CONFIGURING:

ANALYTICO-SYNTHETIC PROPERTIES OF COMPOUND CONDITIONING

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ABSTRACT

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Previous literature on the topic of configuring was examined comparing studies within both the post-Pavlovian and American frames of reference. It was found that although no conclusive demonstration of configuring existed outside the post-Pavlovian literature, a number of explanations of the phenomenon in terms of orienting responses and in terms of generalization-decrements had been produced.

The present study employed a CER technique using hooded rats as subjects. The first experiment in the present series was designed to demonstrate configuring and the second to refute explanations of it in terms of other, more simple, processes. Both of these experiments were successful. A third experiment examined the properties of component stimuli after experience in a compound; and a fourth experiment looked at the effect of previous conditioning experience of a stimulus component on the development of a configure composed partially of such a component.

Discussion of the evolution of configuring as a "higher level of learning" focussed on post-Pavlovian comparative and physiological studies which suggest that configuring is dependent upon some as yet unknown neural development within the cerebral cortex.

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INTRODUCTION

As early as 1939, Razran held that there exists a level of neurobehavioral organization, above that of simple conditioning, where elemental stimuli synthesize to form configures - stimulus compounds whose governing laws are synergistic rather than related directly to the functional valences of their component elements. Like Beritov (1932) Razran (1971) maintains that integrated compound conditioning results in the emergence, during the course of training, of a new CS center - distinct to that formed to its elements - which connects independently with the US center.

The evidence for this view derives from two sources: a large number of Russian experiments begun in Pavlov's laboratory, and a small number of more available American experiments. Since, according to Razran (1971), Russian experiments related to configuring number approximately 750, these will only be sampled, while the less than a dozen American experiments will be dealt with in some detail.

Palladin (1906) paired a weak thermal stimulus as a CS with an acid US which readily evoked salivation and obtained the usual conditioned salivation to the CS. When the thermal CS was paired with a tactile CS as well as the acid US, test trials to each CS seperately showed that the thermal CS was not effective. The tactile CR was then experimentally extinguished. Presentation of either CS alone evoked no CR. Presentation of the compound, on the other hand, continued to be an effective CS. A patterning or configuring effect in afferent-afferent interaction seemed to have occurred.

Similarly Zeliony (1910) trained dogs with a compound of tone and light. Reinforced compound trials were occasionally interrupted by unreinforced component trials which served as an index of component CR efficacy. At no time was the light component an effective stimulus, but the response to the tone required 399 unreinforced trials to extinguish. After this differential training was completed, however, compound presentation of the two inactive stimuli continued to evoke a full CR. Numerous other examples from the Pavlov laboratory can be found in Razran (1939a, 1965b, and 1971).

Experiments conducted in the Beritov laboratory by Beritov and his colleagues (see Razran, 1965b) revealed several new findings. Not only could simultaneously presented stimuli lead to configuring, but successively presented compounds also led to the same result. Beritov concluded that "integrated action of the cerebral cortex" developed through several stages culminating in the formation of a "new extra" neural center which specifically mediated responses to the compound. In the majority of Beritov's experiments the method of producing configuring was through differential reinforcement, that is, reinforced trials of the compound alternating with nonreinforced trials of the components. This was not the case in all the experiments, however. Beritov (1932) states plainly that "differentiation of individual components of a compound is effected by itself through training of the compound" (p. 340). This fact is of more than methodological importance as will be seen when the studies of Baker (1969) and of Rescorla (1972; 1973) are discussed below.

Voronin (1948) and his colleagues replicated and extended the work begun in the Pavlov and Beritov laboratories. Specific findings of interest were that a) overtraining of a CS compound is sufficient to inactivate components of a compound and that b) differential reinforcement produces inactivation of components more rapidly than does overtraining alone.

Konorski and Lawicka (1959) in reviewing the literature on configuring are in agreement with the views of Beritov, of Voronin, and of Razran. They conclude that "there is much evidence collected both by Pavlov's school and in our laboratories showing that the cortical representation of the compound of conditioned stimuli cannot be simply considered as composed from the particular centers representing each element of the compound" (pp. 195-196).

The evidence presented so far relates only to the "mere existence" of the phenomenon. A considerable amount of post-Pavlovian research has begun to explore more deeply the dynamics of configuring. The implications of this research go well beyond what has been accomplished not only in the few American experiments to be reviewed here, but beyond the present study as well. The nature of these later experiments can be more profitably taken up, then, in the general discussion section of the present report.

As is well known, early Russian conditioning experiments were often poorly designed, lacking in controls, and as often as not lacking in statistical analyses (Razran, 1971). Therefore the burden of much of the recently revived experimental investigation has been to define configuring operationally, and to derive an appropriate research design. Baker (1969) has suggested that rather than interrupting compound trials with nonreinforced component tests as training continues - in order to determine component CR efficacy - a between-subjects design with several groups receiving an increasing number of compound trials should be used. Comparison of component tests following increasing amounts of compound conditioning would then provide the necessary data on the degree of response elicitation of each component. Furthermore, according to Baker (1969) and Booth and Hammond (1972) the defining characteristic of configuring should be the accelerating decrement in CR efficacy of each component of a compound through overtraining alone.

Are any of the current American experiments on configuring consistent with these two criteria? The answer is unfortunately no. Rescorla (1972; 1973) was unable to show decreasing CR efficacy of the components; similarly both Baker (1969) and Wickens, Nield, Tuber, and Wickens (1970) failed to report successful configuring. Of those experiments which were "successful" Wickens, Wickens, and Nield (1965), Thomas, Berman, Serednesky, and Lyons (1968), and Guth (1967) used within-subjects designs which leave open the possibility of contamination from differential conditioning. As Baker (1969) has pointed out "since this procedure (the presentation of nonreinforced test trials) is identical to that for the establishment of differentiation, it still remains an empirical question whether data obtained from a between-subjects design will support the hypothesis that components synthesize as a function of training" (p. 347).

The only American experiment to escape this criticism is that of Booth and Hammond (1972). Unfortunately they were unable to fulfill the second criterion stated above, namely the accelerating decrement in CR efficacy of the stimulus elements as a function of trials. As can be quite readily observed from their results, although one of the two component elements does decrease in CR efficacy, response to the other element actually <u>increases</u>.

It would appear then that to date there is no unequivocal evidence for configuring in non-Russian literature. This has led both Baker (1968; 1969) and Rescorla (1972; 1973) to assert that differential reinforcement is necessary to produce what appears to be configuring. This is, however, a mistake; reference to either Beritov (1932) or Voronin (1962) would have uncovered experiments wherein configuring was brought about through overtraining alone.

Perhaps because of this repeated failure to obtain configuring experimentally, several attempts to "explain" the phenomenon in terms of hidden, but more simple, processes have been developed.

In a sense, differential reinforcement is already an explanation of this type. Further, Baker (1969) suggested a generalization-decrement hypothesis wherein a decrement in CR to a component after compound training was due simply to generalization, that is, the growing lack of similarity between the compound and its components as conditioning proceeds. An orienting response hypothesis has also been advanced by Baker (1968) and examined by Booth and Hammond (1972). The argument here is that the increasing novelty of the components of a compound as compound training continues will lead to larger and larger orienting responses to the components, which would in turn increasingly inhibit the CR. It can be seen that these two "explanations" are very closely linked. Common to both explanations is the idea that the subject would notice a difference between the compound CS and the component as a CS and that noticing this difference would lead to an inhibition of the CR.

What is also common to these two explanations is that they both stem from a failure to produce the configuring effect *per se*; and that although they do not depend on the differential reinforcement concept in any logical way, they are embedded within that context.

The purpose, then, of Experiment 1 in this series is to demonstrate the configuring effect without differential reinforcement, but with a between-subjects design, and with the defining characteristic of accelerating decrement in CR efficacy of the components over trials.

Experiment 2 examines both the orienting response hypothesis and the generalization decrement hypothesis.

Experiments 3 and 4 step into what Razran (1971) has referred to as the "beyond of configuring". In other words some of its basic empirics are at issue. Extensions made, at this point, into the area of configuring must necessarily be somewhat arbitrary. Since very little is known about the area many paths could be taken. Experiment 3 examines the nature of component stimuli after experience in a configuring compound. Would single elements which no longer possessed substantial CR efficacy require more or less reconditioning trials to become effective? In Pavlovian terms, we wanted to know whether these single elements became "excitatory" or "inhibitory" after experience in a configure. Experiment 4 examined the effect of previous conditioning experience with a component on the development of a configure composed partially of such a component. Could a single element which had become a consistently predictive CS join with a previously neutral stimulus to become a configure? Or, on the other hand, would a previously conditioned CS retain its response eliciting properties and prevent the process of configuring?

Again, Experiments 3 and 4 may be arbitrary but they are first steps taken in the opening up of a learning process which may turn out to be quite important, but about which we know almost nothing.

EXPERIMENT 1 - DEVELOPMENT OF CONFIGURING

Subjects and apparatus. Subjects were 48 experimentally naive, male hooded rats that weighed between 250 and 300 grams when received from the supplier, Canadian Breeding Farms of Quebec. They were reduced to 75% of their ad libitum body weight over the course of about 10 days, and maintained on a 22 hour food deprivation schedule.

Experimental apparatus consisted of eight standard Grason-Stadler conditioning units, enclosed within a sound and light resistant shell. (Ambient noise level within these units, when the ventilation fan was operating was 65 db). The grid floor of these units could be electrified by Grason-Stadler model E1064GS shock generators. Experimental events were controlled and recorded automatically by appropriate relay equipment located in an adjoining room.

Procedure. Initial magazine training was followed by two daily, two-hour, bar-press sessions for food on a 2.5 min VI schedule. Reinforcements were 45 mg Noyes food pellets. All preliminary training occurred in the dark.

During the following three bar-press sessions pretest presentations of noise, light, and of the compound of noise and light were programmed so that four presentations of each stimulus (or compound stimulus) were given over the course of the three pretest days.

The noise element was an 80 db white noise, the light a 7 w illumination of the entire unit, and the compound CS a simultaneous activation of the noise and light components. All CSs lasted 3 minutes.

The next session began conditioning and the 48 rats were divided into six groups of eight animals each. These groups were designated C-4, C-8, C-12, C-24, C-40, and C-60; the numeral indicating the number of compound CS trials presented to the group. During conditioning, the animals were presented with 4 CS-US pairings superimposed over the regular 2-hr bar-pressing session at approximately 20 min intervals. The US consisted of a 0.5 sec 1 Ma shock delivered through the grid floor of the conditioning unit immediately contiguous with CS termination. The CS during conditioning was always a reinforced noise/light compound. At no time during conditioning was either component presented to the animal either with or without reinforcement.

Following 4, 8, 12, 24, 40, or 60 compound CS presentations, all animals were given a single noise presentation and a single light presentation. Comparison of the final compound trial and the two single element trials would provide a comparison of the CR efficacy of the compound and its components.

<u>Index of conditioning.</u> The index reported is a suppression ratio that compares the animal's rate of bar pressing during the CS to the rate during an immediately preceding period of equal duration. The ratio is B/(A+B) where B represents the number of responses

during the CS and A the number of responses in the immediately preceding 3 minutes. A ratio of .00 indicates complete suppression, while a ratio of .50 indicates no change in the rate of bar-pressing. Ratios between .00 and .50 therefore indicate varying degrees of conditioned suppression.

Results and discussion. There was no tendency to suppress to the CS during pretest. Median suppression ratios for each group during each of the three pretest days approximated .50.

Suppression to the compound remained relatively stable from 8 trials through 60 trials. The slight upward curve for the compound tests (see Figure 1) is misleading. Independent data indicate that the apparent attenuation is due entirely to inhibition of delay (see section below entitled "Inhibition of delay").

Suppression to both components, however, shows an accelerating decrement in CR efficacy as a function of compound CS overtraining. While at 8 and 12 trials both components elicit complete conditioned suppression as does the compound, after 24 trials of compound suppression to the components is severely attenuated although the compound itself is entirely effective. Between groups effects were significant at the .001 level; $F = 9.62$, $df = 5/42$. Differences between the modality of the CS (either compound or component) was significant at the .001 level; $F = 10.23$, $df = 2/84$. Table 1 presents the complete source table for this analysis. Table 2 analyzes through a multiple-comparison procedure for

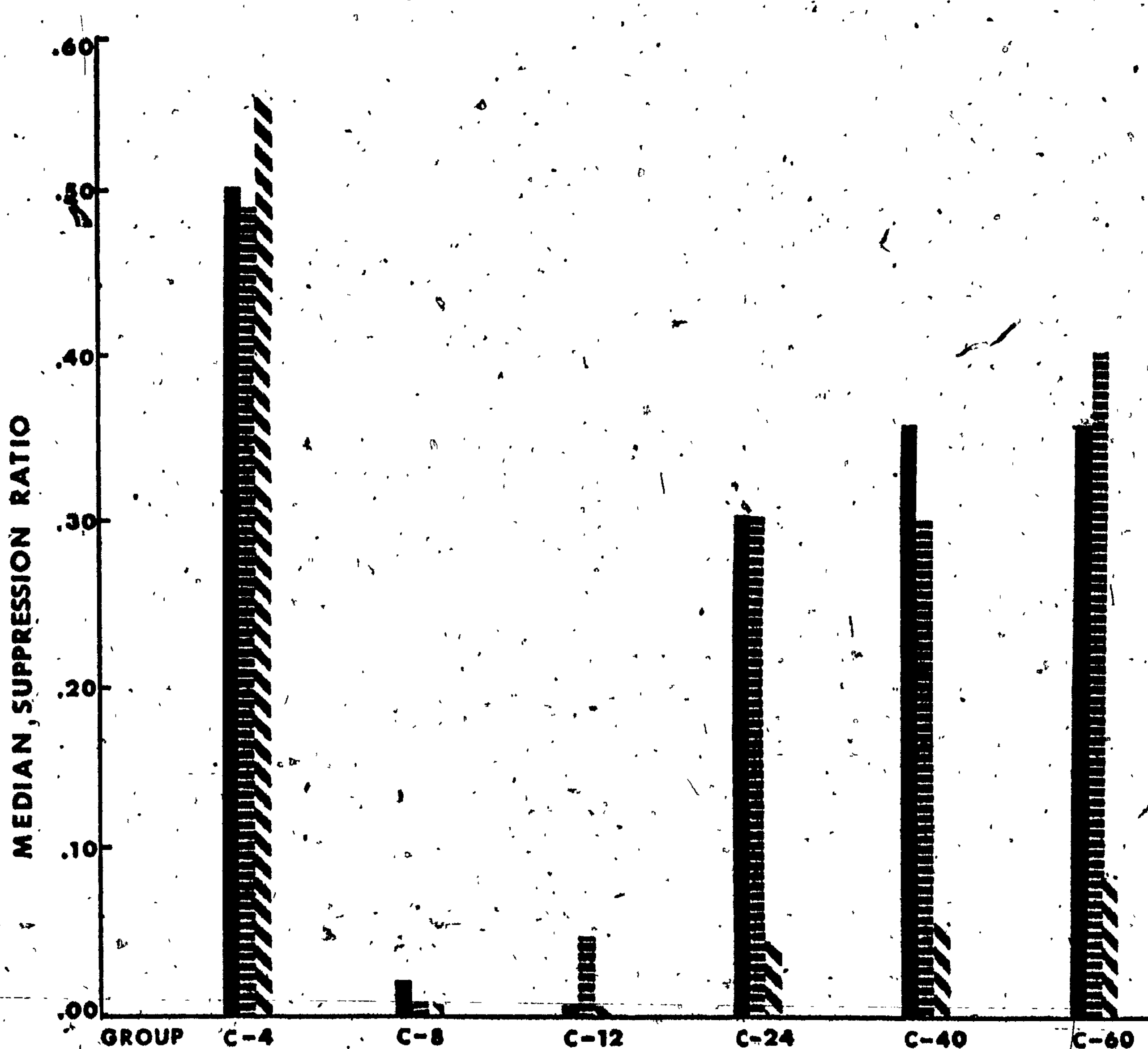

Figure 1. Development of configuring. Black columns indicate noise element; horizontally striped columns indicate light element; diagonally striped columns indicate noise/light compound.

TABLE 1. ANALYSIS OF VARIANCE SOURCE TABLE
FOR DEVELOPMENT OF CONFIGURING

Source	SS	df	MS	F	p
Total	74691.83	143	--	--	--
Between Ss	53063.16	47	--	--	--
Groups	28333.54	5	5666.71	9.62	<.001
Error B	24729.62	42	588.80	--	--
Within Ss	21628.67	96	--	--	--
Modality	3452.77	2	1726.39	10.23	<.001
Mod. x Gr.	3982.65	10	398.27	2.36	<.02
Error W	14193.25	84	168.73	--	--

TABLE 2. MULTIPLE t-TESTS FOR WITHIN EFFECTS: Modality Comparisons in the Development of Configuring. C = compound N = noise L = light

Group	Comparison	t	p
C-4	C vs N	1.02	N.S.
	C vs L	1.10	N.S.
	N vs L	0.08	N.S.
C-8	C vs N	0.41	N.S.
	C vs L	0.42	N.S.
	N vs L	0.83	N.S.
C-12	C vs N	1.14	N.S.
	C vs L	0.46	N.S.
	N vs L	0.67	N.S.
C-24	C vs N	3.91	<.005
	C vs L	3.20	<.005
	N vs L	0.70	N.S.
C-40	C vs N	2.99	<.005
	C vs L	2.52	<.025
	N vs L	0.46	N.S.
C-60	C vs N	3.51	<.005
	C vs L	2.47	<.025
	N vs L	1.04	N.S.

within effects (Lindquist, 1953) the significance of differences between each component and the compound, and between each component in relation to the other component. In no group were the components significantly different from each other. In all three overtraining groups the compound differed significantly from the components; at the .005 level for the noise element in all three groups, and at the .005 level for the light element in Group C-24, and at the .025 level for the light element in Groups C-40 and C-60. During the pretest phase of the experiment, response to the compound did not differ from response to either element.

It would appear then that configuring has been demonstrated according to the criteria developed by Baker (1969) and Booth and Hammond (1972). Configuring was found using a between-subjects design, without differential reinforcement, and with an accelerating attenuation of conditioned suppression to the components as a function of overtraining.

Inhibition of delay. Using the data from the C-40 group the number of responses in the first half of the CS was recorded separately from the second half. Separate suppression ratios could then be created using these data. Median suppression ratios for each trial were then averaged as a "daily ratio" consisting of the mean of the suppression ratios for each of the four daily trials. No inhibition of delay was evident during the first five days of compound conditioning. This is consistent with Zielinski (1966) who found inhibition of delay after approximately 18 trials of the CER using a somewhat different procedure.

From trial 21 on, however, responding in the second half of the CS approaches .00, where it remains (see Figure 2). Responding in the first half of the CS continues to increase as reflected in the upward slope of compound trials in Figure 1. The difference between the first 90 sec and the second 90 sec of the 3 min CS was found (using a 2 within analysis of variance) to be significant at the .01 level; $F = 13.68$, $df = 1/7$. The difference over trials (an increasing inhibition of delay) was also significant - $F = 2.73$, $df = 4/28$, $p<.05$. Table 3 presents the full source table.

Since all bar-pressing would appear to occur only during the first 90 sec, it can only be concluded that the CS still retains considerable conditioned suppression eliciting properties, and that while the upward slope of component CR efficacy is due to configuring, the much less extreme apparent attenuation of suppression to the compound is due to an inhibition of delay effect.

Handling control. A control group was run to insure against the possibility of "pseudoconfiguring." It seemed possible that time alone could have been responsible for the attenuation of suppression noted to the components; perhaps the compound overtraining was not in fact responsible. To test this, a group of eight animals was treated as described previously. The animals were given eight noise-shock presentations over two days using the same procedure and stimuli as those described above. Following conditioning, the animals were mrely handled for ten days - no bar-pressing was permitted and no stimuli presented. After 10 days the animals were

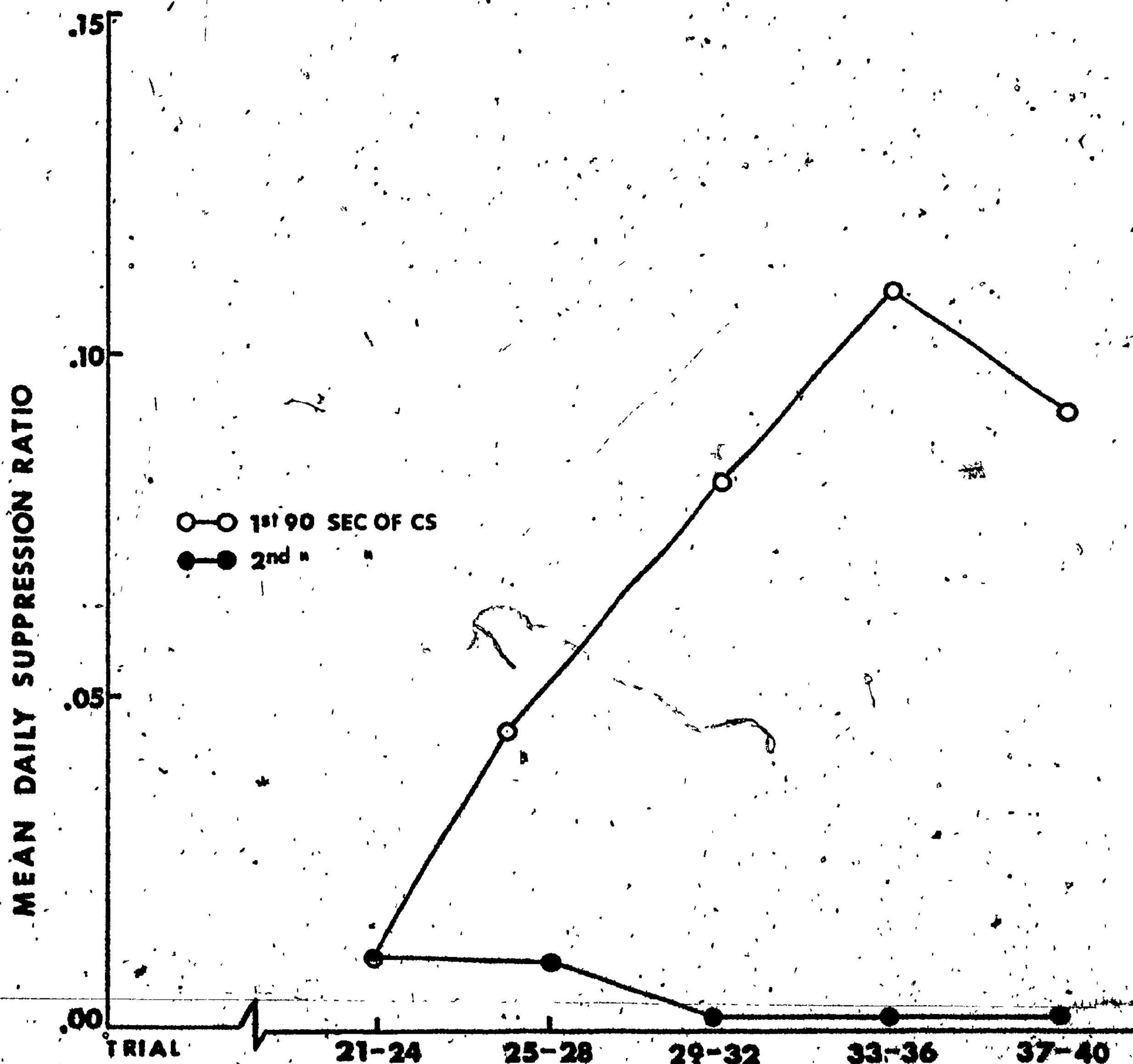

Figure 2. Inhibition of delay

TABLE 3. ANALYSIS OF VARIANCE SOURCE TABLE FOR INHIBITION OF DELAY

Source	SS	df	MS	F	p
Total	4730.69	79	--	--	--
Subjects	618.59	7	--	--	--
CS	1288.02	1	1288.02	13.68	<.01
Trials	272.25	4	68.06	2.73	<.05
CS x Trials	738.05	4	184.51	11.33	<.001
CS Error	659.28	7	94.18	--	--
Trials Error	698.35	28	24.94	--	--
CS x Tr. Error	456.15	28	16.29	--	--

returned to the conditioning units and a single presentation of noise was given. A related t-test comparing the resultant suppression ratios to the CS on the last trial of conditioning and on the test trial revealed no significant difference - $t = 1.74$, $df = 7$. Median suppression ratios for both trials were .00. Time alone, then, cannot be considered a factor in the attenuation of conditioned suppression in the configuring design.

EXPERIMENT 2 - THE INADEQUACY OF THE ORIENTING RESPONSE HYPOTHESIS, AND OF THE GENERALIZATION-DECREMENT HYPOTHESIS

If subjects in the experimental groups in Exp. 1 were attenuating suppression due to the growing lack of similarity between the compound and its components as conditioning proceeds, then by the same logic, test trials to the compound after 8, 24, or 40 single element conditioning trials should show an increasing attenuation over trials. Similarly, if accelerating decrements in CR efficacy of the components in configuring tests were due to an increasing novelty over trials, test trials to the compound after 8, 24, or 40 single element trials should again show an increase in attenuation of conditioned suppression; novelty of the compound after component trials should be just as great as novelty to components after compound trials.

Subjects and apparatus. Three groups of eight rats each were employed. Conditioning apparatus and stimulus values were the same as those used in Exp. 1 above.

Procedure. After initial magazine training and pretests to noise, light, and compound, Group 8N received eight trials of noise alone followed by a single trial of noise/light compound; Groups 24N and 40N received 24 or 40 noise trials respectively, followed by compound. Comparisons were made between the first trial of compound after 8, 24, or 40 single element trials, with the corresponding 8th, 24th, or 40th compound trial of Groups C-8, C-24, and C-40 from Exp. 1.

Results and discussion. Independent t-tests revealed no significant differences in any of the three comparisons - $t = 0.23$, $t = 0.78$, $t = 1.90$, with degrees of freedom at 14 in each case (see Table 4).

As can be clearly appreciated, since suppression to the compound in Groups C-8, C-24, and C-40 was complete (at or near .00), and since there exists no difference between these suppression ratios and those to the "novel" compound in Groups 8N, 24N, and 40N, it follows that stimulus novelty did not lead to either response-inhibitory orienting responses, or to decrement due to generalization. It would be difficult then to argue that stimulus novelty (to use the converse logic) led to the resultant attenuation of suppression in configuring tests. The lack of attenuation of suppression in switching from component to compound, precludes the possibilty that the observed attenuation of suppression in switching from compound to component was due to orienting responses.

TABLE 4. REJECTION OF THE ORIENTING RESPONSE HYPOTHESIS: No Signifigant Differences in Conditioned Suppression between 'Familiar' and 'Unfamiliar' Stimuli

1st Trial N/L After 8 Noise vs 8th Trial N/l	1st Trial N/L After 24 Noise vs 24th Trial N/L	1st Trial N/L After 40 Noise vs 40th Trial N/L
t = 0.23 df = 14 p = N.S.	t = 0.78 df = 14 p = N.S.	t = 1.90 df = 14 p = N.S.

A similar argument applies to the generalization-decrement hypothesis. While it may not be the case that the addition of an element constitutes precisely the same changes in generalization as the subtraction of an element the very clear and unambiguous results obtained here suggest strongly that generalization-decrement is not a major factor in the configuring process. A definitive rejection of the generalization-decrement hypothesis could be performed but the evidence reported here suggests that such an approach would not be promising.

EXPERIMENT 3 - NATURE OF COMPONENT STIMULI AFTER EXPERIENCE IN A COMPOUND

After the configuring phenomenon was found to exist, and explanations in terms of other processes refuted, the functional nature of component stimuli after they had been integrated into a configure was still unknown. Would single elements which no longer possessed substantial CR efficacy require more, or less reconditioning trials to become effective once again? In Pavlovian terms, would these single elements become "inhibitory" or "excitatory" after experience in a configure?

<u>Subjects and apparatus.</u> A single group of eight rats was employed. Conditioning apparatus and stimulus values were identical to those used in Exp. 1 above.

<u>Procedure.</u> After initial magazine training and pretests to noise,

light, and compound, Group 40-ACQ received 40 compound noise/light trials followed by 4 trials to noise. All trials were US-reinforced. This group was identical to Group C-40 in Exp. 1 except that after compound trials were complete, a series of 4 acquisition trials, rather than a single extinction trial, was begun. Comparisons were made between the 4 acquisition trials in Group 40-ACQ and the first four acquisition trials to noise of a group from the following experiment (Exp. 4; Group 32-40)[1].

Results and discussion. As can be seen from Figure 3, acquisition to a stimulus element after synthesis in a configure is considerably more rapid than conditioning to a novel stimulus; $F = 20.87$, $df = 1/14$, $p < .001$. The full analysis of variance source table can be found in Table 5. Whether acquisition to one element of a configure leads to cross-modal acquisition of the other element remains an empirical question. Certainly such a possibility ought to be explored. Further, it is interesting to note that a stimulus which had become inhibitory over the course of 40 trials could so easily become excitatory after only one reconditioning trial.

[1]Group 32-40, in Experiment 4, received 32 acquisition trials to noise alone followed by 40 reinforced noise/light compound trials. The data used here consists of the first 4 of the 32 noise acquisition trials. The use of data from this group is purely arbitrary - data from any naive group receiving noise acquisition trials could have been used.

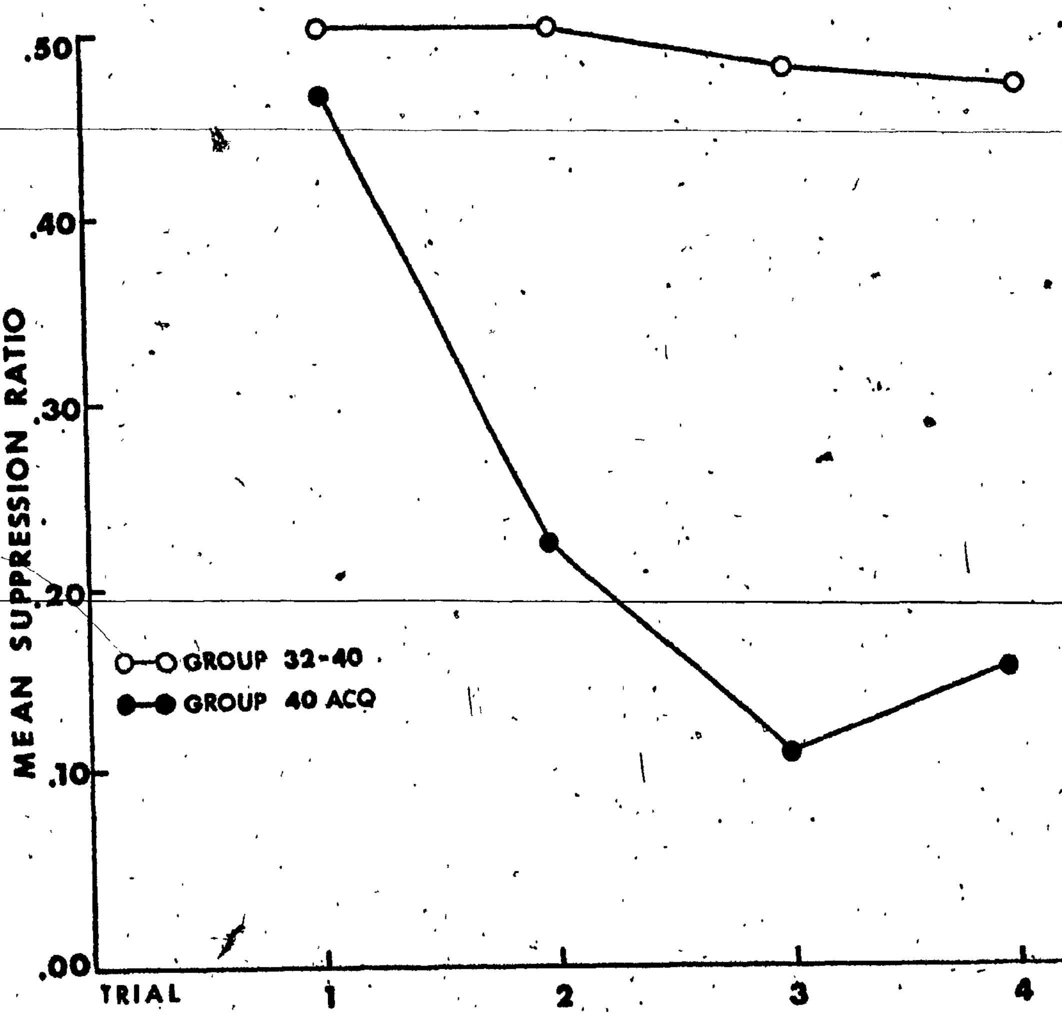

Figure 3. Acquisition to noise after 0 or 40 compound trials

TABLE 5. ANALYSIS OF VARIANCE SOURCE TABLE FOR ACQUISITION TO NOISE AFTER 0 OR 40 COMPOUND TRIALS

Source	SS	df	MS	F	p
Total	22909.44	63	--	--	--
Between Ss	13607.94	15	--	--	--
N. Groups	8145.07	1	8145.07	20.87	<.001
Error Between	5462.87	14	390.21	--	--
Within Ss	9301.50	48	--	--	--
Trials	2973.32	3	991.11	8.34	<.001
Trials x Gr.	1334.80	3	444.93	3.74	<.02
Error Within	4993.38	42	118.89	--	--

EXPERIMENT 4 - EFFECT OF PREVIOUS EXPERIENCE WITH A COMPONENT ON THE DEVELOPMENT OF A CONFIGURE - THE BLOCKING EFFECT

The final experiment in the series examines the effect of previous conditioning experience with a component on the development of a configure composed partially of such a component. Could a single element which had become a consistently predictive CS join with a previously neutral stimulus to become a configure? Or, on the other hand, would a previously conditioned CS retain its response eliciting properties and prevent the process of configuring?

It is well known that several trials with an element will lead to a failure to condition to a second element paired with the first in a series of compound trials. The second or "redundant" stimulus will show no CR efficacy when tested after compound trials, while the first element will continue to be effective. This is known as the blocking effect (Kamin, 1969).

When we asked, therefore, what effect previous conditioning to an element would have on the development of configuring, we were also asking whether the blocking effect could be overcome by extended overtraining with the compound. The number of compound trials used in this experiment was 40, which had been previously shown (see Exp.1) to be sufficient to produce configuring, while the number of previous single element trials was varied.

Subjects and apparatus. Two groups of eight rats each were employed.

Conditioning apparatus and stimulus values were identical to those used in Exp. 1 above.

Procedure. After initial magazine training and pretests to noise, light, and compound, Group 16-40 was given 16 noise-shock presentations followed by 40 noise/light-shock pairings. Similarly, Group 32-40 was presented with 32 reinforced single element trials followed by 40 reinforced compound trials. Test trials to noise and to light were then given to each group. The first trial of noise and of light after 16 or 32 "blocking" trials of single element followed by 40 compound trials was compared to the first test trials of noise and light after zero blocking trials followed by 40 compound trials (Group C-40 from Exp. 1 was used for comparison purposes).

Results and discussion. Figure 4 presents the results graphically. Attenuation of suppression to the noise element in Groups 16-40 and 32-40 would have meant that blocking could be overcome and that previous experience of a component would not interfere with configuring. The opposite is, however, the case. Test trials to noise revealed considerable CR efficacy of the blocking element. (Note that the lack of suppressive powers of the light element would be predicted both in the case of blocking, and of configuring.) Mean conditioned suppression elicited by the noise component in Group 16-40 was 0.10; in Group 32-40 0.11. Independent t-tests showed that there was no significant difference in CR efficacy of

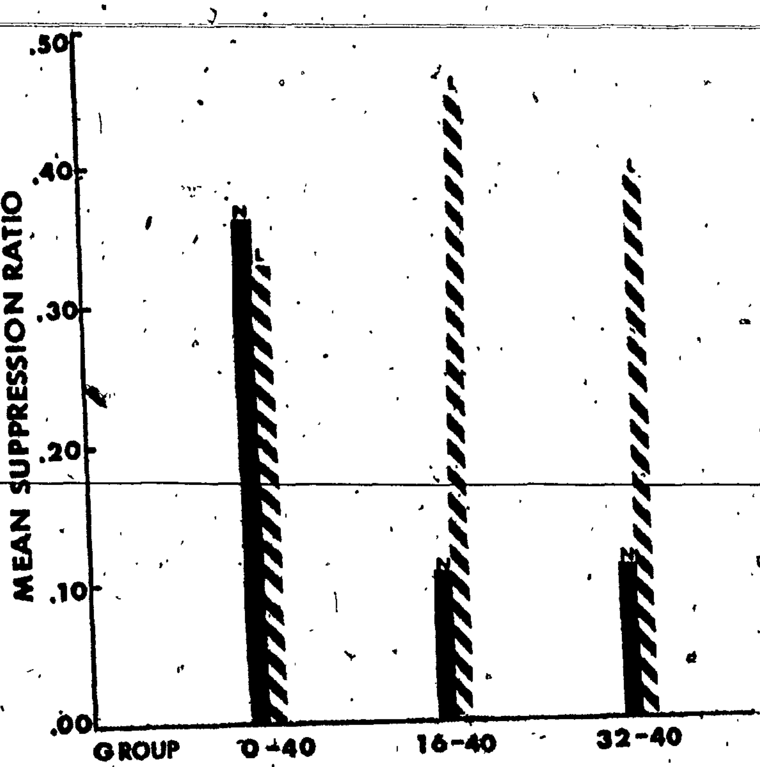

Figure 4. Effect of prior experience with a component on the formation of a configure: N = noise; L = light

the light component in either the 16-40, 32-40 or 0-40 groups. Suppression to noise did not differ significantly in groups 16-40 and 32-40 but both differed significantly from Group 0-40 at the .02 level; t = 2.80 in Group 16-40, t = 2.81 in Group 32-40, with degrees of freedom at 14 in each case (see Table 6).

It would appear that previous conditioning experience of a component prevents synthesis in a configure (at least within the limits of the number of trials employed); the CR efficacy of such a component is maintained.

TABLE 6. INDEPENDENT t-TESTS (2-TAILED) FOR DIFFERENCES BETWEEN 1st TRIAL OF NOISE OR LIGHT AFTER 0 (CONFIGURING) 16 OR 32 (BLOCKING) TRIALS OF NOISE ELEMENT FOLLOWED BY 40 COMPOUND N/L TRIALS

N(0-40) vs N(16-40) t = 2.80 df = 14 p < .02	N(0-40) vs N(32-40) t = 2.81 df = 14 p < .02	N(16-40) vs N(32-40) t = 0.37 df = 14 p = N.S.
L(0-40) vs L(16-40) t = 1.85 df = 14 p = N.S.	L(0-40) vs L(32-40) t = 0.60 df = 14 p = N.S.	L(16-40) vs L(32-40) t = 0.88 df = 14 p = N.S.

GENERAL DISCUSSION

The experiments reported here demonstrate configuring, or differentiation between compound and components through overtraining of the compound. Differential reinforcement was not employed. Degree of configuring was measured with a between-subjects design. Reductionist explanations which would explain configuring in terms of more simple processes have been shown to be inadequate. What then is configuring?

A possible answer may be found in the post-Pavlovian experiments on configuring (variously known as analytico-synthetic activity, afferent-afferent integration, interanalyzer connections, etc.) performed in the last twenty years. It is important to realize that configuring is not "pre-existent in the compound CS but develops in the course of its conditioning" (Razran, 1971). It is important also to note that configuring is not, in essence, a conditioning phenomenon. After all, what exactly is going on in these experiments? A compound CS is being reinforced, nothing more. No attempt is made to bring the CS components to asymptotic CR efficacy after a few trials, or to attenuate such efficacy after a more extended series. These occurances are not under the direct control of the experimenter - they are configural effects produced by the brain which processes such stimulus information and which is merely reflected in behavior through the conditioning process. The significance of these two points infuses the post-Pavlovian view of configuring.

The Darwin-Sechenov-Pavlov view of evolution (Karamyan, 1968) in cortical function provides the basis of a viewpoint which sees the afferent integration of configuring as a "higher level of learning" than simple conditioning; a level which may be the learning basis of perception. Gezalen (1960) states that the "Pavlovian idea of systematic pattern in the cortical function represents a new and important stage in the development of the physiology and pathology of higher nervous activity" (p. 133).

The findings of the post-Pavlovians fall into two categories which are nevertheless connected by evolutionary theory: comparative studies of configuring, and physiological studies.

Summaries of the comparative studies can be found in Voronin (1962), Karamyan (1968), and Razran (1971). The important feature of these studies is that they very strongly suggest that configuring develops throughout the phylogenetic scale in a way which is closely related to the evolution of the central nervous system (see Karamyan especially on this point). Fish, turtles, and reptiles appear to be incapable of configuring (Baru et al, 1959). Sergeyev (1964) reinforced this view in experiments on toads, tritons, and axolotls, and found that none of of these species was capable of configuring. Examining a further six species of reptiles, Sergeyev (1964) found that the highest of them - swamp turtles and varans - while incapable of interanalyzer configuring were able to develop intraanalyzer configures. Baru et al (1959) and Sergeyev (1961; 1964; 1967) have shown that while reptiles and lower species are incapable of true configuring, birds - after a very large number of trials - do master it. Configuring does not come into its own, however, until the mammalian series. Rabbits, guinea pigs, hedgehogs, bats, dogs, baboons, and chimpanzees form an ascending order in terms of the number of trials required to form a configure. Toporkova (1961) and Vedayev (1956) working with only single species (cats and rabbits, respectively) found similar results. To quote Karamyan (1968) "these forms of temporary connection are perfected in the ascending mammalian series" (p. 438).

While this sort of comparative evidence is based on post-Pavlovian views of evolution which may not coincide totally with certain developments in comparative-evolutionary theory developed in the West, and while it may be argued that all animals now living do not constitute a strictly ascending series so much as a diffusion of interrelated species descended from extinct progenitors, rough divisions in terms of phyla still pertain. Worms, fish, rats, dogs, monkeys, and men are representatives of a growth in generalized neural complexity and in concomittant learning potential. Nowhere is it assumed that such growth is strictly linear. Different species have developed unique and often startlingly "advanced" forms of learning well beyond what their place in a somewhat artificial evolutionary hierarchy would suggest - often it depends upon what kind of learning is measured. But in terms of configuring certain facts are clear. Animals below mammals are largely incapable of configuring.

Within the mammalian series there are large differences in the speed and efficiency of configuring. These differences now seem to be related to evolutionary developments within the brain, and especially within the cerebral cortex.

Physiological studies of configuring reveal that "configuring ... is mediated by higher cortical regions, whereas simple and differential conditioning may, as is well known ... be effected and retained even after decortication." (Razran, 1971). This view is definitely shared by Karamyan (1968) and by Batuyev (1964; 1969). Batuyev (1964) found that bilateral ablations of areas 3, 4, and 6 of the cat cortex permanently abolished configures and prevented learning of new configures. Batuyev (1969) found that bilateral ablation of the frontal lobes of the dog led to the same result; similarly Lagutina and Batuyev (1966) revealed that frontal lobectomy of the monkey again aboloished configuring. It should be noted that in all of these experiments conditioning to single elements was found to be unimpaired after lobectomy. Adrianov (1961), Voronin (1948), and Sovetov (1967) have all reported similar results after cortical operations.

Razran (1939a; 1939b; 1955; 1965a; 1965b; 1971; & 1972) after reviewing many of the studies mentioned above, has concluded that configuring is a learned modification through afferent-afferent integration and that it is the learning basis of perception. Configuring gathers and integrates incoming information into unified and organized wholes. It is "a unitary reaction to a multiplicity of stimuli." In all these things lies the heart of the definition of perception itself. Evidence of configuring only in animals with highly developed brains supports the proposition. It is Razran's view that "configuring is to perception as conditioning is to association; and that configures, percepts, Gestalten, and perceptual images are basically equal" (Razran, 1971; p. 239).

Although it has gone largely unrecognized successful experiments in configuring provide experimental evidence for Hebb's theory of perception (Hebb 1949; 1963). The essence of Hebb's argument is that the perception of "x" is deoendent on the learning separately of its various features by different neural units (cell assemblies). A large number of simultaneous experiences of these features, resulting in the simultaneous activation of the neural cell assemblies, would lead to the "superordination" of these assemblies into a unified whole. "The resulting superordinate system must be essentially a new one, by no means a sum or hooking together of a, b, and c. Instead of abc, which might suggest such an idea, a better notation for the new structure is t: the assembly of cells whose activity ... is perception" (Hebb, 1949; p. 97). How similar this is to the views of Beritov (1932) and of Konorski and Lawicka (1959) on the new CS center for the configure! The resemblance of Hebb's formulation to Exp. 1 in the series reported here is obvious. The light and noise features of the compound are first learned separately (trials 1 -12); after a large number of simultaneous presentations (trials 24 - 60) the components are synthesized into a unified whole.

Configuring, as an authentic phenomenon, has been difficult to demonstrate and consequently research in the area is only barely begun. Of first importance is the replication and extension of the comparative-physiological explorations of Sergeyev, Batuyev, and their colleagues, and the eventual discovery of the mechanism and locus of configuring as a physiological event. Of overriding importance is the question of to what degree configuring is the basis of perception - is it a fringe phenomenon of compound classical conditioning, a bizarre but merely technically interesting artifact with no relevance to the way animals learn and learn-to-percieve in the real world; or is the conditioning procedure a method which conveniently provides a slow-motion frieze of the learning basis of perception?

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