

Separation of the Salivary and Motor Responses in Instrumental Conditioning

Abstract. If an instrumental conditioning schedule is arranged so that a dog must repeatedly perform a movement in response to one stimulus in order to secure the presentation of another stimulus, which is then followed by food, a virtually total separation of motor and salivary responses is observed. The first stimulus elicits the trained movement without salivation, and the second stimulus elicits salivation without instrumental responding. These experiments show a relative independence between classical and instrumental conditioned responses and clarify the rather complex relations between the two in the usual experimental procedure.

In early papers by Konorski and Miller (1) a method was described for studying the relations between the salivary and the motor responses in instrumental conditioning. According to the views then held by these authors, the instrumental response produced its proprioceptive feedback which became a classical conditioned stimulus signaling the presentation of food. In consequence it was predicted that salivation should closely follow the instrumental response.

However, their own experimental data (2), as well as those of later workers (3), showed that although in many cases the predicted relation is in fact observed, in others large discrepancies exist between the two responses: the motor response may be either preceded by the salivary response, or the two responses may not even coincide at all. The origins of these discrepancies have been poorly understood, and the causal relation between the salivary and instrumental responses has remained obscure. The experiments reported here were designed to clarify this situation.

The subjects were four mongrel dogs trained in the following manner: first a classical conditioned response (for

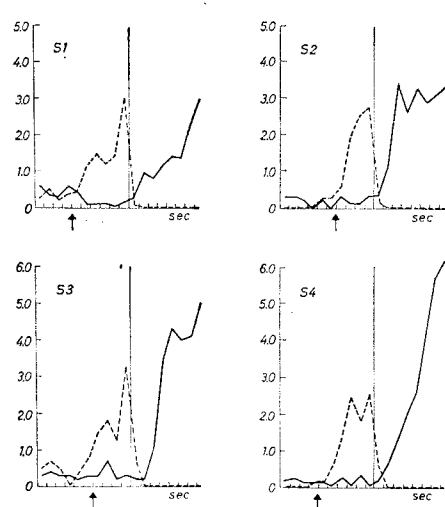


Fig. 1. Mean rate of lever-pressing (dashed line, presses per second) and salivation (continuous line, drops per second) during a typical session (about 15 trials) late in the training of each dog. The vertical line represents the onset of the classical CS, and the curves end at the time of reinforcement. The arrows indicate the median time (in seconds) of onset of the instrumental CS.

food) was established to a stimulus (hereafter called the classical CS), with a 1-second interval between the conditioned stimulus and the unconditioned stimulus (US). Then the animals were trained to perform an instrumental movement: pressing with the right forepaw a lever situated in front of and well to the right of the feeder, this response being reinforced with presentation of the classical CS and then food. When this task was mastered a second stimulus, the instrumental CS, was introduced, and subsequently only those instrumental movements performed in the presence of it were followed by the classical CS and then food. During subsequent training, both the instrumental CS and the classical CS were gradually prolonged until nine lever-presses occurred in the presence of the instrumental CS and the CS-US interval for the classical CS was 8 seconds. The instrumental CS was turned off immediately after the ninth press, and at the same moment the classical CS was turned on. Thus, the schedule involved two segments: the first segment required working for the second segment, and the second segment required only waiting for food.

The food reinforcement was a small portion of cooked meat and broth-soaked bread presented automatically.

Recordings of salivation, begun only after the animals were well-trained, were obtained in the manner described by Sheffield (4), a cannula of polyethylene tubing being permanently implanted in the parotid gland. For three of the dogs, a light was used as the instrumental CS and a buzzer as the classical CS; for the fourth dog this arrangement was reversed.

Throughout the training the following behavior was observed in all dogs. The instrumental CS evoked a motor excitement of the animal, and this was accompanied by vigorous instrumental movements. Immediately after the instrumental CS was turned off and the classical CS was presented, the dog calmed down and waited for food, staring intently at the food bowl. The instrumental response was not performed in the presence of the classical CS (except, of course, occasionally immediately after the onset of the classical CS), although no precautions were taken to discourage the animal from such response.

The results with salivation were quite different. On most trials, there was either no salivary response to the instrumental CS or nearly none, although there was regularly a large salivary conditioned response to the classical CS. Often when the animal was salivating slightly during the intertrial interval, he would stop doing so upon the onset of the instrumental CS and lever-pressing. A reciprocal relation between salivation and the instrumental response was also observed in two dogs during the operation of the instrumental CS. These two animals would occasionally stop pressing the lever sometime during the instrumental CS, look toward the feeder and salivate, and then stop salivating when they finally returned to complete the ratio of presses. The typical relations between salivary and motor responses in each dog are presented in Fig. 1.

When these experiments had been completed, additional training was given to two of the dogs with the classical CS omitted and food presented immediately after the ninth press of the lever. Although substantial training was required, it was eventually possible to reach a state where salivation and instrumental responding were concomitant, as has been found in other studies in which there has been immediate reinforcement of the instrumental CR (3).

We have evidently found a method of complete, or nearly complete, separation of the motor and salivary responses in instrumental conditioning. This separation takes place when an instrumental response elicited by a given stimulus is a prerequisite for the presentation of a well-established classical CS, and when there is no close contiguity between the instrumental response and the place of feeding.

If we accept the well-documented thesis that instrumental responding for food reflects the presence of the hunger drive, the immediate conclusion to be drawn from our experiments is that conditioned salivation does not constitute a primary effect of that drive. This fact has not been previously observed because the instrumental response has always been experimentally intermixed with a classical CR elicited by the feedback from an immediately reinforced movement and by CS itself. Since in our experiments neither the instrumental CS nor the trained movement were followed immediately by food, the pure character of the instrumental CR could be revealed.

If instrumental responding and conditioned salivation reflected the same process, recording only one of these two responses would yield the same information as recording both. The present result, in showing a clear difference between the two responses and perhaps the rules governing them, emphasizes the necessity of studying both of them concomitantly in order to obtain a better understanding of learning processes.

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References and Notes

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 5. Research conducted while one of us (G.D.E.) held a PHS postdoctoral fellowship (MH 16,185) at the Nencki Institute.
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8 September 1964