THE MEASUREMENT OF ATTENTION

BY

KARL M. DALLENBACH

A THESIS

Presented to the Faculty of the Graduate School of Cornell University in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

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Reprinted from the AMERICAN JOURNAL OF PSYCHOLOGY
October, 1913, Vol. XXIV, pp. 465-507

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CONTENTS

I. Introduction

In his *Postulates of a Structural Psychology* (1898) Titchener expressed the opinion that *clearness* is to be considered

[1] From the Psychological Laboratory of Cornell University.

as an intensive attribute of sensation, and that this attributive clearness is the elementary phenomenon of attention.[2] The same view is worked out in detail, and with reference to current theories of attention, in the *Feeling and Attention* of 1908.[3] In the following year, Geissler published " an attempt at a new measurement of attention in terms of clearness values."[4] "A very close parallelism was found to exist between introspectively distinguishable variations of attention and corresponding differences in the precision of work performed at these levels, under the condition that the estimation of degrees of attention was made in terms of clearness and that the work itself was not influenced by anything else but change in attention."[5] The attempt thus yielded a positive result. Geissler, however, worked only with material which was visually presented; and it is clear that the investigation must be carried further into the domains of hearing, touch, and imagery. The present study is an attempt to do for audition what Geissler has done for vision. Since Geissler prefaced his experiments by a fairly full " critical study of previous views and methods,"[6] we may ourselves dispense with any longer introduction. And since this paper deals only with audition, and experiments upon touch and imagery are still to follow, we have thought it best to offer our results by themselves, without criticism of studies which have appeared since Geissler wrote, and without reply to the occasional criticisms of Geissler's method which we have met with. The results which we have obtained confirm those of the previous investigation, so that we find no reason to change our fundamental view of the nature of the elementary phenomenon of attention; and the discussion of minor points of controversy may be postponed until the experimental material covers a wider ground.[7]

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[2] *Philosophical Review*, vii., 1898, 461 f. See also M. W. Calkins, *Introduction to Psychology*, 1901, 137 ff.; I. M. Bentley, *Mind*, N. S. xiii., 1904, 242 ff.

[3] *Lectures on the Elementary Psychology of Feeling and Attention*, 1908, Lects. i., v., vii.

[4] This Journal, xx., 1909, 502 ff.

[5] *Ibid.*, 529. It may be noted that Geissler anticipates an obvious criticism by the statement: " under the same conditions, the introspective [we should prefer to say 'subjective'] estimation of the quality of the work was not as reliable as the evaluation of the degrees of attention."

[6] *Ibid.*, 473 ff.

[7] The writer takes this opportunity to thank Professor Geissler for important suggestions with regard to the method of the experiments reported below.

Observers.—Three observers served in all of the experiments: Dr. W. S. Foster (F), instructor in Psychology, Miss Mabel E. Goudge (G), graduate student in Psychology, and Mr. J. S. Johnston (J), fellow in Psychology. G and J worked without knowledge of our problem. F was familiar with Geissler's investigation, and knew in general the aim of the present study.

II. Methods and Results

A. *Preliminary Training in Introspection*

Our first problem was to familiarise our observers with differences of attributive clearness.

To this end a large number of preliminary experiments was given them. The experiments were of two kinds: with attention directed to the stimulus, and with attention directed away from the stimulus and upon some mental task. In the experiments of the first kind, two metronomes were set going at the rates of 100 and 120 strokes per minute respectively, and the observer, who sat with his back toward them, was instructed to direct his attention to the sounds, and to count the number of sounds between coincident strokes. The observation began with a signal, and ended after a minute and a half, with the word *Introspect.* The observer was then required to describe, in as great detail as possible, the pattern of consciousness during the period of observation. In the experiments of the second kind, the same stimuli were used, but the observer was required to perform some mental task, such as continuously adding, subtracting, multiplying, dividing, reciting, singing, or repeating the alphabet backwards. At the end of a minute, or a minute and a half, the observer was asked, as before, to give as full and complete an introspection as possible. These two kinds of experiments were alternated throughout the preliminary training; four observations were taken in an hour. The observer F gave in all 62 introspections; G, 60; and J, 128. After relatively few trials, the observers were able not only to compare the clearnesses of the stimuli in the two types of experiments, but also to say that the sounds were not always equally clear or obscure during an observation. Thus, F reports, after an experiment in which the task was to add 7 continuously: "The sounds of the metronomes, as a series of discontinuous clicks, were clear in consciousness only four or five times during the experiment, and they were especially bothersome at first. They were accompanied by strain sensations and unpleasantness. The rest of the experiment my attention was on the adding, which was composed of auditory images of the numbers, visual images of the numbers, sometimes on a dark grey scale which was directly ahead and about three feet in front of me. This was accompanied by kinaesthesis of eyes and strains in chest and arms. When these processes were clear in consciousness the sounds of the metronomes were very vague or obscure." Similar reports were made, during the first three weeks of training, by G and J.

When this degree of proficiency had been reached, the observers were asked to estimate, first the larger, and later the finer differences in the clearness of the sounds. They constructed, independently, a rough scale of five or six steps, from very clear to obscure; but they were presently able to assign a percentage value to the clearnesses. At first this gradation was difficult; and the observers, particularly F, felt uncertain of its correctness. As the preliminary training advanced, however, they grew more confident; and toward the end they were able not only to give an analysis of consciousness during the period of an observation, but also to estimate, without difficulty, the clearness or obscurity of the mental processes experienced. At the end of three months, they had worked out (with some suggestion from the experimenter, which, however, bore only upon uniformity of grades) the following scale:

1. 100-90%....................maximally clear.
2. 90-80%....................very clear.
3. 80-70%....................clear.
4. 70-60%....................fairly clear.
5. 60-50%....................fair.
6. 50-40%....................fairly vague.
7. 40-30%....................vague.
8. 30-20%....................very vague.
9. 20-00%....................obscure.

We give a single illustration. F, after an experiment in which the task was to repeat continuously the alphabet backwards, reports: "Repeated alphabet backwards two and a half times. Practice has made this task much easier than at first, so that it is easier for the distraction (the metronomes) to catch attention. Four times for several seconds the sounds of the metronomes were the clearest processes in consciousness, perhaps 75% clear. The repeating process (*i.e.*, the complex of repeating the alphabet backwards, which was composed of visual images of dark grey lines stretching from right to left, eyes following along on lines sometimes with vague visual images of several letters in a group; accompanied by these visual images, or where visual images were lacking accompanied by the kinaesthetic images of eye movements, sibilant auditory images of letters) was only 10-20% clear. Aside from these four times the repeating processes were 85% clear, and the sound of the metronome was 10-15% clear."[8]

At this point we turned to the main problem of measuring attention in terms of clearness; in other words, of discovering how closely the attributive clearness of the processes attended to and of those attended from is correlated with quantitative and qualitative changes of an auditory stimulus of an objectively measurable character.

B. *Preliminary Practice in Observation Under the Conditions of the Main Experiments*

1. *Apparatus.*—Our stimulus, the tone of a Stern variator, varied from 300 to 600 vs. in the 1 sec. The Whipple air-tanks were used to supply the blast. The intensity of the tone was controlled by an air-valve, and the pitch, by the

[8] With this account *cf.* Geissler, *op. cit.*, 510 f.

crank of the variator. Both valve and crank were fitted with large scales and long moving arms, which permitted us to make gross movements in their adjustment.

The Whipple tanks[9] were devised for the purpose of giving a constant air-pressure; but further to insure this result we registered the pressure graphically. Between the air-valve and the variator a T-tube was inserted, the one arm of which led to the variator and the other to a large eosin manometer. A delicate Marey tambour was attached to the manometer, and its writing point rested upon the surface of a smoked drum. When the air-blast was turned on, the pressure was recorded upon the drum. The tanks as set up by Whipple showed a very slight variation, due perhaps to the small size of the intake valve. We therefore disconnected the tanks, and tried them individually. We found that the pressure was now sensibly constant; indeed, between the limits of height 25 and 50 cm., it remained, by our manometer, absolutely the same. During a single experiment the tank was therefore always kept within this central region. Curtains, hung directly over the variator and at other places about the room, eliminated echoes; and thus the constancy of the tone was further insured.

The observer sat about 2.5 m. from the source of sound, his head secured in position by a biting-board, and his right hand resting upon a silent electrical key. In an adjacent room was placed a kymograph with three writing points. One of these points was connected to the observer's key, another to an electrical push-button in the experimenter's hand. The third point, the lever of a Jacquet chronoscope, wrote fifths of seconds between the other two. It was added to give an approximate record of the observer's reaction-times.

2. *Instructions.*—The following instructions were read to the observer:

"You are to sit at the table with your back to the stimulus, your head held firmly in position by the mouth-piece and the biting board, your right arm and hand resting upon the table, and your forefinger, or forefinger and thumb, lightly pressing the electrical key. The experiment will begin upon the signal *Ready, Now,* and will end when the experimenter says *Introspect.*

"The stimulus, which will be the tone of a Stern variator, may vary in intensity or in pitch. The rate of change from one intensity to another, or from one pitch to another, will also vary, the change being made either gradually or very quickly. There are then two points upon which you will report: 1. kind of change, whether of pitch or intensity; and 2. rate of change, whether rapid or slow. As soon as a change is perceived, you will press the key.

"One pressure denotes a change of intensity;

"Two a change of pitch;

"The rate of change must be given in the introspection.

"You are to give your attention to the sound of the variator. At the end of 30, 45 or 60 seconds, as the case may be, you will introspect. and give a detailed description of your consciousness during the experiment."

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[9] G. M. Whipple, this JOURNAL, xiv, 1903, 107 ff.

It will be observed that no mention is here made of the word clearness." This omission was made advisedly; for we wished, so far as possible, to keep the observers in ignorance as to the subject of the experiment. It is true that *F* knew, in a general way, the aim of this study; but neither he nor the other observers knew the particular phase of the problem that we were studying. We expected, however, in view of the long preliminary training, to receive, without requesting them, detailed introspections upon the relative clearness of the processes in consciousness. In this expectation we were not disappointed; for both G and J continued to estimate the relative clearness of their mental processes in percentage terms, while F, throughout these experiments, used such descriptive terms as very clear, fairly clear, vague, obscure, etc.

In the experiments of 30 seconds, only one or two changes in pitch or intensity were made, while in the experiments of 45 and of 60 seconds, three and four changes in pitch or intensity were made respectively. A 'change' means a variation either of pitch or of intensity; not of both together. The rate at which the change was effected was either rapid or slow. The rapid changes were made as quickly as the adjustments allowed, requiring about one-fifth of a second; the slow changes occupied three seconds.

3. *Series.*—In the series given to the observers all the possible types of change were represented. In the experiments, *e.g.*, in which only one change was made during an observation, the change was in one case of pitch, in another of intensity; in one case it was made rapidly, in another slowly. The standard pitch and intensity were also varied, as was the place of the change within the 30 second interval (near beginning, middle, near end). Again, in the experiments in which four changes were made, the changes of pitch and of intensity occurred an equal number of times in the first, second, third, and fourth places. The rates of change, rapid and slow, likewise occurred an equal number of times in the first, second, third, and fourth places. The series itself varied from four changes of pitch to four changes of intensity.

The series in detail were as follows:

Series I. One change. Duration of experiment 30 seconds.

Variation.	Change of Pitch.	Change of Intensity.	Rate.
1.	0 (350)	1 (l-h)	r.
2.	0 (400)	1 (h-l)	s.
3.	0 (450)	1 (h-l)	r.
4.	0 (300)	1 (l-h)	s.
5.	1 (350-400)	0 (low)	r.
6.	1 (300-400)	0 (low)	s.
7.	1 (500-400)	0 (high)	s.

Series II. Two changes. Duration of experiment 30 seconds.

Variation.	Changes of Pitch.	Changes of Intensity.	Rates.
1.	0 (350)	2 (l-h-l)	s.r.
2.	0 (450)	2 (h-l-h)	s.r.
3.	0 (500)	2 (l-h-l)	r.s.
4.	1 (350-450)	1 (h-l)	s.r.
5.	1 (500-400)	1 (h-l)	r.s.
6.	1 (300-400)	1 (l-h)	r.r.
7.	2 (300-400-500)	0 (high)	r.s.
8.	2 (400-350-300)	0 (low)	s.s.

Series III. Three changes. Duration of experiment 45 seconds.

Variation.	Changes of Pitch.	Changes of Intensity.	Rates.
1.	0 (500)	3 (l-h-l-h)	r.r.s.
2.	0 (400)	3 (h-l-h-l)	s.r.s.
3.	1 (300-400)	2 (l-h-l)	r.r.s.
4.	1 (500-400)	2 (h-l-h)	s.s.r.
5.	1 (450-350)	2 (h-l-h)	s.s.r.
6.	2 (400-350-450)	1 (l-h)	r.s.r.
7.	2 (400-500-450)	1 (h-l)	r.r.s.
8.	2 (400-300-450)	1 (l-h)	s.r.s.
9.	3 (300-400-300-400)	0 (high)	r.s.s.
10.	3 (400-300-400-300)	0 (low)	s.r.r.

Series IV. Four changes. Duration of experiment 60 seconds.

Variation.	Changes of Pitch.	Changes of Intensity.	Rates.
1.	0 (350)	4 (l-h-l-h-l)	s.r.s.r.
2.	0 (400)	4 (h-l-h-l-h)	r.s.s.r.
3.	1 (350-450)	3 (l-h-l-h)	r.s.r.r.
4.	1 (450-350)	3 (h-l-h-l)	s.s.r.s.
5.	1 (500-400)	3 (l-h-l-h)	s.r.r.s.
6.	1 (400-450)	3 (h-l-h-l)	r.s.s.r.
7.	2 (500-400-350)	2 (l-h-l)	s.s.r.r.
8.	2 (350-450-350)	2 (l-h-l)	r.s.s.r.
9.	2 (350-450-500)	2 (h-l-h)	s.r.r.s.
10.	2 (350-400-450)	2 (h-l-h)	s.r.r.r.
11.	2 (500-400-300)	2 (l-h-l)	s.s.r.r.
12.	2 (400-500-400)	2 (h-l-h)	r.s.r.r.
13.	3 (400-300-400-500)	1 (l-h)	s.r.r.s.
14.	3 (300-400-500-400)	1 (l-h)	r.s.s.r.
15.	3 (400-300-400-300)	1 (h-l)	r.s.s.r.
16.	3 (300-400-450-500)	1 (h-l)	s.s.r.s.
17.	4 (450-500-450-400-300)	0 (low)	r.s.r.r.
18.	4 (400-350-450-500-550)	0 (high)	s.r.s.s.

The figures in parentheses under *Changes of Pitch* show the vibration-rates of the tones employed. The letters in parentheses under *Changes of Intensity* show the direction of change, from lower to higher, or conversely. The letters *r* and *s* under *Rates of Change* show the rates at which the changes were effected, *r* signifying *rapid* and *s*, *slow*.

There were thus 125 changes, 61 of pitch, and 64 of intensity. Of these 125 changes, 62 were made slowly and 63 rapidly.[10]

In the preliminary practice, variations of the above series were chosen at random. For a given experiment, *E* set the variator and the air-valve at the points required. On the signal *Ready, Now, E* released a spring-clip that closed the rubber tube between the air-valve and the variator, and at the same time pressed the push-button held in his hand. At every subsequent change, and at the end of the experiment, *E* again pressed the push-button; so that, by comparison with the time-line and with *O*'s line, the length of the experiment, the times of change, and the time of *O*'s reaction were graphically recorded.

F gave in all 52 introspections; G, 56; and J, 112. This preliminary practice covered the three months February to April, 1912. At its completion we turned to the main experiment, using the Single Task Method.

C. *Single Task Method*

1. *Apparatus.*—The same apparatus was used as for the preliminary practice; but the room, which before was light, was now darkened. The observer was, moreover, enclosed in a muslin booth, which was illuminated from above by an electric light, controlled from the experimenter's desk. The experiments were conducted in darkness, unless flicker was used as a distractor; and the light was turned on at the end of the experiment. *O* was thus able to write his introspections, while *E* marked the record and set the apparatus for the succeeding experiment.

Distractors.—In the preliminary practice the experiments were performed without distraction. In the present series, eight distractors were employed:

1. Flicker (9 rhythms and 4 intensities).
2. Electrical current (3 intensities).
3. Flicker and current (with above variations).
4. Clicks of single metronome (3 rates; 60, 100, and 150).
5. Clicks of metronome and current (with above variations).
6. Clicks, flicker, and current (with above variations).
7. Two metronomes beating at different rates (60, 100, and 150).
8. Phonograph.

(1) *Flicker.*—Behind and somewhat above the observer was placed a second electric light, enclosed within a reflector which directed the light upon a white screen in front of the observer. This light was also controlled from the experimenter's desk; it had four variations in intensity, from very weak to maximally strong. A large cardboard disc., from which were cut four sectors of 30°, rotated before

[10] The changes are indicated under the separate headings: thus, Series I yields 3 changes of pitch and 4 of intensity; and so forth.

the reflector. Cardboard shields adjustable over the sectors made it possible to obtain nine different rhythms in the flicker. Since there were four variations of intensity, and nine in rhythm of the light, there were altogether 36 variations of the flicker.

The cardboard disc that served as shutter was driven by a motor, which because of its noise was placed in an adjoining room. The motive power was transmitted by a reduction-system of string belts and gutta-percha pulleys to a large wheel, upon the shaft of which the shutter turned. As the light was controlled from the experimenter's desk, this part of the flicker apparatus, since it was noiseless, was started at the beginning of the hour and ran throughout the entire period.

(2) *Current.*—The faradizing current was also controlled from the experimenter's desk. The induction-coil was placed in an adjacent room. The strength of the primary current was governed by a three-way switch connected with a rheostat. This gave three intensities of the induced current. The current ran direct from the coil to the electrodes, which were moistened and applied to the observer's left arm, the one a little below the elbow, and the other at the wrist. During the first few experiments, the electrodes were bound one on each wrist; this plan was, however, abandoned because the strongest current caused a violent contraction of the muscles of the arm and hand, which seriously interfered with the observer's reaction. The contraction was none the less severe after the change to the left arm; but the right hand could now operate the key without hindrance.

(3) *Flicker and current.*—The third distractor was formed by the combination of the first two, and varied within their limits. There were therefore 108 possible variations of this distractor.

(4) *Metronome.*—Two metronomes were placed upon the experimenter's desk, and were there controlled. In the case of the fourth distractor only one metronome was used. The rate of the beat varied from 60 to 100 and 150 strokes in the minute.

(5) *Metronome and current.*—The fifth distractor was formed by the combination of the clicks of a single metronome and the electrical current. It was variable within the limits of these two distractors.

(6) The sixth distractor, formed by the combination of flicker, clicks of a single metronome, and electrical current, varied within the limits of these distractors. In all, 324 variations were possible.

(7) *Two metronomes.*—Both metronomes were set going at different rates, 60, 100 or 150. There were therefore only three variations within this form of distraction.

(8) *Phonograph.*—The phonograph was likwise controlled from the experimenter's desk. Various records were used, including popular and classical pieces, songs, instrumental and band music.

Previous experimenters have found that distractors very soon lose their power of compelling the attention; the observers become habituated. It was for this reason that we selected eight distractors which were capable of variation and extension. During the first few experiments those forms of distraction were employed which we supposed to be the least disturbing. Habituation was in some measure counteracted by increase of intensity, or by change in rhythm of the distractor. Thus in the case of the flicker, and also of the electric current, the weaker intensities were used first, the stronger later.

2. *Instruction.*—The general instruction remained unchanged. The specific directions were as follows:

"The stimulus, which will be the tone of a Stern variator, may vary in intensity or in pitch. The rate of change from one intensity to another, and from one pitch to another, will also vary, the change being made either gradually or very quickly. There are then two points upon which you will report: 1. kind of change, whether pitch or intensity; and 2. rate of change, whether rapid or slow. As soon as a change is perceived you will press the key.

"One pressure denotes a change of intensity;

"Two a change of pitch;

"The rate of change must be given in the introspection.

"You are to give your attention to the sound of the variator, and to neglect as far as possible any distraction, purposive or accidental. At the end of 30, 45, or 60 seconds, as the case may be, you will introspect. In the general description of consciousness, in previous experiments, you have among other things assigned clearness values to the various processes reported. You are now to estimate clearness values only: that is, you are to report, using a scale of 100, the relative clearness of the processes which you observe in consciousness. For example: 'First change, rapid, clearness of so-and-so $x\%$, of so-and-so $y\%$; second change, slow, clearness of so-and-so $m\%$, of so-and-so $n\%$.'"

3. *Number of experiments.*—The experiments by this method were conducted in May and June 1912, and in February and March 1913. Each observer gave in all 86 introspections.

4. *Series.*—The series employed were those outlined above. The order of presentation was determined by lot. Each series was employed twice. Five or six observations, one of which was taken as a control without distraction, were made during the hour. The experiment without distraction occurred an equal number of times in the first, second, ... and sixth places. The distractions were also so distributed that each kind occurred but once in an hour, and as often in the first as in the other positions. During a single experiment the same distractor persisted without change.

5. *Results.*—The Single Task Method was employed, as we have said under 3 above, at two periods. During the interval the Double Task Method was employed. The results of G and F for the two periods of the Single Task Method

agree throughout, and are therefore grouped together. J, however, gave different results in the two periods; and they are therefore considered separately. J_1 denotes the results of the first, and J_2 those of the second period. The observer had for some time been depressed by a visual disability which oculists had failed to overcome, and in the first period was anxiously awaiting the outcome of a new treatment; this is probably the ground of the incapacity for high degrees of attention shown under J_1 in Tables I and II. In the second period, the reason for depression had been removed. It is possible, also, that the practice in concentration gained during the rather exacting observations of the Double Task Method helped the observer to give the improved results under J_2. We cannot offer more than this general explanation of the discrepancy.

In some of the experiments, from the nature of the series, one change was made, in others two, three, and four. In working over the results, each change was considered separately, was judged as a single case and so recorded. Hence in Table I only the *number of such cases* is given. Under *Right* are grouped all the right judgments of kind and rate of change, and under *Wrong* all the wrong judgments. The scale of attention in terms of clearness is arranged above.

TABLE I

Number of Cases, Kind and Rate of Change

Report	Change	O.	Right 10-9	9-8	8-7	7-6	6-5	5-4	Wrong 10-9	9-8	8-7	7-6	6-5	5-4
Kind and Rate	Ps	F	33	14	2									
		G	2	22	9	5	2			2				
		J_1	2	5	5	3		1						
		J_2	9	9	1	1			1		2			
	Pr	F	32	5										
		G	3	18	11	8	1				2			1
		J_1		2	4	1	2							
		J_2	18	5	4	2	1							
	Is	F	13	11										
		G	2	19	6	2		1						
		J_1		3	6	1	2							
		J_2	4	5	3	2	1							
	Ir	F	27	10										
		G	2	13	15	3	3							
		J_1		2	7		2	1		1	1		1	
		J_2	6	3	1						1		1	

TABLE I—*Continued*

Report	Change	*O.*	Right 10-9	Right 9-8	Right 8-7	Right 7-6	Right 6-5	Right 5-4	Wrong 10-9	Wrong 9-8	Wrong 8-7	Wrong 7-6	Wrong 6-5	Wrong 5-4
KIND	Ps	F	1	2										
		G		1	1	4	1			1	3	4	1	
		J_1		1		2	2					2		
		J_2;	2		2	1			1	1				
	Pr	F	4	9	1				1					
		G		2	1	4				1	2	3	1	
		J_1		1	1	6	2	1		1				
		J_2	1	3	2	1								
	Is	F	2	4	1					4				
		G		2	6	3	1					1		
		J_1		1		2	1	2					1	
		J_2	2	1										
	Ir	F	3	6	3				1	3		1		
		G		3	7	3	2					1		
		J_1		1	7		3							
		J_2	3	4	3		1	1	1					
RATE	Ps	F							1	2				
		G		1	3	4	1			1	1	4	1	
		J_1				2				1		2	2	
		J_2	1	1					2		2	1		
	Pr	F	1						4	9	1			
		G		1	2	3	1			2	1	4		
		J_1		1						1	1	6	2	1
		J_2							1	3	2	1		
	Is	F		4					2	4	1			
		G				1				2	6	3	1	
		J_1					1			1		2	1	2
		J_2							2	1				
	Ir	F	1	3		1			3	6	3			
		G				1				3	7	3	2	
		J_1								1	7		3	
		J_2	1						3	4	3		1	1

TABLE I—*Continued*

Report	Change	O.	Wrong 10-9	9-8	8-7	7-6	6-5	5-4
Subjective Reaction	Ps	F	1	2				
		G				1		
		J_1						1
		J_2						
	Pr	F		2				
		G						
		J_1						
		J_2						
	Is	F	1	2	1			
		G				2	1	1
		J_1			1		1	
		J_2						
	Ir	F	1	8	1			
		G			3			1
		J_1						
		J_2						
No Reaction	Ps	F						
		G						
		J_1						
		J_2				1		
	Pr	F						
		G						2
		J_1						
		J_2						
	Is	F	1	4	3	2	1	1
		G				8	6	4*
		J_1				1	2	1
		J_2		1	1	11		1
	Ir	F		1	1	1	1	
		G				3	4	1
		J_1					1	
		J_2				6	3	

* These four cases occurred in the region 4-3 (40-30% of clearness).

The observers' reports may, however, be grouped under five heads: 1. reports in which kind and rate of change are both right or wrong; 2. reports in which kind is judged aright, and rate is wrong; 3. reports in which rate is judged aright and kind is wrong; 4. reports of change in the absence of objective change (subjective reactions); and 5. reports which failed to note an objective change. Under each one of these captions the data are further analysed, according as the objective change is of pitch or intensity, and is made rapidly or slowly. *Ps*, then, means that the objective change was a slow change of pitch; *Pr*, a rapid change of pitch; *Is*, a slow change of intensity; and *Ir*, a rapid change of intensity. In the case of the subjective reaction, the analysis depends upon the rate and kind of change reported by the observer.

In Table II the right cases, the wrong cases and the failures are grouped according to the kind and rate of the objective change. The subjective reactions are grouped as they were reported by the observer. A summary of the entire number of cases appears at the end of the table. It is clear that the greatest number of right cases occurs with the higher degrees of attention, and that the greatest number of wrong cases occurs from one to two steps lower upon the scale of attention. That this ordering is due to attention, and that it is not the result of any specific reaction to one kind or one rate of change, can be seen by referring to the separate captions of the tables. The relation of the right cases to the wrong cases for all changes, whether of pitch or intensity, whether rapid or slow, is remarkably constant.

TABLE II

NUMBER OF CASES GROUPED ACCORDING AS THE CHANGE IS OF PITCH OR INTENSITY, AND IS RAPID OR SLOW, WITH SUMMARY

Kind or Rate	Report	*O.*	Clearness						
			100-90	90-80	80-70	70-60	60-50	50-40	40-30
PITCH	Right	F	70	30	3				
		G	5	43	22	21	4		
		J_1	2	9	10	12	6	2	
		J_2	30	17	9	5	1		
	Wrong	F	1						
		G		4	7	7	2	1	
		J_1		1		2			
		J_2	2	1	2				
	Subjective	F	1	4					
		G					1		
		J_1						1	
		J_2							
	No-reaction	F							
		G						2	
		J_1							
		J_2				1			

TABLE II—*Continued*

Kind or Rate	Report	O.	Clearness 100-90	90-80	80-70	70-60	60-50	50-40	40-30
INTENSITY	Right	F	45	31	4				
		G	4	37	34	11	6	1	
		J_1		7	20	3	8	3	
		J_2	15	13	7	2	2	1	
	Wrong	F	1	7		1			
		G				2			
		J_1		1	1		2		
		J_2	1		1		1		
	Subjective	F	2	10	2				
		G			3	2	1	2	
		J_1			1		1		
		J_2							
	No-reaction	F	1	5	4	3	2	1	
		G				11	10	1	4
		J_1				1	3	1	
		J_2		1	1	17	3	1	
SLOW	Right	F	61	18		1			
		G	4	42	18	12	3	1	
		J_1	2	9	11	6	2	1	
		J_2	14	15	4	3	1		
	Wrong	F	7	15	4				
		G		5	7	7	2		
		J_1		2		4	3	2	
		J_2	5	1	4	1			
	Subjective	F	1	10	1				
		G				2	2	1	
		J_1			1		1	1	
		J_2							
	No-reaction	F		1	1	1	1	1	
		G				8	6		4
		J_1				1	2	1	
		J_2		1	1	12		1	

TABLE II—*Continued*

Kind or Rate	Report	O.	Clearness 100-90	90-80	80-70	70-60	60-50	50-40	40-30
RAPID	Right	F	46	29	2				
		G	5	32	28	15	5		
		J_1		4	11	1	5	1	
		J_2	25	8	5	2	1		
	Wrong	F	3	6	1				
		G		5	10	7	2	1	
		J_1		3	9	6	6	1	
		J_2	4	7	6	1	2	1	
	Subjective	F	2	4	1				
		G			3			1	
		J_1							
		J_2							
	No-reaction	F	1	4	3	2	1	1	
		G				3	4	3	
		J_1					1		
		J_2				6	3		
SUMMARY	Right	F	222	108	9	1			
		G	18	154	102	59	18	2	
		J_1	4	29	52	22	21	7	
		J_2	84	53	25	12	5	1	
	Wrong	F	12	28	5	1			
		G		14	24	23	6	2	
		J_1		7	10	12	11	3	
		J_2	12	9	13	2	3	1	
	Subjective	F	6	28	4				
		G			6	4	4	4	
		J_1			2		2	2	
		J_2							
	No-reaction	F	2	10	8	6	4	2	
		G				22	20	6	8
		J_1				2	6	2	
		J_2		2	2	36	6	2	

Inspection shows, further, that the subjective reactions occur for the most part under a relatively high degree of clearness, and conversely that the failures, the no-reactions, occur under a relatively low degree of clearness. We may infer that a subjective reaction is, under our conditions, a less serious error than a no-reaction. Emphasis was laid, throughout the experiment, upon reaction to change of the tone of the variator, and the observer was 'set' for change; it is consequently but natural that he should sometimes 'imagine' a change; whereas failure to notice a change objectively presented argues a definite lapse of attention.[11] In view of these considerations, we have ventured to 'weight' our results as follows:

A right or wrong judgment of Kind and Rate counts as.... ±2.0
A right or wrong judgment of Kind counts as............ ±1.0
A right or wrong judgment of Rate counts as............ ±1.0
A Subjective reaction counts as........................ —2.0
A No-reaction counts as................................ —2.5

In Table III the results appear as thus weighted.

TABLE III

WEIGHTED SUMMARIES

O.		Clearness						
		100–90	90–80	80–70	70–60	60–50	50–40	40–30
F	Total right	222.0	108.0	9.0	1.0			
	Total wrong	20.5	68.5	19.0	8.5	5.0	2.5	
G	Total right	18.0	154.0	102.0	59.0	18.0	2.0	
	Total wrong		14.0	30.0	54.5	35.0	13.5	10.0
J_1	Total right	4.0	29.0	52.0	22.0	21.0	7.0	
	Total wrong		7.0	12.0	14.5	20.5	7.5	
J_2	Total right	84.0	53.0	25.0	12.0	5.0	0.5	
	Total wrong	12.0	11.5	15.5	47.0	10.5	3.5	

The crest of the curve of right judgments now falls, with F, 1 place; with G, 2 places; and with J, 2 and 2 places respectively to the left, that is, above the crest of the curve of wrong judgments; and we have evidence, once more, that introspectively distinguished variations of clearness are closely paralleled by corresponding differences in the accuracy of the judgments passed.

The relation of the report to the kind and rate of the objective change appears in Table IV.

[11] Of the 1400-odd cases reported in these tables only 61 were subjective. We regard this small number (about 4%) as evidence both of the quality of our observers and of the accuracy and reliability of our apparatus and method.

TABLE IV

RELATION BETWEEN THE OBSERVER'S REPORT AND THE KIND AND RATE OF OBJECTIVE CHANGE, EXPRESSED IN NUMBER OF CASES

O.	Kind								Rate							
	Pitch				Intensity				Slow				Rapid			
	R.	W.	S.	N.	R.	W.	S.	N.	R.	W.	S.	N.	R.	W.	S.	N.
F	103	1	5		80	9	14	16	77	10	7	12	80	26	12	4
G	95	21	1	2	93	2	8	26	80	21	5	18	85	25	4	10
J_1	41	3	1		41	4	2	5	31	11	3	4	22	25		1
J_2	62	5		1	40	3		23	37	11		15	41	21		9
Total	301	30	7	3	254	18	24	70	225	53	15	49	228	97	16	24

R., right report. S., subjective report.
W., wrong report. N., no report.

Here we see, in spite of individual differences, first, that a change of pitch, under the conditions of our experiment, is more compelling than a change of intensity; and, secondly, that a rapid change of stimulus is more attractive than a slow change.

Our observers are more correct as regards changes of pitch than as regards changes of intensity. F, J_1, and J_2 report more errors for intensity than for pitch. G, on the other hand, reports more errors for pitch than for intensity. This difference, however, is more than offset by the greater number of cases in which she failed to observe a change of intensity. A like failure to apprehend changes of intensity is evinced by F, J_1, and J_2. F and J_1 noted "change" for every variation in pitch, and J_2 for every variation but one; while they failed to observe "change" in 16, 5, and 23 cases, respectively, of change in intensity.

Slow changes are, as Stern has noted, "less likely than rapid to cause a reaction of attention." This rule is borne out, in a measure, by our results. The objective change was neglected 44 times when it was made slowly, and only 24 times when it was made rapidly. Moreover, the change when rapidly effected was reported correctly 228 times, and when slowly effected, 225 times. On the other hand, more wrong reactions were made to rapid changes (97 reported as slow) than to slow (53 reported as rapid). The law, however, rests upon a fairly large body of experimental results.[12]

(1) *The promptness of voluntary action, i. e.,* the time of a simple reaction, was first used to express degrees of attention by Obersteiner in 1879.[13] He employed two distractors, an induction current and a musical box, and found that the observer's reaction was slower under distraction. He therefore assumed that "this retardation stands in inverse proportion to the intensity of attention." "The differences in the reaction period," he continues, "which may serve directly as the measure of attention, vary in different individuals, and in the same individual under different conditions."[14] Many investigators[15] have used the reaction method to measure the attention. Their results show, for the most part, that reaction-time increases with distraction, though there are those who deny the correlation. Cattell,[16] for example, found that there is no corresponding lengthening of the reaction-time with reduction of attention; and Geissler writes that "the final outcome of the reaction experiments, as used for the measurement of attention, has been on the whole negative; it has been impossible to establish a positive correlation between high degrees of attention and short reactions, and between lower degrees and correspondingly lengthened reactions."[17] In his own experiments, however, Geissler found a remarkably high correlation between "the observers' estimates of attentive concentration and the calculated quickness and accuracy of their results,"[18] and remarks that "with all three observers there is a perfect correlation between their best attention and their shortest time, and between correspondingly lesser degrees and longer times."[19]

Our apparatus was arranged, as we have said, to measure roughly the reaction-time of our observers. The average and the mean varia-

[12] G. E. Müller, *Zur Theorie der sinnlichen Aufmerksamkeit,* 1873, 125 ff.
A. Pilzecker, *Die Lehre von der sinnlichen Aufmerksamkeit,* 1889, 20 f.
W. James, *Principles of Psychology,* I., 1890, 416 f.
L. W. Stern, *Psychologie der Veränderungsauffassung,* 1898, 211 ff.
W. B. Pillsbury, *Attention,* 1908, 30.

[13] H. Obersteiner, *Brain,* I, 1879, 439-453.

[14] *Op. cit.,* 444.

[15] G. Buccola, *Rivista di filos. scientif.,* I, 219 ff.
G. S. Hall, *Mind,* VIII, 1883, 170-182.
W. Wundt, *Grundz, d. physiol. Psychol.,* I, 1874, 749 f.; II, 1887, 293 f.; III, 1903, 441 ff.
E. J. Swift, this JOURNAL, V, 1892, 1-19.
W. James, *Principles of Psychology,* I, 1890, 425, 427-434.
S. E. Sharp, this JOURNAL, X, 1899, 356.
A. Kästner and W. Wirth, *Psychol. Stud.,* III, 1907, 361-392; IV, 1908, 139-200.

[16] J. McK. Cattell, *Mind,* XI, 1886, 242.

[17] *Op. cit.,* 498.

[18] *Ibid.,* 508.

[19] *Ibid.,* 514.

tion of the reaction-times in the total number of experiments,[20] irrespective of the rightness or wrongness of the judgments, appear for each observer in Table V.

TABLE V

AVERAGE REACTION-TIME IN SECONDS AT THE DIFFERENT LEVELS OF ATTENTION

Observer	Clearness											
	100–90		90–80		80–70		70–60		60–50		50–40	
	Av.	m.v.	Av.	m.v.	Av.	m.v.	Av.	m.v.	Av.	m.v.	Av.	m.v.
F	.9	.48	1.1	.55	2.0	1.1	1.0	.0				
G	.5	.3	1.9	.93	2.0	1.03	1.9	1.05	2.1	1.07	4.0	.0
J_1	.3	.1	1.1	.4	1.3	.9	1.3	.45	1.8	.66	1.6	.8
J_2	1.5	.7	1.8	.8	1.8	.83	2.3	1.2	2.3	1.9	2.6	.0

Av., average reaction time. m.v., mean variation.
Where the mean variation is given as 0, only one experiment occurred under that rubric.

There is evidently a positive correlation between attention, introspectively estimated in t rms of the attributive clearness of mental processes, and rate of reaction. In the whole table there are but four cases in which a lower degree of clearness gives a shorter average time than the next higher degree. Three of these may be summarily dismissed because they are the averages of too few cases: 1, 5, and 1 respectively. The fourth case, that under the fourth rubric of G, cannot be so disposed of. Neither can we consider it as an effect of practice, for this was minimized by the long preliminary series, while the several component reactions were also well distributed throughout the experiment. It is, perhaps, worthy of note, that the mean variation is high. In any case the exception is not of sufficient weight to affect seriously the coefficient of correlation as figured by Pearson's familiar "product moments" method.[21] Calculation yields the following results:

O	Correlation[22]	P.E.
F	0.95	0.038
G	0.76	0.118
J_1	0.94	0.032
J_2	0.98	0.048

This correlation is surprisingly high, when it is remembered that no emphasis was laid, in our instructions, upon the observers' reaction.

[20] The subjective reactions and the failures to react, *i. e.*, the "no-reactions," of course are not considered here; neither case gives a reaction-time.

[21] G. M. Whipple, *Manual of Mental and Physical Tests*, 1910, 27 f.

[22] In computing this correlation, the data under the fourth rubric for F, and the sixth rubric for G, J_1, and J_2, were omitted, for the reason that they represent too few cases: 1, 1, 5, and 1, respectively.

Moreover, no one of our observers, so far as we know, was aware that the reactions were being measured.[23]

(2) *The mean variation* has frequently been proposed as a measure of attention. A small mean variation would correspond to a high degree, and a large variation to a low degree of attention. Obersteiner was probably the first to suggest this correlation. He showed not only that the reaction-times were longer, but also incidentally that the mean variation was greater, in experiments made under distraction.[24] Later, Friedrich remarks: "It is tempting to fix definitely the somewhat unsettled concept of attention by making it proportional to the measure of precision, *i. e.,* to the reciprocal value of the average error, so that a small average error should correspond to a high degree of attention and, conversely, a large average error to a low degree of attention." [25] Although his results show close agreement with theory, he nevertheless is careful in his interpretation of them. He thinks that only "in the case of the simplest mental processes, which are as homogeneous as possible and but little subject to practice, may one assume that the average error is essentially dependent upon the degree of attention." Other authors, however, have been less cautious, and have insisted that attention may be measured by mean variation.[26]

Our own results tend to confirm this view. The increase of the m. v. in Table V is not due in any measure to fatigue or practice. It is not due to fatigue, for only five experiments of 30 to 60 seconds were conducted during an hour; and it is not due to practice, for this was raised to a maximum by the long practice series. In the entire table, with the exception of the levels at which only one experiment is reported, there are but two cases where a lower degree of attention has a smaller m. v. than the next higher. The mean variations for F and G increase uniformly with decrease of the attentive level. Those for J_1 and J_2 are less regular. Nevertheless, the lower degrees of attention still show a greater m. v. We seem justified then, even on Friedrich's principles, in drawing the conclusion that degree of attention can be introspectively estimated in terms of clearness.

(3) The *relation of the reaction-times to the kind and rate of the objective change* appears in Table VI.

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[23] In our case, therefore, the reactions were not known to be reactions, *i. e.,* were not made under the *Aufgabe* of reaction. It is possible that a "reaction" of this sort indexes attention, whereas a formal and set reaction, so understood by the reactor, is too complex a matter to serve as an index.

[24] *Op. cit.,* 446, 447.

[25] M. Friedrich, *Philos. Stud.,* I, 1883, 73.

[26] H. Griffing, this JOURNAL, VII, 1895, 235.
A. Oehrn, *Psychol. Arbeiten,* I, 1895, 92 ff.
V. Henri, *L'année psychol.,* III, 1896, 245.
J. J. van Biervliet, *Journ. de Psychol.,* I, 1904, 230.
A. Binet, *L'année psychol.,* XI, 1905, 71.
W. Peters, *Arch. f. d. ges. Psychol.,* VIII, 1906, 403 ff.

TABLE VI

RELATION BETWEEN THE REACTION-TIME IN SECONDS AND THE KIND AND RATE OF THE OBJECTIVE CHANGE

Observer	Kind				Rate			
	Pitch		Intensity		Slow		Rapid	
	Av.	m.v.	Av.	m.v.	Av.	m.v.	Av.	m.v.
F	.80	.28	1.27	.76	1.30	.60	.76	.42
G	1.70	.79	2.40	2.14	2.50	1.13	1.50	.75
J_1	1.18	.37	1.50	.58	1.60	.63	1.00	.35
J_2	1.41	.72	2.45	1.21	2.56	1.08	1.18	.56

Av., average reaction-time. m.v., mean variation.

The average reaction-time to a change of pitch is, under the conditions of our experiment, much less than that to a change of intensity; and, further, the average reaction-time to a rapid change is shorter than that to a slow change. This relation is constant for all observers. There is, to be sure, great individual variation, but this tallies in general with the character and quality of the observer's report. F, *e. g.*, gives an exceedingly low reaction-time, but, on the other hand, he makes few errors, and his attention is most frequently judged to be of the highest degree.

(4) A comparison of Tables IV and VI shows that there is a close *relation between reaction-time and accuracy of report; i. e.*, the shorter the reaction-time, the greater is the probability that the report is correct. Of the kinds of change, pitch has the shorter reaction-time, and also the greater number of right cases and the smaller number of failures. Of the rates of change, the rapid has the shorter reaction-time and also the greater number of right cases and the smaller number of failures. It would seem then that there is a direct relation between the quality and character of the report and the reaction-time.

This relation becomes apparent at once if the reaction-time is compared directly with the reports. Table VII shows the average

TABLE VII

THE REACTION-TIME IN SECONDS AND THE MEAN VARIATION OF THE RIGHT AND THE WRONG REPORTS

Observer	Right		Wrong	
	Av.	m.v.	Av.	m.v.
F	.93	.50	1.2	.63
G	1.96	1.06	2.3	1.23
J_1	1.28	.62	1.45	.60
J_2	1.71	.81	1.80	1.05

Av., average reaction time. m.v., mean variation.

and mean variation of the reaction-times for both the right and the wrong cases. It confirms the conclusions drawn from the comparison of Tables IV and VI.

The average reaction of the right reports for all of our observers is shorter than that of the wrong reports. While the difference is very small for J_2, it is so marked in the cases of J_1, and especially of G and F, that we may conclude with Whipple[27] that there is a close correlation between rate of judgment and character and quality of report.

(5) The *effect of the distractors* is shown in Table VIII. The average clearness of the focal processes (the sounds of the variator), its mean variation, and the number of cases are given for each distractor.

TABLE VIII

THE AVERAGE CLEARNESS OF THE AUDITORY SENSATION AS AFFECTED BY THE DISTRACTORS

Observer		Distractor								
		0	1	2	3	4	5	6	7	8
F	Av.	89.5	85.7	88.6	86.4	85.8	87.5	88.8	87.0	77.5
	m.v.	3.6	4.4	3.9	3.6	7.3	5.3	4.1	3.8	12.1
	No.	38	22	21	15	25	24	30	27	26
G	Av.	85.0	73.2	80.3	70.6	76.0	65.8	71.0	74.5	57.8
	m.v.	4.9	8.3	3.3	7.6	7.4	7.3	6.5	8.9	8.8
	No.	29	23	31	27	25	31	23	25	34
J_1	Av.	73.7	72.0	58.7	62.1	70.0	63.3	58.0	67.6	54.0
	m.v.	5.1	4.8	13.1	9.1	5.1	9.0	8.2	9.0	8.7
	No.	14	10	8	13	8	7	14	14	9
J_2	Av.	94.0	84.0	77.7	80.0	74.0	79.6	75.7	73.0	60.0
	m.v.	1.5	8.0	11.8	9.0	9.0	10.5	8.5	10.5	14.6
	No.	11	15	9	20	18	15	17	13	15

Av., average clearness of tone. m.v., mean variation. No., number of cases. 0, normal conditions. 1, flicker. 2, current. 3, flicker and current. 4, single metronome. 5, metronome and current. 6, metronome, flicker and current. 7, two metronomes. 8, phonograph.

[27] G. M. Whipple, this JOURNAL, XII, 1900-01, 433 ff. Whipple gave his observers two successive tones, the second of which varied between the relations equal, greater, or less by eight vibrations per second from the first. The second tone was judged in terms of the first. He divided the observers' judgments into three classes according as the report was immediate, slow, or deliberate. He defined the "immediate" as the judgment made without conscious comparison; the "slow," as the judgment made with conscious comparison; and the "deliberate," as the judgment in which the decision was the result of internal debate. He found that a much greater percentage of the immediate judgments was correct than of the slow or the deliberate.

It will be seen that the number of cases under the several distractors varies. This fact appears to confute the statement (made in the discussion of the method) that the distractors were used an equal number of times. But the discrepancy is explained by the nature of the series. In some, only one change was made, in others 2, 3, and 4. The distractors were to be employed an equal number of times, as many times first as last, etc., so that their order had to be prearranged. The order of the series, however, was not predetermined. Though every series was used an equal number of times, choice was made at haphazard. The series with the large number of changes thus accidentally fell to some distractors more frequently than to others. Still, on the whole, the variation in number of cases is slight and of little consequence.

There is wide variation in the effect of the distractors both upon the individual observers and upon the same observer at different times. F was little affected by any distractor save the phonograph. This result agrees closely, as we have said, with the general character and quality of his work. His attention during the experiments was higher, he made fewer errors, the reaction-time of his judgments was quicker, the mean variation smaller, than those of either of the other observers. The phonograph served to distract his attention; but even with it attention might be as high as under normal conditions. He could disregard it provided that unfamiliar pieces were played. When familiar records were played, his attention was "compelled" by them, he was "unable to attend from" them.

The phonograph proved to be the most efficient distractor for all the observers; and attention under normal conditions without distraction proved to be highest for all observers. This is shown in Table VIII; and also, perhaps more clearly, in Table IX, in which the effectiveness of the distractors is arranged in ascending order from least effective (normal conditions) to most effective (phonograph). In other respects, however, there is little or no agreement. G, J_1, and J_2 show, unlike F, a wide distribution of effectiveness; while F's average attention for all distractors, with the exception of the phonograph, lies within four degrees of clearness and is very nearly as high as under normal conditions.

TABLE IX

ORDER OF THE EFFECTIVENESS OF THE DISTRACTORS FROM LEAST TO GREATEST

Observer	Order								
	1	2	3	4	5	6	7	8	9
F	0	6	2	5	7	3	4	1	8
G	0	2	4	7	1	6	3	5	8
J_1	0	1	4	7	5	3	2	6	8
J_2	0	1	3	5	2	6	4	7	8

0, normal. 1, flicker. 2, current. 3, flicker and current. 4, single metronome. 5, metronome and current. 6, metronome, flicker and current. 7, two metronomes. 8, phonograph.

That the effect of the distractors is different for the same observer at different times is shown by J. Though his results for the two periods of the experiment show a gradual change in the effectiveness of the distractors, maximal attention under normal conditions, and minimal attention under the distraction of the phonograph, they can in no other detail be compared. In the first period the degrees of clearness of the focal processes ranged from 73.7 to 54.0; in the second period they ranged from 94.0 to 60.0. An explanation has been suggested above.

Table IX shows, further, that there is no uniform gradation of the distractors. Thus the flicker (no. 1), which next to the phonograph proved to be most effective for F, was only moderately effective for G, and had the least effect of all upon J. And so on with the rest.

It has usually been supposed that attention is best under slight distraction. Titchener says: "It has been shown experimentally that we attend best under a slight distraction,"[28] and Geissler finds that "the results of the second group of experiments showed plainly that even the most complex combinations of distractors, after a few days' work, were unable to induce great variations of attention. Instead, toward the end of the whole group, most of the normal series were actually performed at a slower rate than the distraction series."[29] Hamlin also gives a similar report. She used adding as a distractor, and remarks that "the subjects usually found that it acted as a spur rather than as a check to the attention."[30] Our results show, on the contrary, that attention is best under normal conditions; the distractors lower the attention. The advantage of the normal series is, in the case of F, not very great; but it is uniform, and in the cases of the other observers well-marked. Under the conditions of our experiment, therefore, the observers attended best under normal conditions.

Owing to the precautions that we had taken, the effect of *practice* and *habituation* in these experiments was practically negligible. In the first place, the work was divided into two parts, separated by a period of nine months; in the second place, a large number of distractors were employed, and these were capable of wide variation in intensity and in rhythm; and thirdly, as the experiments advanced, the intensity and rhythm of the distractors were proportionally increased and complicated. Habituation was therefore reduced to a minimum.

In choosing the distractors, our ideal was that of Drew, "to arrange a series of tasks of increasing degrees of complexity which should from the normal make ever greater demands on the mind until the attention should pass from a fully concentrated to a completely distracted state."[31] This is the principle laid down by Stumpf in his *Tonpsychologie*,[32] and by Titchener in his *Psychology of Feeling and Attention*.[33] The results show that we were not successful in obtaining such a series of graded distractors. There appear to be four main reasons. (1) A change in the stimulus may cause the corresponding conscious processes to rise *involuntarily* in clearness. It "catches" the attention. The tone may be comparatively obscure

[28] *Psychol, of Feeling and Attention*, 1908, 203.
[29] *Op. cit.*, 513.
[30] A. J. Hamlin, this JOURNAL, VIII, 1896, 49.
[31] F. Drew, this JOURNAL, VII, 1895, 533.
[32] C. Stumpf, *op. cit.*, I, 1883, 73-75.
[33] E. B. Titchener, *op. cit.*, 1908, 277, 278.

just before the moment of change, but at and during the change it may be maximally clear. (2) There are, in many of the distractors, brief *moments of interruption*, during which the change may occur and the reaction may be performed as if under normal conditions. (3) The distractors *vary in effect from individual to individual.* What may be a graded series for one observer would affect another very differently. (4) The distractors *do not even affect the same observer* in the same way from day to day. Factors are here involved which are subjective in nature (mood, general organic tonus, etc.), and which it is therefore extremely difficult to bring under objective control.

D. *Double Task Method*

1. *Apparatus.*—The Single Task Method involved only the higher degrees of attention. Under the instructions, this could hardly have been otherwise; with attention directed *to* the sounds of the variator and *from* the distractors, the tones would necessarily be of the higher degrees of clearness. It was incumbent upon us, therefore, to extend the work by some method which should induce the lower degrees of attention, and thus to discover if the conclusions so far drawn hold when the lower levels of attention are involved.

Geissler gives four essential requirements for such a method.[34] The efficiency of the work performed must depend as exclusively as possible upon the degree of attention given to it, and as little as possible upon such factors as practice, fatigue, mood, etc. The performance should never become entirely automatic or habitual. It must require absolutely continuous attention, so that a momentary lapse should at once manifest itself in a momentary reduction of the quality of the work. And the execution of the work must easily submit itself to a scale of quantitative gradation.

The method that seemed best to fulfill these requirements was the Double Task Method. This seems to have been first used by Loeb in 1886,[35] but since that time it has been employed successfully by many experimenters.[36] It requires the

[34] *Op. cit.*, 515.

[35] J. Loeb, *Arch. f. d. ges. Phys.*, XXXIX, 1886, 592-597.

[36] A. Binet *Rev. philos.*, XXIX, 1890, 138-155.
H. Münsterberg, *Beitr. z. exper. Psychol.*, IV, 1892, 200 ff.
W. G. Smith, *Mind*, N. S., IV, 1895, 50-73.
F. Drew, this JOURNAL, VII, 1895, 533-572.
V. Henri, *Année psychol.*, III, 1896, 232-278; VII, 1900, 250 ff.
J. C. Welch, *Am. J. Phys.*, I, 1898, 283-306.
W. McDougall, *Brit. J. Psychol.*, I, 1904, 435-445.
W. Wirth, *Psychol. Stud.*, II, 1906, 30 ff.
A. Kästner and W. Wirth, *Psychol. Stud.*, III, 1907, 361-312; IV, 1908, 139-200.
S. de Sanctis, *Zeits. f. Psychol.*, XVII, 1898, 205-214.
L. R. Geissler, *op. cit.*, 515-529.

observer to divide his attention, and to perform simultaneously two different mental tasks.

The first task which we selected was essentially the same as that of the previous experiment,—judging and reporting the changes of an auditory stimulus. The recording apparatus, the Stern variator, and the apparatus for the control of the tone, were the same as before. The second task consisted either of counting discrete objects, or of continuous adding.

In the counting of discrete objects, no. 12 BB shot were first used. Since the right hand rested upon the electrical key, the counting was done with the left. The shot proved to be too small to be picked up one by one and thus counted; and an apparatus was constructed whereby they rolled, as they were counted, down an inclined plane to a common receptacle. The rolling, however, made a slight noise; this gave rise to a distraction which under the conditions of the Double Task Method was objectionable; and accordingly a felt pad was substituted for the box. But now the observers had trouble in separating the shot, in moving them rapidly over the surface of the felt; so that, even under the best conditions, accurate records were seldom made. We therefore abandoned the shot in favor of small corks. These permitted of gross movements, could be taken up separately as counted, and were noiseless. They were placed upon a felt pad in front of the observer, and were transferred as counted to a felt-lined box which stood a few cm. to the left.

In the continuous adding, five series of thirty figures were selected to constitute five different degrees of difficulty. The easiest contained all the figures from 1 to 9; with the exception of figure 3, which occurred six times, each integer appeared three times in the series. In the second series all the figures from 3 to 13, with the exception of 10, occurred three times. In the third series all of the figures from 13 to 23, with the exception of 20, occurred three times. In the fourth series the following figures 23 to 27 were used once; 33 to 37, 43 to 47 were used twice; and 53 to 57 once. In the fifth and last series the figures 63 to 67 were used once; 73 to 77 and 83 to 87 twice; and 93 to 97 once. By using a different starting-number, the effect of practice and memory of previous results were entirely eliminated. The starting-number varied in regular order from day to day between the odd numbers from 3 to 25.[37]

The numbers were presented visually by an exposure apparatus which was constructed from a kymograph drum. This was slowly revolved by the motor which, in the Single Task Method, actuated the flicker. The drum was concealed behind a neutral-gray screen which stood in front of the observer at a distance of about 30 cm. A rectangular slit 1 x 3 cm. was cut in the center of the screen directly in the observer's line of regard. The apparatus was so arranged that the numbers appeared from above. The rate of presentation was variable as slow, moderate, and rapid. It was controlled from the experimenter's desk by a three-way switch, and was governed by increase or decrease of the strength of the electrical current. The rate of presentation was also controlled by the spacing of the

[37] *Cf.* Geissler, *op. cit.*, 504.

figures upon the drum, which was constant throughout an entire experiment. In Series I the figures were single-spaced; in Series II, doubled-spaced; and in the other series, III, IV, and V, triple-spaced. The exposure slit was illuminated by an electric light which was fixed just above and somewhat behind the observer. The illumination was constant and uniform, and the observer's head cast no shadow upon the visual field.

A slight shift of the drum upon its shaft made it possible to expose a number-series of any degree of difficulty in the rectangular window. The easier series were first shown, variation occurring only in the starting-number and in the rate of presentation. As the observers became practised in addition, the more difficult series were gradually introduced. We sought to keep the mental task of such difficulty that a high degree of attention was required, and that a lapse in attention should manifest itself directly in the quality and character of the work. Great care, however, had to be exercised not to increase the difficulty of the series and the rate of presentation beyond the limits of the individual observer. F was the only observer to add successfully series V, even when presented at the slowest rate.

2. *Instruction.*—As a control, every third experiment was conducted under the normal conditions of the Single Task Method; *i. e.*, the sole task was observation of, and response to, the changes of the auditory stimulus. Five experiments were usually made during an hour. They began at the signal *Ready, Now,* and the observer directed his attention as instructed, either to the tone of the variator, or to the counting of the corks, or to the adding of the figures. The instruction was as follows:

"In this experiment you are to record all changes of intensity and of pitch as in the previous experiment, by one and two pushes respectively upon the key, and are also in the subsequent introspective reports to give the rate of change.

"You are to direct your attention (to the tone of the variator,) (to the counting of the corks,) (to the adding of the figures). At the end of the experiment, which may run for thirty seconds, you shall (give the number of corks you have counted,) (give the sum of the figures you have added,) answer the following questionary:[38]

1. How much attention in terms of clearness was given:
   - *a.* To the auditory stimulus?
   - *b.* To the other required task,—if there was one?
   - *c.* To any other sensory or ideational processes which may have entered consciousness during the course of the experiment?
2. What affective mood prevailed during the experiment?
3. Have you any comment to make?"

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[38] *Cf.* Geissler, *op. cit.*, 519.

These instructions were read to the observer before each experiment.[39] The three kinds of experiment, in which the attention is directed to different tasks, will henceforth be represented by the numerals 0, 1, and 2. 0 refers to the normal or check series, in which attention is directed to the sound of the variator; 1 refers to the Double Task Method, in which it is directed also to the counting of the corks; and 2 refers to the Double Task Method, in which it is directed also to the adding of the figures. These three kinds of experiments are taken an equal number of times, and occur as many times in the first place as the second, third, fourth, and last places.

3. *Number of experiments.*—The experiments were made during the autumn of 1912. The same observers who had taken part in the other series were, fortunately, available. F gave in all 152 introspections: G, 150; and J 151.

4. *Series.*—The series of the Double Task Method differed from those of the Single Task Method in two respects. First, the time of the experiments was reduced uniformly to 30 seconds. This reduction was thought advisable, since the shorter period tended toward accuracy in the introspective reports, and since it tended also to rest the efficiency of the work performed upon degree of attention, and as little as possible upon fatigue. Secondly, the number of changes within a single experiment was reduced to two. The four, and even the three changes which were introduced in the Single Task Method had there proved to be a source of difficulty; and we could not anticipate their successful use under the new conditions, in which the attention was divided between two tasks. In four of the series but one change was made. This precaution was taken in order that the observer might not become habituated to two changes. In all other respects, the series agreed with those of the Single Task experiment.

[39] The importance of repeating the directions is not to be overlooked. On one occasion, the observer was merely directed to "count corks" and not as usual to "direct attention to the counting." The effect on the experiment was plainly shown in the report and introspection. The report was correct, and the clearness was maximal. The introspection read: "At first attention divided equally between tone and counting, both on upper level. On the whole the tone was slightly clearer. Eyes right; turned toward source of sound. These two processes, tone and counting, on upper level for short time. Later they rapidly fluctuated; now the tone was clearer, now the counting."

In detail, the series were as follows:

Series	Time of change	No. of Pitch changes	Pitch of tone	No. of intensity changes	Intensity of tone	Rate of change
I	10″	1	400–450	0	h	r.
II	15″	1	350–450	0	l	s.
III	20″	0	450	1	h-l	r.
IV	25″	0	300	1	l-h	s.
V	5″–10″	2	500–400–500	0	h	r.r.
VI	5″–15″	2	400–500–400	0	l	s.s.
VII	5″–20″	2	500–400–300	0	h	r.s.
VIII	5″–25″	2	300–400–500	0	l	s.r.
IX	10″–15″	1	400–450	1	h-l	r.r.
X	10″–20″	1	500–450	1	l-h	s.s.
XI	10″–25″	1	300–400	1	l-h	r.s.
XII	10″–28″	1	500–400	1	h-l	s.r.
XIII	2″–28″	0	300	2	l-h-l	r.r.
XIV	15″–20″	0	500	2	h-l-h	s.s.
XV	15″–25″	0	400	2	l-h-l	r.s.
XVI	15″–28″	0	450	2	h-l-h	s.r.

SUMMARY

Kind of change	No. of changes	No. slow changes	No. rapid changes
Pitch	14	7	7
Intensity	14	7	7
Total	28	14	14

5. *Results.*—In working over the data, the observers' reports were grouped as in the other experiment. It soon became apparent, however, that this classification was not entirely adequate. There were occasions when the observer reported " change " without giving either kind or rate. Such cases did not occur with the Single Task Method. We dispose of them by grouping them under a new heading, as *Fact of Change.*

The results appear in Table X. The data from the check or normal experiments are not here considered. Only one task was set in those experiments, and the attention was directed to the tone of the variator; consequently, the clearness of the auditory processes was nearly always maximal, and the reports were nearly always correct; the results add nothing to those of Tables I and II (Single Task Method), and are therefore omitted here. Our object in giving the normal series was, it will be remembered, not to confirm the results of the Single Task experiment, but merely to afford a means whereby the observer could, from time to time, compare the clearness of the auditory processes in concentrated and divided attention.

TABLE X

NUMBER OF CASES, KIND AND RATE OF CHANGE

Report	Change	O.	Right									Wrong								
			10-9	9-8	8-7	7-6	6-5	5-4	4-3	3-2	2-0	10-9	9-8	8-7	7-6	6-5	5-4	4-3	3-2	2-0
KIND AND RATE	Ps	F	4	13	6	2								1					2	
		G		1	1	1			1							7	7	2	1	
		J						5	6	5								1	3	2
	Pr	F	4	10	4									1						
		G		1	1	17	7	2										1		
		J						10	15	6	1								1	
	Is	F	1	3	7							1	1		1					
		G		1			1	1								4	5	1	2	
		J						5	4	2	1									
	Ir	F	5	11	4	4							1			1				
		G			3	1		1	1							2	2	3		
		J						5	4	2	1									
KIND	Ps	F		3	5	1	3						1	1						
		G				4	8	3							1		1			
		J						1	6	7	1							4	4	
	Pr	F		5	8	7	1							1						
		G				1	1	1							1	1	2			
		J						3	9	5										
	Is	F		11	4	1	1							1						
		G			3	2	1	1		2										
		J						1	3	7										
	Ir	F			6	1							1	2						
		G			1					1					3	5	2	1		
		J						1	3	14									1	
RATE	Ps	F		1	1								3	5	1	3				
		G				1		1							4	8	3			
		J							4	4							1	6	7	1
	Pr	F			1								5	8	7	1				
		G				1	1	2							1	1	1			
		J															3	9	5	
	Is	F			1								11	4	1	1				
		G												3	2	1	1		2	
		J															1	3	7	
	Ir	F		1	2									6	1					
		G				3	5	2	1					1					1	
		J								1							1	3	14	
FACT OF CHANGE	Ps	F			1															
		G				1	1	1												
		J							1											
	Pr	F			1															
		G						1												
		J																		
	Is	F	1																	
		G						1	2											
		J							1		1									
	Ir	F		1																
		G					1	1												
		J																		

TABLE X—*Continued*

Report	Change	O.	Wrong 10-9	9-8	8-7	7-6	6-5	5-4	4-3	3-2	2-0
SUBJECTIVE REACTION	Ps	F									
		G									
		J									1
	Pr	F									
		G									
		J									
	Is	F		1		1					
		G									1
		J							1	2	
	Ir	F	1		1	1					
		G									
		J								1	
NO REACTION	Ps	F									5
		G						1	2	1	7
		J									4
	Pr	F									2
		G							1	2	5
		J								2	2
	Is	F				1			1	4	16
		G						2	4	7	13
		J								2	16
	Ir	F								1	12
		G						1		5	10
		J								3	11

Table X gives only the number of cases. A comparison of the right and wrong cases, the subjective reactions and the failures is more clearly presented in Table XI. This table shows that a lower degree and a greater scope of attention were uniformly, in the case of all observers, induced by the Double Task Method. F's introspective estimations cover nearly the entire attentive scale, though there is nevertheless a marked tendency toward the higher degrees. This distribution agrees closely with his introspections, for he reports that the clearness of the auditory processes rises when a change is perceived; as a change is perceived, the processes immediately become clearer, the judgment of kind and rate is made, and then the auditory stimulus again lapses into obscurity.

G likewise covers the entire scale. Her results are very regular, and show a tendency towards the central part of the scale. J's estimations, unlike those of the other observers, are limited to the lower degrees of clearness. His attention upon the secondary tasks was maximal; and his work in them was, throughout, of the highest order.

TABLE XI

NUMBER OF CASES GROUPED ACCORDING AS THE CHANGE IS OF PITCH OR INTENSITY AND IS RAPID OR SLOW, WITH SUMMARY

Kind or Rate	Report	*O.*	Clearness 10-9	9-8	8-7	7-6	6-5	5-4	4-3	3-2	2-0
PITCH	Right	F	8	31	23	10	4				
		G		2	2	23	16	6	1		
		J						19	36	23	2
	Wrong	F		1	4					2	
		G				2	8	10	3	1	
		J							5	8	2
	Sub-jective	F									
		G									
		J									1
	No-reaction	F									7
		G						1	3	3	12
		J								2	6
INTENSITY	Right	F	6	25	21	6	1				
		G		1	7	3	2	3	1	3	
		J						11	18	28	1
	Wrong	F	1	3	3	1	1				
		G				3	11	9	5	2	
		J							1	1	1
	Sub-jective	F	1	1	1	2					
		G									1
		J							1	3	
	No-reaction	F				1			1	5	28
		G						3	4	12	23
		J								5	27
SLOW	Right	F	5	17	15	2					
		G		2	1	2	1	2	1		
		J						9	18	14	
	Wrong	F	1	15	10	3	4			2	
		G			3	6	20	16	3	5	
		J						2	11	17	4
	Sub-jective	F		1		1					
		G									1
		J							1	2	1
	No-reaction	F				1			1	4	21
		G						3	6	8	20
		J								2	20

TABLE XI—*Continued*

Kind or Rate	Report	O.	Clearness 10-9	9-8	8-7	7-6	6-5	5-4	4-3	3-2	2-0
RAPID	Right	F	9	22	11	4					
		G		1	4	22	13	7	2		
		J						15	19	9	2
	Wrong	F		6	15	8	2				
		G			1	1	3	3	4	1	
		J						4	12	20	
	Sub-jective	F	1		1	1					
		G									
		J								1	
	No-reaction	F								1	14
		G						1	1	7	15
		J								5	13
SUMMARY	Right	F	28	95	70	22	5				
		G		6	14	50	32	18	5	3	
		J						54	91	74	5
	Wrong	F	2	25	32	12	7			4	
		G			4	12	42	38	15	9	
		J						6	31	46	7
	Sub-jective	F	2	2	2	4					
		G									2
		J							2	6	2
	No-reaction	F				2			2	10	70
		G						8	14	30	70
		J								14	66

Table XI shows further that the greatest number of right cases occurs in the higher degrees, and conversely that the greatest number of wrong cases occurs in the lower degrees of clearness. This relation between the right and wrong reports is more clearly shown in Table XII, in which the reports are weighted.[40] The same system of weights is here employed as in the Single Task Method. A single addition is, however, made: half a point is added to the right cases for all reports grouped under *Fact of Change*.

[40] We again call attention to the "subjective" reactions. Out of 1160 cases reported under this method only 22 (about 2%) were "subjective."

TABLE XII

WEIGHTED SUMMARIES

O.	Report	Clearness								
		10–9	9–8	8–7	7–6	6–5	5–4	4–3	3–2	2–0
F	Right Wrong	28.5 4.0	95.5 27.0	71.0 35.0	22.0 18.5	5.0 7.0		 2.5	 16.5	 87.5
G	Right Wrong		6.0	14.0 4.0	50.5 12.0	33.0 42.0	20.0 48.0	6.0 32.5	3.0 46.5	 89.5
J	Right Wrong						54.0 6.0	92.0 33.0	74.5 69.5	5.0 91.5

The crests of the curves of right judgments now fall with F, 7 places; with G, 5 places; and with J, 3 places, respectively, to the left of the crests of the curves of wrong judgments. The crests of the latter curves lie uniformly, for all observers, in the lowest degree of clearness, from 0 to 20. This result, as is shown by the preceding tables, is due to the great number of changes which were unobserved and during which the tone of the variator was very obscure. The general relation holds, however, even if the no-reactions are not considered: in that case, the crests of the curves of wrong reactions still fall 1, 2, and 1 place for F, G, and J respectively below the crests of the curves of right reactions. The results thus substantiate those of the Single Task Method, and confirm our conclusion that a close parallelism exists between the introspectively distinguished variations of attention and the accuracy of the work done,—provided, first, that the estimation of the degrees of attention is made in terms of the attributive clearness of the processes attended to; and, secondly, that the work itself is not influenced by anything other than a change in the attention. That this second requirement is fulfilled under the conditions of our experiment, and that our results are due to attention and not to any other influence, such as a specific reaction to a particular kind and rate of change, is not to be doubted. It is clearly shown in Table XI that the relation holds irrespectively of the kind and rate of the change. The crests of the "right" curves lie from one to two, three and four steps above the crests of the "wrong" curves.

It might be objected that the precision of the work is no more dependent upon degree of attention than upon duration of attention. That the *moment* of change is significant, an objector might say, cannot be questioned. Sometimes a change will occur when the addition is easy, or a cork has just been deposited within the box. Under such conditions a change may be freely attended to, and consequently both the degree and the duration of attention will be increased. If, on the other hand, a change occurs at some critical point in the counting or adding, though it may be perceived as clearly as in the former case, yet the duration of attention will necessarily be shorter; and consequently the precision of the work (judgment of kind and rate of change) will be decreased. In other words, the accuracy of the report will vary directly with duration of attention. This, indeed, might be a formidable criticism if the facts were found to justify it; but they are not. We might, in any event, raise the question whether attention, under the unfavorable conditions of the second case given above, could be as high as under the favorable conditions of the first. We might also point out that our observers were instructed to estimate the *clearness-values only*, that a long preliminary and practice period was allowed in order that they might accurately estimate the attributive clearness of mental processes attended to and attended from, and lastly that their introspective estimation of clearness-values was entirely independent of duration of attention. But we need only refer to the results of the Single Task Method. There, the observers were directed to attend *to* the tone, and *from* the distractors. They were not instructed to react as quickly as possible, but only to respond "as soon as a change is perceived;" there was no pressure upon them to hasten their report.[41] If the duration of attention varied at all, it varied quite independently of, and apart from, the clearness of the mental processes during the change, and the accuracy of the reports made after the change. As now the results of the two methods agree very closely, we may conclude without hesitation that degree and not duration of attention is responsible in our experiments for precision of work done.

It is apparent, however, from the preceding tables, that there is a difference in the *accuracy of reaction to the various changes*. The relation between report and objective change in the Double Task Method is shown in Table XIII.

This table shows, first, that a change of pitch is more compelling than a change of intensity; and, secondly, that a rapid change is more attractive than a slow. The results are uniform for all observers. With changes of pitch, more reports were correct, fewer were wrong, fewer subjective errors were made, and fewer objective changes were unobserved, than in the case of intensity; and likewise, though not so markedly, more rapid changes were reported correctly, fewer wrongly, fewer subjective errors were made, and fewer

[41] The phrase "as soon as" was not felt as a temporal pressure; for, as we have said, no one of the observers knew that the "reactions" were being measured. Had they possessed this knowledge, the instructions might have received a temporal interpretation. In fact, their only concern was to report correctly.

rapid changes were passed over unobserved, than was the case with slow changes.

TABLE XIII

RELATION BETWEEN THE OBSERVER'S REPORT AND THE KIND AND RATE OF OBJECTIVE CHANGE, EXPRESSED IN NUMBER OF CASES

O.	Kind								Rate							
	Pitch				Intensity				Slow				Rapid			
	R.	W.	S.	N.	R.	W.	S.	N.	R.	W.	S.	N.	R.	W.	S.	N.
F	76	7		7	59	9	5	35	39	35	2	27	46	31	3	15
G	50	24		19	20	30	1	42	9	53	1	37	49	13		24
J	80	15	1	8	58	3	4	32	41	34	4	22	45	36	1	18
Total	206	46	1	34	137	42	10	109	89	122	7	86	140	80	4	57

R., right report. S., subjective report.
W., wrong report. N., no report.

(1) The interval between the moment of change and the observer's reaction was measured, as before, in fifths of a second. The *average reaction-time* was computed for each degree of attention as estimated by the clearness of mental processes. This time, together with the m. v. and the number of cases at each level, appears in Table XIV.

TABLE XIV

AVERAGE REACTION-TIME IN SECONDS, MEAN VARIATION, AND NUMBER OF CASES AT THE DIFFERENT LEVELS OF ATTENTION

O.		Clearness								
		10–9	9–8	8–7	7–6	6–5	5–4	4–3	3–2	2–0
F	Av.	1.13	1.22	1.46	1.30	2.10			2.30	
	m.v.	.48	.50	.66	.45	1.36			.30	
	No.	13	54	44	13	6			2	
G	Av.		1.30	.95	1.83	2.17	4.00	4.00	5.80	
	m.v.		.30	.27	.73	.77	1.30	.60	.13	
	No.		3	7	23	18	3	2	3	
J	Av.						1.10	1.32	1.61	1.10
	m.v.						.52	.63	.87	.20
	No.						24	46	48	4

Av., average reaction-time. m.v., mean variation. No., number of cases under rubric.

The number of cases in this table does not agree with that shown in Tables X and XI, although the table includes every reaction-time at our disposal. The difference is due to three causes. First, the subjective reactions and the failures gave no reaction-times. Secondly, the delicate writing-point of the Jacquet chronometer not infrequently bound on the smoked drum. Since the apparatus was in another room, we had no intimation of this defect until the experiment was ended. Though such cases could be (and were) used when we were concerned only with a correlation between the introspective variation of attention and the accuracy of the reports, they were useless for the correlation between introspective variation of attention and rate of report. And thirdly, the observers under the Double Task Method did not always react as soon as the change was perceived and judgment made. They were not instructed to react immediately; and if a change occurred at a critical point, they might voluntarily delay their reaction until a more favorable opportunity to react presented itself. Such delayed reactions were noted in the observer's introspections, and are naturally omitted from the table.

The table itself corroborates Table V; there is a positive correlation between variation of attention and rate of reaction. The reaction-times in the higher degrees of clearness are shorter, and the mean variations are smaller, than in the lower degrees. The numerical expression of this correlation (for length of reaction-time) and of its probable error is as follows:

O.	Correlation[42]	P.E.
F	0.88	0.068
G	0.59	0.253
J	0.60	0.248

(2) Table XI shows that there is a positive correlation between variation in attention and accuracy of work performed *irrespectively of the kind and rate of the objective change.* Nevertheless, we have seen that changes of pitch, and rapid changes, are more compelling

TABLE XV

RELATION BETWEEN THE REACTION-TIME IN SECONDS AND THE KIND AND RATE OF THE OBJECTIVE CHANGE

O.	Kind						Rate					
	Pitch			Intensity			Slow			Rapid		
	Av.	m.v.	No.	Av.	m.v.	No.	Av.	m.v.	No.	Av.	m.v.	No.
F	1.29	.61	71	1.52	.65	48	1.78	.98	58	.99	.34	61
G	1.91	.75	42	2.28	1.40	15	2.73	1.01	18	1.68	.76	39
J	1.24	.53	73	1.54	.85	48	1.93	.82	49	.96	.28	72

Av., average reaction-time. m.v., mean variation. No., number of cases.

[42] In computing this correlation we omitted the data for F under the 8th rubric, for G under the 2d, 6th, 7th, and 8th rubrics, and for J under the last rubric. If these data had been considered in the computation the correlation would have been much greater. They are, however, the averages of too few cases: 2, 3, 3, 2, 3, and 4, respectively.

then changes of intensity or slow changes (see Table XIII). In Table XV, in which the relation between the average reaction-time of the observers' reports and the kind and rate of the objective change appears, this result is further confirmed.

The average reaction-times and the mean variations are uniformly, for all observers, smaller for pitch than for intensity, and smaller for rapid changes than for slow. These results agree with those of the Single Task Method.

(3) Table XIII shows the greatest number of right cases under the rubrics *pitch* and *rapid*, and conversely the greatest number of wrong cases under the rubrics *intensity* and *slow*. Since Table XV shows that the former rubrics have a more rapid reaction than the latter, it would appear that the *reaction-time for the right answers was faster* than that for the wrong. This inference is borne out by Table XVI.

TABLE XVI

THE REACTION-TIME IN SECONDS AND THE MEAN VARIATION OF THE RIGHT AND THE WRONG REPORTS

Observer	Right			Wrong		
	Av.	No.	m.v.	Av.	No.	m.v.
F	1.26	63	0.52	1.51	56	0.79
G	1.56	29	0.70	2.45	28	1.46
J	1.26	59	0.59	1.46	62	0.73

Av., average reaction-time. m.v., mean variation. No., number of cases.

(4) The *effect of the secondary tasks upon attention* is shown in Table XVII. The average clearness of the sounds of the variator, the mean variation, and the number of cases for each task are given.

This table shows the effect of the division of attention. The fact that F and J have less changes under 0 than under 1 and 2 is due to the nature of our procedure. In some series, only one change occurred during the period of observation; and since the order was haphazard, these series might fall to one kind of experiment more frequently than to another. The difference, however, is small.

The average clearness of the auditory processes in the normal experiments is, for all observers, uniformly higher, and the mean variation is correspondingly lower than in the Double Task experiments. The secondary tasks are, on the average, very effective, though the large mean variation shows that there were cases in which the auditory processes were normally clear. This result is borne out by the introspective reports of the observers. There were many cases in which the change compelled the attention, so that the auditory process momentarily became maximally clear, and the task of counting or adding became obscure. The table shows, further, that the task of adding was uniformly more efficient than the task of counting. The larger size of the mean variation may be ascribed in the light of the introspective reports to the more frequent occurrence of "critical points" in the adding. It will be remembered that the rate at which the corks were counted was governed entirely by the observer, while the adding was objectively controlled.

TABLE XVII

THE AVERAGE CLEARNESS OF THE AUDITORY STIMULUS AS AFFECTED BY DIRECTION OF ATTENTION ON THE PRIMARY OR SECONDARY TASK

Observer		Attention directed to		
		0	1	2
F	Av.	88.5	70.3	53.4
	m.v.	4.5	13.1	29.5
	No.	87	98	100
G	Av.	85.0	48.4	35.1
	m.v.	3.1	12.5	17.7
	No.	93	92	94
J	Av.	92.1	25.5	21.8
	m.v.	2.8	7.3	8.9
	No.	82	100	101

Av., average clearness of tone. m.v., mean variation. No., number of cases under rubric. 0, attention directed to tone of variator. 1, attention directed to counting of corks. 2, attention directed to adding of figures.

TABLE XVIII

COMPARISON BETWEEN THE AVERAGE CLEARNESS OF THE MENTAL PROCESSES INVOLVED IN COUNTING CORKS AND THE DEGREE AND ACCURACY OF THE WORK PERFORMED

Observer		Clearness of Mental Processes Involved in Counting Corks			
		100–90	90–80	80–70	70–60
F	Av.	44.0	36.0	34.2	27.0
	m.v.	5.1	3.2	2.2	0.0
	W.	4	8	3	1
	No.	16	21	8	1
G	Av.	32.6	28.6	23.5	21.0
	m.v.	1.7	2.7	2.8	0.0
	W.		6	2	1
	No.	9	33	4	1
J	Av.	65.0	61.3	58.4	
	m.v.	3.5	3.5	2.8	
	W.	6	9	2	
	No.	17	29	5	

Av., average number of corks counted. m.v., mean variation. W., number of experiments in which the corks were incorrectly counted. No., number of experiments.

(5) Tables XVIII and XIX show the *relation between the character and quality of the work performed, and the attention* as estimated in terms of attributive clearness. Since the tasks occupied the entire period of observation, the clearness of the processes involved in them was obtained as the average of the period.[48]

F and G it should be remarked, counted the corks singly; J counted them in pairs.

The results under Av. and W. confirm our previous conclusions. When the mean variation is considered, however, a discrepancy appears. F and J show a greater m. v. for the higher degrees of attention than for the lower; G alone follows the rule. We can only suggest that the irregularity is due to the small number of cases.

TABLE XIX

COMPARISON BETWEEN THE AVERAGE CLEARNESS OF THE MENTAL PROCESSES INVOLVED IN CONTINUOUS ADDING AND THE ACCURACY OF THE WORK PERFORMED

Observer	Report	Clearness of Mental Processes Involved in Continuous Adding			
		100–90	90–80	80–70	70–60
F	Correct	20	6	1	
	Nearly correct	14	3	1	
	Failures		4	2	
	No. cases	34	13	4	
G	Correct	9	12		
	Nearly correct		18	2	
	Failures		4	4	1
	No. cases	9	34	6	1
J	Correct	13	5	2	
	Nearly correct	5	6		
	Failures	6	11	4	
	No. cases	24	22	6	

In Table XIX the correct additions are grouped under the heading *Correct.* Those in which there was a mistake of one digit, as 164 for 165, or 219 for 229, are classified as *Nearly correct.* And lastly those cases in which the error was greater, or in which the observer lost count of the numbers, are brought together as *Failures.* The degree of attention is determined, as in the previous table, as the average clearness of the mental processes involved in the adding during the entire period of observation.

F and J give the results that we have learned to expect: G's showing

[48] This average, though not asked for in the instruction, was voluntarily estimated introspectively by both F and G, and the value was taken that they ascribed. J gave no such estimation. His average was computed from his estimations prior to and between the moments of change. We may add that the same data were at hand (or the same plan was followed) for estimating the clearness of the mental processes at times when No Reaction was made to an objective change (see Tables I and X).

is less regular. During maximal attention, however, all of her additions were reported correctly. In absolute number, it is true, more correct answers were returned in the next lower degree of attention; but at this level we also find not only 18 cases in which the answer contained a slight error, but also 4 cases of failure. In view of the small number of cases, we may be fully satisfied with the general confirmation of our earlier experiments.

(6) The large number of introspective reports obtained during these experiments, nearly 1400 in all, should yield information concerning the *number of levels* of attention. Titchener, in his *Psychology of Feeling and Attention*,[44] reviews and discusses the literature, and concludes that "a diagram of consciousness would show . . . a two-level formation. The surfaces are not smooth; the upper certainly, the lower probably, is creased or wrinkled." These creases or wrinkles correspond to the finer differences of attributive clearness at the two main levels of consciousness. Since this review, two important contributions to the subject have been made. Wirth[45] finds, under certain conditions, that there are more than two levels of clearness in his own consciousness, and maintains that at any moment of attention all possible degrees of apperception may be represented. Geissler suggests that there are two more or less distinct types of observers: those for whom the dual division is the most natural and most common; and those who as a rule experience several levels of clearness.[46] Only two of his observers reported a multi-level formation, and he was therefore very cautious in drawing his conclusions. "There seem," he says, "to be two types of the attentive consciousness, the dual division and the multi-level formation." Later, in a review and criticism of Wirth's results, he expresses the opinion that Wirth, and probably also Wundt, belong to the latter type.[47]

Our own results throughout corroborate Titchener's original conclusions.[48] All of our observers reported, without exception, the dual division: a clear focus and a vague background, which varied reciprocally.[49] In not a single instance was the multi-level formation even hinted. The distinction of the two types is, then, apparently, a true individual difference, and is not dependent upon external conditions.

The records thus show to date three observers of the multi-level type: Prof. W. Wirth,[50] Prof. M. Bentley,[51] and Dr. H. M. Clark;[52]

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[44] *Op. cit.*, 220-242.

[45] W. Wirth, *Phil. Stud.*, XX, 1902, 493 f.

[46] *Op. cit.*, 528 f.; *cf.* Titchener, *Text-Book*, 1911, 302.

[47] This JOURNAL, XXI, 1910, 155.

[48] *Op. cit.*, 220-242; also *Text-Book*, 276 ff., 290.

[49] The values of the upper and lower levels of attention did not in every case total 100. The discrepancy, however, was never very great, varying only about 5 degrees on the one side or the other There was some individual variation among the observers. F was ordinarily about 5 *per cent.* short in the total; he never, however, made an error greater than this. G's totals were on the average 5 *per cent.* too large; frequently they were correct; at times they were 10 *per cent.* too large; the value never fell below 100. J's results almost always totaled 100.

[50] *Cf. op. cit.*, IV, 1908, 139 f.; *Phil. Stud.*, XX, 1902, 493; and L. R. Geissler, this JOURNAL, XX, 1909, 120-130.

[51] Geissler, *op. cit.*, 527 f.

[52] *Ibid.*, 528.

and eight observers of the dual type: Prof. E. B. Titchener,[53] Prof. W. H. Pyle,[54] Dr. T. Okabe,[55] Dr. A. de Vries,[56] Prof. L. R. Geissler,[57] and our observers, Dr. W. S. Foster, Miss M. E. Goudge, and Mr. J. S. Johnston.

III. *Summary.*

The general results of our study may be summarized as follows:

(1) Attention may be measured introspectively in terms of attributive clearness. For introspectively distinguished variations of attention (*i. e.*, clearness) are closely paralleled by corresponding differences at the same level in accuracy of work performed, in rate of reaction, and in degree of precision as expressed by the m. v.

(2) Under our conditions, the time of reaction, as is shown throughout by the high coefficients of correlation, serves accurately to measure the attention.

(3) Changes of pitch and rapid changes are more compelling than either changes of intensity or slow changes. The accuracy of judgment for change of pitch and for rapid change is greater than that for change of intensity or for slow change; and, furthermore, the reaction-time to the former changes is smaller than that to the latter.

(4) A close correlation exists between accuracy and rate of report.

(5) Under our conditions, distraction, no matter how slight, tends to lessen the degree of attention.

(6) The difficulty of obtaining a graded series of distractors is very great. In our experience, the action of the distractors is not constant, but varies from day to day, and from observer to observer.

(7) There are two types of the attentive consciousness: the dual division, and the multi-level formation. These types represent true individual differences, and do not depend upon external conditions of observation.

(8) In the dual-division type of attention, the levels vary reciprocally.

[53] E. B. Titchener, *Lectures on the Experimental Psychology of the Thought-processes*, 1909, Lect. I.; also *Psychology of Feeling and Attention*, 220.

[54] Geissler, *op. cit.*, 527.

[55] *Ibid.*, 527.

[56] *Ibid.*, 527.

[57] *Cf.* this JOURNAL, XXI, 1910, 154 f.