PRO LABORATORIO

Porous Polyethylene for Adsorption Columns

During work with columns made from polyethylene, porous discs of the same material were needed. Discs made according to the following method were found to be satisfactory.

Powdered polyethylene (e.g. Telcothene Powder, The Telegraph Construction and Maintenance Co. Ltd. England) is mixed with sodium chloride in the ratio of 1 to 4 parts by weight. The mixture is packed to a depth of about ¼ inch in a mould, e.g. a small tin lid or an evaporation dish, and heated in a thermostat for 15 min at 130°C. After cooling, the specimen is removed from the mould, and washed for several hours with water in order to remove the sodium chloride. Discs are then cut out with a cork drill, and freed from traces of metal by soaking in $5N$ hydrochloric acid.

By changing the relative amounts and particle size of the ingredients, discs with different properties may be obtained.

Even in cases when polyethylene as such is not necessary, these discs may be a good substitute for sintered glass discs and plugs of glass wool generally used as support and cover for the adsorbent.

N.-O. Bodin

Institute of Zoophysiology, University of Uppsala (Sweden), May 27, 1957.

Zusammenfassung

Scheiben von porösem Polyäthylen können als Unterlage und Decke für Adsorbentien in Säulen verwendet werden. Eine Methode zu ihrer Herstellung wird beschrieben.

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STUDIORUM PROGRESSUS

Changes in Animal Behaviour a Result of Conditioning

By J. ten Cate*

The behaviour of animals can be modified by changing the conditions under which they live. This can be attained by transferring the animals from their natural to an artificially altered environment. In this manner it is possible even to change congenital reactions to stimuli into reactions conditioned by the new circumstances.

An example can be found in the experiments which I made with *Amphioxus* (*Branchiostoma lanceolatum*). I have made observations on this fish-shaped animal, 4–6 cm in length, during repeated stays on the Mediterranean coast.

The animal lives buried in sand, from which only the cranial end protrudes. Mechanical stimulation of some part of the body of the *Amphioxus* causes the animal to withdraw immediately into the sand, in which it rapidly disappears. Under natural conditions the animals are but seldom found swimming freely in the water[1].

I have attempted to modify the innate reaction of the *Amphioxus*—evasion of stimuli by burying in sand—into a flight reaction by swimming away. For this purpose the conditions under which these animals naturally live were altered. The animals were placed in small aquarium tanks, the bottom of which was covered by only a thin layer of sand so that the animals could only partially bury themselves. If the animals are stimulated by touching them with a horse hair under these changed conditions, they first attempt to burrow into the sand, in which they fail. They then take flight and continue to swim about in the aquarium for some considerable time.

Repetition of these experiments with mechanical stimuli under constant conditions causes the animals to lose their habit of burying on stimulation within a few days; instead, they immediately swim away when touched. The animal behaviour thus has been altered by means of a change in environment.

Once the innate reaction of burying in sand when subject to tactile stimuli, was replaced by a flight reaction which constantly appeared after any stimulation, the animals were placed in an aquarium which was provided with a thick layer of sand. The flight reaction remained unaltered. If, however, an *Amphioxus* accidentally succeeded in burying itself, then the innate flight reaction by swimming was replaced again by the congenital reaction of burying, which henceforth remained predominant again.

These experiments with *Amphioxus* show that an innate instinctive reaction can be changed into a conditioned reaction by a change in the environment in which the animals live.

Another example of conditioned modification of the behaviour of animals by changing environmental conditions is found in Drzewina's experiments with hermit crabs (*Eupagurus*).

These animals are known to conceal their soft hind parts in empty snail shells, which they leave only when they grow too large for them and as soon as they have found new and larger shells. The transfer from shell to shell is effected extremely swiftly.

In her experiments with hermit crabs deprived of their shells, Drzewina placed them in an aquarium containing empty snail shells, the opening of which was hermetically closed by means of a cork.

The animals were initially restless, turning the shells over and attempting to remove the cork. After complete failure of all their attempts to enter the shells during a few days, however, they became completely indifferent and no longer touched the shells. According to Drze-

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[1] J. ten Cate, Arch. néerl. Physiol. *23*, 409 (1938).

wina, a new association formed in the animals due to the change in environmental conditions; this altered their behaviour[2].

Yet another possibility of causing a change in animal behaviour by conditioning involves no alteration of the environment but consists of stimulating a part of the body which is inaccessible to this particular type of stimulus under natural conditions. In this way the animals can be forced to perform movements which are never or hardly ever observed under normal conditions. Systematic repetition of such stimuli for some considerable time can modify an innate reaction of the animals into a conditioned reaction. This may result in a marked change in animal behaviour[3].

In collaboration with Mrs B. ten Cate I have made similar experiments with hermit crabs (*Eupagurus bernardus*)[4].

As pointed out, hermit crabs conceal their hind parts in an empty snail shell. If the animal is stimulated, e.g. by touching it with tweezers or another object, it withdraws into the shell so that only its pincers are visible, obstructing the opening of the shell. It is difficult to cause the hermit crab to leave its shell. If one of the extremities is pulled too hard, then autotomy readily occurs.

It seemed interesting to establish how hermit crabs behave if their hind parts, which are always kept concealed in the shell, are mechanically stimulated. In order to have access to the hind parts in the shell an opening was made in one of the upper spirals of the snail shell. It was thus possible to stimulate the abdomen and its appendices (telson and uropods) concealed in the shell.

Stimulation by touching the abdomen causes the hermit crab to move towards the opening of the shell, which it does not leave; it immediately withdraws again as soon as the stimulation ends. In the case of intermittent brief stimulations of the abdomen the animal moves to the shell exit but immediately afterwards withdraws again. This process can be continued interminably without causing the crab to leave its shell.

Continuous stimulation of the hind parts for a few minutes, however, causes *Eupagurus* to leave its shell after some to-and-fro movements; the animal then moves about in the aquarium in search of another shell. Hermit crabs can be made to leave their shells, therefore, by continuous mechanical stimulation of the hind parts.

In subsequent experiments an attempt was made to cause *Eupagurus* to leave its shell upon the first touch on the abdomen. In this way we wished to form a conditioned reaction to mechanical stimulation of the abdomen in these animals.

Every day at least ten experiments were made for this purpose, in which the abdomen was stimulated sufficiently long to cause the animal to leave its shell.

After a few days the animals were found to leave their shells sooner than before. After about ten days (there were individual differences) the hermit crabs left their shells immediately after the abdomen was touched, and subsequently even the slightest touch was sufficient to cause flight from the shell. A conditioned reaction had been formed.

Experiments with stimulation of the abdomen of hermit crab

Number of experiments	Start of stimulation	Moment of flight from the shell	Moment of return to the shell
12/viii			
1	9 h 12 min	9 h 24 min	9 h 38 min
2	9 h 45 min	9 h 55 min	10 h 12 min
3	10 h 35 min	10 h 42 min	10 h 57 min
4	11 h 40 min	11 h 49 min	12 h 12 min
5	4 h 10 min	4 h 19 min	4 h 44 min
6	5 h 02 min	5 h 12 min	5 h 27 min
7	5 h 35 min	5 h 42 min	6 h 05 min
15/viii			
31	9 h 05 min	9 h 09 min	9 h 19 min
32	9 h 35 min	9 h 39 min	9 h 48 min
33	10 h 30 min	10 h 32½ min	10 h 40 min
34	11 h 10 min	11 h 11½ min	11 h 19 min
19/viii			
65	10 h 30 min	10 h 30½ min	10 h 32 min
66	10 h 45 min	10 h 45 min	10 h 48 min
67	11 h 15 min	11 h 15½ min	11 h 22 min
68	11 h 45 min	11 h 46 min	11 h 47 min

An interesting feature was the fact that the animals initially moved round the shell which they had left in search of a new shell, whereas subsequently they sat near the shell which they had left and re-entered the same shell after a relatively short time (see the Table).

These experiments show that the reaction of withdrawal into the shell, which dominates the behaviour of hermit crabs under natural conditions, gradually diminishes and is replaced by a reaction of flight from the shell, which after some time occurs at the first touch on the abdomen. The experiments demonstrate that, under certain conditions, an inborn, instinctive reaction of *Eupagurus* can be modified to a conditioned reaction by stimulation of a part of the body which is normally not accessible to stimuli. In this manner the animal's behaviour is completely altered.

Other instances of modification of animal behaviour can be seen during experiments with conditioned reflexes by the Pavlov method. An example which I should like to discuss is found in the changes in the behaviour of cats in which I formed a conditioned contraction of the pupils resulting from stimulation by means of an electrical bell[5].

It is an established fact that intensive acoustic stimuli cause fright reactions in cats, which are based on excitation of the cerebral cortex. I have been able to demonstrate this by experiments involving extirpation of different parts of the cortex. The extent to which the thalamus and the reticular substance are involved in this process has not hitherto been determined. Excitation of the orthosympathetic system occurs simultaneously with cortical excitation, as indicated by the following phenomena: dilatation of the pupils is the most characteristic and constant symptom. Acceleration of the cardiac rhythm and of respiration can be demonstrated in addition as can also be an increase in the adrenaline secretion by the adrenal glands.

In these experiments, changes in the width of the pupils were used as an aid in the accurate determination

[2] A. Drzewena, Arch. Zool. exp. gén. *5*, 47 (1910).
[3] J. ten Cate, Arch. néerl. Physiol. *15*, 242 (1930).
[4] B. ten Cate, Arch. néerl. Physiol. *19*, 502 (1934).
[5] J. ten Cate, Arch. néerl. Physiol. *19*, 408, 417 (1934).

of the occurrence and disappearance of fright reactions. In a few cases the cardiac rhythm was registered in addition.

In order to attain a conditioned reflex in the form of pupillary contraction in response to the ringing of an electrical bell—a strong acoustic stimulus—the effect of this bell (conditioning stimulus) was combined with the effect of a beam of light directed at the animal. The bell was set ringing first, and the light was aimed at the animal 15 s later. The combined action of both stimuli lastet 1 min. As many as six of these combined stimulations were effected every day, at intervals of 5–30 min.

During the first few days the pupils invariably dilated when the bell was set ringing; this dilatation changed into a contraction only when the light was brought to bear. It was not until after about a week that the bell no longer caused dilatation of the pupils. Only after 100 repeated stimulations using bell and light in combination was pupillary contraction seen immediately at the onset of the acoustic stimulus. A conditioned reflex was formed.

There was an unmistakable change in the behaviour of the cats simultaneously with the formation of the conditioned reflex (pupillary contraction due to the ringing of an electrical bell). During the first few days the cats reacted to the ringing by turning the head and displaying general restlessness. When the pupils no longer reacted to the ringing by dilatating, i.e. after a week, a marked change was observed in the behaviour of the animals. They quietly sat through the ringing of the bell, reacting to the sound merely by moving the ears.

The fright reaction disappeared as a result of repeated stimulation by means of the bell sound. This disappearance of the fright reaction of cats completely corresponds with the disappearance of the so-called orientation reflex described by PAVLOV[6] as associated with the formation of conditioned reflexes in dogs. This orientation reflex (a certain excitement in the dogs as soon as the conditioned stimulus is produced) disappeared when experiments with the same stimulus were repeated.

PAVLOV observed that the disappearance of the orientation reflex (extinction of the reflex, to use his own designation) is based on inhibitory processes which arise in the cerebral cortex after repeated application of the same conditioning stimulus.

Since there is complete analogy between the occurrence and the disappearance of the fright reaction described and PAVLOV's orientation reflex, the conclusion can be reached that the disappearance of the fright reaction must be based on the occurrence of inhibitory processes in the brain. Besides a process of excitation which results in a transient connection (association) between the centres stimulated by the acoustic stimulus and the centres governing contraction of the pupils, inhibition of the fright reaction occurs. The conclusion therefore seems justified that the change in the behaviour of cats is likewise attributable to the occurrence of inhibitory processes in the brain.

It is highly probable that the changes described above in the behaviour of invertebrates are likewise based on the occurrence of transient inhibitory processes in the central nervous system by which the innate reactions are temporarily abolished.

[6] J. P. PAVLOV, *Lectures on conditioned reflexes*. London 1928.

Conclusions

(1) The experiments described above showed that animal behaviour can be modified by changing conditions of life.

(2) By alteration of the environment of the animal a change in its behaviour can be conditioned (experiments with *Amphioxus*).

(3) A change in behaviour can be effected by applying a stimulus to a part of the body which is normally inaccessible to such stimuli (experiments with hermit crabs).

(4) The formation of conditioned reflexes is also associated with a change in behaviour, simultaneous with the formation of the conditioned reflex (experiments with cats).

(5) The extinction of the fright reaction in cats resulting from exposure to marked acoustic stimuli (electrical bell) is analogous to the extinction of the orientation reflex as described by PAVLOV. In both cases extinction is caused by the occurrence of inhibitory processes in the brain.

(6) The changes in the behaviour of invertebrates as a result of conditioning should likewise be attributed to the occurrence of inhibitory processes in the central nervous system.

Zusammenfassung

Auf dreifache Weise konnte im Tierexperiment durch Veränderung der Lebensbedingungen das Verhalten variiert werden:

1. Durch Veränderung der Umgebungsbedingungen.
2. Durch Reizung von Körperteilen, die normalerweise für solche Reize unzugänglich sind.
3. Durch die Anwendung der Pavlovschen Methode bei der Bildung bedingter Reflexe.

Alle Verhaltensänderungen werden auf Konditionierung zurückgeführt.

THEORIA

Theoretical Genetics

Von RICHARD B. GOLDSCHMIDT

563 Seiten, 23 Abbildungen

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$8.50

Im Rahmen der Biologie ist für das Fachgebiet der Vererbungswissenschaft eine ungewöhnliche Allgemeingültigkeit der grundlegenden Erkenntnisse charakteristisch. Damit sind auch die Voraussetzungen gegeben, die zu einer Theorie der Genetik führen können. Ansätze zu einer zusammenfassenden Theorienbildung finden sich in vielen älteren und modernen Arbeiten. Mit GOLDSCHMIDTS Buch aber wird erstmals versucht, eine theoretische Gesamtdarstellung der genetischen Gesetzmässigkeiten und Erscheinungen zu entwickeln. Dabei kann sich der Verfasser auf seine früheren Bücher und auf seine zahlreichen Originaluntersuchungen stützen, die bereits nach Problemstellung und vor allem in ihrer Auswertung stets ausgesprochen theoretisch ausgerichtet waren. Uns Lesern aber wird bewusst, auf wievielen Gebieten der Verfasser wichtige Pionierarbeit geleistet hat. Seine ersten genetischen Arbeiten gehen auf das Jahr 1911 zurück, und bereits 1920 entwickelte