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ON THE HOMOGENEOUS AND HETEROGENEOUS TRANSFORMATIONS OF CONDITIONED REFLEXES: A COMMENT ON THE OVERMIER AND PAYNE CASE OF POSITIVE TRANSFER

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How does the acquisition of a conditioned reflex (CR) proceed when the conditioned stimulus (CS) is not merely a novel indifferent stimulus (S^0) but has been previously used as a positive CS or an inhibitory CS connected with another CR? There are several reasons to assume that no simple answer is possible. The outcome of such a transformation of a CS eliciting one CR into a signal of a different CR depends on a number of parameters of the learning situation. Let us mention the most obvious ones.

CLASSICAL VERSUS INSTRUMENTAL AND DRIVE VERSUS CONSUMMATORY

The problem of mutual relations between Pavlovian and Thorndikian types of behavioral plasticity has been obfuscated by applying the same terms, such as "conditioning", "reinforcement" "conditioned response" etc. to different procedures or phenomena. The issue has been further complicated by postulating separate neural mechanisms for preparatory or drive reflexes and consummatory behaviors (Sołtysik 1960, Jaworska et al. 1962, Sołtysik and Konorski 1966). Although both consummatory and drive reflexes are subject to classical conditioning, a special sort of asymmetry in the interaction between them has been revealed: While the drive facilitates homogeneous consummatory responses, the consummatory activity exerts a strong inhibitory effect upon the drive reflexes.

This creates a situation where positive or negative transfer (proactive facilitation or inhibition) is to be expected in reversal conditioning using homogeneous reinforcement: positive in case of transformation of a drive CR into a consummatory CR, and a negative one in the transformation of a consummatory CR into a drive CR. Since the drive CR is most often observed as a motivational component of the instrumental CR, the above considerations will concern practically all types of transformations of classical into instrumental homogeneous CRs and vice versa. Less clear are the predictions in heterogeneous classical-into-instrumental or consummatory-into-drive and vice versa transformations. In the present state of knowledge these are experimental rather than theoretical questions, although the inherent antagonism between unconditioned responses (UR) elicited by the reinforcers should be the best guide if well overtrained CRs are employed.

AMOUNT OF TRAINING AND THE STAGES OF CR ACQUISITION

Acquisition of a classical CR is a relatively slow process with a time base of several days or even weeks. Although the signal function of a newly established CS may be evident after a few trials, the full consummatory CR, characterized by its 100% performance level and constant parameters, develops only after dozens of experimental sessions undergoing a specific evolution. In the *first stage* of classical food conditioning, for instance, there is an interplay between the orienting reflex (with its electroencephalographic arousal, visceral-autonomic and specific targeting-exploratory components) to the novel S^0 and the consummatory reflex to the food US, as these responses are partially incompatible yet elicited in close temporal contiguity. The orienting response to S^0 is known to never fully habituate in case of a positive CS and eventually becomes, in an attenuated form, an initial part of the entire conditioned reaction. This reaction is an overt indication of the fact that positive CSs retain some degree of arousal-eliciting capacity, normally exhibited by novel stimuli. Stępień and Stępień (1965) have shown that this reaction may be pathologically exaggerated after specific cortical-frontal lesions.

Soon, a *second stage* develops, when the hitherto indifferent (in respect to the consummatory UR) stimulus becomes a signal of the reinforcing US. The conditioned behavior elicited during this stage is characteristically *variable*. This variability has two main sources. One is the obvious interaction of the diminishing orienting response with the increasing conditioned behavior. The second is the simultaneous formation of two different CRs: a drive CR (a hunger CR in this case) and a consummatory CR (*see* Kieryłowicz et al. 1968, Konorski 1967). The proportions of these two CRs depend on such factors as the level of food deprivation, previous experience and, particularly, the duration of the CS-US interval. Longer intervals are preferable for drive conditioning while the short ones favor the consummatory CR. In a typical Pavlovian procedure with gradually extended CS-US intervals the consummatory CR takes over and its final domination over other conditioned behaviors marks the transition to the *third stage* of fully established consummatory CR. After a very long overtraining the *fourth stage* may appear in the form of a gradual disappearance of the CR — a phenomenon called by Pavlov "chronic extinction with reinforcement". If a classical food CS is reinforced by a heterogeneous US the result of such transformation will certainly depend on the stage of the CR development during which the old reinforcer is substituted by a new one. Unfortunately, there is not much experimental evidence on this problem.

All these considerations are raised by a provocative paper of Overmier and Payne (1971), who obtained a positive transfer in heterogeneous transformation of conditioned reflexes, i. e., better acquisition and performance scores of a new CR to the previously heterogeneous CS+ than to heterogeneous inhibitory CS− or a pseudoconditioned stimulus S^0). This interesting result prompted the authors to express their disbelief in the earlier experiments and concepts of Konorski and Szwejkowska (1956) and instead of the "principle of the first training primacy" (Konorski and Szwejkowska 1952) they proposed a more general explanations, such as "learning set" or "attentional processes".

It seems, however, that there is no necessary contradiction between Overmier and Payne's results and those of other authors. First of all, Overmier and Payne's experiment differs in many respects from Konorski and Szwejkowska's. Let us enumerate the differences; for brevity the two experiments will be referred to as O. and P. exp. and K. and S. exp., respectively.

1. K. and S. exp. concerned the classical food CR into classical defensive CR transformation, whereas in O. and P. exp. it was classical food CR into instrumental defensive CR transformation.

2. K. and S. exp. deals with the difficulty in transforming a well established food CR (in the third stage of acquisition) into a well established defensive CR (up to the third stage), while O. and P. exp. shows the effect of a newly conditioned CS (a second stage probably, as no consummatory CRs were recorded) on the acquisition of an avoidance CR (stage 1 and perhaps 2) during the first session.

3. K. and S. exp. was carried out in the same experimental situation, while Overmier and Payne used two different situations, a wooden platform for food conditioning and a shuttle box for avoidance learning.

4. In K. and S. exp. the same CS was used first as a food CS and and later as a defensive CS, whereas in O. and P. exp. the food CS was tested against different background (different room acoustics) in compound with the raising of a drop-gate which could be the main cue eliciting an avoidance CR. Unfortunately we do not know how the avoidance learning would proceed in raising of a drop-gate alone served as a warning signal.

It seems evident that in these two experiments two different phenomena were observed. If such experiments are aimed at studying the interaction between heterogeneous conditioned "central processes" or "motivational states" (as O. and P. exp. was), then preferably the CRs in the third stage of acquisition should be used. On the other hand, the transformations, homogeneous or heterogeneous, conducted in the early stages of acquisition are extremely interesting of their own as they reveal new aspects of plastic changes in the CNS occurring during learning. Overmier and Payne initiated this line of research by a discovery that a newly established CS+ (after 7 days of training) facilitates learning of a motivationally different response in a *different situation* during the first twenty acquisition trials, as compared to a differential CS− or a pseudo-CS.

What, thus, makes a CS in statu nascendi a better stimulus for heterogeneous conditioning than other, equally often received but not reinforced, stimuli? The concept of learning set does not seem quite satisfactory here, as it was only the second learning and animals have not yet been exposed to the procedure of serial reversal learnings. While a purely psychological explanations have not yet been offered some clue of what might be the mechanism of the increased "conditionability" of the CS+ in a heterogeneous reinforcement situation comes from the neurochemical and electrophysiological studies. Hydén and Egyházi (1962, 1964) found that during the first few days of learning considerable changes in RNA metabolism occur in neurons receiving messages from the relevant stimuli. Electrophysiologically, Galambos et al. (1956) have shown that reinforcement produces dishabituation (enhancement of evoked potentials) in the auditory cortex when rhythmic clicks were used as CS+. Characteristically, however, these electrophysiological and biochemical correlates of acquisition do not persist and tend to disappear after the CR becomes well established. Probably in the first period of learning the relevant neurons become more excitable and "learnable". If so, the CS+ in statu nascendi is a "perceptually" stronger stimulus and a more conditionable one (due to biochemical mobilization of the receptive neurons) than partially habituated, non-reinforced stimuli. But why the consummatory food CR, however feeble and labile, does not counterbalance the increased conditionability by inhibiting the antagonistic fear response?

Here, it seems the answer lies in the differences between specific-gnostic nervous system subserving perception and consummatory activities on the one hand and unspecific-emotive part of the brain constituting a substratum for the motivational (drive) and arousal processes. It is known from everyday CR-laboratory practice that consummatory CRs are strictly bound to a given situation and that the CSs applied in another millieu fail to elicit the learned response. It is not quite so, however, with the emotive CRs. Wyrwicka (1956) has demonstrated a transsituational character of a hunger drive CRs. Also partially habituated stimuli elicit stronger arousal in a different situation, showing thus, that stimulus emotogenic properties may be augmented in a different sensory context. Theorefore, the change of the experimental situation in Overmier and Payne's experiment could promote the proactive facilitation in a heterogeneous consummatory-into-drive CR reversal conditioning by simultaneous suppression of consummatory CR and enhancement of the arousal-inducing capacity of CS+. Plus the increased conditionability of the biochemically mobilized neurons receiving this CS+. Since the CS− and pseudo-CS were more habituated and their neurons presumably not mobilized biochemically, the superiority of the CS+ in prompting the animals to jump over the hurdle becomes understandable. The more so that there is a synergism between arousal and fear responses.

If this explanation is true, further predictions could be made and tested. For instance, using a newly trained food CS+ as a warning signal to make an avoidance CR in exactly the same situation should give less or no positive transfer because the food or hunger CR, however feeble, will tend to inhibit the fear CR. Prolonging the food CR training up to the third stage and using the food CS+ and CS− in avoidance or classical defensive conditioning in the same situation should replicate the Konorski and Szwejkowska data, namely, negative transfer with the CS+ and less or no proactive suppression with the CS−. And even testing the food CSs during avoidance learning in a different situation should result in proactive suppression if some hunger drive CR (and not anonymous arousal) is transferred [1]; antagonistic drives like hunger and fear obviously do not summate but inhibit each other.

It should be very interesting to find out if Overmier and Payne's result could be obtained in the reverse, defensive-into-food CR, transformation. Most likely not, since the enhanced arousal or even transfered

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[1] An interesting case of such an interaction between hunger CR and fear CR is provided by John A. Bull (1970) where the appetitive food CR (i.e., hunger CR) should have prevailed over consummatory food CR because of relatively long and variable CS-US intervals and small portions of food presented as an US.

fear CR would not corroborate with either hunger drive or food consummatory CRs. But one cannot exclude the possibility of some facilitation if a moderate arousal (the defensive conditioning would have to be extremely short) is confronted with hunger drive, e. g., food instrumental (but not classical consummatory) conditioning.

Experiments of Overmier and Payne and of Bull (1970) clearly show the inadequacy of our knowledge on the relations between motivationally different behaviors, and, particularly between different behaviors during learning.

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