generation while the sensory do not. He seems to think that ordinary motor fibres give off finer branches that are vaso-motor. He gives figures of his presumably sensory nerve-endings, but does not really give much proof that muscle, as distinguished from the connective tissue of muscle, possesses sensory nerve-ending.

A. D. W.

Langendorff (*Pflüger's Arch.*, 1894, p. 521) finds that the surprisingly rapid loss of irido-constrictor power of the motor oculi *post-mortem* is due to the intervening ciliary ganglion. Excitation of the third nerve above the ganglion quickly ceases to produce any effect. Excitation of the third nerve below the ganglion has a powerful effect long after death, *via* the short ciliary nerves. Constriction of the pupil *post-mortem* is conveniently demonstrated on the rabbit's eye by laying the optic stump across the electrodes; this excites the long ciliary (dilators) as well as the short ciliary (constrictors), but constriction predominates. The ciliary ganglion, then, is a ganglion traversed by motor fibres, and not an analogue of posterior root ganglia.

A. D. W.

Betheiligung der Nerven an der Schwankungen in der Pupillen Wiete. *Pflüger's Archiv.* June 1, 1894.)

Excitation of the cervical sympathetic causes, in addition to the well-known dilatation of the pupil on the same side, reflex constriction of the pupil on the opposite side, presumably due to retinal excitation of the eye whose pupil is dilated. Excitation of the central end of the vagus gives reflex constriction of the pupil on the same side, reflex dilatation on the opposite side. These effects vary with the state of excitation of the animal (cat, rabbit).

A. D. W.

Wundt on Psycho-Physical Interactions.

In a recent number of *Philosophische Studien* (x. 1, *Ueber psychische Causalität, und das Princip des psychophysischen Parallelismus*), Wundt points out that psycho-physical interactions are two-fold: physico-psychical (centripetal) when the

external stimulus produces a psychical result in the organism, resulting in *sensation*; psycho-physical (centrifugal), when the psychical process, *e.g.*, will, motives, has a physical effect and produces *movement*. There is thus an empirical basis for psychophysics, but it is needful to protest against the current tendency to conclude that this covers the whole field of psychology. For example, the parallelism can only apply to processes of consciousness. The physical concomitants of *unconscious* psychical processes can only belong to metaphysics, and again no association of physical processes can explain the nature of the connection between psychical elements any more than our ideas are able to throw light on the physiological processes which accompany them. Wundt criticises sharply the "materialistic psychology" of Münsterberg and Ziehen. These psychologists, he says, throw "matter" out of the window as unthinkable, and bring it in again under the name of "material processes." They affirm matter to be a hypothesis, and yet use it to explain psychological phenomena. The old materialism at least believed in "matter" *per se* and in its molecular motions. Here we have really a new metaphysic, the more dangerous in that it is sheltered behind the theorems of natural science. Experimental psychology, moreover, reduces psychological processes to anatomical elements, until it seems almost superfluous to maintain with Münsterberg that psychology is a science. It rather appears as an appendix to muscular contraction. The real subject of psychology is not the physical but the psycho-physical individual. "Bad analogies," concludes Wundt, "are intellectual opiates," and the soul is not explained, though it may be interpreted, by reflex determinism. The rest of the number is occupied by articles on *das Mass-princip der psycho-physik*, by F. Lange; *die Abhängigkeit-zwischen Reiz u. Empfindung*, Merkel, part iv., and Dr. Van Biervliet's account of experiments to show that the duration of reaction-times is considerably affected by the pulse-rate.

II. *Die Empfindung als Funktion der Reizänderung*. Ebbinghaus's *Zeitschrift für Psychologie u. Physiologie der Sinnes-organs* (vii., 4). Preyer extends Du Bois-Reymond's law of muscular contraction in response to electrical excitation, to all sensory and motor nerves, in response to any adequate stimulus. He finds that the threshold of sensation may be considerably raised with a continuous and steadily increasing stimulus, whereas sudden changes or interrupted stimuli produce sensations at a lower level. The sensation or the contraction corresponds, not to the actual magnitude of the stimulus, but to its alteration from

moment to moment, and is also determined by the rapidity and time-duration of the stimuli. The nervous system has in its evolution learned to respond to marked and rapid changes of excitation, rather than to small or steady stimuli. In a former number of the *Zeitschrift* (vi. 472) Scripture had given applications of the same law to changes of sound and of temperature. A very gradual change of stimulus may raise the pitch as much as a whole tone imperceptibly, whereas more rapid changes produce an immediate change of sensation. In temperature changes, also, a gradual rise of 10° C. or more may be unnoticed, although a sudden change of $\frac{1}{4}^{\circ}$ is perceptible. The unnoticed pressure of the atmosphere is another instance. In *Zwei Fälle von Grünsehen* (*ib.*, p. 305), Somya draws attention to the rare phenomenon of chloropia or green vision. He attributes it to minute changes in the choroid, and not, as has been supposed, to retinal modification.

In regard to the question of central, *versus* peripheral, fusion of sense-impressions in the case of sound, Wundt (*Phil. Stud.*, viii., 641, 1893, *1st der Hör-Nerv direct durch Tonschwebungen erregbar*) sums up the arguments of Scripture and Karl Schäfer, as well as the earlier work of Cross and Goodwin, and Sylvanus Thompson. The conclusions of Scripture (and also of Ewald) run counter to the theory of specific nervous energies, according to which each auditory fibre can convey one tone only, whatever the nature of the stimulus. Wundt refers to other analogous phenomena equally unfavourable to this theory, *e.g.*, the beats and beat-tones of König, which indicate that beats can arise in the brain without interference at the periphery, and that direct periodical stimulation of the auditory nerve can, at a certain frequency, give rise to tone-sensations. Even if we accept the theory of Helmholtz, it connotes a mechanical excitation of the nerve-fibres at the organ of Corti; and it is equally conceivable that direct excitation of the nerve might occur without peripheral intervention. Ewald, in his investigations on the end organs of the auditory nerve, found that pigeons whose labyrinths had been extirpated still reacted to auditory stimuli, whence he concluded that the sound waves directly stimulated the stump of the nerve by transmission through the bones of the cranium. A later series of observations (*Die centrale Entstehung von Schwebungen zweier monotonisch gehörten Töne*, *Pflüger's Archiv.*, June 1, 1894) seem to justify the same conclusion in regard to man. It would follow that when deaf people hear sounds conducted through the cranial bones this is not a proof, as is generally supposed, of the

integrity of the labyrinth. If the trunk of the nerve is capable of direct stimulation, the labyrinth might in these cases be completely disorganised. Again, if the nerve be thus directly excitable, the case for a central origin of beats is greatly strengthened, seeing that interference in the terminal apparatus is not an indispensable condition of their production.

K. Schäfer maintains that the bones of the cranium conduct sound from one ear to the other, thus making peripheral fusion. Ewald, however, arranged two tuning-forks so that they could each be heard by one ear only. One was tuned to give 130 vibrations per second, the other to a slightly higher rate. Heard separately there was no indication of oscillation; heard together there was a distinct and easily-counted beat. The conclusion is that sounds conveyed separately to each ear may be *centrally* fused into a beat. The beat moreover coincided with subsequent binaural observations with the same tuning forks. The case seems to stand upon the same footing as the analogous case of the eye, in which the balance of evidence is to the effect that two complementary colours presented separately to each eye may give rise to the sensation of a single resultant colour, the mechanism of which fusion must obviously be central.

Another interesting analogy between eye and ear is that established by Zwaardemaker (*Das presbyacousische Gesetz Zeitschrift für Ohren-heilkunde*. June, 1893. *Der Umfang des Gehörs in den verschiedenen Lebensjahren*. *Ebbinghaus Zeitschrift*. March, 1894) who formulates a law of what he terms presbyacousia. He gives a curve founded on 219 observations to show that the range of hearing of the upper notes diminishes from e 7 (41,440) max. in infants, to a 6 (28,160) or even g 6 (25,344) in adults. He refers to an earlier paper in proof of the same limitation in regard to the lower notes, which, however, he admits to be far more uncertain. In short, from the age of 4 to 70, hearing, he says, undergoes a continuous restriction, losing as much as half an octave. In the second paper he alludes to the inductively established fact that bone conductivity decreases with age. He connects the beginning of the decline curve of hearing with the end of bone-growth.

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