A PRESTAGE OF PERCEPTUAL INTEGRATION

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Abstract

Rows of six circles, digits and letters were exposed in both visual fields at 100 msec. to five groups of 10 to 16 college students. The six stimuli were preceded by presentation at 100 msec. of either a full black or white field, or a left or right half-field containing a black rectangle, or rows of three circles, digits, or letters. Recognition scores of the second exposure stimuli are significantly better in the doubly exposed visual field than in the other field when the second stimuli are of the same kind as those in the preceding first exposure, but not when the second stimuli are different. The first exposure stimuli are better recognized when they are different from the second. The number of stimuli in the second exposure is overestimated when the preceding stimuli are circles, digits and letters. These facts were explained on the basis of the concepts of sub- and super-ordinate cell assemblies.

Hebb (1949) discussed the difficulties caused by "equipotentiality" in Gestalt theory broadly conceived. He interpreted the findings of Mishkin and Forgays (1952) as being inconsistent with equipotentiality. They showed that more words were recognized in the right visual field than in the left when the stimuli were tachistoscopically presented on either side of the fixation point. They attributed their results to the left-right reading habit. Orbach (1952) reported that English-Jewish subjects could recognize more English words in the right and more Jewish words in the left, but only when they had learned Jewish before English. Forgays (1953) approached the problem developmentally to show that left-right directionality was differentiated by the seventh grade.

Heron (1957) discovered that there was left-dominance when letters were presented simultaneously on both sides of the central fixation point. He employed a square of four letters as the stimulus-pattern and noticed almost invariably the same reporting order : left top, right top, left bottom, right bottom. At this point, the problem of field dominance, having turned from "equipotentiality", came to focus on "serial order".

Bryden (1967) developed a theory of serial order, "a model for sequential organization", based on his several studies on integrative scanning, particularly on the tendencies to eye-movements suggested by Heron. He called the temporal processes of directional scanning "ordering systems," and he tried to analyse more particularly the central scanning mechanism that Lashley (1951) had inferred in observing ordinary behavior.

According to Crovitz and Daves (1962), it seems to be more reasonable to think of eye-movements occurring after presentation as the peripheral sign of some central process rather than as the important factor in an integrating process. This does not mean that eye-movements are an unimportant process in perception. Japanese can read and write freely three kinds of letters, Katakana, Hiragana and Kanji. When we learn the most complex type of letter or Kanji, it is very effective to write down the letter repeatedly and in the proper order. When we recall a forgotten letter, we often write it in the air with an index finger in the proper order. We surely try to recall with eye-movements a form of Kanji as well as the order of writing it.

This observation makes it even more plausible to expect that the integrative processes of serial order would be revealed by a perceptualmotor approach. I believe that it is necessary to distinguish "perceiving" from "percept," as Hebb (1968) has pointed out. Baba (1969) has reported that the phenomenon of serial order must be based upon two central activities named the "sliding" and "gearing" processes, the former being assumed to act rapidly, roughly and driftingly in close relationship with retinal or sensory patterning of stimuli, while the latter acts slowly, steadily and in a fixed way, probably as a central motor event. The present study was designed to investigate the phenomenon of serial order from the point of view of the central activities described above.

Method

Subjects

The Uchida-Krepelin Psycho-motor Test and three personality tests (Yatabe-Guilford Personality Inventory, Rorschach Test and TAT) were administered to 138 young female college students in an introductory psychology course. Baba (1969) showed that visual recognition scores are significantly related to psycho-motor or personality traits of subjects (Ss). The psycho-motor test was conducted once a week for fifteen weeks. On each trial all students were requested to write the answers to one-unit-additions continuously, as rapidly as possible, for ten minutes--changing a row once per minute. This was carried out alternatively either in the left-right or right-left direction. Three minutes of warming up exercise was followed by two minutes of rest and then by the test. The minimum, maximum and mean scores per minute of each trial and the performance curve were recorded. In the results of personality tests, introvert-extrovert traits, Rorschach M and FM responses and degrees of identification of self with a person in the drawings were checked. Based upon the results of pretests five equalized groups of 10 to 16 Ss were selected for the following experiments.

Stimulus materials

Four different types of stimulus patterns were employed: 1) filled and open circles, 2) the eight digits from 2-9, 3) thirty-five Hiragana letters (a kind of Japanese ordinary alphabet) and 4) a mixed set. There were ten different sequences of each type of pattern. Each sequence of circle, digit and letter patterns contained six elements in a horizontal row. Mixed set patterns contained six or eight elements, which were geometrical forms, digits, capital letters of the alphabet and Katakana letters (another kind of Japanese alphabet). Mixed set patterns were composed for the purpose of making it more difficult for Ss to anticipate what kind of patterns and how many elements would be presented.

The patterns were matched in pairs as far as possible,and divided into A- and B-series. Each element was drawn in 1 mm broad lines of black India ink within limits of 16 mm wide and 20 mm high. The spacing between two elements was 4 mm at least. Each pattern had a central fixation point, which was made by lighting a 4 mm hole on the stimulus board from the back by a small 2.5 volt lamp. These forty stimulus patterns were presented in random order at an exposure duration of 100 msec.

Three other shorter stimulus patterns were composed from 1) filled and open circles, 2) the eight digits from 2-9, and 3) thirteen Hiragana letters. There were ten sequences of each type of pattern. Each sequence contained three elements in a horizontal row. Five pairs were the same, being drawn either to the left or to the right of a fixation point in the same position as the patterns described before. All of these patterns were divided into L- and R-series. They had the same size of elements and spacing as those of A- and B-series. These thirty stimulus patterns were presented at an exposure duration of 100 msec in combination with the main patterns.

When exposed in the tachistoscope, the L- and R-series display subtended an over-all visual angle of $1^0 12'$ vertically and of $4^0 17'$ horizontally. The A- and B-series display was $1^0 12'$ vertically and of $8^0 58'$ horizontally. The visual angle of each element was 0.58' wide and $1^0 12'$ high.

Procedure

The stimulus patterns were presented in the improved KYS Dodge type tachistoscope. Ss were asked to sit as still as possible and to look into two 40 mm eye-holes binocularily. Ss could see nothing but the eye-holes for the only light was from a faint 2 watt bulb from above. The visual field of the Ss was almost dark. The fixation point was lit about one second before every exposure. Ss were told to watch it and to report orally what they saw immediately after the display. All Ss were given 20 trials as preliminary practice exposures. E recorded the responses in the order in which they were given.

All experiments were carried out in a sound-proof room in which the temperature was kept about 18-21°C and humidity about 60 %. The duration of the experiments was from November, 1968 to February, 1969.

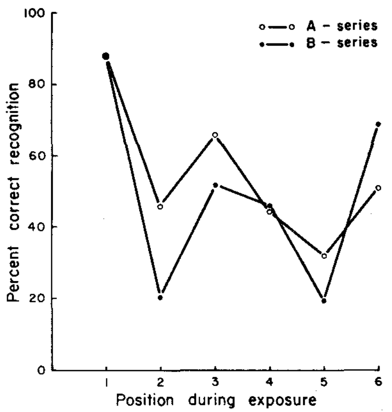
Experiment 1

The purpose of the first experiment was to ascertain the standard scores and recognition characteristics of the A- and B-series. The six stimulus positions were numbered 1, 2. . .6 from left to right, in order to describe them exactly.

As for letters and digits, the elements which Ss reported to have appeared in the exposure, were scored as correct regardless of the reporting order. The circle patterns were recorded as correct (scored one point) only when all six elements of a pattern were completely reported in the correct order. Percentage correct scores were as shown in Figures 1 and 2.

Although the legibility of letter patterns (Matsubara and Kobayashi, 1967) was equated for every position, scores of the second and the fifth positions were very different in the A- and B-series. However, the overall scores of all six positions in the A-series were not significantly different from those in the B-series (F 1, 18 = 1.31, $p > 0.25$). Ss identified letters in the first, second and third positions more accurately than those in the latter three positions (F 1, 18 = 7.28, $p < 0.05$). In comparing digits recognized in A-patterns with those in B-patterns, scores of the same position were almost equal (F 1, 18 = 0.48, $p > 0.25$). And also there was no significant difference, with digits, between scores of the three positions to the left of the fixation point and those to the right (F 1, 18 = 0.26, $p > 0.25$). As for circle patterns, Ss showed no significant difference between points scored in the A- and B-series (F 1, 18 = 1.58, $p > 0.1$), although Ss got thirty-one points in B-patterns but only twenty-one points in A-patterns.

As Figure 1 shows, two sensory or retinal effects are observed in this experiment. Baba (1969) has pointed out that there might be end and fixation point effects. The end effect means that the primitive figure-ground segregation occurs more rapidly for stimuli located at both ends because three sides of them were completely open, and the fixation point effect implies that any stimulus subtending about 2°visual angle from fixation is more sensitively received because it falls on the fovea centralis.



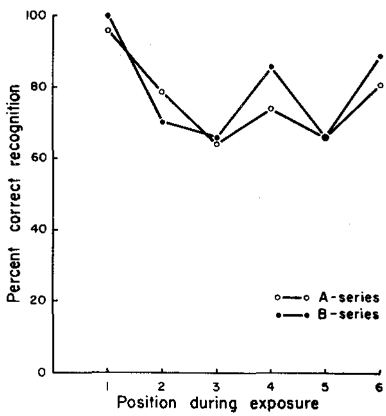


Figure 1. Percentage of letters recognized in the single A- and B- series presentations.

Figure 2. Percentage of digits recognized in the single A- and B- series presentations.

The ratio of the total number of correct digits / letters was 467 /

310 = 1.51 and the percentage of circle patterns completely recognized was 52.0 %.

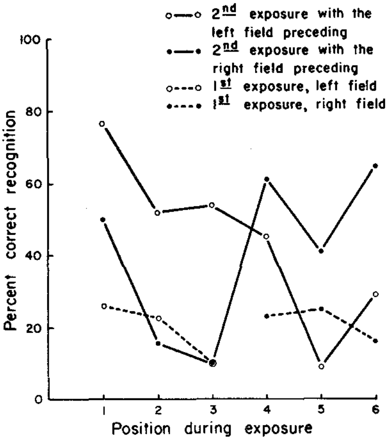
These results all indicated that although the A- and B-patterns were rather well equated for the following experiments, it would be much better to consider them as separate factors in a two factor design.

Experiment 2

Experiment 2 was designed to discover the relation of a preceding (recognition) ordering process to a process following. The L- and R-series were employed as the preceding patterns and A- and B-series as the following patterns. The following pattern was exposed 100 msec after the termination of the preceding presentation. In these double pattern presentations both patterns were of the same stimulus type. There were twelve Ss. Half of the Ss were given L-A and R-B trials, and the other half L-B and R-A trials. In the L-series presentations, the three elements of the preceding exposure were presented in the same positions as the first, second and third elements of the following patterns and in the R-series presentations, three elements of the preceding pattern appeared in the same positions as the fourth, fifth and sixth elements of the following. Subjects were asked to report orally everything they saw following the second exposure. This was the standard procedure for all the experiments.

The percentage recognition scores for positions in every series were as shown in Figures 3 and 4. The results of some presentations in the L- and R-series were discarded, for one or two digits were the same in both preceding and following patterns. With both letters and digits, scores of the following patterns were singnificantly higher on the side of the preceding pattern than on the other side. In the L-series presentations, letters and digits were better recognized in the first, second and third positions than in the latter three (with letter, $F\ 1, 22 = 22.02$, $p < 0.01$ and with digits, $F\ 1, 22 = 10.69$, $p < 0.01$), while in the R-series presentations, letters and digits were better recognized in the fourth, fifth and sixth positions than were those on the left side (with letters, $F\ 1, 22 = 19.32$, $p < 0.01$ and with digits, $F\ 1, 22 = 11.04$, $p < 0.01$). As for circle patterns, there was no significant difference between correct recognition scores in the L-series presentations and the R-series ($F\ 1, 22 = 0.72$, $p > 0.25$).

The ratio of all scores of digits / letters in the A- and B-series was 490 / 305 = 1.60 and the ratio of the mean recognition percentage of letters in



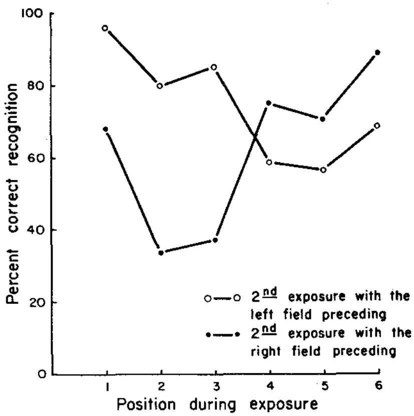


Figure 3. Percentages of letters in the second exposure recognized after preceding letter presentation in either the left or right visual field.

Figure 4. Percentages of digits in the second exposure recognized after preceding digit presentation in either the left or right visual field.

each position of L- and R-series / A- and B-series was 20.8 % / 42.21 % = 0.49. The percentage of circle patterns recognized completely was 37.5 %.

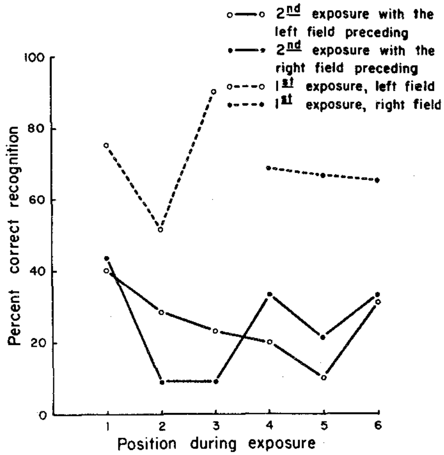
Experiment 3

The aim of Experiment 3 was to find out how stimuli were recognized in presentations where the stimulus type of the preceding pattern was different from the type of the following. The procedure of this experiment was the same as of Experiment 2 except that the preceding and following exposures were of different types. There were sixteen Ss.

Six A- and B-series letter patterns were presented after either three circles or digits of the L- and R-series were exposed: six digits were presented after either three letters or circles, and six circles after either three digits or letters.

All results from the three circle patterns of the L- and R-series were discarded, because separate scores of each of position could not be determined.

Percentage scores in Experiment 3 were as shown in Figures 5 and 6. No significant differences were found between scores of the three positions in which the preceding pattern was exposed and those of the other three in which the preceding pattern did not appear (in the L-series presentations, with letters, $F_{1, 30} = 4.00$, $p > 0.05$, and with digits, $F_{1, 30} = 3.16$, $p > 0.05$; in the R-series presentations, with letters, $F_{1, 30} = 3.65$, $p > 0.05$ and with digits, $F_{1, 30} = 0.77$, $p > 0.25$).



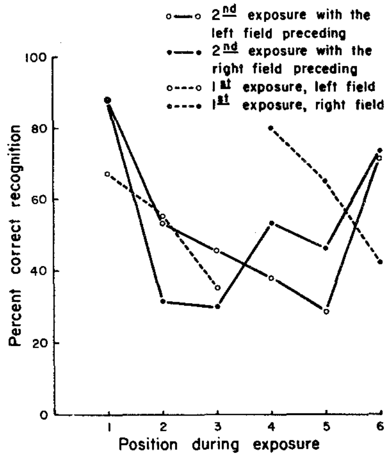


Figure 5. Percentages of 1st exposure digits and 2nd exposure letters recognized with preceding digit presentation in either the left or right visual field.

Figure 6. Percentages of 1st exposure letters and 2nd exposure digits recognized with precending letter presentation in either the left or right visual field.

The ratio of all scores of digits / letters in the A- and B-series presentations was 523 / 240 = 2.18. The ratio of the mean percentage of digit scores in every position in R- and L-patterns to that of letter scores in A- and B-patterns was 70 % / 25.17 % = 2.78, and the ratio of the mean percentage of letter scores in every position in L- and R-patterns / digit scores in A- and B-patterns was 57.5 % / 54.9 % = 1.05. The percentage of circle patterns recognized completely was only 7.5 %.

In addition, an overestimation phenomenon was observed in this type of presentation. Ss often estimated more than six items when they were asked how many elements there were in the A- and B-patterns. Although this fact had been noted in the same-kind presentation, it could not be determined whether Ss answered by adding the stimuli in the preceding pattern to the following one. In the different presentations when the response was, for example, "black, white, black circles ; seven, two," E (experimenter) could further ask Ss how many digits were presented. An indication of "overestimation" was considered an estimate of eight or more, for Ss sometimes gave seven responses even in the single six-item presentation of Experiment 1.

In this experiment all Ss except one reported the overestimation. The results are as shown in Table 3.

Short Discussion

In comparing scores for the same kind of successive presentation (Experiment 2) with those for the different kind (Experiment 3); the preceding stimuli were significantly better identified in the different kind than in the same kind (with letters, $F\ 3,\ 52 = 12.89$, $p < 0.01$, and with digits, $F\ 3,\ 52 = 3.47$, $p < 0.05$), while the following stimuli were significantly better recognized in the same kind than in the different kind (only with letters, $F\ 3,\ 52 = 10.44$, $p < 0.01$).

When two sequences of inputs are sent to sensory organs successively, if the two are the same, the scanning processes of the two might be fused, while, if the two are different, the process for the preceding stimuli might suppress the following activities.

So far as scores of the left and right three positions of the following pattern are concerned, stimuli presented in the three positions occupied by the preceding stimuli were significantly better recognized than those presened to the other three, but only in the same-kind presentation. The excitation of the preceding stimuli might facilitate a kind of "opening" process to the same side for the following stimuli. However, in the different-kind presentations, the formation process for the preceding stimuli might interfere with that of the following, where an "immature" perception would probably be observed. However, the facts discussed above do not demonstrate that the overall capacity for recognition in the different kind presentations is inferior to that of the same kind.

Recognition capacities for the different digit and letter conditions were calculated by multiplying the percent correct times the number of positions exposed. Letter values were multiplied 1.5 to compensate for their greater intrinsic difficulty, as empirically determined in Experiment 1. The obtained values were :

1. The preceding pattern, three letters ; the following pattern, six letters : the recognition capacity value $= (20.8 \times 3 + 42.4 \times 6) \times 1.5 = 475.2$

2. The preceding pattern, three digits; the following pattern, six letters: the recognition capacity value = $(70.0 \times 3 + 25.2 \times 6 \times 1.5) = 436.8$

3. The preceding pattern, three letters; the following pattern, six digits: the recognition capacity value = $(57.5 \times 3 \times 1.5 + 54.9 \times 6) = 588.15$

That is, the best capacity is in the case of Number 3, or three letters followed by six digits.

Although it could be understood that the preceding process might either facilitate or suppress somewhat the recognition of the following patterns, the recognition score for six circles was very much lower in the difffrent kind than in the same kind presentation (in the same kind, 37.5 % ; in the different kind, 7.5 %). This fact suggested that it would be necessary to further examine the sensory activities produced in the double presentation.

Experiment 4

Experiment 4 was conducted to examine how stimuli were recognized when a black rectangle had been presented either in the left or right visual field. The size of a rectangle was 3 cm high × 7 cm wide ; large enough so that it could cover the three following stimuli in place of the L- and R-series. There were fourteen Ss. Instructions, as before, were to report orally everything they saw following the second exposure.

No significant differences could be found between scores of the left three and right three positions (in the left rectangle presentations, with letters, $F_{1, 26} = 0.05$, $p > 0.25$ and digits, $F_{1, 26} = 0.74$, $p > 0.25$; in the right rectangle presentations, with letters, $F_{1, 26} = 1.81$, $p > 0.1$ [in this case, L > R] and with digits, $F_{1, 26} = 0.00$). As for circle patterns, there was no significant differences between recognition in the left and right rectangle presentations ($F_{1, 26} = 0.80$, $p > 0.25$).

The ratio of all scores of digits / letters was 636 / 427 = 1.46. The pecentage of circle patterns recognized perfectly was 70.7 %. The phenomenon of overestimation could not be observed in this double presentation.

From these results, it can be concluded that a stimulus figure which excites the same part of the retina does not necessarily suppress or interfere with recognition of the following stimuli.

Experiment 5

Experiment 5 was designed to obtain scores of A- and B-series when the preceding stimulus was a simple black (BL) or white (W) field. There were fourteen Ss. Half of them were given W-A + BL-B presentations, the latter half BL-A + W-B exposures.

No significant difference could be found between scores in the left and right three positions(in the black presentations, with letters, $F_{1,26} = 0.32$, $p > 0.25$, and with digits, $F_{1, 26} = 0.34$, $p > 0.25$; in the white presentations, with letters, $F_{1, 26} = 0.36$, $p > 0.25$, and with digits $F_{1, 26} = 0.17$, $p > 0.25$).

The scores of letters and digits were almost equal between black and white presentations. There was also no significant difference between the points scored on circle patterns in the black and white presentations ($F_{1, 26} = 3.28$, $p > 0.05$). The ratio of all recognition scores of digits / those of letters was 639 / 437 = 1.46. The percentage of circle patterns recognized completely was 75.7 %. The phenomenon of overestimation could not be observed in the black and white presentations.

Short Discussion

In comparing the results of Experiment 4 and 5 with those of Experiment 1, one of the most important facts is the weak appearance of the fixation point effect in Experiment 4 and 5, for the overall visual field was rather strongly illuminated. However, a strong excitation occurring in the overall retinal regions a moment before had no effect on recognition scores of letters and digits. Moreover, even though the excitation pattern had occurred in the left and right visual field of the fixation point, it did not bring out the left or right differentiation of letter and digit scores. This fact implies that recognition of letter and digit patterns did not depend upon the general excitation intensity at retinal regions. It can be said that recognition of those patterns is " perceiving," but perhaps it is not related very closely to sensory activities.

But it is another matter with respect to the circle patterns. The results of Experiment 4 and 5 showed clearly that the overall excitation increased recognition of circle patterns (in the single presentations, 52.0 %, in the rectangle presentations, 70.7 % and in the black or white presentations, 75.7 %). This fact means that to "perceive" circle patterns is probably a function of excitation intensity on the retinal regions.

Discussion

Recognition of digits and letters is understood to be "perceiving," which usually involves (a) a sensory event ; (b) a motor output ; (c) the resulting feedback ; (d) further motor output, further feedback, and so on (Hebb, 1968, p. 468). Here, eye-movements which might actually occur must be discussed. It is not reasonable to suppose that there would in fact occur eye-movements so particular that Ss' eyes could trace the fairly complex lines of more than three Hiragana letters per one exposure. When Ss made eye-movements to the left in the left preceding presentation, they must have moved their eyes to the right in the following. When they made eye-movements to the right in the right preceding exposure, they must have moved their eyes from the right end to the left in the following. It would not be impossible to assume occurrence of such eye-movements, for there was about a 300 msec duration from the beginning of the first exposure to the ending of the second. If so, it can be expected that the first exposure to the left would bring out a higher score to the left in the second, while the preceding exposure to the right would produce right superiority in the following pattern.

The results of Experiment 2 showed that the inference about eye-movements discussed above was perhaps correct. It should be stressed that the main direction of eye-movements probably plays an important role in serial integration. In this regard, Hebb (1949)has quite rightly discussed effects of eye-movements on perceptual integration. However, it is still doubtful whether the eye-movements were explicit or remained implicit as central motor events. Baba (1969) has discussed left or right score distributions as a function of the central motor events resulting from left or right fixation point presentation.

Why did Ss not show left or right score differentiation in the different kind presentation of Experiment 3, in which the same eye-movements occur as in the same kind exposures of Experiment 2 ? Another important question is why the preceding stimuli were more readily identified in the different kind than in the same kind presentation.

The results of Experiment 2 and 3 showed that stimuli were not necessarily perceived in order of their timing and spacing relationships. It should be argued that patterns of stimuli, not stimuli only, were primitively processed. In the primitive stage of perception "what kind" must be known before "what stimulus element." Ss very often answered that they could see circles, digits or letters after reporting the preceding stimuli in the different-kind presentation.

Hebb (1949) said that the super-ordinate assembly takes the process of generalization or abstraction further. "Perception of kind" certainly means the present process of generalization or abstraction. But it cannot properly be called "perception." It may be a process rather similar to imagination.

The phenomenon of overstimation provides an explanation of "kind perception." It cannot always be said that Ss could see more than six elements in the phenomenon : Ss might perhaps imagine that there were so many elements. When Ss answered the question about number with "so many," or "lots of," and E further asked "so many means how many ?" Ss often gave E the response that they could "surely" see eight or more elements there.

One stage of the transition from sensation to perception may be revealed somewhere in this phenomenon. The "imagery of kind" presupposes a parsimony of sensory inputs, and it means the dominance of cortico-diencephalic activity. Central activity may filter the sub-ordinate activity, which is connected directly with sensory inputs or with the activity of sub-assemblies. When the activity of a super-ordinate assembly is the "same" as the sub-ordinate activity, the former may "pass" the latter, while when "different," the former may "check" the latter.

This idea should be expressed differently, for the phrases "pass the same" and "check the different," certainly have an anthropomorphic sound. What "pass the same" or "check the different" implies is that the central activity probably spreads over much more than half of the neurons included in the cortico-diencephalic system. When the preceding stimuli are of the same kind as the following, the super-ordinate activity triggered by the preceding stimuli need not change and will spread over more and more regions of the system. The following stimuli will then have a more steady and more advantageous background as sensory inputs stream into sub-ordinate assemblies individually. When the preceding stimuli are different from the following, the preceding super-ordinate activity will suppress the other "type" of activity, or interfere with it,or give way to the "new activity" according to conditions of various factors. Taking every case, the following stimuli will have a more unbalanced and more immature background than the preceding. This condition of super-ordinate activity might explain the differences in scores on the preceding and following exposures between the same and the different types of double presentation.

Summary

The present study was designed to investigate the perceptual integration of serial order, giving further consideration to dual central activities. A psycho-motor test and three personality tests were administered to 138 college women over a period of six months. Based upon the results of pretests, five groups of 10 to 16 Ss selected, each of which was equalized on perceptual-motor traits, introvert-extrovert activity aspects, perceptual-motor responses, and self- or body-images.

The first group was studied to obtain the standard recognition scores and characteristics for A- and B-patterns which consisted of horizontal rows of three kinds ; six circles,six digits, and six Hiragana (a kind of Japanese ordinary alphabet) letters. Having added ten mixed patterns of six or eight stimuli to the thirty A- and B-patterns, all forty patterns were exposed to the five groups in random order at 100 msec. The second group was presented three circles, three digits or three letters (L- and R-series) on the left or right visual field of the same kind as the following patterns (A- and B-series) for 100 msec duration, 100 msec before exposures of the A- and B-patterns. The third group was similarly presented a L- and R-series in combination with an A- and B-series, although the stimulus type of the L- and R-series, when exposed, was different from that of the A- and B-series.

The main results were as follows :

1. Ss identified significantly more digits and letters of A- and B-series on the left or right visual field where the preceding stimuli were presented, but only when the preceding stimulus was of the same kind as the following A- or B-pattern.

2. Ss could recognize significantly more letters of the preceding L- and R-series in the different- than in the same-kind presentation.

3. A phenomenon of overestimation was observed in the different-kind presentation. Ss estimated more than six elements when they were asked how many stimuli there were in the A- and B-patterns.

In order to check the effects of retinal stimulation produced by the preceding stimuli on the following, the fourth group was presented with a black rectangle on the left or right visual field, before exposures of A- and B-series. Although the partial (left or right visual field) or the overall rise of retinal excitation produced better recognition of circle patterns, it proved

to have no relation to recognition scores of digits and letters.

These results were explained by reference to the main directions of explicit or implicit eye-movements, and further, by the activities of the sub- and super-ordinate assemblies of Hebb's theory.

Table 1

A- and B- series stimulus patterns presented in Experiments 1 — 5

Hiragana patterns							Digit patterns							Circle patterns						
A-series							A-series							A-series						
1)	ke	a	ma	se	mu	te	1)	4	9	5	7	2	8	1)	w	b	b	w	w	b
2)	ti	su	to	sa	wa	hi	2)	5	8	3	9	6	7	2)	b	b	w	w	b	w
3)	re	hu	e	me	ro	nu	3)	6	2	9	3	8	4	3)	b	w	w	b	b	w
4)	ya	ni	ta	ne	tu	mo	4)	7	3	6	2	4	5	4)	w	w	b	w	b	b
5)	yo	re	ka	so	ha	ra	5)	8	5	2	4	7	6	5)	w	b	w	b	b	w
B-series							B-series							B-series						
1)	su	o	mi	hi	ki	he	1)	4	9	6	5	3	8	1)	w	b	w	w	b	b
2)	ro	ke	me	te	ti	mu	2)	5	3	7	2	8	6	2)	b	b	w	b	w	w
3)	ta	sa	ni	tu	wa	ne	3)	6	8	3	4	2	7	3)	b	w	b	b	w	w
4)	ru	so	re	nu	hu	ka	4)	7	2	5	9	6	4	4)	w	w	b	b	w	b
5)	ha	ya	yo	ra	na	so	5)	8	4	9	3	7	5	5)	w	b	b	w	b	w

w = white circle   b = black circle

Table 2

Comparisons of legibility of A-series Hiragana letters with that of B-series

A-Hiragana patterns

							Total
	ke	a	ma	se	mu	te	
1)	53.0	58.0	67.0	50.5	49.5	51.5	329.5
	ti	su	to	sa	wa	hi	
2)	42.5	47.0	40.5	41.5	37.5	45.5	254.5
	re	hu	e	me	ro	nu	
3)	29.5	30.0	23.0	39.5	41.5	32.0	195.5
	ya	ni	ta	ne	tu	mo	
4)	21.0	26.0	28.5	34.5	39.0	23.0	172.0
	yo	re	ka	so	ha	ra	
5)	13.0	29.5	13.5	19.0	22.5	10.0	107.5
	159.0	190.5	172.5	185.0	190.0	162.0	1059.0

B-Hiragana patterns

							Total
	su	o	mi	hi	ki	he	
1)	47.0	54.0	57.5	45.5	55.5	57.5	327.0
	ro	ke	me	te	ti	mu	
2)	41.5	53.0	39.5	51.5	42.5	49.5	277.5
	ta	sa	ni	tu	wa	ne	
3)	28.5	41.5	26.0	39.0	37.5	34.5	207.0
	ru	so	re	nu	hu	ka	
4)	20.0	19.0	29.5	32.0	30.0	13.5	144.0
	ha	ya	yo	ra	na	so	
5)	22.5	21.0	13.0	10.0	16.5	19.0	102.0
	159.5	198.5	165.5	178.0	182.0	174.0	1057.5

Table 2

Note — legibility of each letter is based upon a task in which Ss (Junior High School students) were asked to check off all examples of one letter in rows of Hiragana nonsense sequences under a time limit condition.
The legibility was assessed on the basis of number of items correctly checked, the number of letters missed, and the number wrongly checked.
The higher the number entered in the table, the more legibile the letter.

Table 3

Overestimation : Its frequency of report in Experiment 3

Number of stimuli estimated	Number of times estimated															
	Subject no.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8	1	1	3	9	4	8		3	5	3	3	13	8	2	2	9
9					1							1	1			1
10	1	1	1		2				5	2			1			3
11																1
Total frequency of report (maximum possible = 30)	2	2	4	9	7	8	0	3	10	5	3	14	10	2	2	14

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Footnote

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