

SIMULTANEOUS AND SUCCESSIVE ASSOCIATION.

By A. WOHLGEMUTH.

(*From the Psychological Laboratory, University College,
University of London.*)

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I. INTRODUCTORY.

THE present investigation was undertaken principally for the purpose of deciding by experiment, if possible, between the claims of the rival theories of *Simultaneous and Successive Association*. The theory of Simultaneous Association teaches that associations cannot be formed unless the mental experiences be simultaneous. To overcome the evident difficulty that, as we know from everyday life where experiences succeed each other in time, associations are formed, it is held that with the cessation of the actual mental experience the nervous excitation is not abruptly finished but continues, gradually dying away: that is to say, the mental experience is followed by a gradually diminishing subconscious phase, the *akoluthic* phase of Richard Semon¹. The following mental experience coincides then in time with this *akoluthic* phase of the preceding mental experience, and it is due to this simultaneity that the association of the two experiences is formed. The simultaneity is a *sine qua non*. Associations of successive mental experiences then tend to form the limiting case to simultaneous associations.

The rival theory of successive association denies the possibility of associations between simultaneous experiences. In fact, it is an outcome of the theory that the range of our consciousness is not wide

¹ Richard Semon, *Die Mneme*, 2te Aufl., 19.

enough to attend to two things at once, to two objects of consciousness at the same time; but that it is constantly oscillating between two apparently simultaneous contents; and they thus are in reality successive experiences. Associations then between apparent simultaneous experiences form the limiting case to those of successive experiences.

Two other points which it appeared desirable to investigate at the same time were the influence of the closeness of connection between the members that were presented simultaneously, and the influence of certain attitudes of the mind upon the associations.

Altogether apart from the general fact of the unsuitability of nonsense syllables for any investigation on memory as shown by me in a previous paper¹, this unsuitability was here increased by the further fact that two syllables cannot be read simultaneously. I, therefore, chose colours and figures or shapes; and, in order to facilitate matters, I arranged them in pairs, each consisting of one colour and one figure. In doing this I not only overcame many difficulties that would have arisen through paucity of material, but I had also the advantage of having my subjects less troubled by the side-associations formed with the various members of the other pairs. Thus, for example, in a series of six pairs each consisting of a colour and a figure the subject during the examination could not be troubled by more than five side-associations, for, if a colour was shown, there were, beside the correct figure, only five others in the series, whilst if the series had consisted of colours only or figures only the number of possible side-associations would have been doubled, that is, side-associations might have been formed with any of the ten members constituting the other five pairs of the series.

II. EXPERIMENTAL.

I shall now proceed to give a description of the various groups of experiments concerned. These were groups 1, 2, 8 and 9. Groups 3 to 7 dealt with the direction of association and the results have been published in the paper mentioned above. I shall not here go into the technique of these experiments as this is fully described in that paper to which I must refer the reader.

¹ "On Memory and the Direction of Associations," *This Journal*, 1913, v. 447 *seq.*

Group 1. Experiments.

The first purpose of the experiments was to investigate whether and how far the more or less close connection of the two members of a pair influences their association, and subgroups I were devised for this. These subgroups were three in number, viz., I α , I β , I γ . In I α the two members of a pair were the most intimately connected, *i.e.*, the colour was given to the figure itself, *e.g.*, a blue square, a green cross. etc. In I β the two members were less closely connected, the black figure being placed on a coloured background, *e.g.*, a black circle on a yellow field, a black oblong on a red field, etc. The connection was still looser in I γ where the black figure was placed by the side of the coloured field. In another subgroup, viz. II, the members of each pair were presented successively, it being intended that it should subserve by comparison with I γ the second object of this group, viz., to investigate the difference of associations by simultaneous and successive presentations respectively.

Each subgroup consisted of six series of six pairs of which the last four series only were counted, the first two series being regarded as preliminary experiments. The duration of the exposure of each pair in subgroups I α , β , γ and of each member in subgroup II was .33 sec. The number of exposures of the series was the same in all subgroups; hence the total time for learning was equal in subgroups I α , β , γ and twice as long in II. Further details may be gathered from the following printed instructions given to each subject.

Instructions.

Sit down on the chair at such an easy distance from the apparatus that you can well see the window.

You will be presented in the window in rapid succession with a consecutive series, namely,

(I α) a coloured shape on a white ground.

(I β) a black shape on a coloured ground.

(I γ) a coloured field by the side of a black shape on a white ground.

(II) a coloured field followed by a black shape on a white ground or *vice versa*.

You are asked to learn these by attending to them in such an attitude of mind as to take in the sense-presentation without forming any verbal or other association than that given directly by

the presentation. Thus, for instance, if the colour of the field is green, do not try to memorise it by calling it green, or if an octagon is shown you do not try to formulate its name, but simply take in the whole sense-presentation.

Do not try to remember the diagram and the colour by any artificial association (*e.g.*, if you were shown an arrow on a red field, "arrow draws blood—blood red," or a heart-shaped figure followed by a red field "heart love—love red," etc.). Avoid any such or similar associations.

After the series has been presented to you a certain number of times, the window will be closed. Cease at once to think about the experiment. If you find this impossible take up immediately the copy of *Punch* provided, and read it, giving yourself up entirely to your reading, and banish any thought of the experiment.

You will then be shown a colour or a diagram alone. Close your eyes. If a colour is given, look out for the diagram called up by it; if a diagram is given, for the colour it is associated with, or for the redintegration of the sense-presentation of which it formed part.

Avoid using any names for diagrams or colours, either aloud or mentally.

As soon as you have a definite result say "Now!" or as soon as you think that you cannot get a definite result, say "Nothing!" On saying the word "Now!" you will be shown a collection of diagrams or colours, as the case may be, and you are requested to point out, without naming, the diagram or colour called up and to state how they appear to be related. In pointing out the colour or diagram, state whether you feel "certain," "doubtful," "very doubtful," etc. If more than one colour or diagram are called up, point them all out and give details.

Record any further points revealed by introspection.

During the interval between the learning and the examinations avoid thinking about the experiment, and, if necessary, occupy yourself with reading the copy of *Punch* provided.

Special instructions for Series II. A coloured field is followed by a black diagram or *vice versa*. You are asked to learn these in pairs, each consisting of a coloured field and a diagram. To differentiate the pairs one from the other, they appear alternately on different sides of the window, *e.g.*, in the left-hand half of the window appears first a coloured field followed by a diagram, whilst the right-hand half is empty; then a coloured field followed by a diagram in the right-hand half of the window, whilst the left-hand half remains empty and so on.

As pointed out above, subgroup II (successive presentation of the members) had been intended for comparison with subgroup I γ (simultaneous presentation of the members). But a comparison of these subgroups seemed of little value for the following reason. In both subgroups the Müller memory apparatus worked at the same speed, *i.e.*, the contents of the window changed at the same equal intervals, and as in subgroup I γ the content was a pair whilst in subgroup II it was only one member of a pair; it is evident that it took twice as long to present a pair of the latter as it took to present a pair of the former. Hence to present the whole series also took twice as long for II as for I γ , and as all series were presented an equal number of times the total time for learning II was twice as long as that for learning I γ . It is, however, essential that the total time for learning should be equal in both cases and this could be accomplished in two ways: (1) giving half the number of exposures with successive pairs whilst their time of exposure is twice that of the simultaneous pairs (here the rate of the memory apparatus is the same in both series); (2) giving the same number of exposures with both series, and making the time of exposure of a successive pair the same as that of a simultaneous pair (here the rate of the memory apparatus has to be twice as fast for the successive as for the simultaneous series). The former condition was fulfilled in experiments of group 8 and the latter conditions in experiments of group 9.

The following diagrams show at a glance the relations of arrangements, of lengths of exposure and of total lengths of learning. A member of a pair is represented by an oblong, colours being shaded, say, horizontally and figures perpendicularly or *vice versa*. Time is represented from left to right. The height of an oblong may be said to represent the degree of consciousness, that is to say, if a single member of a pair is the sole content of consciousness for a given time, as in the successive series, it is represented by an oblong of a given height, as in subgroups 1 II, 8 *b*, and 9 *b*. Then when a whole pair is the sole content of consciousness, as in the simultaneous series, two oblongs of half that height are placed on top of one another, *vide* subgroups 1 I *a* $\beta\gamma$, 8 *a*, and 9 *a*, so that the combined height of the pair is the same as the single height of a member in the successive series.

Groups 8 and 9. Experiments.

We have then two groups in which the total time of learning of both subgroups was of equal duration, viz.:

Group 8 (a) Simultaneous exposures: $\cdot 66$ sec. each pair.

(b) Successive exposures: $\cdot 66$ sec. each pair, *i.e.* $\cdot 33$ sec. for each member.

N.B. The number of exposures per pair is the same in (a) and (b).

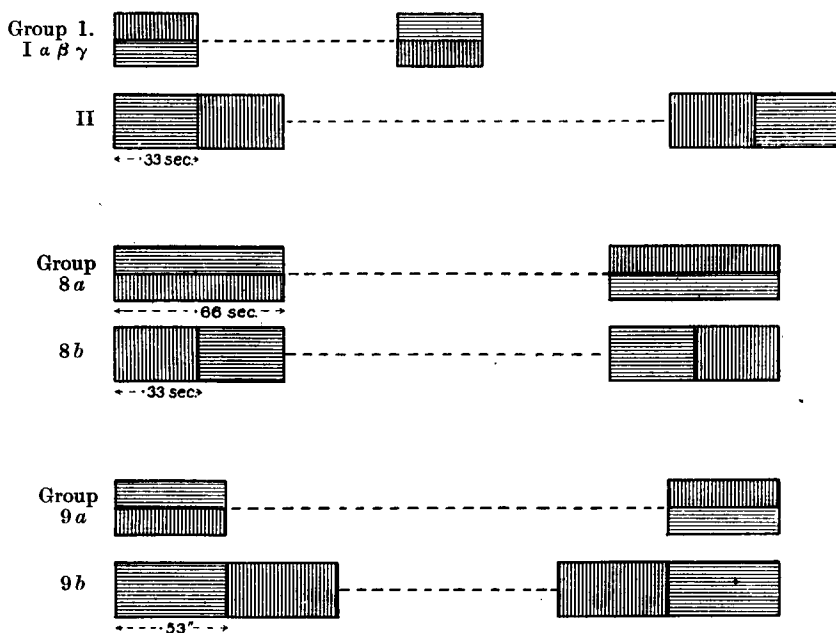


Fig. 1.

Group 9 (a) Simultaneous exposures: $\cdot 53$ sec. each pair.

(b) Successive exposures: $1\cdot 06$ sec. each pair, *i.e.* $\cdot 53$ sec. each member.

N.B. In (a) the number of exposures per pair is twice that of the number of exposures per pair in (b).

In each subgroup 8 a, 8 b, 9 a, 9 b, there were four series of six pairs each, *i.e.*, 24 pairs, and as each member was given once as stimulus, therefore 48 answers were possible. The instructions were similar to those given above for group 1.

Group 2. Experiments.

There remains another group of experiments to be recorded, viz., group 2. Their main purpose was to put to a further test the *Successive Association Theory*. If all associations, as this theory asserts, be due to successive attending, then experiments where this is encouraged by definite instructions to that end ought to yield better results, however short the exposure, than experiments where any such tendency is counteracted by giving definite instructions to attend to the two members of a pair simultaneously. It appeared also desirable to examine what influence certain attitudes of mind had upon the forming of associations. The two attitudes that the subjects were asked to adopt were:

A. The Spectacular Attitude.

B. The Learning Attitude.

In the former attitude the attention was distributed, the subject was more or less passive, he was in a contemplative mood and made no particular effort to learn; he 'took in' the pairs as they were presented. In the latter attitude the attention was concentrated upon the task, the subject was active and made the greatest effort to 'learn' the pairs. In all cases the two members of the pairs were presented together, being placed side by side as in the simultaneous series 1 I y, 8 a and 9 a, and in each attitude the subject was instructed to 'take in' respectively, to 'learn' either simultaneously or successively. The time of exposure of each pair was .33 sec. with three subjects, with the fourth .29 sec.—32 exposures of each series were given. The instructions were similar to those quoted above, but respecting the attitude the following was added:

For the purpose of these experiments you will be asked to adopt various mental attitudes, viz.:

A. The *Spectacular Attitude*: Look at the series, as it is presented to you, merely in a spectacular way, a passive or contemplative mood, making no particular effort to learn the pairs; disregard entirely the result of any subsequent examination; 'take in' the pairs as they pass.

B. The *Learning Attitude*: Do your very best to learn the pairs. Whilst in the spectacular attitude the attention is distributed, you are now asked to make the greatest effort to concentrate your attention on each pair for the purpose of 'learning' it.

You will be asked to '*take in*' (spectacular attitude) or to '*learn*' (learning attitude), as the case may be, either *simultaneously* or *successively*. This is to say: Attend to the members of each pair together for the former, or attend to the members of each pair in succession for the latter. In both cases it may be best to fixate the centre of the window, *i.e.*, a point between the colour and the diagram. This may even be advisable when attending to the members successively, as the time may be too short for eye-movements; allow the attention alone to move. It may perhaps be advisable to do this always in the same direction, say, from left to right, but it is left entirely to you to adopt any method you find easiest to carry out the above instructions.

III. RESULTS AND CONCLUSIONS.

The results of the group 1 experiments are given in the following Table 1:

TABLE 1. *Group 1.*

Subgroup I α : coloured shape	} Simultaneous exposure of shape and colour. Duration of exposure of each pair .33 sec.
„ I β : black shape on coloured background	
„ I γ : black shape by the side of coloured field	
„ II: black shape and coloured field following one another	
	} Successive exposure of members .33 sec. each, <i>i.e.</i> .66 sec. for each pair.

N.B. Total time of learning is twice as long for II as it is for I α , β , γ .

Subject	Right answers											
	Median reaction-times				Actual scores (48 possible in each series)				Percentages of possible scores			
	I α	I β	I γ	II	I α	I β	I γ	II	I α	I β	I γ	II
	sec.	sec.	sec.	sec.								
C	1.8	2.6	1.4	1.3	31	21½	11	31	64.6	44.8	22.9	64.6
F	3.6	4.6	3.7	2.9	45	33	24½	41½	93.7	68.8	51.0	86.4
L	1.0	1.2	1.2	1.0	48	41	35	44	100.0	85.4	72.9	91.7
R	2.0	2.2	1.8	1.6	42	38	23½	44	87.5	79.2	48.9	91.7
Averages	2.10	2.65	2.02	1.95	41.5	33.4	23.5	40.1	86.5 %	69.6 %	48.9 %	83.6 %
M. V.	.75	.97	.83	.65	5.2	6.1	6.2	4.6	10.9	12.8	13.0	9.5

On the left are given the Median Reaction-Times, in the middle the Actual Scores obtained out of a possible 48, and on the right these calculated in percentages.

Let us examine first the scores of the simultaneous exposures, viz., subgroups $I\alpha$, $I\beta$, $I\gamma$. We find then that if the number of correct answers serves as a direct measure of the strength of the associations, this is nearly twice as strong when the members are as closely connected as in a coloured figure ($I\alpha$), than if they are placed side by side ($I\gamma$), being 86.5 % against 48.9 %. The case where the figure is placed on a coloured background ($I\beta$) is nearly halfway between them, viz., 69.6 %.

As to the reaction-times it is remarkable that they do not indicate any difference in the readiness of the associations, for they are all about equal, being 2.10, 2.65, 2.02 sec. for $I\alpha$, $I\beta$ and $I\gamma$ respectively, whilst previous work on associations would lead one to expect a shorter reaction-time for a stronger association, i.e., the reaction-time of $I\alpha$ to be shorter than that of $I\beta$ and this shorter than that of $I\gamma$.

Reverting to the numbers of right answers we find that the predominance of $I\alpha$ over $I\beta$ and of this over $I\gamma$ obtains with all four subjects, there is not a single exception. The number of right answers decreases everywhere with the closeness of the connection between the two members of a pair. In $I\alpha$ the members are connected the most closely, being blended into a coloured shape. The connection is less close in $I\beta$, where the black figure rests on a coloured background, and still less in $I\gamma$ where the black figure and the coloured field are placed side by side. We may therefore state the law:

The more the members of a group are apperceived as a whole, the stronger their association with one another.

As to subgroup II this, as stated above, had been intended for comparison with subgroup $I\gamma$. However, a comparison is really not possible, for although we have the same number of exposures of each pair in both subgroups *each member* of a pair of subgroup II had the same length of exposure as *each pair* in subgroup $I\gamma$, hence each pair of the former was exposed twice as long as each pair of the latter and consequently the whole time of learning a series of subgroup II was twice as long as the learning of a series of subgroup $I\gamma$. As it is, with the same number of exposures but twice the time for learning, the successive series of subgroup II show 83.6 % of correct answers against 48.9 % of the simultaneous series of subgroup $I\gamma$. It is, however, interesting to observe that although the time of learning is twice as long the result does not even come up to that of subgroup $I\alpha$ of the coloured shapes.

To carry out the main purpose of these investigations, viz., to test the claims of the rival theories of simultaneous and successive associations, it became necessary to devise fresh sets of experiments, viz., groups 8 and 9 which have been described above. The results are given in Tables 2 and 3.

TABLE 2. *Group 8.*

Subgroup (a). Simultaneous exposures, .66 sec. each pair.

„ (b). Successive exposures, .66 sec. each pair (*i.e.* .33 sec. each member).

N.B. The number of exposures is the same in (a) and (b), *i.e.* the total time of learning is the same in both.

Subject	Right answers					
	Median reaction-times		Actual scores (48 possible in each subgroup)		Percentage of possible scores	
	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>
B	sec. 2.6	sec. 1.6	20½	6	42.7	12.5
C	1.6	1.7	42½	38	88.5	79.2
F	2.9	2.9	46	42	95.8	87.5
H	2.3	2.0	40	36	83.3	75.0
J	1.7	2.3	31½	45	65.6	93.7
P	3.2	2.9	40	35	83.3	72.9
St	2.2	2.0	30	32½	62.5	67.7
W	2.0	2.8	44	41	91.7	85.4
Averages	2.3	2.3	36.8	34.4	76.7	71.7
M. V.	.44	.39	7.1	7.7	14.8	15.9

The reaction-times of group 8 are the same both for (a) and (b), viz., 2.3 sec., whilst the former series, viz., (a) the simultaneous one, gives 76.7 % correct answers against 71.7 % for (b) the successive series.

In group 9 the reaction-time for (b) is somewhat longer than for (a), viz., 2.6 sec. against 2.3 sec., thus corresponding with the scores, viz. 69.1 % for the former against 73.9 % for the latter, *i.e.*, the series that shows a slightly weaker association also shows a slightly longer reaction time. It may be noted that the percentage of right answers in group 9 is somewhat lower both for (a) and (b) than in group 8. This is doubtless due to the fact that in group 9 the total time of learning was shorter than in group 8, since the time of each exposure was .53 sec. in group 9 and .66 sec. in group 8.

Now comparing the experiments of group 8 with those of group 9 we are led to the following considerations. The experiments of 8 *a* and 9 *a* are identical with the exception of the duration of the exposures.

TABLE 3. *Group 9.*

Subgroup (a). Simultaneous exposures, .53 sec. each pair.

„ (b). Successive exposures, 1.06 sec. each pair, *i.e.* .53 sec. each member.

N.B. Number of exposures of each pair in (a) twice that in (b), *i.e.* the total time of learning the same in both.

Subject	Right answers					
	Median reaction-times		Actual scores (48 possible in each subgroup)		Percentage of possible scores	
	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>	<i>a</i>	<i>b</i>
B	sec. 1.8	sec. 2.7	16	18	33.3	37.5
C	2.0	1.9	41½	35½	86.4	73.9
F	2.6	2.8	45	41	93.7	85.4
H	2.0	2.0	38	30	79.2	62.5
J	2.0	2.7	28	22	58.3	45.8
P	3.2	3.0	37½	41½	78.1	86.4
St	2.6	2.2	38	35½	79.2	73.9
W	2.1	3.1	40	42	83.3	87.5
Averages	2.3	2.6	35.5	33.2	73.9	69.1
M. V.	.39	.38	6.75	7.4	14.1	15.4

But whilst this difference of duration of exposure remains constant in the experiments of 8 *b* and 9 *b* the number of exposures in these two subgroups differs, being twice as great in 8 *b* as in 9 *b*. Hence, if the theory of successive association be correct, *i.e.*, if the formation of association be due to succession *qua* succession, the results of 8 *b* as compared with those of 8 *a* should be greater than those of 9 *b* as compared with those of 9 *a*, in other words we should get

$$\frac{8a}{8b} < \frac{9a}{9b}.$$

But from Tables 2 and 3 we obtain

$$\frac{8a}{8b} = \frac{76.7}{71.7} = 1.07,$$

and
$$\frac{9a}{9b} = \frac{73.9}{69.1} = 1.07,$$

i.e., they are equal. We are therefore forced to conclude that *with colours and diagrams, i.e., with the psychological memory*¹, *the theory that the formation of associations is due to the succession of experiences qua succession is not correct.* From which it follows, since the rival theory seems the only alternative, that *with respect to the psychological memory all associations are due to simultaneity, either simultaneity of the experiences, or simultaneity of the succeeding experience with the akoluthic phase of the preceding experience.*

This question may, however, as already indicated above, be approached from another side. If we expose simultaneously a pair consisting, say, of a colour and a diagram and in one set of experiments instruct the subject to attend to the two members simultaneously whilst in another set the subject is ordered to attend to the members successively, then, if the theory of successive association be correct, the experiments with successive attending ought to give the better results. For here the natural tendency of the subject would be reinforced, whilst the ordered simultaneous attending would have the effect of counteracting such natural tendency. In the preliminary experiments the time of exposure was reduced until it was difficult to attend successively, whilst it was still possible to attend to the two members simultaneously. Thus introspection already indicated the result to be expected. The threshold was found to be at about .33 sec. for most subjects, but with one this length of exposure had to be reduced to .29 sec.

The experiments of group 2 were devised for this purpose and they also subserved another one, viz., that of ascertaining the influence of special attitudes of mind, as explained above on p. 440. Table 4 gives the results.

The reaction-times are decidedly longer for the spectacular than for the learning attitude and whilst in the learning attitude they are nearly equal for simultaneous and successive attending, this latter shows a marked longer reaction-time than the former in the spectacular attitude. It will also be noted that with two of the four subjects, viz., F and Sp, the reaction in the spectacular attitude is longer for successive attending, whilst with the same two subjects it is longer for simultaneous attending in the learning attitude. With subject C these conditions are reversed and with the fourth subject J the reaction-time for successive attending is longer in both attitudes.

It may here be mentioned that all these experiments, but especially

¹ *Vide* my paper "On Memory and the Direction of Associations," *This Journal*, 1913, v. 465.

the learning attitudes than those of successive attending. All subjects were trained observers and they stated unanimously that it was mostly quite impossible to attend successively to the two members of a pair during the short exposures of .33 sec. and .29 sec. respectively, whereas they could be attended to simultaneously with comparative ease.

Turning then to the scores, we find, as was to be expected, that these are respectively decidedly larger for the learning attitude than for the spectacular attitude, and in each attitude also the scores for the simultaneous attending are much larger than those for the successive attending, being:

		Simultaneous attending	Successive attending
Spectacular attitude 40.6 %	11.7 %
Learning attitude 60.2 %	38.7 %

We have therefore the fact that the set of experiments where an oscillation of attention was encouraged produces much feebler associations than those experiments where such oscillation was prohibited; and this confirms the conclusions derived from the experiments of groups 8 and 9, as stated on pp. 443, 444.

To the possible significance of the better results in the learning attitude as compared with the spectacular attitude we shall revert later (p. 450).

It may here be convenient to point to some apparent individual differences that seem to be indicated by the results of groups 8 and 9. If we construct a table putting against the subject's initial in each group that mode of learning (a = simultaneous, b = successive) in which the subject appeared to excel, we get

	Group	8	9
Subject B		a	b
C		a	a
F		a	a
H		a	a
J		b	a
P		a	b
St		b	a
W		a	b

That is, three subjects (C, F, H) excel in simultaneous learning in both groups, the other five subjects excel in simultaneous learning in only one group, viz., B, P and W in group 9, and J and St in group 8. If we go, however, into the figures (number of scores) in order to see how much this excellence amounts to, we find that these figures leave a decided balance in favour of a , the simultaneous exposure. We may therefore conclude that *under the given experimental conditions, viz.,*

with the psychological memory, the simultaneous experience is more favourable for the learning of pairs than the successive experience.

Having finished the examination of the results of our experiments we may attempt an analysis of the wrong answers recorded. All the experiments of the various groups consisted of series of six pairs which

TABLE 5.

Experiment	Subject	Preceding	Succeeding	Others	Experiment	Subject	Preceding	Succeeding	Others
Group 1. I a	C	2	1	5	Group 8 a	B	4	2	11
	F	2	-	1		C	-	-	3
	L	-	-	-		F	1	-	1
	R	-	-	2		H	1	1	-
	β	C	5	3		J	4	2½	5
		F	3	1		P	2	-	-
	L	-	-	1		St	4	6	7
		R	-	1		W	-	1	2
	γ	C	1	2		B	3	4	16
		F	8	5		C	1	1	5
	L	-	-	3		C	-	-	5
		R	2	-		H	-	-	3
	II	C	-	10		J	-	1	-
		F	3	2		P	1	2	-
	L	-	-	-		St	2	2	7
		R	1	3		W	-	-	2
„ 2. A a	C	4	5	5	„ 9 a	B	5	1	16
	C	4	4	10		C	-	-	2
	J	4	4	9		F	1	-	2
	Sp	4	3	2		H	2	-	4
		C	2	1		J	2	2	4
	b	F	6	6		P	-	-	3
		J	3	2		St	1½	3½	2
	B a	Sp	1	2		W	1	1	-
		C	3	2		B	2	1	11
	F	2	1	1		C	2	3	5
		J	3	3		F	3	2	2
	Sp	2	1	1		H	2	2	6
		C	4	4		J	6	6	9
	b	F	1	-		P	-	-	-
		J	5	2		St	5	2	5½
	Sp	-	1	1		W	2	2	-
Totals....							129½	106	307½

we may represent by *A a*, *B b*, *C c*, *D d*, etc., where a capital letter stands for, say, a diagram and a small letter for a colour. Now suppose in the course of the examination *B* be given as stimulus, *b* would be right and any other answer wrong. The wrong answers obtained were classified according to their relative position to the stimulus. If the

reaction to *B* was *a*, then the answer was classed as "*preceding*," if *c*, as "*succeeding*," any other answer as "*others*." In this manner we shall be enabled to see whether any stronger associations exist between the members of adjacent pairs than between members of more distant pairs. Table 5 gives the result of this analysis.

The ratios are

$$\begin{array}{l} \text{preceding : succeeding : others :: 1.2} \quad : \quad 1 \quad : \quad 2.9 \\ \text{or } 23.5 \% : 19.6 \% : 56.9 \%. \end{array}$$

The wrong answers of the four groups of experiments were pooled, for all the experiments agree in that the pairs consist of a colour and a diagram each and they follow one another immediately. If associations were established between adjacent pairs, this would be due to the constant conditions and independent of the variable conditions of these experiments, as described above. On the other hand, it is admitted that taking the numbers of the wrong answers as they stand, without corrections, is open to objection. It may, for example, be argued that there are a great number of cases where no answer at all was given and that these ought to be regarded as potential answers and distributed among the actual right and wrong answers. Treated in this manner the ratios obtained are:

$$\begin{array}{l} \text{preceding : succeeding : others :: 1.1} \quad : \quad 1 \quad : \quad 2.4 \\ \text{or } 24.4 \% : 22.2 \% : 53.4 \%. \end{array}$$

Again it may be argued that the result of each subject ought to be expressed separately in proportions and their average taken. If this be done we get

$$\begin{array}{l} \text{preceding : succeeding : others :: 1.3} \quad : \quad 1 \quad : \quad 3.0 \\ \text{or } 24.5 \% : 18.9 \% : 56.6 \%. \end{array}$$

The small differences between the results obtained by the three methods show plainly that controversy is unnecessary. It will be seen from any of the ratios that there is no decided prevalence of the adjacent pairs. This is to say that the distribution of the wrong answers is approximately according to chance. For five wrong answers are possible to a stimulus and of these one belongs to the "*preceding*," one to the "*succeeding*," and three to "*others*," i.e., according to mere chance the ratio ought to be

$$\begin{array}{l} \text{preceding : succeeding : others :: 1} \quad : \quad 1 \quad : \quad 3 \\ \text{or } 20 \% : 20 \% : 60 \%. \end{array}$$

We may therefore conclude that *under the given experimental conditions, viz., learning in pairs, with psychological memory, no cross-associations between members of adjacent pairs are formed.*

IV. THEORETICAL AND SUMMARY.

In a previous paper above referred to¹ I drew a distinction, as far as the nervous system is concerned, between a higher and a lower memory, the psychological and the physiological memories. An essential difference there pointed out consisted in the experimentally established fact, that in the psychological memory the direction of association, as revealed in ekphory², is of equal value both forward and backward, whilst in the physiological memory it is forward only. That is to say, given a sequence of experiences *k, l, m,*, *l* being given again at some future time, then, with the psychological memory, *k* is as likely to be ekphored as *m*, whilst with the physiological memory *m* only is likely to be ekphored, and never *k*. Possibly, however, there is still another difference, for whilst with the physiological memory, similarly to the old associationist doctrine, a mechanical sequence might suffice to establish association (this is an assumption, and is not proved), my experiments tend to show that this is not the case with the psychological memory. We see from group 2, the special attitudes experiments (Table 4, p. 446), that the learning attitude with successive attending (*B b*) produced in every individual case better results than the same attending in the spectacular attitude (*A b*). This may in some measure be due to the possibility that the conditions of the spectacular attitude approach *more*, while those of the learning attitude approach *less*, to those of mechanical sequence.

The following considerations point in the same direction. If a mere sequence sufficed to establish associations (in psychological memory), these should be as powerful, or nearly so, between the second member of a pair and the first member of the succeeding pair as between the members of a pair itself. Thus if *A a, B b, C c* are succeeding pairs (capitals standing for diagrams and small letters for colours), then the associations between *a* and *B*, *b* and *C*, etc., should be almost as strong as between *A* and *a*, *B* and *b*, etc. This, however, as has been shown above (p. 449), is not the case.

We have therefore some right to assume that a higher psychical function is necessary in grouping, in uniting the members into pairs,

¹ *Loc. cit.* 462-465.

² Richard Semon, *l.c.* 26.

and introspection appears to show that this is accomplished by a corresponding setting of the mind. Not, as might be thought, if, say, *A* is followed by *a*, these are subsequently grouped together as a pair, and so on, but rather the idea of "*a pair*" is given first and *A a* etc. are then, as it were, received into it. To put this diagrammatically, the active formation of pairs appears to be



(time being represented from left to right), *i.e.*, "pair" precedes "*A a* = pair."

The physiological basis of association and of this integrating function of learning in pairs may be conceived in the following manner. Two or more groups of neurones (concerned in psychological memory) that are excited, *i.e.*, either during the simultaneous mental experience or during the akoluthic phase of a just passed mental experience and a present mental experience, become associated by lowering the resistance of the association-fibres, connecting them, so that when on a future occasion one of the groups is excited again this excitation may pass along the association-paths and communicate itself to the other groups of neurones. It does not matter in which direction the excitation passed on the first occasion—the formation of the engram¹,—there is no law of forward conduction in the psychological memory as there is in the physiological memory. As to the learning in pairs this integrating function might be conceived to modify the central occurrence as follows:—

The excitation of groups of neurones corresponding to the idea of "pair" and to the determination to apperceive the expected experiences as such, reinforces the excitation of the groups of neurones constituting the physiological basis of these experiences and facilitates the association-paths between them, inhibiting at the same time the transference of any energy to the groups of neurones that are being excited by the stimuli corresponding to the succeeding pair, and thus blocking any paths that might have served as association-paths between the first set of groups and the second set.

¹Richard Semon, *l.c.*, 22.

To conclude we will summarise the experimental results of this investigation which *refer to the psychological memory only*.

(1) The more the members of a group are apperceived as a whole the stronger their association with one another.

(2) The theory that the formation of associations is due to the succession of experiences *qua* succession is not correct.

(3) All associations are due to simultaneity, either simultaneity of the experiences, or simultaneity of the succeeding experience with the akoluthic phase of the preceding experience.

(4) The simultaneous experience is more favourable for the learning of pairs than the successive experience.

(5) In learning pairs no cross-associations between members of adjacent pairs are formed.

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