A

COURSE

IN

EXPERIMENTAL PSYCHOLOGY

BY

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PART I: SENSATION AND PERCEPTION.

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PREFACE.

THIS collection of experiments has passed through several stages and grown at every stage, until now Part I. is many times larger than the whole course as originally sketched, larger than any one is likely to use in its entirety, and almost too large to justify the title of a course at all. This I regret; but I take comfort in the thought that it will at least be easier for those who use the book to select what they need from it than from the sources from which it has been gathered. What a good laboratory course ought to include is not yet wholly clear, and can only be settled by trial; till this has been done a superfluous liberty of selection may not be wholly a disadvantage.

The experiments cover but a part of the experimental field, chiefly that of sensation and perception, though it is evidently impossible to take out any sort of mental phenomenon for entirely independent examination. In a subsequent volume, if I am able to prepare it, I shall hope to widen the course by chapters on voluntary movement, memory, attention, emotion, and other complicated mental states, in so far as they are open to experiments of moderate difficulty.

To some who turn its pages the book may seem rather a physiology of the special senses than a psychology of sensation and perception. This is not strange perhaps; but it should be remembered that the distinction between the two is not in the experiments themselves, but in the

perspective in which they are viewed. Whether or not the course is one in psychology or physiology must therefore be left in large measure to the user of it himself. In making the collection, I have tried to keep the line sharp in my own mind between those experiments that have a distinct psychological bearing, and those that do not; and while a considerable number of the latter have been included, they have been those that furnish data for other experiments, or are otherwise useful to the main purpose of the course. I trust that in this subordinate position they will not seem out of place.

Most of the experiments are demonstrational in character, and aimed at qualitative rather than quantitative results, even when for convenience they have been given a quantitative form. Precautions necessary for results of the latter sort have therefore been lightly touched upon. The setting of the experiments is generally the simplest, and the apparatus the least expensive, that promised satisfactory results. That no mistakes have been made, even from these points of view, is more than I can hope. I have been careful in the selection, however, and let the book pass from my hands with the hope that it may prove helpful both to those who have psychological courses to give and to those who shall by and by supplant it by a better one.

A few explanations are necessary with regard to particular portions of the book. The first six chapters remain, with the exception of insignificant changes, as they stood in the set of "advance sheets" printed in 1894. The literature from which they are drawn is therefore not later than the fall of 1893. I am sorry not to have brought them up to the date of the last three (the end of 1896), but to do so would have greatly delayed the completion of the work, if it had not prevented it altogether. The litera-

ture that has since appeared — some of it very important — can be followed in the excellent bibliographies of the *Psychological Review*, *Année Psychologique*, and *Zeitschrift für Psychologie*. A few points in the first six chapters had been marked for revision when opportunity offered. The more important of these have been taken up in the section of notes following the appendices (pp. 433 ff.). In three instances (pp. 16, 24, and 27) forward references to literature were made from earlier chapters to Chapter VIII.; but when Chapter VIII. came to be written, its plan was somewhat changed, and these references must therefore be cancelled.

The bibliographies include for the most part books and articles consulted in the preparation of the experiments. A few, however, have been merely scanned, and a very few have been taken at second hand. The purpose and scope of the bibliographies have been indicated more fully in the introduction to the first of them, p. 20.

It has been my intention by the references following the experiments to make full acknowledgment of my obligation to those from whom I have derived them. I may say here in addition, that, in the sense of wholly new experiments, there is hardly anything original in the book. My part in it has been one of selection and adaptation, and in the nature of the case could hardly have been anything else. Where obligations have been so great and to so many, it is difficult to choose for special mention, but mine have been very great to Helmholtz, Hering, Aubert, Wundt, Stumpf, and Goldscheider; and if what I say of the psychophysic methods is compared with Külpe's sections on the same subjects, it will be seen that I have taken advantage of his discriminating treatment of them. A good many of the diagrams used have of necessity been taken from the sources from which the experiments themselves

have been drawn, and are covered by the same references. For the loan of the blocks for several of the illusions in Chapter VII., I am indebted to the courtesy of Messrs. Charles Scribner's Sons and to Professor Joseph Jastrow; and for two of those showing disks for Weber's law, to Dr. August Kirschmann of the University of Toronto.

In a less tangible, but no less real way, I have been assisted by many of my colleagues in Clark University and elsewhere, and by many of my students, and here make grateful acknowledgment of the obligation. This is true especially with reference to President Hall, in whose lectures and seminary at Baltimore the study of several of the topics of this course was begun, and whose inspiration and encouragement have had much to do with its completion.

In the proof-reading and indexing I have been assisted by still others, whose unfailing helpfulness in other ways makes it seem strange to select this alone for mention.

E. C. S.

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TABLE OF CONTENTS.

CHAPTER VII. PAGE

CHAPTER VIII.

CHAPTER IX.

APPENDIX I.

APPENDIX II.

NOTES.

INDEXES.

LABORATORY COURSE IN PSYCHOLOGY.

CHAPTER I.

The Dermal Senses.

THE sense organs of the skin give us besides pain, tickling, shudder, and the like, the more special sensations of contact, heat, cold, and pressure. All these may be received passively when our members are at rest, or actively when our members are in motion, in which case special sensations of motion are blended with those just mentioned. We also assign to each sensation a more or less exact location. To examine some of these skin sensations is the purpose of this chapter.[1]

SENSATIONS OF CONTACT.

1. The Location of Touches. Touch yourself in several places with the same object, and analyze out, as far as you can, the particular quality of the sensation by which you recognize the place touched. This quality of a sensation is known as its "Local Sign."

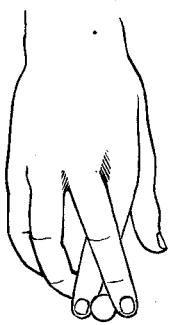
Lotze,[2] *A*, 328 ff., 405 ff.; *B*, 39 ff. Stumpf.

[1] As a general term for perceptions of touch in the widest sense, Max Dessoir (p. 242) suggests *Haptics* as an analogue of Optics and Acoustics. This he further divides into *Contact-sense* (including *a*, pure contact, and *b*, pressure) and *Pselaphesia*, from ψηλάφησις, touching, handling (including *a*, active touch, and *b*, "muscle sense").

[2] For full titles of books and articles referred to, see the bibliography at the end of the chapter. When several articles from one author are given, they have been lettered *A*, *B*, *C*, etc., and the references marked accordingly.

2. Location of Touches. Cause the subject to close his eyes; touch him on the fore-arm with a pencil point; and require him to touch the same point with another pencil immediately afterward. Estimate the error in millimetres and average the results for a number of trials, noting the direction of error, if it is constant. The subject must be allowed to correct his placing of the pencil if not satisfied with it on first contact.

3. Aristotle's Experiment. Cross the middle finger over the first in such a way as to bring the tip of the middle finger on the thumb side of the first finger. Insert between the two a pea or other small object. A more or less distinct sensation of *two* objects will result, especially when the fingers are moved. Some experimenters may find the illusion more marked when the pea is rolled about on the surface of the table with the crossed fingers, or when the third and little fingers are used instead of the first and middle fingers.



Aristotle, Hoppe, James, II., 86–87.

4. Eccentric Projection of Touches. Close the eyes, and tap with the tip of a cane on the floor, or, better still, on the walls and floor near a corner of the room. Notice that the origin of the sensations seems to be the tip of the cane and not the fingers or the arm. Attention to these parts, however, will show the true place of origin. If the cane is held rigidly at the lower end, there is little or no tendency to shift the sensations from the fingers and arm, unless the cane is limber. The eccentric projection of touches is only a special case of their location, and follows the same general laws. See also Ex. 41.

Weber, 483 f.; James, II., 31–43, 195–197; Dessoir, 219–232.

5. Judgments of Motion on the Skin. *a.* Let the subject close his eyes. Rest a pencil point or the head of a pin gently on his fore-arm and move it slowly and evenly up or down the arm. Require him to indicate his earliest judgment of the direction. If the experiment is carefully made, the fact of motion will be perceived before its direction.

b. Try a number of times, estimating the distances traversed in millimetres and averaging for the two directions separately. It will probably be found that the downward distances have been greater than the upward.

c. Starting from a fixed point on the fore-arm, move the pencil in irregular order up, down, right, or left, and require the subject to announce the direction of motion as before. Compare the results found with those found in Ex. 7.

Hall and Donaldson.

6. Feelings of Double Contact. *a.* If two parts of the body of like temperature are brought in contact, the two sensations do not blend, but the part that moves feels the one that does not; i. e., the sensations received by the moving part generally get more attention and are externalized. Try with the tips of the thumbs or fingers in contact. This general rule, however, has exceptions. Feel of the palm of the right hand first with the ball of the left thumb (which gives results in accord with the rule), then with the knuckle of the same thumb sharply bent. Light tapping of the forehead with the finger we feel in the forehead more markedly than in the finger, though usually with the hand on the forehead we feel the forehead.

b. If the parts are not of like temperature that which varies most from the normal bodily temperature will be felt by the other. Warm the right hand by holding it closed for a minute or two and then apply it to the forehead. The higher temperature will be perceived by the forehead, while

at the same time the hand as the more expert touch organ will perceive the form of the forehead. Cool the right hand by holding it a few minutes in cold water, dry it and apply it to the back of the left hand. The right hand may seem to be feeling of a cold left hand. In this case of course both the temperature and form feelings are credited to the right hand. If the temperature is not very different the direction of attention may dictate which shall be felt by the other.

Weber, 556–559; Dessoir, 229.

7. Weber's Sensory Circles. *a.* Find the least distance apart at which the points of the æsthesiometric compasses[1] can be recognized as two when applied to the skin of the fore-arm. Try also the upper arm, the back of the hand, the forehead, the finger-tip, and the tip of the tongue. Be very careful to put both points on the skin at the same time and to bear on equally with both. Cf. Weber's measurements as given in the text-books; also Goldscheider's (quoted by Ladd, p. 411).

b. Compare the distance between the points just recognizable as two when applied lengthwise of the arm with that found when they are applied crosswise. Compare the results found in *a* and *b* with those found in Ex. 5, but remember that this compass experiment requires the discrimination of the points.

c. Give the points a slightly less separation than that found for the fore-arm crosswise, and beginning at the elbow draw the points downward side by side along the arm. They will at first appear as one, later as two, after which they will appear to separate as they descend. Something similar will be found on drawing the points from side

[1] For the apparatus needed in this and later experiments, see the list and descriptions in the chapter on apparatus below.

to side across the face so that one shall go above, the other below the mouth.

d. Make the skin anæsthetic with an ether spray and test the discriminative sensibility as before.

Weber, 524–530, 536–541; Goldscheider, *B*, 70 ff., 84 ff.

8. Filled Space is relatively under-estimated on the skin. Set up in a small wooden rod a row of five pins separated by intervals of half an inch, and in another two pins two inches apart. Apply to the arm like the compasses above. The space occupied by the five pins will seem less than that between the two. A still simpler way given by James is as follows: Cut one end of a visiting card into a series of notches, and the other into one long notch so as to leave two points as far apart as the outer points at the other end, but separated by an empty interval. Apply to the skin as before. This illusion, though very clear for some experimenters, does not seem equally so for all, and some have difficulty with it.

James, II., 141, footnote.

9. Active Touch is far more discriminating than mere contact. Compare the sensations received from simply resting the tip of the finger on a rough covered book with those received when the finger is moved and the surface "felt of."

10. The Time Discriminations of the sense of contact are very delicate. Strike a tuning-fork; touch it lightly, and after about a second remove the finger so as not to stop the fork. The taps of the fork on the skin do not blend into a smooth sensation even when the vibrations are several hundred a second. One may assure himself that the touching does not much alter the rate of the fork by using another that beats with the first. If the touching is carefully done,

the rate of the beats will not be noticeably altered. (On beating forks see Chap. IV.) The roughness may also be felt but not so strongly, by setting the stem of the fork upon the skin. The roughness of the pulses of air from large tuning-forks can also be felt when the hand is brought near, but not into actual contact with them.

Wittich, 335 ff.; Schwaner; Sergi.

11. After-images of Touch. Touch the skin of the wrist lightly with the point of a needle, and notice that beside the original sensation, there is, after a more or less free interval, a second pulse of sensation. The interval is brief, a second or under, and the sensation appears to come from within. In quality it is like the first, but without the pressure component. The prick of the needle point is not essential; the second sensation can be observed when the head of a pin is applied. Too hard touches must be avoided in testing for these images, as they give rise to a continuous after-image that fills the interval. The second image is apparently due to a double conduction in the spinal cord, and is therefore different from the after-images of the other senses. A portion of the original excitation is conveyed in the posterior columns of the cord to the cortex. Another portion goes by a slower path through the central gray matter of the cord. Cf. Ex. 32.

Goldscheider, *H*, 168 f.

12. An Interesting Illusion of Length, based on the time during which a touch sensation continues, may be observed as follows: Require the subject to close his eyes. Take a piece of coarse thread a couple of feet long and make a knot in the middle of it. Place the knot between the thumb and forefinger of the subject, asking him to press it gently. Then draw the thread slowly through between his thumb and finger and ask him to estimate its length. Repeat the

process, this time drawing it rapidly. The drawing must not be too slow in the first case nor too fast in the second, or the nature of the illusion may be suggested to the subject and more or less completely corrected.

Loeb, 121–122.

For Minimal Contact in relation to Pressure, see Ex. 22; in relation to Tickle, see Ex. 31.

SENSATIONS OF TEMPERATURE.

13. Hot and Cold Spots. *a.* Move one of the pointed brass rods, or even a cool lead-pencil, slowly and lightly over the skin of the back of the hand. At certain points distinct sensations of cold will flash out, while at others no temperature sensation will be perceived, or, at most, only faint and diffuse ones. Heat one of the rods slightly in the gas flame and repeat the experiment. More care will be required in locating the hot spots than the cold spots, for their sensations seem less distinct.

b. On some convenient portion of the skin mark off the corners of a square 2 cm. on the side. Go over this square carefully both lengthwise and crosswise for both heat and cold, drawing the point along lines 1mm. apart, and note on a corresponding square of millimetre paper the hot and cold spots found, hot spots with red ink, cold with black. This time the points should be heated or cooled considerably by placing them in vessels of hot or cold water, and should be kept at an approximately constant temperature by frequent change, one being left in the water while the other is in use. Break the experiment into a number of sittings so as to avoid fatiguing the spots, for they are very easily fatigued. A map made in this way cannot hope to represent all the spots, but it will suffice to show the permanence of some of them and possibly to show a little their general arrangement. When the map has been made, select a responsive

and isolated cold spot, and try it with a warm point. Try a similar hot spot with a cold point.

c. Notice the very distinct persistence of the sensations after the point has been removed, that is, the temperature after-images.

An interesting question suggested by this punctual location of temperature sensations is this, namely: How does it come about that we ordinarily conceive such sensations as continuous over considerable areas.

Blix; Goldscheider, *A*, *B*, *E*; Donaldson.

14. Mechanical and Chemical Stimulation of the Temperature Spots.[1] The temperature spots respond with their characteristic sensations to mechanical and chemical stimulation (and some observers find also, to electrical stimulation), and do not give pain when punctured.

a. Choose a very certainly located cold spot and tap it gently with a fine wooden point (not too soon after locating it, if it has been fatigued in locating); or better, have an assistant tap it. Thrust a needle into a well-located cold point. Try both for comparison on an adjacent portion of the skin.

b. Choose a convenient area, say, on the back of the hand or the temple, and rub the skin lightly with a menthol pencil. After a little the sensation of cold will appear. Goldscheider's tests with a thermometer applied to the skin show that the sensation is not due to an actual cooling of it. The menthol makes the nerves of cold at first hyperæsthetic (so that they respond with their specific sensation to

[1] Such experiments as these illustrate the Law of the Specific Energy of Nerves, which may be stated somewhat as follows: Every stimulus that can excite a sensory nerve at all, causes such sensations as follow the stimulation of that nerve in its customary way and only such. As regards the interpretation to be put on the phenomena thus generalized there is dispute. Goldscheider *I*; Wundt, 3te Aufl. I. 332 ff., 4te I. Aufl. 323; Helmholtz, Sensations of Tone, 148; Optik, 2te Aufl. 233, 1te Aufl. 193; Ladd, 307, 353.

mere contact, and give an intenser sensation when a cold body is applied than do adjacent normal portions of the skin); afterward, however, all the cutaneous nerves become more or less anæsthetic.

c. Chemical stimulation of the heat nerves can be tested with CO_2. Provide two like vessels; place them side by side and fill one with CO_2. Plunge the hand into the vessel containing the gas, and for comparison into the one containing air. For the additional experiments necessary to prove this to be a real chemical stimulation, see the literature.

Blix, Goldscheider *A*, *B*, *D*, *F*, and Donaldson; on *c*, R. Du Bois-Reymond.

15. The Temperature of the Skin at any moment is a balance between its gain and loss of heat. Anything that disturbs that balance, causing increased gain or loss, produces temperature sensations. It is common experience that a piece of cloth, a bit of wood, a piece of metal, all of the same temperature as the air that seems indifferent to the hand, cause different degrees of the sensation of cold when touched, because they increase the loss of heat by conduction in different degrees. If a paper bag be placed over the hand held upward, a sensation of warmth is soon felt, because of the decreased loss of heat.

16. The Shifting of the "Physiological Zero." *a.* Provide three vessels of water, one at 30° C., the second at 40°, the third at 20°. Put a finger of one hand into the warmer water, a finger of the other into the cooler. At first the usual temperature sensations will be felt, but after a little they disappear more or less completely, because of the fatigue of the corresponding temperature organs. Now transfer both fingers to the water of normal temperature. It will seem cool to the finger from warmer water and warm to the one from cooler. This experiment has been sometimes regarded as one of successive contrast.