through several long passages, and into a room, preserving the changed system of co-ordinates of which I was entirely unconscious. Had it been my first visit to the hotel, no confusion would have resulted, since every thing

around it would have been referred to this same system; but I entertained a distinct idea of the orientation of the rooms around the court as they existed in my mind during my former visit. The result was, that when I went down to dinner I found my co-ordinates 90° wrong. But I was absolutely powerless to refer the two parts of the hotel to the same system. During the week that I remained, whenever I went from my room down-stairs, to the court, the reading-room, or the dining-room, there was a momentary confusion on reaching the point where I saw that the system was wrong. Momentary glances around, and the co-ordinates changed 90°. On returning to my room, the co-ordinates below were carried up-stairs with me, because there was nothing on the stairway with which I had become sufficiently familiar to fix either set of co-ordinates; and thus one system obliterated the other, as it were. In consequence, I could carry one set all the way down, and another set all the way up; the change occurring at the bottom of the stairway in one case, and at the top in the other. The result was, that during my stay I got no clear idea where my room was situated, or what buildings I saw through the window.

To mention another instance: I lived for a number of years in a house in which I must have made a similar mistake the first time I entered it; since, during my whole stay, the orientation inside the building was 90° different from that outside. In the case of such an inconsistency as this, I find that the orientation corresponds to that of the place to which the attention is directed. So long as I was inside a room, or so long as my attention was directed to things inside the house, there was one orientation. On raising the window, and taking a good view of the street, I would perceive that this orientation was 90° in error; and after a momentary confusion the street would assume its right direction. The reverse change would recur on turning back to the room.

I find this occasional inconsistency of orientation, to which I am very liable when I pay no attention to directions on first entering a house, to be really troublesome. It has twice happened quite recently, that, on going up-stairs in a hotel on my first arrival, I got the co-ordinates reversed 180°. The result was, that unless I staid long enough to go right by mere habit, without thinking about the direction, I was continually in doubt about which way I should go to find the room I wanted.

IV. I find that this fixity of co-ordinates holds in any kind of a building, and in a ship, but not at all in a carriage, and not absolutely in a railway-car. If I am conscious, by looking at surrounding objects, that a railway-car turns 90°, I can change its relation to the system of co-ordinates accordingly. It appears, therefore, that it is only in fixed structures that the co-ordinates inure in my conceptions of enclosed space; yet I feel perfectly sure, that, if a house in which I lived be turned through 90° or 180°, the system would turn with it, in spite of any thing I could think to the contrary.

V. I now come to the modifications of fixity to which I have already referred. The imaginary sense of direction is not absolutely always present. In travelling over a new road to a new place, the sense of direction is, for the time being, apt to be lost. In this case, and in this alone, it is to a certain extent under control of the will; but, if the will fails to act promptly on arriving at a place, the co-ordinates fix themselves, as it were, and that quite arbitrarily, so far as I have been able to perceive. Once fixed, they stay. But, while under control of the will, I am in the habit of so directing them that the ideal directions shall correspond to the points of the compass, in case I know them.

VI. I have recently noticed that it is not necessary that I should actually have seen a place, in order that the co-ordinates should be fixed in it. If I study on a map a place which I am to visit, I unconsciously fix the co-ordinates to correspond to the points of the compass. Thus, on arrival, I readily find my way about. But it may happen, that, when I arrive, I am mistaken as to the direction in which the railway-station stands. Then, take what pains I will, the same confusion arises when I arrive at a street or hotel which I have studied on the map, and find the co-ordinates to be wrong. The directions change to those in which I have thought of the house or street.

Of this fixing of the co-ordinates in advance, I recently had a curious example. I got on board a steamship at Liverpool, resolving that the ideal and real west on board ship should correspond. I went down to seek out my state-room, and, on returning to the deck, I was chagrined to find that the co-ordinates had got changed 180°. In consequence, I had to think before knowing which side of the ship I looked at. For some time I was puzzled to imagine how the mistake could have occurred. I finally traced it to the fact, that, on studying the position of my state-room on the plan of the ship a month before, I had held up the

plan with the stern in the direction in which west is on the map. I constructed the orientation of the passageway and of the state-room accordingly. It happened, that, when I joined the ship, her stern was towards the east; but, on descending into the cabin for the first time, I fixed the orientation to correspond to the one previously formed from the plan, forgetting at the moment that I was thus making a change of 180°.

VII. A universal law of the four cardinal directions is, that they always arrange themselves along visible lines, such as roads, boundaries of a room, etc.: in other words, the directions never subdivide themselves. In going along a new road which I know ought to bisect the angle between two directions, I can, by an effort of the will, imagine it to do so; but, the moment attention is relaxed, one cardinal direction is sure to take possession of the road, and of course, once in possession, keeps it: so, no matter how well I may know that the walls of a room are at an angle of 90° with the other walls of a building, the directions are sure to arrange themselves parallel to the walls.

It may be asked, How does this system work, in case of a number of rooms radiating like a fan from a central space? I answer, that in such a case my ideas of direction simply get unutterably confused, and only by long habit can I get the relations of the different rooms to each other. SIMON NEWCOMB.

THE ARAGO LABORATORY AT BANYULS.

AMONG the zoölogical stations or laboratories along the coast of France, none is more widely known or more firmly established than the laboratory at Roscoff,[1] in Finisterre, organized in 1872 by Professor Lacaze-Duthiers as an adjunct of his zoölogical laboratory of the Sorbonne at Paris. Encouraged by the success of his laboratory at Roscoff, which during August, 1881, had twenty-five workers, but which, owing to its exposed position at the north-west extremity of France, was only available for work from March until October, at the most, Professor Lacaze-Duthiers sought to establish a winter laboratory on the Mediterranean, to furnish seaside work the remaining months of the year. After careful examination of the French coast of the Mediterranean, a location was chosen for the laboratory at the base of the rocky promontory of Fontaulé, at the entrance of the little harbor of Banyuls-sur-mer, within a few miles of the Spanish frontier in the department of Pyrénées-Orientales.

The municipal council of Banyuls, through the mayor, M. Pascal, who took much interest in the establishment of the laboratory, offered a site for building, twelve hundred francs for immediate use, and an income of five hundred francs annually for twenty years; M. Thomas, a wealthy gentleman of Banyuls, offered two hundred and fifty francs annually for ten years, and a boat; the council of the department of Pyrénées-Orientales voted twenty thousand francs toward the construction of the laboratory; and subscriptions were received from the citizens of this rich wine-producing neighborhood. These were some of the means employed to induce Professor Lacaze-Duthiers to locate at Banyuls. Port Vendrès, a neighboring village, offered inducements to locate there; but the great number of fishermen in Banyuls, its nearness to the open Mediterranean, and its freedom from the distractions due to commercial and other activities, together with the earnest interest taken by its inhabitants in the laboratory, won the choice of that village. What a novel sight it would be, here in America, to see villages contesting for the honor of possessing a scientific laboratory! The Academy of sciences at Paris took the laboratory under its protection; and the establishment was called 'Laboratoire Arago,' to honor the name of the most distinguished *savant* of the Pyrénées-Orientales, a former member of the academy.

It is, of course, impossible to speak of much work already accomplished at the Arago laboratory, as one might describe studies completed at Roscoff; for the laboratory at Banyuls was scarcely finished in the winter of 1881–82, when, with another American and a French student, I had the pleasure of being one of the first to work within its walls: so I will write only of the region and of the laboratory.

The eastern end of the Pyrenees descends suddenly upon a north and south coast by a series of radiating ridges, between which are small indentations of the sea, forming harbors, with rocky promontories at each side of their entrances, and a sandy beach within. This kind of coast offers numerous advantages to those searching for marine animals. On each of the larger of the beaches are villages, most of which date back to Roman times. These villages were recently connected by a railroad which follows the coast, passing through tunnels between them.

Banyuls is situated upon one of these beaches, at the head of a small harbor, which is partly

[1] For a detailed account of the laboratory at Roscoff, with maps and plans, see *Revue scientifique*, Nov. 26, 1881, xxviii. 673–680.