REACTION TIMES TO THE CESSATION OF STIMULI

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CONTENTS.

REACTION TIMES TO THE CESSATION OF STIMULI.

It is a striking fact that, in spite of the great number of researches running into the hundreds, that have been made on reaction times, and the large number of details that have been worked out so minutely in this field, there have, as yet, appeared no results upon reaction times to the cessation of stimuli.

The effect of varying the intensity of the stimulus, the resistance of the reaction key, the instructions given to the subject, and such technical details as the accurate levelling of the chronoscope, and reversing after each reaction the direction of the current passing through the chronoscope magnets, have all been experimented upon. In all this experimental work reactions have always been to the beginnings of stimuli. We are unable to discover in all the literature on reaction times any experiments in which the reactions were to the cessations of the stimuli.

Cessation Reaction Problems.

The study of reactions to the cessations of stimuli presents, however, a number of points of in-interest; the question immediately arises as to what one reacts in reacting to the cessation of the stimulus, and is this reaction made as readily and directly as when it is to the beginning of the stimulus? In reactions to the beginnings of the stimulus we have energy acting on the individual's nervous system which, it is easy to understand, would produce a positive motor effect. In the cessation reaction, however, where we have merely the removal of this energy, which would readily account for the cessation of a motor effect, it requires reference to more complex processes in order to explain this removal of energy producing a positive reaction involving muscular contraction. It is necessary to refer to something more complicated than merely a reflex redirecting of the incoming stimulus in order to explain the cessation reaction. Again, what is the relation which exists between the time for beginning and cessation reactions? Is the time for cessation reactions just the same, slower, or faster than for beginning reactions, or is no generalization possible? Does the after-image have anything to do with these cessation reaction times? If there is an after-image the subject might confuse that with the real stimulus, or would the reaction take place before the after-image presented itself? Would the after-image be as intense as the stimulus and thus delay reaction? Is the relation of intensity to reaction times the same in case of beginning and cessation reactions? With reaction to the beginning of the stimulus the weaker the stimulus the longer the reaction time; is this reversed in the case of cessation reactions, as it would be, for example, in the case of an electric current acting by magnetic action upon an armature? If the electric current is weak the armature comes down slowly with the make of the current, but at its break rises as quickly, or more quickly than with a strong current.

Relation to Light.

The problem of cessation reactions is also related to the question as to why reaction times for light are found to be in general longer than those for sound. Why light reactions are longer is a matter of controversy. The ordinary explanation is that light is a chemical sense and that this is a slower process than the merely mechanical transmission of energy by physical process which occurs in reaction to sound. This is questioned by Dunlap*. What intensity in sound will be equivalent to a certain intensity of light would have to be considered. Furthermore, in all studies with intensities in sound the given intensities are only approximate, not absolute, for, as yet, no instrument has

*Psychol.Rev.vol.17,p.319.

been invented whereby exact intensities of the sounds at the ear have been obtained so far as we can discover. With reactions to the cessation of stimuli the difference in the intensity of the stimulus might conceivably be of much less importance. Prof.W.B.Pillsbury, in an article on Methods for the Determination of the Intensity of Sound, discusses this subject and arrives at the conclusion that "to know how intense the sound will be at the ear, one must know how great the amplitude of vibration is at the sounding body, and the distance from the ear together with the way in which the sound spreads from the source, or one must have some means of measuring the intensity of the tone at the ear itself."*

Increase of Intensity.

It seems to us that the study of cessation reaction times should also throw some light upon the cause of the apparent increase in intensity with increase in duration of stimulus. It is known that a sound of constant physical intensity gradually increases in apparent intensity as it increases in duration up to a dur-

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*Psychol.Monog.Dec.1910.

ation of at least one second, the increase in apparent intensity being at first rapid and then slow. It ought, then, to be possible to obtain a sound so weak that it could not be heard at all or reacted to until the end of a second. It should be of interest, then, to determine in the case of a sound so weak that it could not be heard at all with a duration of less than one second, whether or not, after the sound was once heard by the subject, if it were then suddenly stopped, it would take him an equally long time to get its cessation.

The above questions are sufficient to show the desirability of research on cessation reaction times. Aside from these questions, the problem should, of course, be studied for the light it may throw upon the important but little understood problem of the mechanism of human action. Prof.E.B.Titchener in his chapter on Action, says that the reaction time experiment "has now come to be, in essentials, a qualitative experiment. It allows to repeat, over and over, a particular type of consciousness; it allows us to vary this type in manifold ways and still to repeat our observations as often as is necessary to their complete analysis; it thus affords an admirable control of introspection."* The problem is also important because of the value of the reaction experiment as a method for the study of a great variety of mental processes. Indeed, the reaction experiment may best be thought of as a method for the study of higher mental processes, such as attention, association, judgment and will. Since the reaction time experiment is coming to have this significance as a psychological method, all its aspects and all ways of applying it should be developed.

The Problem.

The specific problem upon which we have been working is an attempt to discover whether or not the reactions to the cessations of stimuli were the same as those for the reactions to the beginnings of the same stimuli. Sound and light were used for stimuli, and reactions were "simple" for each.

In these experiments both beginning and

*A Text-book of Psychology, p.431.

cessation reactions were taken with each subject at the same sitting and the apparatus was arranged accordingly. Thus we were able to compare the times of each subject for both beginning and cessation reactions under the same conditions.

Apparatus.

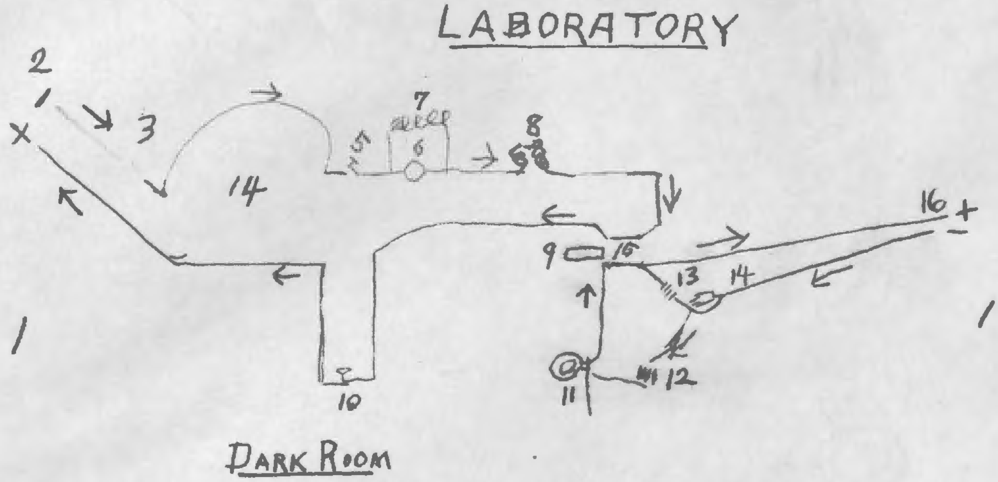
The apparatus used for sound reactions consisted of a Hipp chronoscope, resistance coils, Scripture's noiseless reaction key, electrical tuning fork, and telephone receiver. The University direct current was used. The chronoscope was controlled by a Wundt fall-hammer and a tuning fork of 250 d.v. per second. The results are given in Table The fall hammer was, in turn, tested by a smoked drum record made by the tuning fork and time-marker.

The reaction times given in the tables are rather long, and it is possible that the chronoscope contained a slight error. When the experiment was started the chronoscope tested correctly, but when the

APPARATUS

CESSATION REACTION TIMES

SOUND



1 Wall

2 Source of Current

3 Switch

4 Resistance

5 Switch

6 Chronoscope

7 Resistance

8 Time-marker

9 Non-conductor

10 Subject's Key

11 Telephone

12 } Resistance
13 }

14 Tuning-fork

15 Operator's Double Key

16 Source of Current

reactions for Series I. were finished another test was made which showed an error of about 24 sigma (see Table). To obtain more accurate results a second series(Series II.) was made in whish the chronoscope was tested at each sitting and corrected. A storage battery was used in this series to run the chronoscope to insure an absolutely steady current. Another possible source for the long reactions was in the double key. The latent period for this was also taken with the smoked drum record. Moreover, the interval, after the signal, was four seconds, which was not the most favorable for attention, and most of the sounds were too weak to give the shortest reaction times.

There were two circuits, as illustrated, called, for convenience, the Chronoscope cirsuit and the Telephone circuit. The chronoscope circuit was the one which contained the chronoscope in circuit(1). The current entered at 2 and might go through resistance at 4 or through the chronoscope 6. A switch was placed at 3 to throw off the whole current from the rest of the apparatus; the experimenter's key at 5 opened and closed the circuit. The current could go through the chronoscope(6) or the resistance coils at 7. This resistance was used to help control the chronoscope. At 3 a time-marker was also used to control the chronoscope, though this was not in the circuit during the time the reactions were taken. There was a double key at 15, the two sides of which were separated by a non-conductor 9; this key was arranged so that when the handle of the key was raised the telephone circuit was closed, and when it was down the chronoscope circuit was closed and the telephone circuit was broken. The current passed through the wall(1) and connected with the subject's key(10). When this reaction key and the double key were closed the chronoscope was running. The telephone circuit entered at 16-and passed through the tuning-fork at 14, a possible resistance at 13, then to the telephone(11) and a possible shunt at 12, through the double key(15) and out at 16σ.

The subjects sat in the dark room which was made as free from distracting noises as possible. The reaction key was clamped to the table; the telephone receiver, which produced the sound used for the stimuli, was about one and one-half feet from the subject's ear.

The Telephone.

Difficulties have been found with the source of any continuous sound, and the telephone has been criticised. Prof. W. S. Pillsbury* and others have found that one difficulty with the telephone is that when the current is broken a very noticeable "click" occurs which is more noticeable than the continuous sound. To avoid this the tuning-fork, above referred to, was placed in circuit with the telephone. Though no click could be detected with the ear, we made sure that none was present by taking a smoked record. This was done by attaching a slender glass rod with wax to the center of the telephone plate. As the plate vibrated the vibrations were recorded on the drum. When

* Psychol. Monog. Vol. XIII., 1:1910, p. 14.

the sound was continuous and regular the vibrations showed no variation. Had there been a click the record on the drum would have registered it by an irregular mark interrupting the vibration wave as the current was made or broken. No such mark was recorded and the sound ceased or started abruptly with the make or break of the current. The record also showed that the sound started in at its maximal physical intensity. As to the wisdom of usâng the telephone Prof. Pillsbury says: "Taken all in all the telephone is probably the most satisfactory instrument in use for sound experiments in the psychological laboratory. It can be made to give a constant sound that can be varied at will in pitch, in intensity, and duration."* A noise was produced which had a dominant tone similar to that of the tuning-fork. The sound was regular for each intensity, as was shown by measurements of the amplitude of vibration. For determining this the record by the fine glass point attached with wax to the center of the plate was taken on smoked glass. Readings were made with a microscope which had

*Psychol. Monog. Vol.XIII.,1:1910,p.14.

a micronometer eye-piece.

Four intensities were used: loud, medium, weak, very weak

The Subjects.

The subjects in this experiment were Dr. H.H. Woodrow, under whose direction the research was made; four graduate students: S. and B. (women), K. and C. (men), all taking work in the department of psychology; a college graduate in chemistry, W-s(man), three seniors, M., E., and W-t(women), who were taking advanced work in psychology.

The subject sat in the dark room with his right arm resting easily on the table, his first two fingers lightly placed on the reaction key. The subject was instructed to confine his attention entirely to the movement (thus giving a motor reaction,) and to react as quickly as possible after the stimulus had been given. Each sitting lasted for about an hour and a half.

The Stimuli.

For beginning reactions a very short signal was given on the telephone four seconds before the stimulus was given. The stimulus was continued until the subject reacted. There was some question as to whether the reaction might not be quicker if the sound was not continuous. This was tested out by replacing the telephone with a Wundt sound-hammer, but there was no appreciable difference between that and the telephone in beginning reactions. George R. Wells*reports, in his study on The Relation of Reaction Time to the Duration of Auditory Stimulus, no difference whether the sound used as a stimulus is long or short. For cessation reactions no signal was given, except the beginning of the sound which acted as a signal and the subject was instructed to press down the reaction key and thus close the circuit as soon as the telephone sound was heard, and to react by lifting his fingers from the key as soon as the sound was discontinued. The sound was continued four seconds.

*Proceedings of Am.Psychol.Assoc.
Psychol.Bulletin,Vol.IX.,Feb.15,1912.

At each sitting the following was the order of stimuli: Cessation, ~~loud~~, beginning loud; beginning medium, cessation medium, cessation weak, beginning weak, etc. Sometimes the operator would go through the whole series with the same subject, at other times the subject and operator would change places at the end of one series of stimuli. No variation appeared in reaction times due to the order of giving stimuli. This order was followed for twenty-five reactions and then reversed for twenty-five, that the subject might not get practice with one form of reaction more than he would with another with a given stimulus. By thus taking cessation and beginning reactions alternately we were able to compare each subject's beginning and cessation reactions under the same conditions.

SERIES I.--Table 1.

Sub-ject	Reac-tion	Loud N	Loud Av.	Loud Mv	Medium N	Medium Av.	Medium Mv	Weak N	Weak Av.	Weak Mv	Very weak N	Very weak Av.	Very weak Mv
W-w	B	59	181	32	67	179	25	71	188	31	78	228	35
	C	136	213	39	129	207	26	124	211	29	118	232	26
S	B	16	233	47	18	257	28	31	249	34	16	298	35
	C	42	264	16	35	239	33	33	256	36	33	264	41
M	B	29	263	53	30	270	67	33	264	41	28	274	60
	C	28	252	63	31	293	50	29	238	68	28	270	67
C	B	76	191	18	70	188	19	81	203	18	74	239	19
	C	121	201	13	125	195	27	120	214	18	110	261	16

Explanation:

W-w, S, M, C, were the subjects.

BC, BC, in the second column: B means beginning reactions, C means cessation reactions.

N, the number of reactions

Av., average (in sigma) for that subject in the given sound.

Mv. the mean variation from the given average and with the given number of reactions.

Loud, Medium, Weak, Very weak, are the intensities of the stimului.

SERIES II.--Table 1

Subject	Reaction	Loud N	Loud Av.	Loud Mv	Medium N	Medium Av.	Medium Mv	Weak N	Weak Av.	Weak Mv
W-w	B	49	123	18	52	141	20	51	194	35
	C	52	159	17	53	161	15	51	215	37
C	B	50	155	17	52	194	16	49	236	32
	C	52	191	13	51	165	14	49	296	60
S	B	54	190	27	56	175	23	51	178	21
	C	52	196	18	53	204	30	52	204	31
K(1)	B	65	205	29	51	184	36	52	191	15
	C	56	188	30	51	216	30	53	220	11
K(2)	B	51	138	20	50	157	25	52	192	34
	C	52	185	30	49	229	43	53	222	37
E	B	47	180	23	58	205	35	45	239	39
	C	57	178	19	55	199	38	50	195	23
W-s	B	52	147	19				51	194	25
	C	51	174	17				56	197	17
W-t	B	31	153	30						
	C	42	140	26						
B	B	76	207	29						
	C	75	252	48						

Explanation:

W-w, C,S, etc were subjects for the second series.
BC,BC, in second column is Beginning and Cessation reactions.
N,Av.,Mv, Number, Average, Mean variation respectively.
Loud, Medium, Weak, are the intensities of the sounds.
K(1) and K(2) are the same subject but on different days.

SERIES I.---Table 2.

Results on Chronoscope Control.

Wundt Fall Hammer.

Vibrations of tuning-fork	Sigma	Mean Variation.
51.7	206.8	.3
51.8	207.2	.1
51.7	206.8	.3
51.8	207.2	.1
52.	208.0	.9
51.9	207.6	.5
51.6	206.4	.7
51.7	206.8	.3
51.	208.0	.9
51.5	206.0	1.1
	2070.8	5.2

Chronoscope

Sigma	Mean Variation.
232	1
232	1
229	2
231	0
232	1
228	3
232	1
231	0
231	0
231	0
2309	9

SERIES I.--Table 2, Continued.

Results on Chronoscope Control.

Explanation:

During ten successive drops of the fall-hammer the tuning fork recorded on a smoked drum the vibrations registered in the column headed "Vibrations of tuning-fork."

During the same time the chronoscope registered the sigma hnadolumn headed "Sigma."

The mean variation is found in the last column.

The fall-hammer and the chronoscope were then compared and the chronoscope registered the number of sigma in the column headed "Sigma" under "Chronoscope."

The mean variation is recorded in the next column.

The results were as follows, and it will be seen that, according to this test the chronoscope was about 10% to slow:

	Av. Sigma	M.V.
Fall-hammer	207.08	.5
Chronoscope	230.9	.9

SERIES I.--- Table 3.

Latent period of Operator's Key.

Dr. Woodrow Operating.

Vibrations	Sigma	Variation
.8	3.2	.8
2.6	10.4	6.6
.1	4.0	.2
.6	2.4	1.4
.7	2.8	1.0
.8	3.2	.6
1.6	6.4	2.6
,6	2.4	1.4
.4	1.6	2.2
.5	2.0	1.8
	38.4	18.4

W.M.Crawford Operating.

Vibrations	Sigma	Variation
.0	.0	2.3
.0	.0	2.3
.0	.0	2.3
1.0	.4	1.7
.4	1.6	.7
.8	3.2	.9
.8	3.2	.9
1.5	6.0	3.7
	18.0	14.8

	Average	Mean Variation
Dr. Woodrow	3.84	1.8
W.M.Crawford	2.3	1.85

SERIES I.---Table 3--Continued.

Latent period of Operator's

Key.

Explanation:

This is the double-key referred to which has the non-conductor between the two sides. In seeking for possible errors this was tested with the smoked drum record and the tuning-fork, and the chronoscope registered the sigma. It will be seen that there is a slight variation in the way in which the two operators used the key, but this adds very little to the length of time for the reactions. There were no other operators except Dr. Woodrow and myself. Each took about half the reactions in this series.

Results.

According to the Tables in both Series I.and II. the reactions show a slight increase in the cessation reaction times over the beginning reaction times of the same intensity, but the differences are so slight that we are able to draw the conclusion, tentatively, that there is practically an equality in reaction times to the cessation and beginning of stimuli.

A few subjects show their beginning reaction time shorter than that of their cessation reaction time; In Series I--Table 1, subject S. shows this in "medium" and "very weak" intensities; Subject M. shows this in "loud""weak" and "very weak" intensities. In Series II--Table 1, shorter reaction times are shown to the cessation of stimuli in Subject K. in the "loud" sound, while Subject E shows cessation reaction times uniformly shorter. We believe this might be changed with more practice to cessation reaction times.

The results also show the general tendency is as usual as respects intensity---the weaker the intensity the longer the reaction time.

Experiments were also made with reaction times to the cessation and the beginning of visual stimuli and the results showed the same general relationships as those for sound stimuli but the results were too meager to draw a definite conclusion.