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THE PERCEPTION OF COMPETING VISUAL PATTERNS

Experiments were conducted to investigate the interaction of two familiar simple visual patterns unified into an unfamiliar one. In Experiment I subjects were trained for 4 days in recognizing (among similar patterns) two simple visual patterns: one linear and one dotted, shown for durations of 20, 30, 50 and 75 msec. In Exp. II these simple patterns were combined, the linear pattern being placed above the dotted one. In Exp. III the dots were above the lines. In Exp. IV subjects were instructed to watch either the dots alone, or the lines alone, in order to keep apart the two elements of the complex. The following results were obtained: while learning to recognize the simple patterns subjects initially committed more errors with dots than with lines. This difference disappeared gradually so that on the fourth day of learning subjects performed equally well on both patterns, making few errors. But on combining the two patterns the number of errors increased only in relation to the dotted element. This result was not affected by a shift of elements (Exp. III), nor by the instruction to disregard the linear element (Exp. IV).

The results of the four experiments are discussed in the framework of Konorski's theory which assumes that there are antagonistic interactions between gnostic units involving the mechanism of lateral inhibition.

According to electrophysiological evidence, the visual system has at various levels neurons that react selectively to such simple stimuli as dots, lines of certain inclination and direction, angles, etc. (Hubel and Wiesel, 1959, 1961, 1962, 1965).

As postulated by J. Konorski (1967), in the gnostic region of that system the lower-level units converge to form higher-level units called gnostic units; the latter react selectively to complex stimuli, as for instance familiar faces or objects. The gnostic units of one and the same analyzer (modality) may remain in antagonistic relation so that the simultaneous occurrence of two stimuli reduces the response to one or both of them. In the case of a familiar complex stimulus the component elements of the stimulus have been integrated by a gnostic unit and are thus perceived as a whole. An unfamiliar complex stimulus, on the other hand, is analyzed by different gnostic units, due to which it is less easily perceived.

This hypothesis is supported by data obtained by Konorski et al. (1973) in a study which demonstrates the presence of inhibitory action between the elements of a complex stimulus. Inhibition decreases with separation of elements of a nonsymmetric complex stimulus and with their combination in a symmetric complex stimulus. The hypothesis has received further support from data obtained in masking experiments in which the exposition of two complex visual patterns in rapid succession has led to the masking of one by the other (Schiller, 1965, 1966).

The present study was devised to trace the interaction of two familiar simple visual patterns (which are presumably represented by separate gnostic units in the nervous system,) once they are combined into a geometric whole; specifically, to ascertain whether these patterns would become integrated, or whether they would interact antagonistically. Four experiments were run: in Exp. I subjects (*Os*) had to learn to recognize two simple visual patterns, in Exp. II, III and IV the same patterns were shown simultaneously to investigate their interaction and the conditions of this interaction.

METHOD

Subjects

The same subjects were used in all four experiments. There were 12 *Os* in Exp. I, II, III, and 10 *Os* in Exp. IV. All *Os* had high school education; their vision was of normal acuity (20/20). None had ever taken part in experiments on visual perception.

Material

Two kinds of visual patterns were used: simple and complex patterns (see Fig. 1). Simple patterns were used in Exp. I, complex patterns in the remaining experiments. The simple patterns were rectangular, angular dimensions being 2°07′ × 54′. The rectangle was circumscribed by a line of 5′ thickness. In the rectangular space there were either dots (simple dot pattern) or lines (simple line pattern). A dot measured 15′, and the minimum distance between two dots measured between their centers was 32′. The lines were of 5′ thickness. One of the simple line patterns and one of the simple dot patterns were designated positive stimuli, the remaining ones negative. The patterns were arranged in series of 30 elements each: ten positive patterns were randomly distributed among 20 negative patterns.

A complex pattern consisted of a simple dot and a simple line pattern. There were two kinds of complex patterns: those combining the two simple patterns into a whole (unified patterns) and those keeping them apart (separated patterns). In each case the dots were either below the lines (pattern A), or vice versa (pattern B). The complex patterns measured 2°07′ × 2°07′. Both unified and separated patterns were arranged in series of 30 patterns each. As in Exp. I, there were 10 positive and 20 negative patterns (randomly distributed) in Exp. II and II. In Exp. IV the positive pattern recurred 20 times and the negative pattern 10 times.

Apparatus

In all experiments the above described patterns were exposed on a white rectangular screen, 32.5 cm × 23 cm, with a light reflection coefficient of $\alpha = 0.55$. The "Łucz" film projector used for exposing the patterns had an additional mechanism by which the single frame could be exposed for 350, 75, 50, 30, or 20 msec.. The background on the screen was illuminated with 55 lux. During the exposure the screen was illuminated with 66–73.5 lux over the white areas while the dots and lines received 59–64.5 lux.

Procedure

Each *O* was tested separately in a soundproof chamber. He was seated at a distance of 270 cm from the screen.

In Exp. I, subjects were trained to recognize the simple patterns at sessions on four consecutive days; the final results (of the fourth day) were then compared with the results of Exp. II, III and IV, when the two simple patterns were combined into a complex pattern.

At the first session, before learning to recognize the positive simple pattern among the negative simple patterns, the subjects were shown the positive pattern three times for 350 msec. and six times for 75 msec., and once the whole series consisting of positive and negative patterns (trial series).

At the next sessions the patterns were exposed in series (dot series separate from line series) for durations of 75, 50, 30 and 20 msec. Before each series the positive pattern was exposed five times for the same duration as the series. The intervals between exposures lasted 5 sec., the intervals between the series 5 min. Half of the subjects began

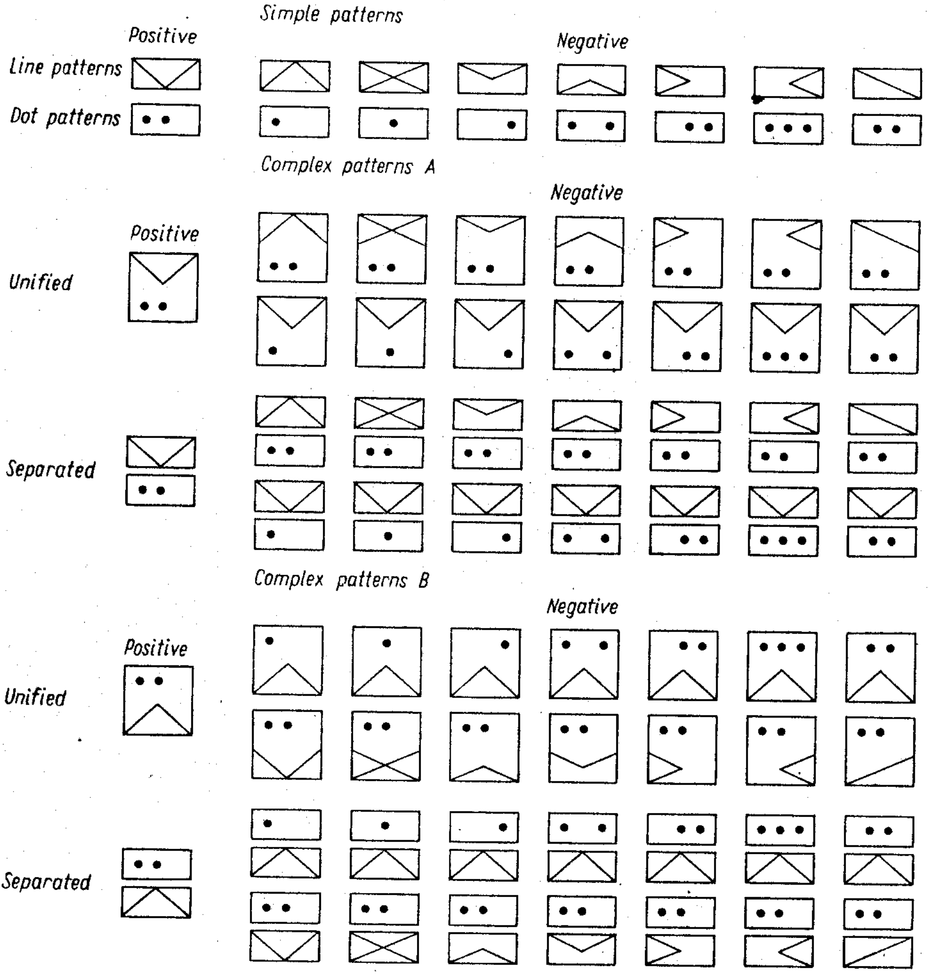

Fig. 1. Patterns used in Experiments I, II, III and IV

with the dot series, the other half with the line series. The subject was told each time whether his response was correct or not.

The same manner of exposure and measurement obtained in Experiment II, III, and IV.

In Exp. II complex patterns A were exposed in series. For two days four series of unified, and four series of separated patterns were exposed. In each series the upper element consisted of the simple line pattern, and the lower element was the simple dot pattern.

In Exp. III the complex pattern B consisted of the dot pattern above the line pattern.

In Exp. IV the A complex pattern was again exposed, but *Os* were now instructed to watch only one of the two elements: either dots or lines. Half of *Os* began with watching dots and later watched lines, while the other half did the reverse.

In Exp. II, III, and IV *Os* were not told whether their responses were correct or not.

RESULTS

In processing the obtained data we adopted the percentage of errors made in identification as a measure of performance. The following types of errors were taken into consideration: (a) errors made when the positive pattern was exposed, hence positive errors (+), (b) errors made to negative stimuli, hence negative errors (−), (c) errors made to dot patterns (marked D), (d) errors made to line patterns (L). A subject could thus commit errors marked: +L (when erroneously reacting to a positive simple line pattern, or to the line element of a complex pattern), +D (error in response to a positive simple dot pattern, or to the dot element of a complex pattern), −L (error to a negative simple line pattern, or to the line element of a complex pattern), and −D (error to a negative simple dot pattern, or to the dot element of a complex pattern). Since in Exp. II and III *Os* were made to respond to the pattern as a whole, their positive errors could not be separated into dot and line ones.

In summing up the results, we disregarded the scores for the 20-msec, exposure, since these did not differ from chance. The errors committed in response to unified and separated complex patterns were treated jointly, the differences being statistically nonsignificant.

The statistical treatment of the data included an analysis of variance, for which the data were transformed according to the formula $y = \sqrt{x+1}$, where x stands for raw data and y for transformed data.

TABLE 1

TRAINING IN RECOGNITION OF SIMPLE PATTERNS
(Experiment I)

	Error categories	1st day		2nd day		3rd day		4th day	
		x	y	x	y	x	y	x	y
positive errors	+L	4.2	1.4	1.9	1.2	3.9	1.3	2.0	1.2
	+P	12.2	2.0	8.3	1.7	6.6	1.6	4.4	1.4
negative errors	−L	2.1	1.3	3.0	1.5	1.4	1.3	0.7	1.1
	−P	2.1	1.4	2.1	1.4	1.8	1.3	1.2	1.2

The data obtained in Exp. I on the successive days of learning to recognize the simple patterns are shown in Table 1. Table 2 contains the results of the analysis of variance performed on the same data. The basic variables in the analysis of variance for data of Exp. I were: **A** — the successive days of the experiment, **B** — the ratio of negative to positive errors, **C** — the ratio of dot errors to line errors. Furthermore, the following interactions were tested: AB, AC, BC, ABC.

TABLE 2

ANALYSIS OF VARIANCE FOR DATA OF EXP. I

Source of variation	*df*(1)	*MS*(2)	*F*(3)
A (days)	3	0.59	1.72
B (positive errors vs negative errors)	1	1.30	3.93*
C (line errors vs dot errors)	1	2.04	6.18*
AB	3	0.21	< 1
AC	3	0.09	< 1
BC	1	1.76	5.33*
ABC	3	0.21	< 1
Error	176	0.35	—

Analysis of variance for the data of Exp. I has revealed a significant predominance ($p < 0.05$) of positive over negative errors as well as of dot over line errors. There is no statistical evidence, however, of any influence of successive days of the experiment on the differences between the aforementioned categories of errors (interactions **AB** and **AC**). But applying analysis of trends for y data we discovered a significant decrease in the overall number of errors on the successive days ($r = 0.98$; $p < 0.02$). A similarly declining trend emerged with respect to the positive dot errors ($r = 0.98$; $p < 0.05$), which were more frequent than any others. This produced a statistically significant decrease in the difference between the number of positive-line and positive-dot errors ($r = 0.95$; $p < 0.05$). A similarly declining trend—though only slightly above the 0.05 level—was found for the difference between the overall number of dot and line errors ($r = 0.92$; $p < 0.07$).

TABLE 3

COMPARISON OF ERROR CATEGORIES IN EXP. I, II, III AND IV

	Error categories	Exp. I Simple patterns		Exp. II Complex patterns A		Exp. III Complex patterns B		Exp. IV Complex patterns A (selective perception)	
		x	y	x	y	x	y	x	y
positive errors	+L	2.0	1.6	20.5	3.3	12.5	2.9	0.8	3.2
	+P	4.4						8.1	
negative errors	−L	0.7	1.1	4.3	1.8	3.7	1.4	0.8	1.2
	−P	1.2	1.2	19.5	3.3	14.00	2.6	5.1	2.2

The results yielded by Exp. I suggest that although the learning of this relatively simple discrimination task did not proceed very efficiently the subjects performed better from day to day on the experimental patterns and after four days of learning had familiarized themselves with them. A striking fact is the disappearance of differences in perceptual performance in response to dot and line patterns. It might be reasonably assumed that the differences between the two categories of errors would disappear if the learning were continued for another few sessions.

With reference to the basic question of this study—as to the reciprocal effect of the two familiar simple visual patterns once unified—the results of the fourth day of Exp. I were compared with the scores of Exp. II, in which the A complex patterns were exposed (lines above, dots below), and with the scores in Exp. III, in which the B complex patterns were used (dots above and lines below), and further with the results of Exp. IV, in which A complex patterns were exposed but *Os* were told to watch either dots or lines alone. The pertinent data are shown in Table 3.

An analysis of variance applied to the same data as above is demonstrated in Table 4. The basic variables were: **A**—the successive experiments, **B**—categories of errors; also tested was the interaction between error categories and the particular experiments (**AB**).

TABLE 4

ANALYSIS OF VARIANCE FOR DATA IN TABLE 3

Source of variation	*df*(1)	*MS*(2)	*F*(3)
A (experiments)	3	14.09	16.19**
B (error categories)	2	21.46	24.66**
AB	6	2.14	2.46*
Error	128	0.87	—

** $p < 0.01$

* $p < 0.05$

Analysis of variance has revealed significant differences between the data obtained in these experiments ($p < 0.01$) for the overall numbers of errors (variable **A**). Similarly significant differences ($p < 0.01$) have been discovered between the error categories (variable **B**). The ratio of errors of different categories varied also from experiment to experiment (**AB** interaction; $p < 0.05$).

In a more detailed analysis of results the numbers of errors made in Exp. II, III, and IV were found to be significantly larger than the numbers of errors made in Exp. I ($p < < 0.01$). This increase was particularly striking in the number of negative dot errors ($p < 0.01$). There was no significant increase in negative line errors in Exp. II, III, and IV when compared with Exp. I. As has been said before, the procedure employed in the study precluded a separation of dot from line errors among the positive errors in Exp. II and III. But the overall number of positive-dot and -line errors was in Exp. II, II, and IV significantly larger than in Exp. I ($p < 0.01$). The pronounced increase in the number of negative dot errors as contrasted with the rather small, statistically nonsignificant, increase in the number of negative line errors suggests that the rapid growth in the number of positive errors may have been due to the defective perception of the dot element of the complex patterns.

When comparing the data for Exp. I with those for Exp. II, III and IV we are struck by the ratio of line to dot errors. Whereas in Exp. I the number of dot errors on the fourth day of learning to recognize simple patterns did not differ significantly from the number of line errors, the number of dot errors became significantly larger than the number of line errors in the experiment with the complex patterns which comprised both dots and lines ($p < 0.01$ for Exp. II and III, $p < 0.05$ for Exp. IV).

DISCUSSION AND CONCLUSIONS

The results of Exp. I, and in particular the diminishing differences in the number of errors committed in the perception of the two simple patterns, seem to justify the assumption that the reciprocal inhibition between elements of the simple patterns tends toward extinction as the subject becomes increasingly familiar with the patterns. We may suppose that, with continued training, the performance of *Os* would not depend on the component elements of the patterns because each pattern would acquire its own distinctive representation in the nervous system, enabling the subject to perceive the patterns at once, rather than by an analysis of its elements, as in the initial phase of the experiment. Evidence in support of this assumption is forthcoming from Glezer's laboratory (Glezer and Nevskaya, 1971; Prazdnikova, 1972), where experiments on humans and animals have shown that well—known visual stimuli are perceived as a whole without dismemberment into component elements (2nd type of recognition), whereas little known (unfamiliar) patterns are recognized through the isolation of their features (1st type of recognition).

The two simple patterns with which *O* had become familiar in Exp. I were combined into a new whole, in an attempt to trace the interaction between the two familiar elements. From our data it appears that in Exp. II, III, and IV these simple patterns did not become integrated into a complex pattern but rather functioned as two separate elements, each affecting the other, although not with equal force. This is borne out by the finding that, with the unification of the simple patterns, the number of errors pertaining to dots increased markedly whereas the number of errors pertaining to lines remained approximately at the same level as in Exp. I.

It seems highly improbable that the predominance of dot errors could have been exclusively due to the reciprocal influence of dots alone, for once the dot pattern had been fully assimilated (and was exposed alone—on the fourth day of Exp. I), it was almost as easily perceived as the line pattern. When both elements were combined into a geometric whole, there was a significant increase only in the number of dot errors.

Once we found that the interaction of the two component elements of the complex pattern is such that the line pattern interferes with the perception of the dot pattern, it was surmised that this might be an effect of the relative positions of the two elements in the complex pattern (lines above, dots below—the A pattern). In order to test this hypothesis we ran Exp. III, in which the dot element was placed above the line element (the **B** pattern). The results showed that the interference was not due to the relative positions of the elements: even when the dots were above the lines the number of dot errors was statistically larger than the number of line errors.

In Exp. IV it was checked out whether the predominance of dot errors might be due to the fact that the positive linear pattern resembled an envelope and was therefore easier to recognize than the dot pattern, since it might attract more attention. Should the predominance of dot errors over line errors have been caused exclusively by an orientation of perception toward the line element, then a change in the conditions of the problem toward equal favorization of perception of dots and of lines could be expected to yield a similar ratio between dot and line errors as that on the last day of Exp. I, when the line and the dot stimuli were exposed separately. The findings of Exp. IV suggest that the predominance of dot errors in the perception of complex patterns was not due to a preference for lines because when *Os* were instructed to watch the dots and disregard the lines they also committed more dot errors than line errors.

The results of this study have provided no answer to the question as to what factors caused better perception of line elements in the complex pattern and at the same time greater susceptibility to interference on the part of the dot elements. Further experiments are in progress to elucidate the issue. But the results of the present study suggest that the complex pattern composed of two familiar simple patterns, as applied in the experiments, was in all probability not perceived as a whole since one of its well-known component element interfered with the perception of the other one, thus hampering the recognition of the complex pattern.

These facts are well accounted for by Konorski's hypothesis that postulates an antagonistic interaction of elements constituting an unfamiliar complex pattern—which has no representation of its own in the neuronal system, being represented by separate gnostic units corresponding to its component elements.

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