which the working library is kept and all its technical periodicals — a hundred of them — filed. In the court is the boiler-house with its 600 horse-power of water-tube boilers, selected for safety and compactness; at the left, the dynamo-room with its driving engines; beyond, the machine-shop, 165 feet by 40, and its office, toilet-rooms, and lockers (of the latter some 500, including those at the foundry and forge across the road). The latter building is 150 feet by 40, and, though a frame building, one of the neatest buildings on the campus. Between this building and the main building of Sibley College, and east of the latter, is the large building, 150 by 40, devoted to the work of the Department of Experimental Engineering,—the mechanical laboratory,—in which

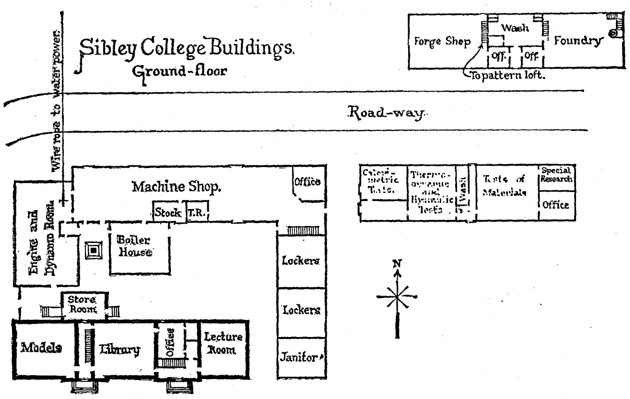

FIG. 1.

are placed all the testing-machines for metal and materials of all sorts, from 10,000 to 100,000 pounds capacity; a number of lubricant testing-machines; and also a considerable amount of miscellaneous apparatus of research in engineering. The boiler-test department is fitted up in the main boiler-house; and the several engines are placed adjacent, both the half-dozen devoted to experimental use and those employed for driving the dynamos used for electric lighting. The plans of the second floor, Fig. 2, exhibit the extent of the wood-working shops, 165 by 40; the upper part of the laboratory building, in which the problems of design and of the laboratory are worked out; and the arrangement of the main building; in the latter the offices and lecture-room of the

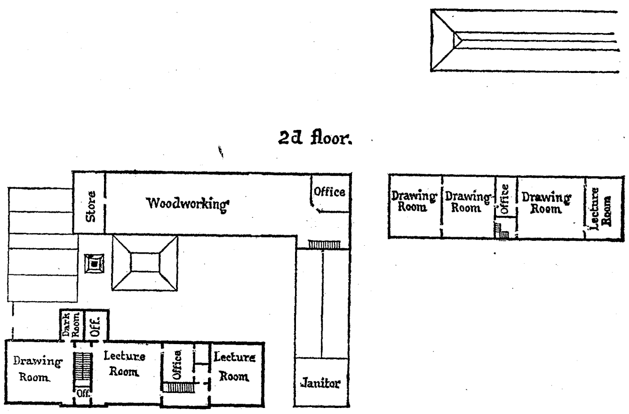

FIG. 2.

director, and the lecture-room of the professor of electrical engineering. The professor of mechanic arts, the professor of machine construction, and the professor of experimental engineering share the other lecture-rooms shown in this and the other plans; while the officer detailed from the United States Naval Engineer Corps to give instruction especially in steam and naval engineering finds accommodations in the laboratory building.

These plans are not, however, precisely accurate in their apportionment of apparatus. The Department of Electrical Engineering and that of physics have become so large, and their stock of apparatus so extensive, that it is probable that the coming college year may see all their larger machinery transferred to the dynamo-room, and even overflow into the west end of the machine-shop floor, which is, however, only a provisional arrangement of the professors of physics and of electrical engineering, and subject to amendment as the exigencies of the case may require. The crowd of small dynamos for individual instruction, of which there are a half-dozen each, for example, of the Edison and the Westinghouse, and a number of others of the better known types, will be used in the physical building. Other dynamos and other engines are continually coming in, and it is thought to be but a matter of very short time before it will be found imperatively necessary to put up a great engineering laboratory, in which to group every thing demanding power and steady speed, as well as all the apparatus of the Sibley College proper. It is presumed that, when built, it will bear the name of the "coming unknown," who will thus at once do a great work and build himself a permanent monument.

Space will not permit the description of the improved and numerous courses of instruction open to technical students at Cornell to-day. They include purely professional courses in agriculture and in engineering, courses in chemistry and physics, in all the natural sciences, and in mathematics, pure and applied, and undergraduate and advanced, in every line in which the ambitious student may desire to excel. For those entering the professions, the courses in patent law and in political and social economy, in ethics and in history, are well adapted, and are found fittingly to supplement the work in the engineering and other technical courses. Many students are taking advanced work in technical departments, and at the same time such outside work as their plans may seem best to warrant. All students in regular mechanical engineering are given instruction in electricity; and, for those who desire it, work is specialized, in the senior and post-graduate years, for students in electrical engineering, as in steam, marine, and other lines of engineering, and in professional work having relation thereto. Of all this, the interested student may learn by applying to the President of the University; to the Director of Sibley College, and to the heads of the other great departments, in either of which he may desire to work.

THE TIME-RELATIONS OF MENTAL PHENOMENA.

[Continued from p. 117.]

HAVING thus considered the time-relations of a simple re-action, we may proceed, on the line of analysis there laid down, to the consideration of the more complex forms of re-action.

Adaptive Re-actions.

It has been noted that the prominent characteristic of a useful re-action is the adaptation of the response to the excitation by which it was called out. This adaptation involves a recognition of the stimulus, and its association with the movement in question. In this recognition we found it convenient to distinguish between the recognition of the presence and that of the nature of the stimulus; but it may be questioned whether we can recognize the presence except by noting some point of the nature of the stimulus, and whether the noting of this point does not involve its distinction from others. If, in re-acting to a sound, I recognize that it is the stimulus to which I am to re-act, and press the key, does this mean that I know that the stimulus is not a visual or a tactile one, that it is not a higher or a lower, a louder or a feebler, sound? Here, as still more in the analysis to follow, our experimental basis is defective. Experiment has naturally followed the lines of convenience and ready analysis; and as there has been little harmony in these analyses, and as the one here adopted differs somewhat from those adopted by other writers, it will be difficult to maintain the parallelism between theoretical discussion and the obtained results. If we understand by the simple re-action the mere signalling that a definite, predesignated, and expected stimulus is present, and by an "adaptive" re-action one in which the mode of response depends upon and varies with the nature of the stimulus, we may distinguish the following stages of connection between the two:—

I. *A single stimulus with a single mode of re-action.*
II. *Several stimuli with a single mode of re-action.*
  (*a*) The subject *foreknows* the stimulus.
  (*b*) The subject *does not foreknow* the stimulus.
III. *A single stimulus with several modes of re-action.*
IV. *Several stimuli with several modes of re-action.*
  (*a*) The subject foreknows the *stimulus and* also the *re-action.*
  (*b*) The subject foreknows the *re-action*, but *not* the *stimulus.*
} SIMPLE RE-ACTIONS.
  (*c*) The subject foreknows *neither stimulus nor re-action.* } ADAPTIVE RE-ACTION.

Or, more simply, if the re-action is foreknown, the process is a simple re-action; if not, it is an adaptive re-action. In addition, in the simple re-action the foreknowledge of the stimulus may be entirely definite, the stimulus always being the same, or there may be a known range of variation or an unknown range of variation; while in the adaptive re-action the possibilities are limited to the latter two.

I. has been fully considered. In II. (*a*) we have a number of different simple re-actions; but, instead of investigating them in separate series, we have different kinds in one series: e.g., a sound, a light, or a touch may appear, it being announced to the subject which it is to be; and he in each case re-acts by pressing the key. The impressions may be more homogeneous, as a series of colors; but in all cases the subject need not appreciate the nature of the stimulus, but simply that a stimulus has appeared. In II. (*b*) the subject knows the possible stimuli, but does not know which is to come next; otherwise the conditions are precisely the same as above. Wundt's experiment with the irregular change between two intensities of sound would belong here, and would indicate that this is an essential factor. In III. the several modes of re-action are necessarily known in advance. Instead of testing the different forms of re-actions in separate series, we have several in one series. For example: we re-act to a sound now with the thumb, then with the forefinger, the subject always knowing in advance what he is to do. In IV. (*a*) we are combining into one series different forms of simple re-actions, differing both in stimulus and form of re-action; but the complete re-action (e.g., red color to be re-acted to by middle finger) is announced beforehand. In IV. (*b*) the subject is told in advance how to re-act, but not what the stimulus is to be. However, in both this and the foregoing case he need not wait to recognize the nature of the stimulus, but re-acts as soon as he detects its presence. All these are variations of simple re-action times. When we pass to IV. (*c*), we have a different, namely, an *adaptive*, re-action. The subject is not told any thing in advance except the association upon which he is to re-act: e.g., if a blue light, with the right hand; if a red light, with the left hand; and so on. The essential difference here is that the subject must first distinguish a certain feature of the nature of the stimulus, in this case the color; then call up the appropriate movement and perform it. A re-action of this kind, therefore, involves a definite distinction of stimuli, and a choice of movements.

Distinction and Choice.

The mental processes involved in an adaptive re-action, in addition to those involved in the simple re-action, are thus a more specific recognition of the stimulus, and a choice between movements. By maintaining all other factors alike, the difference of time of the two modes of re-action measures the combined time of distinction and choice. The first determinations of this nature were made by Donders and his pupils (1865–68). A simple re-action to a light, white or red, was made in 201σ (average of five observers);[1] but an adaptive re-action with the right hand for the one light, and the left hand for the other, in 355σ,—a difference of 154σ. Cattell makes a simple adaptive re-action to two colors in 340σ, his simple re-action time being 146σ, or a difference of 194σ (XI.). Münsterberg re-acts simply with any of the five fingers in 141σ, but re-acts with a definite finger (according as the numbers of the fingers "one," "two," "three," etc., are called) in 195σ longer (XXIV.). Accepting these as values for the combined distinction and choice time under simple conditions, our next step would naturally be to determine how much of the time is due to distinction, how much to choice. This is a difficult step; for we cannot readily determine that a distinction has been made, except by indicating it in the mode of re-action, and we cannot execute a choice except upon the basis of some distinction. The most usual experiment by which it has been attempted to overcome this difficulty consists in re-acting to only a designated one of a group of stimuli, allowing all others to pass without re-action. To take a simple case, let red and blue be the possible stimuli: if red appears, re-act; if blue, do nothing. While this form of experiment is interesting and useful, the inferences from it are not as clear as could be wished. It may be termed the "incomplete adaptive re-action," or briefly the "incomplete re-action." It involves a distinction of the stimulus to be re-acted to, from those not to be re-acted to, and a choice between motion and refraining from action. It seems probable that these processes are respectively easier than a distinction that cannot be anticipated and a choice between two movements; but it seems equally probable that the extent of these differences will vary considerably under different circumstances. If the simple re-action is of the quick, motor form, and the incomplete re-action involves an additional distinction of the stimulus, as well as the choice between motion and rest, the additional time above the simple re-action would be long, and the difference between it and the adaptive re-action short. This is evidently the case with Cattell and Berger, who, with a simple re-action of 146σ and 150σ, perform the incomplete re-action in 306σ and 277σ, the adaptive in 340σ and 295σ (IV. and XI.). On the other hand, Donders, with an evidently sensory mode of re-action, has a simple re-action of 201σ, an incomplete of 237σ, and an adaptive of 284σ. A second method attempts to deal with the difficulty by delaying the re-action until the precise nature of the stimulus has been appreciated, and regards the difference in time between this and the simple re-action as the time needed for the distinction of the stimulus. There is nothing but the subjective guaranty that the moment of re-action is coincident with the process of recognition, and we have no reason to regard this guaranty as valid. There may be a tendency

[1] The sign σ indicates one one-thousandth of a second.

to make the distinction on the basis of the after-image, and thus signal the appreciation of it too soon; or, again, an extreme desire not to re-act before the distinction is made may delay re-action to an unusual length. Friederich's investigations show for colors a simple re-action time of 175σ, and a "subjective distinction" time of 267σ (XXXIX.); while Tigerstedt, and also Tischer, find only about half this difference for nearly the same re-action. It seems wisest, under these circumstances, not to decide the relative shares of the distinction and choice in the adaptive re-action, but to study the combined time as a whole, and the influences by which it is affected. We can thus utilize the results of all the methods for comparative purposes; and, in addition, we can vary the complexity of the distinction while leaving the choice the same (and to a more limited extent can vary the choice without the distinction), and thus can in many cases distinguish whether an increased complexity of an adaptive re-action is to be referred to an increase in the difficulty of the choice or to an increase in the difficulty of the distinction.

Table of Complex Re-action Times.[1]

No.	Nature of Distinction Between.	Character of Experiment.	Nature of Re-action.	Observer.	TIME.	Simple Re-action Time.	No. of Possible Impressions.	Remarks.
I	Black and white-on-black ..	Incomplete.	Finger.	Cattell.	241	146	2	Re-act to white-on-black.
II	White and a particular color.	“	“	“	249	146	2	Re-act to color, varied amongst ten.
III	White and a color	“	“	“	264	146	2	Re-act to color, but need not distinguish same.
IV	Red:blue or green:yellow....	“	“	“	306	146	2	Re-act to predesignated color
V	Colors.......	“	“	“	313	146	10	“ “ “ “
VI	Roman capital letters........	“	“	“	326	146	26	“ “ “ letter
VII	Short English words..........	“	“	“	360	146	26	“ “ “ word (printed).
VIII	Long “ “	“	“	“	375	146	26	“ “ “ “ “
IX	Short German “	“	“	“	367	146	26	“ “ “ “ “
X	Pictures of objects..	“	“	“	309	146	26	“ “ “ picture.
XI	Red:blue or green:yellow....	Adaptive.	Right & left hand.	“	340	146	2	
XII	Pairs of short English words.	“	Naming.	“	401	170	2	5 sets. Average of re-actions to all.
XIII	“ “ colors............. ..	“	“	“	438	170	2	“ “ “
XIV	“ “ pictures.............	“	“	“	437	170	2	“ “ “
XV	Capital Roman letters..... ..	“	“	“	424	170	26	
XVI	“ German letters.......	“	“	“	526	170	26	
XVII	Short English words..........	“	“	“	409	170	26	
XVIII	“ German “	“	“	“	439	170	26	
XIX	Colors.........................	“	“	“	601	170	10	
XX	Pictures of objects............	“	“	“	545	170	26	
XXI	Words in construction........	Continuous series.	“	“	138	170	Indefinite.	English.
XXII	“ “	“	“	“	250	170	“	German.
XXIII	“ “	“	“	“	288	170	“	English, read backward (right to left).
XXIV	Spoken words, “one,” “two,” “three,” “four,” “five”....	Adaptive.	5 fingers.	Münsterberg.	383	162	5	Sensory.
XXV	“ words, “lupus,” “lupi,” “lupo,” “lupum,” “lupe”	“	“	“	465	162	5	“
XXVI	Spoken words, 3 groups of 5 grammatical forms.	“	“	“	688	162	5	Ich meiner mir mich wir. “ Du deiner dir dich ihr. Der des dem den die.
XXVII	“ words, 5 categories...	“	“	“	712	162	5	“ *Noun, pronoun, adjective, number, verb.*
XXVIII	“ “ “ ..	“	“	“	893	162	5	“ *City, river, animal, plant, element.*
XXIX	“ “ “ ..	“	“	“	1122	162	5	“ *Author, musician, naturalist, philosopher, statesman.*
XXX	Direction of light............	Incomplete.	Finger.	Kries: Auerbach.	209	195	2	Whether right or left spark goes first.
XXXI	Colors.........................	“	“	“	227	209	2	
XXXII	Distance of points	“	“	“	2·3	177	2	Whether in front or in back of fixation-point.
XXXIII	Localize touch................	“	“	“	161	132	2	On middle finger or back of hand.
XXXIV	Tones of different pitch	“	“	“	177	143	2	Re-act to higher.
XXXV	Tone and noise................	“	“	“	176	142	2	
XXXVI	Strong and weak touch.......	“	“	“	176	134	2	“ “ strong.
XXXVII	Tones of different pitch......	“	“	“	202	158	2	“ “ lower.
XXXVIII	Strong and weak touch.......	“	“	“	219	140	2	“ “ weak.
XXXIX	White and black.............	Subjected.	“	Friederich's 3 subjects.	267	175	2	
XL	White, black, red, green.....	“	“	“	296	175	4	
XLI	One-place numbers	“	“	“	318	186	9	Read.
XLII	Three-place “	“	“	“	397	186	900	“
XLIII	Five-place “	“	“	“	697	186	Indefinite.	“
XLIV	Sounds of different intensity	“	“	Tischer's 6 subjects.	146	114	2	
XLV	“ “ “	“	“	“	164	114	3	
XLVI	“ “ “	“	“	“	178	114	4	
XLVII	“ “ “	“	“	“	194	114	5	
XLVIII	Visual impressions...........	Adaptive.	2-10 fingers	Merkel's 10 subjects.	276	188	2	Any two of the numbers 1, 2, 3, 4, 5, and I., II., III., IV., V.
XLIX	“ “	“	“	“	394	188	4	“ four of the Nos. 1, 2, etc.
L	“ “	“	“	“	489	188	6	“ six “ “ “
LI	“ “	“	“	“	562	188	8	“ eight “ “ “
LII	“ “	“	“	“	588	188	10	The ten numbers “
LIII	100 words.....................	Continuous.	Naming.	Cattell.	255	—	—	
LIV	100 letters	“	“	“	224	—	—	

[1] Roman numerals in the text refer to the corresponding experiments in this table.

It is desirable to analyze more particularly the nature of the difference between the simple re-action and the "subjective," and between the simple and the incomplete. An essential point relates to the mode of re-action, whether motor or sensory; nor is it necessary that the same mode of re-action be followed in all cases. The possibilities thus are (1) that both the simple and the subjective times will be sensory; (2) both motor; or (3) the simple sensory, and the other motor; or (4) the simple motor, and the other sensory. (1) This seems to be the mode best suited to the subjective method. It supposes the processes to take place serially, and the simple time not to involve the recognition of the specific nature of the impression. (2, 3) If the subjective distinction is made on the motor plan, it can only mean that the re-action takes place too soon, and that the distinction is really made after the movement has been made. In this case the distinction time would be too small. (3) probably does not occur. (4) is apt to occur, and would yield a very long distinction time. That these considerations are practically important can be illustrated by Tischer's results upon nine subjects with sound re-actions and distinctions. The average of the nine gives a distinction time of 159σ, and a simple time of 118σ. Four of the subjects evidently make use of the motor re-action, their simple time being 107σ, and their subjective distinction 116σ; i.e., they anticipate the distinction. Berger and Cattell express the same difficulty, and for this reason discarded the method. Their simple re-action to weak light was 198σ, with distinction of intensity 208σ. Two of the subjects evidently re-act according to the sensory method, their simple re-action being 141σ, and the subjective distinction 246σ. That these are not individual differences is shown by the fact that the adaptive re-actions are about alike in all. Similarly with regard to the difference between the simple and the incomplete re-action times. If both are sensory in character, we might expect that the incomplete would be longer by the addition of an easy distinction and choice, and this seems to be only a slight addition. Donders, and those of Tischer's subjects who re-act by the sensory method, show a relatively small difference, though this is not true of Friederich's subjects. While Tischer's "motor" subjects show a difference of 159σ between the simple and the incomplete, the "sensory" subjects show one of only 61σ. (2, 3) If the incomplete re-action is motor in form, the difference between it and the simple re-action will be very small; more so in (3) than in (2), though (3) is not likely to be used. The expectation is entirely directed to the stimulus upon which re-action is to follow, and the fact that other stimuli may appear hardly enters into the experiment. Under this head it seems fair to classify the results of Kries and Auerbach, who, with clearly motor re-actions, find a difference of 30–40σ for (XXX.–XXXVI.) a variety of incomplete re-actions. (4) It is much more likely that the change from the simple to the incomplete form of re-action will bring with it an attention to the sensory part of the process, and thus make the difference between it and the simple time long. This seems to be the case with Berger and Cattell, who, with a simple re-action time of 147σ and 150σ, have an incomplete re-action time of 306σ and 277σ. The difference between the incomplete and the adaptive re-action seems to be uniformly small (many of the differences being not far from 40σ), though the individual variations are considerable. It is likely that the effects attributed to practice and fatigue may really be due to a change from the sensory to the motor form of re-action. Thus Kries and Auerbach mention that their incomplete times were at first very long, but that they became very small, the reduction continuing long after the effect of practice upon the simple re-action had ceased. Again, the fact that simple re-action times are long when following complex ones, or that subjective times are longer when following adaptive re-actions, seems to be not so much the effect of fatigue as of a continuance of a sensory mode of re-action. It should also be mentioned that Tigerstedt ingeniously proposes to measure the distinction time by taking the difference between two incomplete re-actions, in one of which we re-act to a definite simple impression, and in the other to the impression requiring distinction (e.g., in one series I re-act to white, but not to a color; in the other, to a color, but not to white); and the difference in time will be needed for distinguishing a color from white. The general fact remains, then, that while the combined distinction and choice times exhibit only such individual and other variations as seem explicable by the differences in the conditions of experiment (the adaptive re-action times of eight of Tischer's nine subjects fall between 293 and 320σ), the estimates that have been attempted of the portions of the time due to distinction and to choice separately, show such large variations as to force the conviction that the different experimenters were not measuring the same processes.

Conditions Affecting Distinction and Choice.

Bearing in mind that we are dealing with comparative results only, — comparisons restricted mainly to the results of the same observer, obtained by the same method, — we proceed to investigate the conditions by which these processes involving distinction and choice are affected. It will be convenient to begin with the effect of (1) *the number of distinctions and of choices*. The effect of the number of objects among which distinction is to take place, upon the time needed to make the distinction, is best shown in the "incomplete" and subjective methods, in which the range of distinction may be varied without affecting that of choice. For example: Cattell makes an incomplete re-action to a certain color when either that or one other color may appear in 306σ, when either that or any one of nine other colors may appear (IV. and V.) in 313σ. Friederich's subjects make a subjective distinction between two colors in 267σ, between four in 296σ (XXXIX. and XL.). Six of Tischer's subjects make a subjective distinction between two sounds of different intensity in 146σ (simple re-action, 114σ); between three sounds, in 164σ; four sounds, in 178σ; five sounds, in 194σ (XLIV. and XLVII.). Other experiments cited in the table show the same slight increase of distinction time with the increase of the range of impressions, but complicated with other factors as well. With regard to the effect upon the choice time when the number of possible choices increases, we have the results of Merkel, who found for the simple re-action time of ten subjects to visual impressions 188σ; for an adaptive re-action between two impressions, 276σ; between three, 330σ; between four, 394σ; between five, 445σ; between six, 489σ; between seven, 526σ; between eight, 562σ; between nine, 581σ; and between ten, 588σ (partially cited in XLVIII.–LII.). The impressions were the numbers 1, 2, 3, 4, 5, and I., II., III., IV., and V. The re-actions to movements of the ten fingers naturally associated with these impressions, and the naturalness of this association doubtlessly contributes to the small increase in time. Münsterberg *called* these numbers and re-acted in the same way, finding for a choice between five movements 383σ, and between ten 478σ (simple re-action being 162σ). It being established that but a small share of the increase is due to the distinction (Merkel has experimentally shown this for his subjects), we may conclude, that, with an increase in number, the difficulty of choice increases more rapidly than the difficulty of distinction. In addition, we have reason to believe that the increase would be still more marked in case the association between impression and motion is artificial. When this association reaches the maximum of naturalness, in naming objects, the increase with the number of impressions is slight. Thus it may be calculated from Cattell's results that it takes him but about 10σ longer to name 26 letters or short words than to name one of two, but 60σ longer to name one of 26 than one of two pictures, and 163σ longer to name one of ten than one of two colors; the action of naming being more closely related to letters and words than to pictures and colors.

It is the ability to deal promptly and correctly with a large and varying number of impressions, disposing of each in its appropriate way, that we recognize as evidence of mental power, and it is this that experiment shows to be a factor of great influence upon the time of an adaptive re-action. It is the skill in disposing of so large a number of adaptive re-actions that we admire in the post-office clerk, and in many other exhibitions of manual dexterity. It is this that necessitates the division of labor, there being a limit to the number of adaptive re-actions that can be economically controlled. Again: the fact that a large number of distinctions does not complicate the process as much as a large number of choices, finds its analogue in the observation that our power of reproduction falls below our powers of appreciation. This plays a part in the fact that we learn to understand a language long before we learn to speak it, and in many similar processes. The development of mental power reveals itself as an increasing facility in performing a large number of complicated adaptive re-actions; and here, too, the power of appreciating distinctions develops earlier than the power of choosing. This result was illustrated experimentally in a brief study of the re-action times of a ten-year-old child as compared with those of an adult. While the pure distinction time rose from 58σ to 250σ as the impressions to be distinguished increased from two to five (subjective method, with colors), as compared with 44σ and 78σ for adults, for the adaptive re-action for two impressions the time was 120σ, for five impressions 603σ, as compared with 79σ and 210σ for adults.

We may conveniently introduce the general topic of the effect of the nature of the distinction and the choice upon the time of its performance with the consideration of a few points affecting the distinction alone. (2) *The similarity of the impressions.* The endowment of the various sense-organs varies considerably (e.g., the sense of musical pitch is finer than that of sound intensity); but, in the absence of a standard of comparison of sense-differences in disparate types of sensation, we can only illustrate the point in question by varying the difficulty of distinction within the same sense. Thus Kries and Auerbach find that it takes much longer to tell whether a sound is to the right or to the left, according as the two points at which the sound is produced are closer together when they form an angle of 35°–120° with the centre of the face. The additional time (by the incomplete method) was 17σ; when varied between 35° and 26°, the time was 78σ; when within 26° and 11°, it was 137σ. The ease of distinction is largely a function of practice. We readily seize the slight optical differences furnished by the different letters of a known language, but constantly confuse much greater sense-differences with which we are less familiar. (3) *The specific nature of the impression.* Very many of the results cited in the table may be said to illustrate the effect of a change in the nature of the distinction; but it is difficult to show this, uncomplicated with other variations. The determinations of Kries and Auerbach (XXX.–XXXVIII.) show the result of distinctions of various kinds, though an analysis of the causes of these differences is hardly practicable. It is quite clear that in re-acting by the incomplete method the re-action is shorter when the stimulus is the stronger of two intensities than when it is the weaker of the two (XXXVI. and XXXVIII.). Berger has also shown that the intensity of the stimulus has some influence upon the distinction time beyond what would be due to the effect upon the simple re-action time therein contained. The difference between the corresponding simple and the incomplete re-action to a bright light is 85σ; to a medium light, 119σ; to a weak light, 114σ; while similar differences for adaptive re-actions are 167σ, 179σ, 192σ; the inference being that the intensity of the stimulus affects the distinction rather than the choice. Again (in the series VI.–X.), we find that Cattell recognized most quickly that an expected one of 26 pictures was present, then that one of 26 letters, next one of 26 short English words, next one of 26 short German words. The differences between the time for recognizing letters and short words is very slight compared to the increase in complexity of the impression, and thus shows the effect of practice in recognizing words as a whole. Furthermore, in the series of experiments (partly cited in XLI.–XLIII.) in which one to six place numbers were recognized, while there is a concomitant increase in the number of possible impressions, it seems fair to refer the main increase in time to the increasing complexity of the impression. In passing from the recognition of one to two or of two to three place numbers, the increase in time is slight; but from there on, the increase itself increases with the increase of the number of numerals (53σ, 147σ, 322σ),—a fact probably related to the practice in grasping numbers in groups of threes. Another series (XXIV.–XXIX.) may be mentioned here, and is interesting as indicating that it is more difficult to tell to which of five categories (*a city*, *a river*, etc.) a word belongs than what part of speech it is; and this is in turn easier than to tell the sphere of activity of a noted man. It should be noted that the choice, the range of impressions, the connection between impression and movement, the method of re-action, are equivalent in all three experiments; so that the difference is fairly referable to the distinction process involved. We may finally notice as here pertinent the observations of Vintschgau upon the distinguishability of different tastes. He found that by the incomplete method it took longest to re-act to bitter when the alternative was distilled water, next long to sweet, next to sour, and shortest to salt. Similarly, in adaptive re-actions with the two hands to all possible combinations of two of the four tastes, salt was most quickly re-acted (384σ), sour next (397σ), sweet next (409σ), and bitter last (456σ).

(4) *The Foreknowledge of the Subject.* Within the restriction that the foreknowledge of the subject shall be limited to the knowledge of the associative bond between stimulus and movement, there is room for variation. The simplest case would present but one stimulus re-acted to, and but one not re-acted to, or, in the adaptive re-action, but one stimulus for each mode of re-action. In all such cases (I., II., IV., XI., XXXVIII., may be cited as instances) the foreknowledge of the subject presents the maximum of definiteness. Any departure from these conditions brings with it an increase in the time of re-action. Cattell finds but a very slight increase (5–7σ) in the incomplete re-action when the stimulus *not re-acted to*, instead of being but a

single one, is any one of ten colors, but finds a greater increase (15σ, difference of II. and III.) when the stimulus *re-acted to*, instead of being a single one, is one of ten colors, though the particular kind of color need not be recognized. Both the stimulus re-acted to and the one not re-acted to might be one of a larger or smaller, a more or less homogeneous group; but I am unable to find a record of such an experiment. The somewhat modified form of experiment adopted by Tigerstedt and Bergrist shows a similar result. They re-acted to a light, when either the light or a one to three place number might appear, in 297σ, and to the number (including its recognition) in 318σ. If the number of digits of the numbers that may appear is foreknown, the time is considerably reduced; and when either the light or a foreknown letter might appear, the time for recognizing the light was still further shortened (190σ). The same series of variations could be applied to adaptive re-actions (i.e., one or more, or all, of the modes of re-action might be associated with any member of a variable group of stimuli), but experiments designed to show the effect of such variations are lacking. Mention should be made, however, of the experiments of Münsterberg, in which he first re-acts with the five fingers to five categories, each limited to one term (XXIV. and XXV.); then to five categories, each comprising three terms (XXVI.); and then to five categories, each comprising a practically indefinite number of terms (XXVII., XXVIII., XXIX.); and finds an increase of time in making these steps, not only in the sensory mode of re-action (as cited in the table), but in the motor as well (as will be noticed below). Although other factors contribute to this increase in time, part of it may be referred to the decreasing definiteness of the foreknowledge of the subject. It may be added, that the mechanism by which an increase in the number of possible re-actions increases the re-action time is allied to that by which a decrease in the foreknowledge of the subject does so.

[Continued on p. 148.]

NOTES AND NEWS.

A PROCESS of manufacture of filtering material is described by the *Engineering and Mining Journal* as consisting essentially in reducing ferric oxide by heating it in contact with gaseous fuel. Small pieces of iron ore, preferably hematite, are packed into a retort heated externally, preferably by producer gas. When the charge is at a cherry-red heat, gaseous fuel is admitted into the retort and brought into thorough contact with the ore. At the end of four or five hours, if the exit gas be inflammable, the process is finished, and the charge raked out and allowed to cool. Ordinary coal-gas or other gaseous fuel may be used instead of producer gas. The magnetic oxide so produced is available for filtering water, sewage, sugar sirups, alcoholic liquors, etc.

— The fourth annual session of the Iowa Academy of Sciences was held Sept. 4 and 5, at Des Moines, Io., in the High School Building, Science Rooms, corner of Fifteenth and Centre Streets. The following is a list of the papers read: "The Gall-Producing Cynipidæ of Iowa," by C. P. Gillette; "Evolution of Strophostylus," by Charles R. Keyes; "Two Quaternary Sections near Des Moines," by R. Ellsworth Call; "Abnormal Pelage in Lepus Sylvaticus," and "Additions to Catalogue of Iowa Hemiptera," by Herbert Osborn; "Further Notes on the Geology of North-western Iowa," and "Exhibition of Volcanic Ashes from Omaha, Neb.," by J. E. Todd; "Varieties and Structure of Oolite," by E. H. Barbour; "The Woody Plants of Western Wisconsin, a Contribution to the Local Flora of La Crosse, Wis.," by L. H. Pammel; "On a Quaternary Section Eight Miles South-east of Des Moines," by R. Ellsworth Call and Charles R. Keyes; annual address, by President F. M. Witter, Muscatine; "A New Cecidomid Infesting Box-Elder," by C. P. Gillette; "Age of the Iowa City Sandstones," and "Notes on the Red Rock Sandstone," by Charles R. Keyes; "Preliminary Notes on Fishes of Polk County and Central Iowa (exhibition of specimens), by R. Ellsworth Call; "Notes on the Life-Histories of Certain Hemiptera," by Herbert Osborn; "The Shore-Lines of Ancient Glacial Lakes," by J. E. Todd; "Some Parasitic Diseases of Iowa Forage-Plants," by L. H. Pammel; "Fishes of the Cedar River Basin," by Seth E. Meek; and "Report of the Committee on Iowa Fauna," by C. C. Nutting (chairman). The following are the officers for 1890: president, F. M. Witter, Muscatine; first vice-president, C. C. Nutting, Iowa City; second vice-president, C. P. Gillette, Ames; secretary and treasurer, R. Ellsworth Call, Des Moines; executive council, the officers, and Professors J. E. Todd (Tabor), Herbert Osborn (Ames), and L. H. Pammel (Ames).

— "Little Giant" Edwin Checkley, who has just broken the long-distance bicycle record between New York and Chicago, making the distance in a little over fourteen days, undertook the task without any previous special training, pursuant to the theories set forth in his book, "A Natural Method of Physical Training," which has been creating so much talk among athletes and members of the medical profession. Mr. Checkley opposes modern athleticism as practised in and out of the colleges, and argues that his own extraordinary strength and agility are to a great extent possible even to persons of comparatively sedentary habits, if a certain simple course is followed. Checkley, who was educated as an engineer, and is now studying medicine, is five feet five inches in height, and weighs only one hundred and twenty-five pounds; but he can lift two men, each weighing two hundred pounds, and trot with them for one hundred yards.

— The American Bankers' Association have devoted much time lately to a consideration of the question, "What can be done to prepare for their future careers those youths who expect to follow banking as a business?" In the course of their investigation, their attention was attracted by the work of the Wharton School of Finance and Economy,—a department of the University of Pennsylvania which has, among other courses, one in banking. Professor Edmund J. James, one of the senior professors in the school, who has devoted much time and thought to educational questions, was invited to deliver an address upon the school and its work before the convention at Saratoga, which met from the 3d to the 6th of September. The address, which was delivered on the evening of the 3d of September, includes, besides an account of the Wharton School of Finance and Economy, a discussion of the general subject of what our colleges are doing for the education of our business-men. It is pointed out that Mr. Carnegie, in his famous interview on the subject, was practically correct when he said that the colleges, speaking generally, are not educating the business-men of the community. A smaller and smaller proportion of the youth of the country are going to college. This is true even of those who expect to become lawyers and physicians, and still truer of the immensely greater number who expect to take up business careers. This fact is also emphasized by Professor Shaler of Harvard, in an article on the subject in the August *Atlantic*. Professor James takes the ground that this is very natural, considering the curriculum of our colleges. It is, however, very unfortunate. The higher education of our business classes is absolutely essential to our permanent welfare. Whether for good or ill, the control of our modern life, the school, society, politics,—the church, in a word, of our civilization itself,—is slipping into the hands of our business classes. The professional world is losing, the business world gaining. It is no longer the great lawyer, statesman, or clergyman, but the great banker, manufacturer, railroad manager, who speaks the decisive word in many matters of public importance. The higher education of these classes is therefore of fundamental importance to our social and political existence. The problem is to be solved by the addition to our existing college curricula of courses which have a direct relation to the wants of educated business-men in some such way as existing courses correspond to the wants of the future teacher, or engineer, or architect.

SCIENCE:

A WEEKLY NEWSPAPER OF ALL THE ARTS AND SCIENCES.

PUBLISHED BY

N. D. C. HODGES,

47 LAFAYETTE PLACE, NEW YORK.

SUBSCRIPTIONS.—United States and Canada............... $3.50 a year.

Great Britain and Europe.................. 4.50 a year.

Communications will be welcomed from any quarter. Abstracts of scientific papers are solicited, and twenty copies of the issue containing such will be mailed the author on request in advance. Rejected manuscripts will be returned to the authors only when the requisite amount of postage accompanies the manuscript. Whatever is intended for insertion must be authenticated by the name and address of the writer; not necessarily for publication, but as a guaranty of good faith. We do not hold ourselves responsible for any view or opinions expressed in the communications of our correspondents

Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

VOL. XVI. NEW YORK, SEPTEMBER 12, 1890. No. 397.

CONTENTS:

THE TIME-RELATIONS OF MENTAL PHENOMENA.

[Continued from p. 147.]

The effect of the *mode of re-action* upon the re-action time is the same here as in the simple re-action. Re-acting by the voice in the incomplete form of re-action has been found to be longer than re-acting by the finger; and whenever the re-action takes the form of speaking or naming, it takes some time to place the organs in position and speak the word. But a very special and important effect in adaptive re-actions is that of (5) *the association between movement and stimulus.*

As the effect of a special or a general practice, certain modes of re-acting to certain types of stimuli have become natural, easy, and familiar, while in other cases (e.g., the re-acting by pressing a key, — a process learned only for the purposes of the experiment) the association is extremely artificial. If we compare, in Münsterberg's series, the experiment in which the five fingers re-act to the numbers "one," "two," "three," "four," "five" (XXIV.), with that in which they re-act to the declensional forms of a Latin noun (XXV.), we recognize that the former is a more natural association than the latter, and seem justified in attributing a good share of the increase in time to this difference. Again: to re-act by naming is a process in which we have had considerable training, and it is quite evident that the time needed for naming one of 26 different impressions (XV.–XVIII., and XX.) is much shorter than would be needed for re-acting by 26 artificial and irregular movements of the hand. The difficulty in learning a foreign language, or a telegraphic code, or a shorthand system of writing, is largely the difficulty of forming associations between complex stimuli and movements; and the great decrease in time that is brought about when such associations have been mastered emphasizes the importance of the factor now under discussion, which, in turn, may be regarded as an expression of the effect of practice.

We may push the analysis a step farther. The process of naming is much more closely associated with a word or a letter than with a picture or a color; for the former are artificial symbols, merely becoming significant only when so interpreted, while the latter reveal their meaning directly without needing to be named or read. Accordingly, we find that it takes longer to name a color (601σ) or a picture (545σ) than to name a letter (424σ) or a word (409σ), though the recognition of a color or a picture is a quicker process than the recognition of a letter or a word (compare XV., XVII., XIX., XX., and V., VI., VII., X). Furthermore, if the time of naming or reading is thus mainly conditioned by the strength of association involved, we may in turn utilize this process as an index of familiarity with the naming or reading, or, more briefly, with the language. Thus Cattell, an American, reads English words more quickly than German (XVII. and XVIII.), while with Berger, a German, this relation is reversed. To name a picture in German occupies Cattell for 614σ; in English, 588σ. It occupies Berger in German for 501σ; in English, 580σ. The inference is the same (though the absolute time is much shorter) if we read words in construction instead of isolated. By this method Cattell finds that he can read an English word in 138σ, a French in 167σ, a German in 250σ, an Italian in 327σ, a Latin in 434σ, and a Greek word in 484σ, this being the order of his familiarity with these languages. The particular nature of the association may be revealed in the study of these time-relations. Thus, while in all cases it takes longer to read words from right to left than from left to right, this difference is relatively least in the least familiar languages; i.e., in those in which the bond of association between the words is least significant. For a like reason letters are read much more quickly from above downwards (102σ) than from below upwards (264σ).

(6) *The Overlapping of Mental Processes.* We pass now to a point of critical importance in the application of results gained in the laboratory, to the mental operations of daily life. While in the former case we are performing a set task in isolation for purposes of investigation, in the latter case (i.e., in such operations as reading, copying, playing upon instruments, and the like) we are performing a continuous, more or less extended, series of re-actions, bound together by bonds of common purpose and associations of habit. It is not a mere aggregate, but an organization of mental processes; and this makes possible the performance of the several factors of the process in part at the same time. It leads to an "overlapping" of the mental elements. It is a

proficiency in thus doing several things at once that constitutes much of the difference between the expert and the novice; and it is this "telescoping" process that seems to be the method by which complicated operations are at length performed in short times. It is for this reason that the time per word of reading 100 words is shorter than the time of reading a single word. Cattell reads a short word in 409σ, a long one in 451σ, but 100 such in 255σ per word, and, if the words are in construction, in 125σ per word; thus indicating how much of the difference between ordinary reading, and reading single words, is due to the continuity of the experiment, how much to the association between the words. So, also, Cattell reads a single letter in 424σ, but 100 such in 224σ (compare XVII., XV., with LIII., LIV.). When the series is too long continued, fatigue sets in, and the time is again longer; it is longer for 500 than for 100 words and letters; and for colors and pictures there is no saving in naming 100 above naming a single color or picture.

A special study of this power of grasping several things at once was made by Cattell by having letters move along on the surface of a rotating drum, and varying the width of a slit in a screen through which they were read. When the slit just allowed one letter to be seen at a time, they could be read at the rate of one letter in 228σ; and as the slit was widened to admit two, three, four, five, and six letters at once, the rate increased to one letter in 200σ, 178σ, 166σ, 160σ, and 160σ. As it takes 424σ to name a letter singly (XV.), it would seem that the whole of a letter need not be seen at once to be recognized,—an inference corroborated by the fact, that, when the slit admits only one-tenth of a letter at a time, the letters can be read at 400σ per letter. The result also indicates that there is a limit to the power in question. M. Paulhan finds similar results in more complex operations. He multiplies numbers and recites a verse or two at the same time; and the time needed for this is shorter than the sum of the times required to do each separately. In very simple cases the time of doing both together is not longer than the time for doing the more difficult of the two separately. The mind should accordingly not be likened to a point at which but a single object can impinge at one time, but rather to a surface of variable extension. It should likewise be noted that the performance of a complex and extended mental task is not the same thing as the separate performance of the several elements into which that task may be analyzed.

The distinction between the *sensory* and *motor* form of re-action requires mention in this connection, because, when applied to complicated adaptive re-actions, it seems to involve overlapping of mental processes. The times cited in the table (XXIV.–XXIX.) in Münsterberg's experiments (and they are the only ones available for the present purpose) refer to sensory re-actions. In these the attention is directed to the word about to be uttered. It is recognized, and referred to its group. The corresponding movement is then aroused and performed, the several processes being successive in time. In the motor form the word is thought of as a "forefinger-moving" word; and the movement upon which the attention is kept fixed is expectantly kept ready to be set off at the slightest notice. The several processes thus play into one another, some perhaps entirely falling away. Both anticipatory movements and errors (moving the finger next to the correct one) are not infrequent. The motor times for the series XXIV.–XXIX. are 289, 355, 430, 432, 432, and 437σ; the differences between motor and sensory times, 94, 110, 258, 280, 461, 685σ. Until these very important and striking results are better understood, it would be unwise to enter into a discussion of them; but it may be noted (*a*) that the increase in the complexity of the processes is more regular and prominent in the "sensory" times, the "motor" times of the last four experiments of the series being about alike; (*b*) that the "motor" complexity seems to be related to the range of the impressions; and (*c*) that the differences in time between the two modes of re-actions increase as the processes become more complex.

(7) *Practice and Fatigue.* What was said under these headings of simple re-actions applies with equal force to complex ones. Various experimenters notice the decrease in time as the experiments proceed. They note that this decrease is relatively greatest at first, and in those individuals and processes whose time is relatively longest at the outset; also that it soon reaches a limit, and, when once thoroughly acquired, is not liable to be lost after a moderate degree of disuse; and that it at times seems to be confused with a transition from a sensory to a motor form of re-action. As illustrative of one or other of these points, it may be mentioned that Tischer finds as a rather typical case the decrease of a distinction time from 160σ in the first set to 95σ in the second, and 86σ in the third, all reduction ceasing on the average after 5.5 sets; that Trautscholdt, in re-actions consisting of repeating a word, finds times of 299, 273, and 258, and in another case of 205, 176, and 155σ, in three successive periods of fourteen days each; that for Berger and Cattell, beginning with some practice in experiments of this kind, find the time for incomplete re-actions reduced by 30 and 20σ after four months' experimentation; and, finally, that the great decrease in the incomplete re-actions of Kries and Auerbach (from 64 and 117 to 21σ, from 153 and 109 to 36σ, from 104 and 97 to 49 and 54σ, in various experiments) strongly suggests a radical change in the mode of re-action. Another aspect of the effect of practice appears in a study by Berger of the times required by the boys of the nine classes of a German Gymnasium, and of the class preparatory to the Gymnasium, to read 100 and 500 words in construction in German and in Latin at a maximum and at a normal rate. There is a constant decrease in time as the boys advance in age. In Latin the several times per word were 262, 135, 100, 84, 79, 57, 54, 49, 48, 43σ; in German 72, 55, 43, 37, 39, 28, 27, 26, 25, 23σ; the great difference between the first two times in Latin being due to the fact that the boys who required 262σ to read a Latin word had never learned Latin at all. That these differences are to be referred to specific practice rather than to general mental maturity, appears from a comparison of the above times with the times required by those boys to name colors; viz., 135, 99, 119, 123, 100, 91, 112, 99, 86σ.

The results regarding fatigue are not equally definite. Many mention the general fact of fatigue, and to avoid it perform but few experiments in a series. We have already seen that it takes relatively longer to read 500 letters, words, colors, pictures, than to read 100. On the other hand, Cattell, after a very long series of re-actions, found no serious or constant increase in the time, but seemed to feel the effects of fatigue on the following day. Both practice and fatigue are subject to large individual variations. Oehrn has studied the minor variations of practice and fatigue in a session of two hours' work, finding first a stage in which practice outweighs fatigue, and then a stage in which the reverse is true.

(8) *Miscellaneous and Individual Variations.* The complex re-actions, just as the simple ones are subject to the influences of distraction, vary under the action of drugs, in morbid conditions, and present large individual variations. These points, though frequently noticed incidentally, have not been subjected to special study, so that briefly citable and conclusive figures are lacking. Regarding the action of drugs, Kraepelin is inclined to believe that the distinction is, under their influence, almost always rendered more difficult, being only slightly subject to the period of shortened times, while the choice factor very readily becomes shorter than the normal. Marie Walitzkaja finds that the complex re-action times in the insane differ more from the normal than do their simple times. An adaptive re-action for the two hands which for the normal required 351–406σ, required 707–943σ in cases of general paralysis, and 1,085σ in a case of mania. These should, however, be regarded as individual rather than general results. The individual variations may be regarded as increasing with the complexity of the re-action. Men differ more from one another in the time needed for doing difficult things than in the time needed for simple things. Systematic experimentation upon this point is lacking: but a suggestion of the truth may be obtained by calculating the average deviation from their mean, of Merkel's ten subjects in their simple re-action times, their subjective distinction times, and their adaptive re-action times; the result being 2.23 per cent, 3.35 per cent, and 6.79 per cent.

JOSEPH JASTROW.

[To be continued.]

LETTERS TO THE EDITOR.

**** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

A Study of California Soils.

THE material greatness of California rests, in the last analysis, upon the vast range and high native fertility of its soils. California is a State with but few deposits of coal and iron, though possessing almost every other kind of mineral. Its food-producing resources, as shown by the character and extent of its soils, are very much beyond any thing that the Californians themselves have ever claimed.

The longest report on California soils that has ever appeared is that in the "Tenth Census Report;" but the work of soil-analysis has been going on ever since, and the larger number of the State University's agricultural bulletins are devoted to this and cognate subjects. The agricultural subdivisions adopted are as follows: the Sacramento valley; the San Joaquin valley; the Sierra foot-hills; the southern or Los Angeles region; the coast region north of San Francisco and San Pablo Bays; the coast region south of those bays.

In all of these districts the variety of soils is very great. Only a few especially representative soils can be tabulated at length in this article. The Sacramento valley, for instance, contains a great variety of rich sediment soils, gray or dun-colored, powdery loam, very rich and easy of tillage; also dark adobe loams, moderately heavy, paler in color a foot below the surface; also clay loams, brown-black when wet; also heavy, black adobes, the strongest of wheat-lands; also light, grayish-yellow "slickens," the mining *débris* deposit. All these soils have a sufficient and often a very generous supply of lime. In all the alluvial soils the amount of potash is large, sometimes very large. The supply of phosphates is not large. Professor Hilgard sums up the Sacramento valley lands by saying that the predominant soils are "fine-grained alluvial loams, with extensive belts of heavy clay," or, in the California phrase, "adobe lands." The California adobe is much like the black prairie soil of the Mississippi, but the phosphoric-acid supply is one-third higher.

Sacramento Valley Soils.

	River Alluvium.	Black Loam Soil.	Valley Soil.	Mining Sediment.
Insoluble matter, and silica	73.444	62.304	71.005	69.062
Potash....................	.652	.305	.929	.300
Soda....................	.077	.221	.124	.124
Lime........................	1.444	2.909	.770	.521
Magnesia..................	2.277	1.042	2.285	.768
Br. oxide of manganese....	.015	.025	.106	.089
Peroxide of iron...........	5.804	9.342	8.011	6 586
Sulphuric acid.............	.030	.068	.120	.067
Alumina.....................	10.397	13 038	9.159	14.229
Phosphoric acid.	.087	.095	.111	.078
Water and organic matter..	5.351	10 149	7.115	8.024
Total	99.578	99.498	99.735	99.848

In the great San Joaquin valley the prevailing character of the soil is sandy, often very coarse. There are also black adobes in narrow belts, near the rivers or sloughs, and hillocky plateau lands, either loamy or of gravelly clay, with much hard-pan. The "red soil" of the foot-hills shows many distinct sorts. Orange-red is nearly the prevailing tint. Red loam, red gravel, red clay, and the red soil of the placer mines, filled with decomposed slate, are among the kinds of Sierra foot-hills soils. The color comes from the presence of four to twelve per cent of iron oxide. The average of phosphates is low, but in some districts the supply is all that can be desired. These soils are eminently well adapted to vines, fruit-trees, and vegetables. In the Coast

San Joaquin Valley Soils.

	Black Adobe.	Brown Adobe.	Dry Bog Land.	Wire-Grass Land.
Insoluble matter and soluble silica	72.058	79.492	67.34	71.420
Potash..............................	.396	.714	1.05	1.224
Soda...............................	.479	.444	.84	3.043
Lime..................................	1.927	1.769	6.51	3.043
Magnesia............................	1.640	2.048	3.96	.087
Br. oxide of manganese............	.056	.041	.04	.030
Peroxide of iron......................	6.815	3.728	5.05	5.823
Alumina..............................	11.620	7.988	7.97	7.137
Phosphoric acid.....................	.179	.038	.32	.239
Sulphuric acid.......................	.037	.074	.08	.655
Carbonic acid........................	—	—	4.42	2.546
Water and organic matter.........	5.871	3.244	3.71	7.091
Total............................	101.078	99.580	101.29	99.972