Acta Biologiae Experimentalis Vol. XVII, Nr 1 1956

RECIPROCAL TRANSFORMATIONS OF HETEROGENEOUS CONDITIONED REFLEXES

J. KONORSKI and G. SZWEJKOWSKA

Department of Neurophysiology, Nencki Institute of Experimental Biology, Warsaw

Received 29 November, 1955

In our previous papers of this series (J. Konorski and G. Szwejkowkska 1950, G. Szwejkowska 1950, J. Konorski and G. Szwejkowska 1952, G. Szwejkowska 1952) we were concerned with the analysis of transformations of conditioned reflexes into reflexes of the „opposite sign", i.e. excitatory reflexes were transformed into inhibitory reflexes and vice versa. It has been found that when the conditioned reflex to a given stimulus had been transformed into its opposite, the new conditioned connections established between the respective cortical „centres" are, so to say, superimposed on the old ones, which are by no means destroyed. And so such a transformed conditioned stimulus acquires a „mixed" significance being neither purely excitatory nor purely inhibitory.

In this paper an attempt is being made to throw some light on the properties of the conditioned reflexes which were transformed into „heterogeneous" reflexes (i.e. reflexes reinforced by other unconditioned stimuli), and as the subject of our analysis we took the transformations of alimentary into defensive reflexes and of defensive into alimentary reflexes.

It can be seen that there is no alimentary response neither to the Rattle nor to the Disk, and that the unconditioned reflex following these stimuli is much diminished. During the application of the Disk the dog remains calm, while to the Rattle he exhibits a vigourous and lasting defensive reaction which stops after he gets food. On the next day (table IIb) the Disk already elicits a quite significant salivary reaction (9 divisions of the scale), while the Rattle evokes again only a strong defensive reaction.

Table II

Transformation of defensive into alimentary reflexes (series V)

a) „Cygan", 28 th March 1953, No 149/1

No of trial	Time in min.	Conditioned stimulus	Its isolated period in sec.	Defensive conditioned reflex	Alimentary conditioned reflex	Reinforcement	Unconditioned reflex (first 10 sec.)	Remarks
1	2	Bell	10	—	6	Food	34	
2	7	Bell	10	—	15	Food	44	
3	14	Bell	10	—	7	Food	47	
4	19	Bell	10	—	9	Food	43	
5	24	*Rattle*	10	4"—10" very strong —	0	Food	29	He puts the leg down at presentation of food
6	29	Bell	10	—	6	Food	42	
7	34	*Disk*	10		0	Food	25	

b) „Cygan", 29 th March 1953, No 150/2

1	4	Bell	10	—	9	Food	27	
2	9	Bell	10	—	15	Food	41	
3	14	Bell	10	—	11	Food	41	
4	15	*Disk*	10	—	9	Food	39	
5	24	Bell	10	—	12	Food	39	
6	29	*Rattle*	10	3"—10" very strong	0	Food	35	At the presentation of food immediately puts the leg down
7	34	Bell	10	—	9	Food	38	

In further experiments the Rattle and the Disk continued to be applied once daily in reverse sequence. The whole course of this series is given in Fig. 5. It can be seen that the defensive reflex to

the Rattle has disappeared after 4 trials, but the alimentary reflex to this stimulus remained weak to the very end of this series and

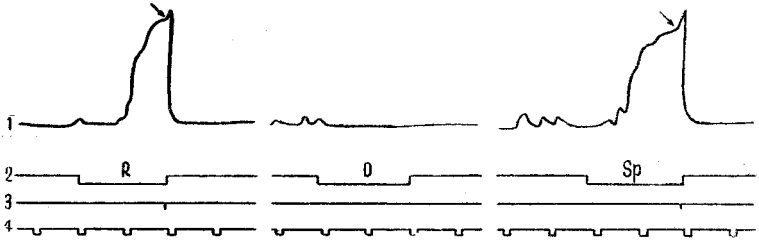

Fig. 4. Elaboration of the excitatory and inhibitory conditioned defensive reflex „Cygan", Series IV. Experiments of 20.XI.52, No 108, and 25.XI.52, No 112 Sp — Splash, R — Rattle, D — Disk. Rattle and Splash evoke defensive reflexes, while Disk does not

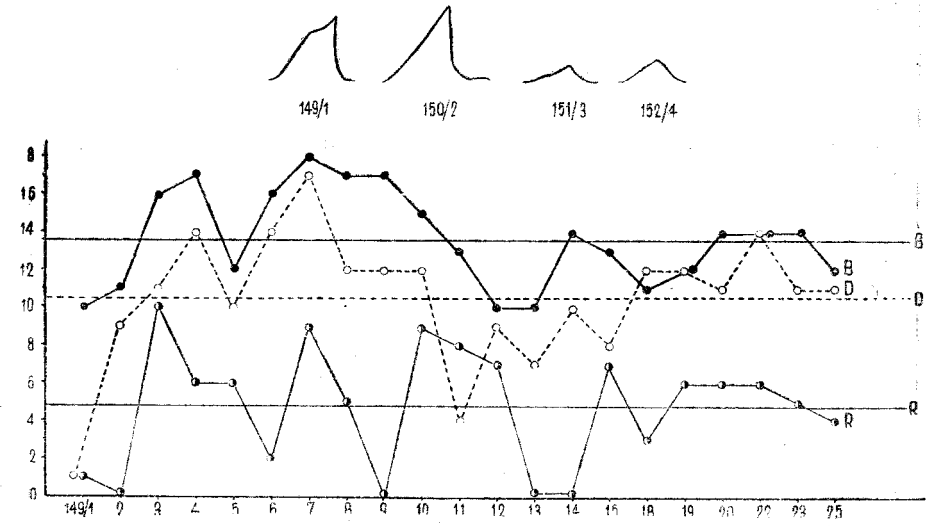

Fig. 5. The course of transformation of excitatory (Rattle) and inhibitory (Disk) defensive stimuli into alimentary stimuli „Cygan", Series V, Abscissae: No of experiments. Ordinates: salivary reflex in divisions of scale. R — Rattle, D — Disk, B — Bell (control). Horizontal lines represent mean values of the respective reflexes. The alimentary reflex to Rattle is much weaker than that to Disk. Above: conditioned defensive reflex to Rattle in the first four days of transformation.

sometimes even dropped to zero. On the contrary, the reflex to the Disk reached very soon the level of 80% of the reflex to the Bell; taking into account the rather moderate strength of the stimulus, this value may be considered as nearly normal.

It must be noticed that the process of transformation of the defensive conditioned reflex into the alimentary one proved rather trying to the animal: the dog, usually very calm, became restless and the salivary reactions to the Bell grew erratic. In these circum-

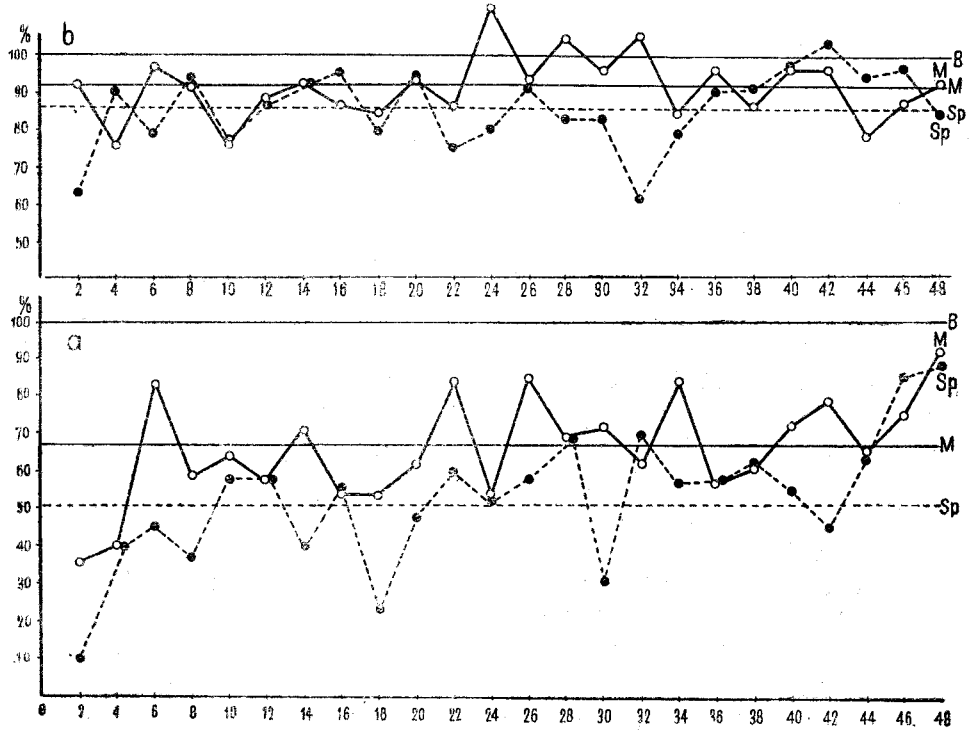

Fig. 6. Transformation of conditioned defensive stimuli (Metronome and Splash) into alimentary stimuli „Cygan", Series VI and VII, Abscissae: No of experiments in the respective series (each point represents two successive experiments). Ordinates: salivary reaction in percentage of that to the control stimuli. a — conditioned reactions, b — unconditioned reactions during first 10 sec. M — Metronome, Sp — Splash. Both reflexes are weaker than the control reflex, but the reflex to Metronome is somewhat stronger than that to Splash.

stances, in order to avoid chronic disorder of the conditioned-reflex activity we had to proceed with great caution and to stop time and again the application of the Rattle and the Disk for several days till the condition of the dog became normal.

When the alimentary reflexes to the Rattle and the Disk became more or less stable, we applied both of them, as previously, along

with the defensive conditioned stimuli. It turned out that against this background the Rattle elicited again a quite considerable defensive response thus proving that it still preserved previous signalling meaning. The Disk on the other hand did not evoke this reaction at all.

S e r i e s VI. 23rd June 1953 — 5th December 1954 and s e r i e s VII, 9th December 1953 — 5th April 1954. The transformation of the Metronome and of the Splash into alimentary conditioned stimuli.

The aim of these two series of experiments was to compare rate and degree of conversion into conditioned alimentary stimuli of the Metronome, a defensive stimulus which had been alimentary before transformation, and of the Splash, so far a purely defensive stimulus. Each of these conversions was accomplished in a separate series of experiments. In these experiments, as usually, between the applications of the Bell (a purely alimentary conditioned stimulus), the Metronome in series VI and the Splash in series VII were applied respectively, once daily, both with food reinforcement. At the end of series VII the two transformed stimuli, the Metronome and the Splash, were applied so that we could compare their respective effects.

The comparison of both series of experiments is presented in Fig. 6. It can be seen that the conditioned reflex to the Bell is generally greater than to the Splash, although it does not attain the „normal" strength, it had before its conversion into the defensive reflex (Fig. 6a). The unconditioned salivary reflex following the converted stimuli was also weaker than that following the control stimulus (Fig. 6b).

The frequent application of the transformed stimuli led (as in series V) to more or less manifest disturbances in animal's behaviour. In order to avoid experimental neuroses we had sometimes to abstain from applying these stimuli till the dog was back to normal.

S e r i e s VIII. 7th April 1954 — 25th May 1954. Analysis of the „conditioned structure" of the transformed stimuli.

At the end of series V we found that when the alimentary conditioned stimulus derived from a defensive one was applied against a purely defensive background, its defensive character came to light again. Presently similar examination of the stimuli transformed in the last series, i.e. the Metronome and the Splash was

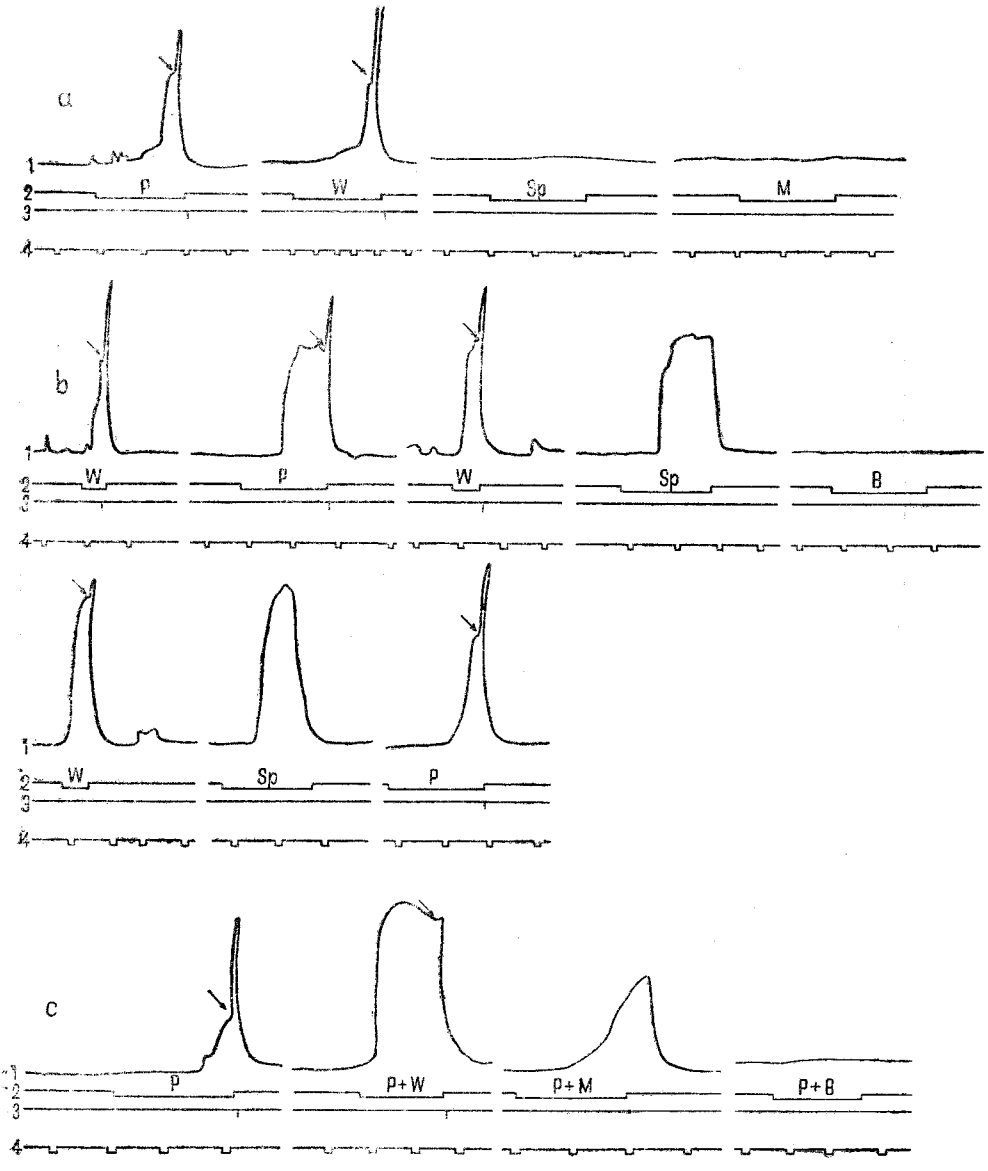

Fig. 7. The various alimentary stimuli applied against the defensive background, „Cygan", Series VIII. a. When all stimuli are applied with 10 seconds isolated period, Metronome and Splash evoke no defensive reaction (exp. 9.IV. 54) b. When defensive stimuli are applied with 3 seconds isolated period, Metronome and Splash evoke a strong defensive reaction, while Bell evokes alimentary reaction (exp. 10.IV.54) c. When Metronome is applied together with Propeller there is a moderate defensive reaction, when Bell is applied with Propeller there is no reaction (exp. 13 and 14.IV.54)

undertaken. To this effect two old defensive conditioned stimuli, the Propeller and the Whistle, were introduced again and were reinforced as usually by a shock. Against this background the Metronome, the Splash and the Bell were tested. In order to keep the defensive character of experiments unperturbed these stimuli were used without any reinforcement.

Table III

Alimentary stimuli applied against the defensive background „Cygan", Series VIII

Background stimuli	Tested stimuli		
	pure defensive stimuli: Propeller, Whistle	mixed stimuli: Metronome, Splash	pure alimentary stimulus: Bell
Defensive stimuli reinforced after 10 seconds	a weak and delayed defensive reaction	no reaction	not tested
Defensive stimuli reinforced after 3 seconds, tested stimuli lasted 10 seconds	very strong and early defensive reaction	strong and early defensive reaction	alimentary reaction, salivation
Simultaneous application of a defensive stimulus with a tested stimulus during 10 seconds.	very strong and early defensive reaction	moderate defensive reaction	no reaction

The first of experiments of this kind is shown in fig. 7a. The Propeller and the Whistle are here reinforced by shock only after the lapse of 10 seconds, and therefore the defensive conditioned reflexes remain rather weak and unstable. The Splash and the Metronome used against such a background evoke neither defensive nor alimentary response.

In order to intensify the defensive conditioned reflexes, in the following experiment (Fig. 7b) the Whistle was reinforced by a shock in the 3rd second of its action, and, after several repetitions of such trials, other stimuli applied for 10 seconds were tested. The result was quite unequivocal. While the Bell produced a slight alimentary response, both the Splash and the Metronome elicited a strong defensive reaction, not less intense than the Propeller.

In other experiments the isolated period of conditioned stimuli was again 10 seconds (due to that the reflexes were rather weak and delayed), and from time to time two stimuli in various combinations were applied s i m u l t a n e o u s l y. In many control experiments it was established that the simultaneous application of two purely defensive conditioned stimuli produces a very strong facilitation: the defensive reflex reaches its maximum and the latent period shortens considerably. Now, if a conditioned defensive stimulus was applied simultaneously with the Metronome or the Splash, the defensive reflex was more or less the same as to a single defensive stimulus, while the combination of a defensive stimulus with the Bell caused complete inhibition of the defensive reaction (Fig. 7c).

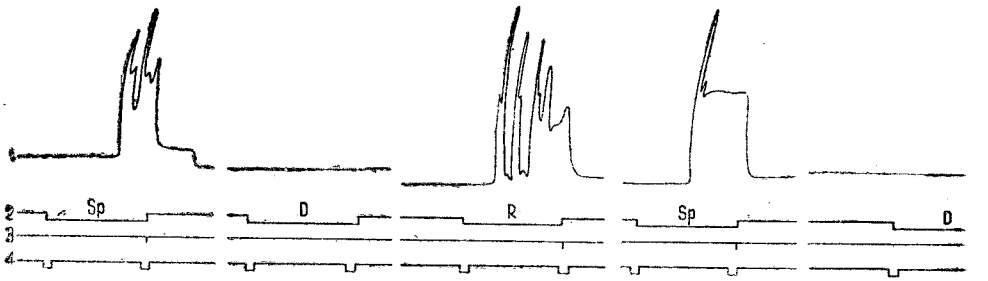

Fig. 8. The elaboration of the conditioned defensive excitatory reflex to Rattle and Splash and of the inhibitory reflex to the oscillating Disk. „Nepek", Series I, Differentiation between Rattle and Disk is established (exp. 28.III.52, No 52)

The results of this series are summarized in table III. The complete sequence of experiments on Cygan is presented in table IV.

The second experimental dog was Nepek, a mongrel who had been living in the laboratory since 1948, when he was 2 years old. This dog had a very copious salivation: in all alimentary experiments he salivated continuously during all intertrial intervals, and did not quite stop even in purely defensive experiments. This gave us the opportunity to study alimentary reactions in more detail than in the case of our other dog, in which the threshold of salivation was much higher. In Nepek a number of conditioned alimentary reflexes had been previously established, to the Bell and the Metronome among others.

S e r i e s I. 22 nd November 1952 — 1 st April 1953. The elaboration of the excitatory conditioned defensive reflex to the Rattle and to the Splash and of the inhibitory reflex to the oscillating Disk.

Defensive conditioned reflexes were formed in this animal without much difficulty, and the dog could easily develop the differentation between the oscillating Rattle and the Disk. The kymographic record of one of the experiments is presented in fig. 8.

S e r i e s II. 2nd April 1953 — 2nd June 1953. The transformation of reflexes to the Rattle and to the Disk into alimentary reflexes.

From the 2nd of April onwards only the alimentary conditioned stimulus, the Bell, with 10 seconds' isolated period was applied, and after a few days the Rattle and the Disk were introduced. Both

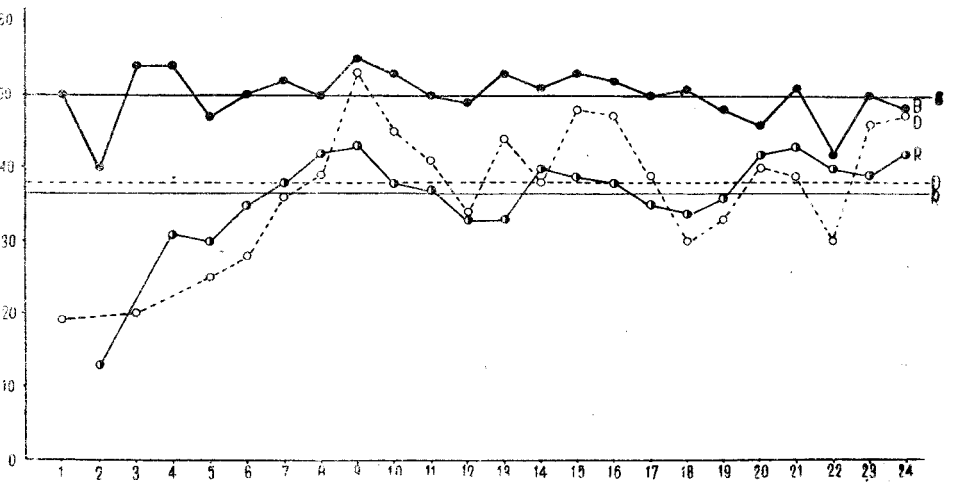

Fig. 9. The transformation of conditioned reflex to Rattle and Disk into alimentary reflexes. „Nepek", Series II. Abscissae: No of experiments. Ordinates: Salivary reaction. B — Bell, D — Disk, R — Rattle. Horizontal lines represent mean values of reflexes to Bell (B), Disk (D) and Rattle (R). There is no significant disparity between the reflex to Rattle and Disk

these stimuli were now (after 10 seconds' action) reinforced by food. The course of these experiments is presented in fig. 9. It can be seen that the conditioned response to both these stimuli reached very soon a stable level amounting to 70% of the reaction to the Bell. In contradistinction to similar experiments on Cygan there

Table IV

The course of experiments on Cygan

Series	Stimuli applied				Results
	Alimentary	Defensive	Transformed from alimentary to defensive	Transformed from defensive to alimentary	
I	Metronome, excitat. Bell, excitatory Whistle, inhibitory	Propeller, excitatory	—		
II	Bell, excitatory	Propeller, excitatory	Metronome Whistle	—	The defensive reflex to Whistle was formed readily, that to Metronome very resistantly
III	—	Propeller, excitat Splash, excita. Metronome, excitat Whistle, excitat.	—	—	The prolongation of the isolated period of the reflex to 10 sec. exposes the weakness of the defensive reflex to Metronome
IV	—	Propeller, excitat Splash, excitat. Rattle, excitat. Disk, inhibitory	—	—	Differentiation of Rattle and Disk
V	Bell, excitatory	—	—	Rattle, Disk	The alimentary reflex to Disk was formed easily, that to Rattle very resistantly. Tendency to exp.neurosis
VI	Bell, excitatory	—	—	Metronome	The effect of Metronome did not return to its previous value. Tendency to exper. neurosis
VII	Bell, excitatory Metronome, excitat.	—	—	Splash	The effect of Splash was even less than that of Metronome. Tendency to exper. neurosis
VIII	Bell, excitatory Metronome, excitat. Splash, excitatory	Propeller, excitat Whistle, excitat.	—		Against the defensive background Metronome and Splash elicited defensive response, Bell did not

was no significant disparity between the reflex to the Rattle and to the Disk. This may be due to the relative weakness of the Disk in comparison to the Rattle and the Bell, and consequently to its lower conditioned reaction according to „the law of effect of conditioned stimuli". Thus while the alimentary reflex to the Rattle was lowered owing to its previous excitatory defensive character, the magnitude of the reflex to the Disk was probably that it would reach in „normal" training.

Table V

The effect of repeated application of Rattle on conditioned-reflex activity „Nepek", Series II

No of trial	13. V. 53 Bell 10 sec	12. 5. 53 Rattle 10 sec	13. V. 53 Bell 10 sec	14. V. 53 Bell 10 sec	15. X. 53 Bell 10 sec	19. V. 53 Bell 10 sec
1	50	36	33	52	47	44
2	44	43	32	42	45	44
3	49	42	Refused to eat	34	45	45
4	43	38	Very excited	36	46	45
5	46	44		Refused to eat	25	38
6	46	37		Very excited	30	45
	Mean: 46	Mean: 40			Mean: 40	Mean: 44

As in experiments on Cygan the transformation of defensive into alimentary reflexes apparently presented a very difficult task for the dog. He was very excited during the experiments, barked vehemently and tried to tear away the salivary capsule. Such behaviour never occurred previously.

In one of the last experiments of this series the Rattle was applied six times in succession instead of once as hitherto (table V). Conditioned reflexes to this stimulus were relatively strong, reaching nearly the values obtained to the control stimulus, but on the

following day a complete collapse of the conditioned-reflex activity took place. The conditioned reflex to the Bell dropped and the dog refused to take food on the stand. This happened for the first time in the entire conditioned-reflex „career" of this dog. On the next day conditioned reflexes were somewhat stronger and the dog stopped eating only at the fifth trial. In the following experiments he gradually returned to normal.

Table VI

Alimentary stimuli tested against defensive background

„Nepek", 29 th May 1953, No 97/1

No of trial	Time in min.	Conditioned stimulus	Its isolated period in sec.	Conditioned reflex: motor defensive reaction: latent period in sec.	Conditioned reflex: motor defensive reaction: strength of reaction	Conditioned reflex: salivary reaction in divisions of scale
7	23	Splash	10	4	+ +	13
8	26	Splash	10	8	+ +	6
9	29	Bell	10	—	0	43
10	34	Bell	10		0	47

„Nepek", 30 th May 1953, No 98/2

5	16	Splash	10	5	+ +	6
6	19	Splash	10	7	+ +	10
7	22	*Rattle*	10	5	+ + +	15
8	27	Bell	10	—	0	47
9	32	Bell	10		0	56

„Nepek", 2 nd June 1953, No 100/4

5	14	Splash	10	6	+ +	0
6	17	Splash	10	5	+ + +	11
7	20	*Disk*	10	—	0	25
8	25	Bell	10		0	44
9	30	Bell	10	—	0	38

S e r i e s III. 29th May 1953 — 17th June 1953. The analysis of the „conditioned structure" of the transformed stimuli.

After the transformation of defensive into alimentary reflexes, the defensive conditioned stimulus (Splash) was introduced again and after a series of defensive trials the Bell, the Rattle and the

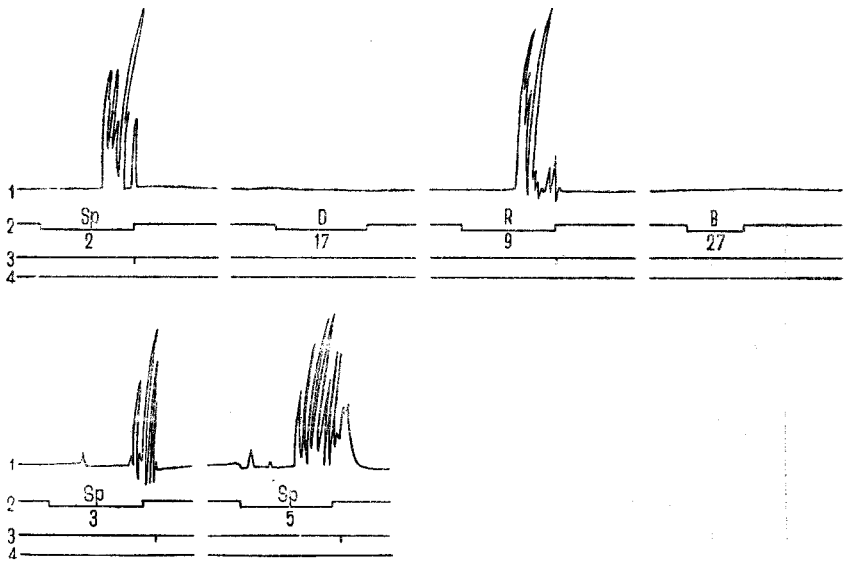

Fig. 10. Alimentary stimuli tested against defensive background. „Nepek". Series III. Exp. of 17.XI.53 Sp — Splash, defensive stimulus. D — Disk, alimentary stimulus transformed from defensive inhibitory stimulus. R — Rattle, alimentary stimulus transformed from defensive excitatory stimulus. B — Bell, "purely" alimentary stimulus. Numbers denote the salivary reactions to respective stimuli

Disk were tested (table VI). In nearly all these experiments the old nature of the Rattle was fully brought to ligth: in contradistinction to the Bell and to the Disk this stimulus evoked a more or less vigourous defensive response, while its salivary effect was much diminished.

In another kind of experiments the Rattle, the Disk and the Bell were applied without reinforcement among defensive trials (Fig. 10). Again, the Rattle evoked only a slight salivary reaction along with a conspicuous defensive response, the Disk evoked a stronger salivary reaction without any trace of a defensive one, and the Bell caused a copious salivation also without defensive reaction.

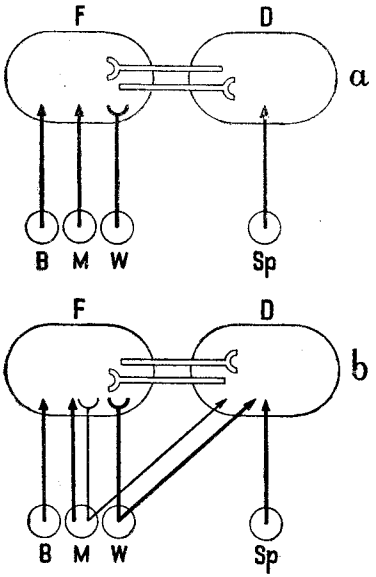

Fig. 11, The schematic presentation of the transformations of an alimentary conditioned reflex into the defensive reflex. F — alimentary centre, D — defensive centre. B — the centre of control alimentary stimulus. M — the centre of excitatory alimentary stimulus transformed into the defensive stimulus. W — the centre of inhibitory alimentary stimulus transformed into the defensive stimulus. Sp — the centre of control defensive stimulus. Double lines represent unconditioned connections; heavy lines represent strong conditioned connections; thin lines represent weak conditioned connections; ↑ represent excitatory connections; ⊤ represent inhibitory connections; a — the connections between centres before transformation; b — the connections between centres after transformation

DISCUSSION

In the previous papers of this series it has been found that when a „primarily inhibitory" stimulus (i. e. a stimulus which was not reinforced from the very beginning of its application) is transformed into an excitatory conditioned stimulus the corresponding positive conditioned reflex does not attain the „normal" value it would certainly achieve if it were reinforced from the beginning. It was concluded that the original inhibitory connections, which had been formed between the „centre" of the conditioned stimulus and the „centre" of the unconditioned stimulus are not destroyed by the formation of new excitatory connections between the centres, but are being preserved for a long time, and, maybe, for ever. In accordance with that we might a priori suppose that with the transformations of conditioned reflexes into reflexes of another kind (e. g. of alimentary into defensive reflexes, or vice versa), this preservation of old connections will also take place and even become more plain. For, when the inhibitory reflex is transformed into the excitatory reflex, the preservation of the old inhibitory connections may be inferred only indirectly from the „dwarfish-

ness" of the respective excitatory reflex, whereas in the case of transformation of reflexes into heterogeneous ones, each of these reflexes can be measured directly.

The preservation of old connections after the transformation of a reflex into heterogeneous one is indicated in the experiments of F r i d e m a n (P a v l o v 1940, p. 227, P a w ł o w 1952, p. 192), R i k m a n (Pavlovian Wednesdays 1949, I, p. 313) and V a t s u r o (1949). P a v l o v, in his description of F r i d e m a n's experiments, draws attention to the fact that when a conditioned alimentary reflex was transformed into the acid conditioned reflex and then back into the alimentary reflex, this last conversion was very rapid. In R i k m a n's experiments an analogous fact was observed: the transformation of a defensive conditioned reflex into an alimentary reflex required much time and was very difficult to achieve, whereas the transformation in the opposite direction occured immediately. V a t s u r o's experiments proved that after the transformation of the defensive into the alimentary reflex the defensive nature of the stimulus can, under certain circumstances, be disclosed again.

The facts presented in this paper confirm and extend the above findings. To begin with, we have found that the alimentary conditioned stimulus which has been transformed from a defensive stimulus evokes a much smaller alimentary reaction than a control stimulus (which was from the very beginning reinforced by food), and conversely, the defensive conditioned stimulus transformed from an alimentary stimulus remains less effective than its control counterpart. Then we have established that when an alimentary reflex has been transformed into a defensive reflex, and then back into the alimentary, it does not reach the magnitude it had before the first transformation. It was also found that an i n h i b i t o r y alimentary stimulus is converted into the defensive stimulus much easier than an excitatory alimentary stimulus, and conversely, an i n h i b i t o r y defensive stimulus is transformed into the alimentary much easier than an excitatory defensive stimulus. Finally, we have established that the alimentary conditioned stimulus transformed from a defensive stimulus and placed once more against the defensive background elicits a defensive reaction thus proving that its original nature has by no means been destroyed.

On the basis of these data let us now try to explain the physiological mechanisms underlying the heterogeneous transformations of conditioned reflexes.

As a starting point of our consideration we take the generally accepted view that the physiological basis of the formation of a conditioned reflex is the establishment of neural connections between the cortical „centre" of the conditioned and the unconditioned stimulus, considering both the concept of „centre" and that of „connections" purely physiologically without precising their morphological meaning.

Let us suppose now that a well established defensive conditioned stimulus is not any more reinforced by an electric shock but instead reinforced by food. We are justified in assuming, that in such a case: 1^0 between the centre of the conditioned stimulus and the defensive centre the inhibitory connections are formed, just as they would be formed if this stimulus were simply no more reinforced by a shock, and 2^0 between the centre of the stimulus and the alimentary centre excitatory connections are formed.

It follows from our previous papers (J. Konorski and G. Szwejkowska 1950, G. Szwejkowska 1950, J. Konorski and G. Szwejkowska 1952, G. Szwejkowska 1952) that when a well established conditioned stimulus ceases to be reinforced, the inhibitory connections which are formed between the respective centres are generally poor, as the existing excitatory connections hinder their development. This explains why the inhibitory reflex transformed from the excitatory reflex is generally weak and unstable. As to the establishment of new excitatory connections between the centre of the stimulus and the centre of the new reinforcing stimulus (in our case food centre) they too have a poor chance of normal development, since the two unconditioned centres concerned, defensive and alimentary, are antagonistic to each other, and therefore the excitation of the defensive centre, owing to the existing connections between the respective centres, inhibits continually the alimentary centre. For this reason the conversion of the defensive stimulus into the alimentary one is difficult and deficient. That the previous connections between the centre of the conditioned stimulus and the defensive centre are preserved for a long time is substantiated by the fact that this stimulus applied against the defensive background elicits the defensive response. On the other hand, the assumption that these

very connections hamper the full development of the alimentary conditioned reflex is substantiated by the fact that an i n h i b i t o r y defensive stimulus is converted into an alimentary stimulus without such a difficulty. Indeed, as this stimulus does not excite the defensive centre, the alimentary centre is free from inhibition and there is nothing that would obstruct the formation of the alimentary conditioned reflex to this stimulus.

In our experiments the overt defensive reaction consisting in leg lifting to the conditioned stimulus disappeared very promptly in the course of its transformation into the alimentary stimulus. This was due to the following circumstances: 1^0 the defensive reinforcement was deliberately kept on a rather low level in order not to complicate too much the process of transformation, and 2^0 the stimulus in the course of transformation was always applied between the alimentary and never between the defensive stimuli. The fact that in spite of disappearance of the motor defensive reaction the alimentary conditioned reflex to the converted stimulus was dwarfed proves that excitation of the defensive centre was still sufficiently strong to exert the inhibitory influence upon the alimentary centre. This is not surprising at all if we take into account that various effects of excitation of the defensive centre may have different threshold values and the threshold of the motor reaction in our type of experiments may be considered as relatively high. This is well proved by the fact that even in normal conditions the conditioned defensive reflex, evaluated in terms of the specific motor response, was often subthreshold (especially when the isolated period of the stimulus was long) which did not mean that it was absent (cf. facilitation of two subthreshold reflexes).

Precisely the same sort of considerations may be applied to the mechanism of transformation of the alimentary into the defensive reflex (fig. 11). Here too, the new conditioned reaction (in this case defensive) was below normal owing to the fact that excitation of the alimentary centre produced by old conditioned connections inhibited partly the defensive centre and did not permit the formation of the defensive connections. This again is proved by the fact that the i n h i b i t o r y stimulus was easily transformed into the defensive stimulus, because it did not excite the alimentary centre. Just as in the case of the previously described transformation, the excitation of the alimentary centre, sufficient to hamper the deve-

lopment of the defensive reflex, may be subthreshold when measured by salivation.

Let us consider for a moment the case in which the alimentary conditioned reflex was transformed into the defensive reflex, and then again into the alimentary one. It has been shown that it did not reach its previous value, although it was a little stronger than the alimentary reflex derived from a „purely" defensive reflex. This shows that, although the connections of the stimulus with the defensive centre built up in the course of the first transformation were not so strong as in the case of a normal defensive reflex, they were nevertheless sufficiently powerful to prevent the alimentary reflex to attain its previous level in the course of the second transformation of the stimulus. The preservation of the connections with the defensive centre has been proved also by the fact that the stimulus applied against the defensive background elicited a defensive response. It may be recalled that in the case of a simple extinction and restoration of a conditioned reflex (when only inhibitory but not heterogeneous connections intervene) the return to normal is practically complete.

In the course of heterogeneous transformations animals are very prone to develop experimental neuroses. In particular this was observed during conversion of a defensive into an alimentary conditioned stimulus and consisted in greater or lesser disturbances of the general behaviour of the animal. This fact can be easily explained if we take into account that the excitatory defensive conditioned stimulus, owing to the antagonism between the alimentary and defensive centres, has a strongly inhibitory effect on the alimentary centre, and therefore its repeated reinforcement by food produces in this centre a violent „clash" between the excitatory and inhibitory processes.

SUMMARY AND CONCLUSIONS

1. When a conditioned defensive stimulus is transformed into a conditioned alimentary stimulus the resulting alimentary reflex is weak and unstable, since the connections established earlier between the cortical centre of the stimulus and the defensive centre prevent the formation of the connections between the centre of that stimulus and the alimentary centre. There is no such obstacle in

the case of inhibitory defensive conditioned stimulus transformed into the excitatory alimentary conditioned stimulus.

2. When a conditioned alimentary stimulus is transformed into conditioned defensive stimulus the resulting defensive reflex is weak and unstable, since the connections established between the cortical centre of the stimulus and the alimentary centre prevent the formation of the connections between the centre of this stimulus and the defensive centre. As in the previous case the process is not hindered when the inhibitory alimentary conditioned stimulus is transformed into the excitatory defensive stimulus.

3. When an alimentary conditioned stimulus is transformed into a defensive and then back into the alimentary stimulus, its effect is smaller than it was originally.

4. When the alimentary conditioned stimulus transformed from a defensive conditioned stimulus is applied against the defensive background (i. e. between conditioned stimuli reinforced by shock) it evokes a more or less prominent defensive response, which proves that the old connections established between the centre of this stimulus and the defensive centre have not been destroyed by the formation of new connections between these centres.

5. The transformation of a defensive conditioned reflex into the alimentary conditioned reflex is a very difficult task for the animal. Very often it leads to more or less serious experimental neuroses evoked by the clash between excitatory and inhibitory processes in the alimentary centre.

REFERENCES

KONORSKI J. and SZWEJKOWSKA G. 1950 — Chronic extinction and restoration of conditioned reflexes. I. Extinction against the excitatory background. Acta Biol. Exper. *15*, 155.

KONORSKI J. and SZWEJKOWSKA G. 1952 — Chronic extinction and restoration of conditioned reflexes. III. Defensive motor reflexes. Acta Biol. Exper. *16*, 91.

KONORSKI J. and SZWEJKOWSKA G. 1952 — IV. The dependence of the course of extinction and restoration of conditioned reflexes on the „history" of the conditioned stimulus (The principle of the primacy of first training). Acta Biol. Exper. *16*, 95.

PAVLOV I. P. 1940 — Conditioned reflexes. Oxford.

PAWŁOW I. P. Wykłady o czynności mózgu. Warszawa.
Pavlovskije Sredy. 1949. Moskwa.

SZWEJKOWSKA G. 1950 — Chronic extinction and restoration of conditioned reflexes. II. The extinction against an inhibitory background. Acta Biol. Exper. *15*, 171.

SZWEJKOWSKA G. 1952 — Chronic extinction and restoration of conditioned reflexes. V. Repeated extinction and restoration of conditioned reflexes. Acta Biol. Exper. *16*, 115.

VATSURO E. G. 1948 — Uslowno-reflektornaja ustanovka i vlijanije jejo na tecenije uslovnych refleksov. Soobscenije II. Trudy Fiziol. Lab. akad. I. P. Pavlova *13*, 21.

VATSURO E. G. 1948 — Uslovno-reflektornaja ustanovka i vlijanije jejo na tecenije uslovnych refleksov. Soobscenije III. Trudy Fiziol. Lab. akad. I. P. Pavlova *13*, 66.

VATSURO E. G. 1948 — Uslovno-reflektornaja ustanovka i vlijanije jejo na tecenije uslovnych refleksow. Soobscenije IV. Trudy Fiziol. Lab. akad. I. P. Pavlova *13*, 95.