Acta Biol. Exper. (Warsaw), vol. 26, No. 2, pp. 159—165, 1966

SALIVATION AND INSTRUMENTAL RESPONDING TO AN INSTRUMENTAL CS PRETRAINED USING THE CLASSICAL CONDITIONING PARADIGM

Gaylord D. ELLISON* and J. KONORSKI

Department of Neurophysiology. The Nencki Institute of Experimental Biology, Warsaw 22, Poland

(*Received August, 1, 1965*)

In our previous paper (Ellison and Konorski 1965) we found that the salivary CR and the instrumental response could be separated in time when special training procedures were used. In our procedure, two CS's — an instrumental CS and a classical CS — were presented on each trial, and the instrumental CS came to elicit only the instrumental response while the classical CS came to elicit only salivation.

It is only with such special procedures that these two responses can be separated, however, and in the procedures usually followed in instrumental conditioning the same CS serves as both the classical CS and the instrumental CS in that it both just precedes food and also serves as the signal for instrumental responding. With these usual procedures the two responses occur at the same time, showing a high positive correlation (Konorski and Miller 1936).

In the present paper we will attempt to demonstrate that the two responses can be shown to be distinct even when they are elicited by the same CS and thereby occur at the same time. The method of demonstrating this follows the procedures of Konorski and Wyrwicka (1950), where it was shown that the learning of an instrumental response to a CS originally trained using classical conditioning procedures occurs extremely slowly, and that instrumental responding to such an altered CS remains

* U.S. Public Health Service Postdoctoral Fellow MH 16,185. Present address : Department of Psychology, U.C.L.A., Los Angeles, California.

weaker, even after extensive training, than that to another CS which had always been trained as an instrumental CS. In the present paper this finding will be replicated and it will additionally be shown that the effects of such retraining on the salivary CR are the converse of those on the instrumental response.

METHOD

Three dogs were used as subjects. Two of the Ss (Nos. 1 and 2) were experimentally naive prior to the experiment. Salivary recording in these Ss was accomplished by means of the shortened duct method described by Sołtysik and Zbrożyna (1957), and the instrumental response trained was that of lifting the right forepaw to a high level and returning it to the floor immediately. The third S had previously served as S No. 3 in the experiment reported by Ellison and Konorski (1965). For this S the lever-pressing response was used as the instrumental response, and salivation was recorded by means of an artificial fistula similar to that described by Sheffield (1957).

The procedure for all Ss was as follows : first a good classical CR was trained to a CS which will henceforth be called CS_1. During the early presentations of this stimulus the CS—US interval was 2 seconds ; this interval was then slowly lengthened to 10 seconds. After a consistent salivary CR had developed with the 10 second CS—US interval, 200 overtraining trials were given. This training procedure was followed in order to develop a strong classical CR to CS_1.

In the next stage of training, CS_1 was never presented while an instrumental response was being trained to a new stimulus, henceforth called CS_2. In order to train the instrumental movement, a response was first elicited in the absence of CS_2 and immediately reinforced, and when the animal began to actively perform the required movement, CS_2 was sporadically presented and only those responses made during it were rewarded. Then the time between presentations of CS_2 and the time between onset of CS_2 and food presentation were gradually lengthened. The intertrial interval averaged four minutes during the final stages of training, and the time between CS onset and presentation of food was 10 seconds. The food was presented exactly at the 10th sec. if one or more responses had occurred during the action of the CS. If no responses occurred, food was withheld until the first response did occur. The CS overlapped 5 sec. with food presentation. Under this contingency, the Ss always made several responses before the 10th sec. of CS action, and the CS—US interval was consequently always 10 sec.

At least 100 further trials were then given with CS_2 so that a strong, stable instrumental response and a consistent salivary CR occurred on each trial. Then CS_1 was reintroduced and trials were alternated between CS_1 and CS_2 with the instrumental reinforcement contingency now applied to both conditioned stimuli. That is, reinforcement was now withheld to CS_1 until an instrumental response occurred and until the CS had been on for at least 10 sec. On the first such CS_1 trial the dog would usually wait patiently for food until after the normal time of food presentation, and then would become impatient and perform the trained instrumental response. This response was immediately reinforced. Several days of this training were sufficient to reach a state where at least one instrumental response was always made before the 10th sec. of CS action, whether CS_1 or CS_2 was presented.

Further training consisted of merely alternating CS_1 and CS_2 trials. The

reinforcement schedule was the same for both stimuli. A daily session consisted of 4 presentations of CS_1 and 4 of CS_2 with intertrial intervals varied around a mean of 4 min. Which of these two stimuli were presented first on any given day was determined by chance. This training was continued daily for at least 200 trials after all Ss were performing the instrumental response well to both stimuli.

The nature of the instrumental response, the method of training, and the specific conditioned stimuli used with each S are presented in Table 1.

Table 1. Methods of training and conditioned stimuli used for each individual S.

Dog	CS_1	CS_2	Method of training
No. 1	Metronome	Buzzer	Passive flexion
No. 2	Buzzer	Metronome	Tactile stimulus to paw
No. 3	Buzzer	Light	Baited lever

RESULTS

The data to be reported will concern the 200 trials given after each S was performing the instrumental response well to both conditioned stimuli. An inspection of the records from these 200 trials revealed a long-lasting difference between the CR's evoked by the two conditioned stimuli. The instrumental response was stronger to CS_2, but the salivary CR was stronger to CS_1.

These results are presented graphically in Fig. 1 for the salivary CR, and in Fig. 2 for the instrumental response. Considering only Fig. 1, it can be seen that a good salivary CR occurs to CS_2, but that its amplitude is much lower than that to CS_1. This effect was long-lasting, continuing over the entire block of 200 trials. The source of this lowered amplitude of salivary CR to CS_2 did not appear to be a lowered CR frequency to CS_2. The frequency of response, whether to CS_1 or CS_2, was always above 95%. Rather, these results reflected a tendency of CS_2 to elicit a consistently lower rate of salivary flow than CS_1.

The results with instrumental responding, as seen in Fig. 2, were just the opposite. This graph depicts the average number of instrumental responses made during the initial 10 sec. of action of the CS. The average number of responses was always well above one for both stimuli, but at least twice as many instrumental responses were consistently made to CS_2 than to CS_1.

These differences in rate of instrumental responding and conditioned salivation reflected a difference in the gross behavior of the dogs to the two conditioned stimuli similar to that described by Konorski and Wyrwicka (1950). Upon presentation of CS_1 S would stare intently

at the food bowl, salivating profusely. Occasionally shifts in body position were made, but few of these developed into instrumental movements. When instrumental movements did occur, they were usually performed while the dog was staring into the food bowl. On the contrary, to CS_2 the attention of the dog was less strongly focused on the food bowl. The body was shifted more frequently. Conditioned salivation occurred with a latency and form similar to that to CS_1, but the maximal rate of salivation was much lower.

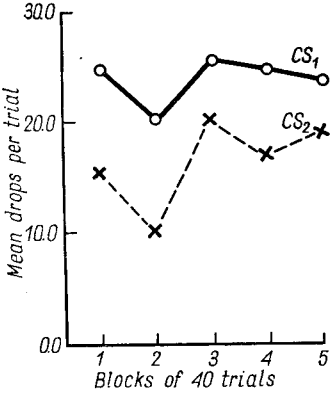

Fig. 1. Mean salivary CR in drops for each conditioned stimulus as a function of training. The amplitude of the salivary CR to CS_1 remains substantially above that to CS_2 throughout training

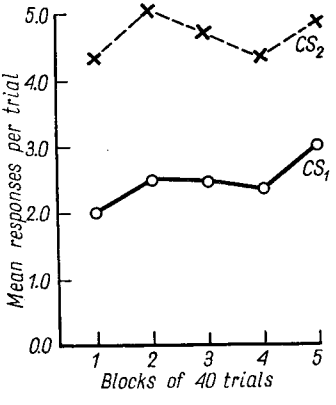

Fig. 2. Mean number of instrumental responses per trial for each conditioned stimulus as a function of training. More responses are made to CS_2 than to CS_1 throughout training

In order to present more clearly the individual results from each dog and the progressive changes in the individual S's records, these data were replotted in terms of a ratio between the responses to the two conditioned stimuli. For each individual S, the ratio between amount of salivation to CS_2 divided by that to CS_1 was calculated for each block of 20 trials. A similar score was computed for the instrumental data : number of responses to CS_1 was divided by the number of responses to CS_2 within each trial block. Figs. 3 and 4 present these data. For each dog, the ratios begin at less than one and slowly rise. These figures show a tendency for the effect to diminish as training progressed which was not apparent in Figs. 1 and 2.

The most persistent difference in instrumental responding was obtained in the dog No. 3 taken from the experiments previously reported by Ellison and Konorski (1965). In this dog, the leverpressing curve

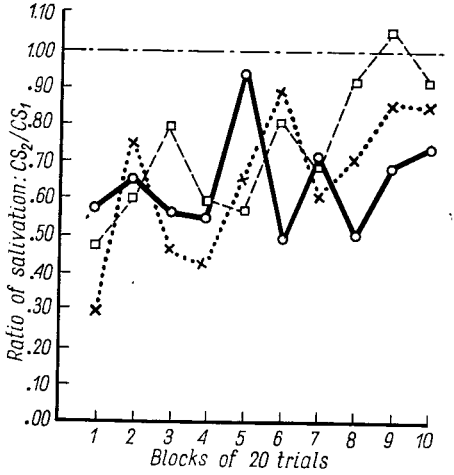

Fig. 3. Individual curves for each S showing the ratio of salivation to CS_2 divided by salivation to CS_1 as a function of training. The dashed line drawn through 1.00 indicates the point of equal CR strength to each stimulus. Legend: filled circles — No. 1; open squares — No. 2; X's — No. 3

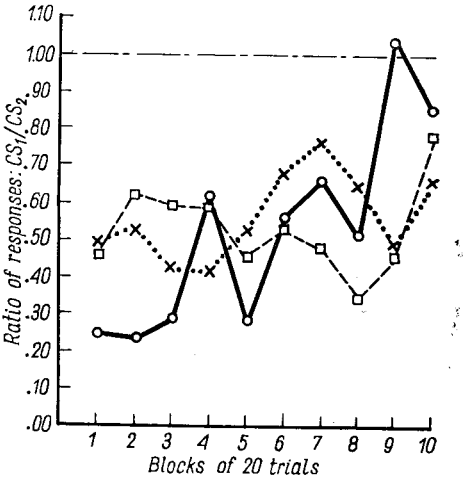

Fig. 4. Individual curves for each S showing the ratio of instrumental responses to CS_1 divided by responses to CS_2 as a function of training. Legend as in Fig. 3

appeared to have reached an asymptote with CS_1 clearly inferior to CS_2 (cf. Fig. 4). In this S the classical CR was even more strongly established than in the other two Ss owing to the extremely protracted training given with this CS.

DISCUSSION

In the present experiment fewer instrumental movements but a larger salivary CR were elicited by a CS originally trained with classical conditioning procedures and then retrained using instrumental methods than by one always trained with instrumental procedures. Although this effect slowly decreased with further retraining, an inspection of Figs. 1 and 2 indicates that differences in amount of classical or instrumental training *per se* cannot be invoked as the sole explanation for these effects. Shifting the CS_2 curve forward or backward 100 trials would not change the conclusions to be drawn from either Fig. 1 or Fig. 2.

An important question which might be raised is whether the decreased salivary responding to CS_2 might have been due solely to increased inhibition of delay. The answer to this question seems clearly to be negative, for the form of the salivary CR was not greatly different for the two

CS's, and furthermore the frequency of CR's remained high to both CS's (cf. Ellison, 1964). These arguments also indicate that the decreased number of instrumental responses to CS_1 was not due to merely a more accurate estimation of the time of reinforcement.

The interpretation favored by the authors is that the strength of the process underlying instrumental responding (the " drive CR ") was greater to CS_2 in these experiments, while the strength of the process underlying the salivary CR (the " consummatory CR ") was greater to CS_1. This was reflected in differences in the general behavior of the dogs to the two CS's : during CS_2 there were more frequent changes in body position, barking, and a higher rate of instrumental responding, while to CS_1 the dogs stood more still, staring intently at the food bowl, and they salivated more profusely.

The reason that decreased salivary responding to an instrumental CS when compared to an equivalent classical CS has not been reported earlier may be related to the finding that the effects of intensity of CS on the elicited CR, for example, are much greater when these effects are compared within subjects rather than between subjects. It should also be noted that the behavior elicited by the classical CS must be clearly the " waiting " type of behavior as seen to CS_1 in this study. For example, in a study by Ellison and Williams (1962) it was found that when dogs were alternated between instrumental and classical trials of comparable length, conditioned salivation was the same on both types of trials. During the " classical " trials presented by these authors, however, the behavior of the animals was more like that seen in the present experiments to CS_2 — the animals would bark at the food bowl and move about on the conditioning stand. Merely the use of the Pavlovian classical conditioning procedure will not, then, guarantee the strong classical CR necessary to observe this effect. Such a strong CR was obtained in the present experiments by the use of initially short CS—US intervals and a preferred food reinforcement, and because the classical CR was trained first and well-trained.

These results further substantiate a separation of the drive CR and the consummatory CR. In our previous communication (Ellison and Konorski 1965) it was found that eventually the salivary CR and instrumental responding were negatively correlated. In that study the experimental procedures to some extent dictated this negative correlation, in that two distinct CS's were used and the place of feeding was clearly differentiated from the place of instrumental responding. In the present experiments, no clear incompatibility was dictated between the salivary CR and the instrumental response. Each CS served both as the signal for food and as the signal for instrumental responding, and the instrumental

response of lifting the leg was not physically incompatible with that of looking into the food bowl and salivating. Nevertheless, even after extensive instrumental training CS_1 showed a weaker instrumental response and a stronger salivary CR than CS_2. While the relations between these two processes need further study, these findings suggest that antagonistic relations between these two processes may be a more general property of learning than has been previously suspected.

SUMMARY

Conditioned salivation and instrumental responding to a CS originally classically trained and then switched to instrumental were compared with the same responses to a CS always trained as instrumental. Conditioned salivation was greater to the originally classically trained CS, while instrumental responding was greater to the CS always trained as instrumental. These effects persisted after further training with both stimuli similarly reinforced. The relationship between these two responses is discussed.

REFERENCES

ELLISON G. D. 1964 — Differential salivary conditioning to traces. J. comp. physiol. Psychol., *57*, 373.

ELLISON G. D. and KONORSKI J. 1965 — An investigation of the relations between salivary and motor responses during instrumental performance. Acta Biol. Exper. (Warszawa), *25*, 297.

ELLISON G. D. and WILLIAMS D. R. 1962 — Conditioned salivation during FI and FR lever-pressing for food. Paper presented at Eastern Psychological Association meetings. Philadelphia.

KONORSKI J. and MILLER S. 1936 — Conditioned reflexes of the motor analyzer. Tr. Fiziol. Lab. Pavlova, *6*, 119 (in Russian).

KONORSKI J. and WYRWICKA W. 1950 — Researches into conditioned reflexes of the second type. I. Transformation of conditioned reflexes of the first type into conditioned reflexes of the second type. Acta Biol. Exper. (Warszawa), *15*, 193.

SHEFFIELD F. D. 1957 — Salivary conditioning in dogs. Yrbk. Am. Philos. Soc., p. 284.

SOŁTYSIK S. and ZBROŻYNA A. 1957 — The chronic fistula of shortened Stensen's duct in dog. Acta Biol. Exper. (Warszawa), *17*, 339.