AN EXPERIMENTAL INVESTIGATION OF THE RELATIONSHIP BETWEEN FIXED RATIO SCHEDULES, OPPORTUNITY FOR AGGRESSION AND RESISTANCE TO EXTINCTION.

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Submitted in partial fulfilment of
requirements for the degree of M.A.
at the University of Cape Town.

October, 1975.

ACKNOWLEDGEMENTS

"The financial assistance of the Human Sciences Research Council towards the costs of this research is hereby acknowledged. Opinions expressed or conclusions reached are those of the author and are not to be regarded as a reflection of the opinions and conclusions of the Human Sciences Research Council".

The author is indebted to the following people for providing a great deal of guidance and assistance:

PROF. W.P. RADLOFF.
MR. F. EGGAR.
MR. A. REYNOLDS.

ABSTRACT

Three experiments were completed designed to measure the effect of opportunity for aggression on resistance to extinction. In Experiment I pigeons were trained on FR10, FR20, FR40 and FR80 schedules holding number of reinforcements constant for all Ss. Extinction session one indicated large increments in resistance to extinction up to acquisition values of FR40 but little apparent effect of FR values above this figure. A second extinction session showed only small differences in resistance to extinction across schedules. Experiment II aimed at measuring the degree of aversiveness experienced by pigeons as a function of FR20, FR40 and FR80. During acquisition and extinction Ss were given the opportunity to attack a restrained target pigeon. Results indicated that more attack occurred the higher the response requirement, both in acquisition and extinction. In Experiment III Ss were trained on FR20 and FR80 in the presence of two key colours. A target pigeon was present during one colour and absent during another; response requirement being held constant. A forty minute extinction was divided into ten minute segments during which the target bird was either present or absent. Results showed that opportunity for aggression did not affect resistance to extinction after FR20 but enhanced it after FR80.

SUMMARY

AN EXPERIMENTAL INVESTIGATION OF THE RELATIONSHIP BETWEEN FIXED RATIO SCHEDULES OPPORTUNITY FOR AGGRESSION AND RESISTANCE TO EXTINCTION.

INTRODUCTION.

When a previously reinforced operant is no longer reinforced a weakening process known as extinction occurs. During this process the originally learned operant becomes progressively weaker until it, theoretically, eventually reaches operant level. During this process, however, certain by-products such as aggression often occur. Azrin, Hutchison and Hake (1966) restrained a live target bird together with an experimental subject in a conventional pigeon Skinner box. During extinction the target bird was vigorously attacked. Flory (1969) observed a similar phenomenon during high fixed ratio training. Did this aggression have reward value? Tetlegen *et al* (1969) showed that opportunity for aggression could be used as a reward for the training of an operant. The present study aimed at improving resistance to extinction in pigeons by providing opportunity for aggression during extinction.

EXPERIMENT ONE.

Experimentally naive Homing Pigeons were trained to respond on fixed ratio values of 10, 20, 40 and 80 in a standard pigeon Skinner box. 4 Ss were trained on each value and received identical numbers of reinforcements during acquisition. Extinction consisted of 2 x 30 minute sessions. In session one small differences in resistance to extinction were found between F10 and F20 Ss but FR40 Ss showed much greater resistance to extinction.

Little improvement in resistance to extinction comparing FR40 and FR80 Ss was noted. In session two resistance to extinction was drastically reduced for all Ss the differences of session one being virtually absent. Experiment I provided the E with valuable base-line data on resistance to extinction after a number of FR values and provided initial insight into the by-products of extinction.

EXPERIMENT II.

In this experiment apparatus was used enabling a live pigeon to be restrained atop a stabilimeter thus enabling the objective measurement of number and duration of attacks by the experimental subjects. 4 Ss were trained on each FR value of 20, 40 and 80 and each S was assigned a target bird which remained in the chamber throughout all experimental phases. Extinction consisted of 2 x 30 minute sessions.

Results showed that attack occurred as the FR value was raised above 40. Below this value aggressive postures predominated. At lower FR values attack generally occurred during the post-reinforcement pause but in the FR80 conditions attacks occurred during the ratio run as well. In extinction attack occurred regardless of acquisition schedule but was far more intense and prolonged after FR40 and FR80. The presence of the target bird appeared to have a disruptive effect on performance after FR20 but little effect was noted after FR40 and FR80. In session two, however, the presence of the target bird seemed to have a facilitatory effect on the operant performance of FR40 and FR80 Ss. Almost twice as many responses were emitted in extinction by Ss who had the opportunity for aggression compared with Ss who did not. The small numbers of Ss employed and slight differences in training regimen between Experiment I and Experiment II necessitated a third experiment.

EXPERIMENT III.

This experiment looked at the problem slightly differently inasmuch as a within-subject design was used where each acted as its own control. Two extreme FR values were chosen (FR20 and FR80) so as to highlight differential effect of the response requirement and when Ss had stabilised on their respective ratios the key colour alternated between Red and Green. When no differences in responding were noted during the different colour key conditions the target bird was removed during red for 10 minutes and replaced during green for 10 minutes. Thus all training sessions were divided into 10 minute segments separated by time-out (TO's) during which the target was either removed or replaced.

Two Ss were trained at each FR value, one receiving on ABAB sequence the other BABA. Once responding had stabilised under these conditions each S underwent a 40 minute extinction session divided into 4 x 10 minute segments of ABAB or BABA depending on the sequence experienced in acquisition. (The sequence was held constant for each S to reduce the likelihood of discrimination of extinction).

Results indicated that the opportunity for aggression had no effect on extinction responding after FR20 but a definite facilitatory after FR80. More responses were emitted by the FR80 Ss when the target bird was present compared with when the target was absent.

DISCUSSION.

This series of experiments clearly showed that (1) aggression is an inevitable by-product of extinction; (2) more aggression occurs after high Fixed Ratio training schedules compared with low; (3) opportunity for aggression enhances resistance to extinction after high ratio requirements. Additional research will be needed, however, to explain why providing opportunity for a competing response in extinction enhances responding after high FR-value training and detracts from responding after low-FR value training.

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1 a. INTRODUCTION: OPERANT STRENGTHENING AND EXTINCTION

When a particular response R1 is not followed by any particular consequences, the response is said to be at "operant level" or "base level". When, however, this same response is followed by stimuli which the animal finds rewarding, a variety of changes in R1 immediately occur. The most immediate and striking change involves the frequency of the response- the rate of the response increases dramatically. The process whereby the frequency of a response is increased above operant level by reinforcement is known as operant strengthening.

But increased response rate is not the only effect of operant strengthening, the sequence of behavior changes as well. When a hungry pigeon is placed in a special apparatus for analysing its behavior certain responses are usually emitted in a fairly random sequence. For example, the bird may (a) preen itself, Rg; (b) approach the feeder, Ra; (c) approach the pecking key, Rk, etc. During operant strengthening, however, all behavior which may be said to be "irrelevant" to obtaining reinforcement is omitted, and a particular response loop develops. This loop, which may follow the form Ra Rk Ra Rk .... , is rapidly established and maintained. (Millenson and Hurwitz, 1961).

Another change occuring during operant strengthening concerns the topography of the response. Operant level responses emitted by a pigeon are extremely variable in form. If a piece of grain is attached to the pecking key, the animal will pick at it from many directions and in a variety of postures. But when the pecks are followed by reinforcement immediate changes in topography occur, the form of the response becoming extremely stereotyped. The pigeon will approach the key from exactly the same position and maintain the same posture and key peck form.

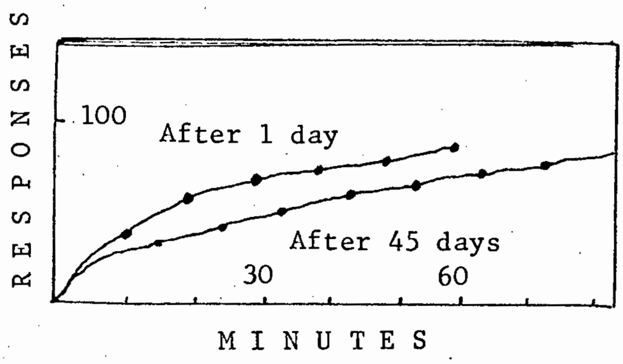
The operant strengthening paradigm may be defined in the following way: (Millenson, 1967).

GIVEN	a) An operant response being emitted in greater than zero frequency; b) a suitable reinforcer.
PROCEDURE	Each selected operant is followed by the reinforcing stimulus.
PROCESS AND RESULT	Abrupt increase in operant rate, its incorporation into a behavioral loop and increasing response stereotype.
IE	R S+ (where R represents an operant response class consisting of r1, r2, r3...........rn; S+ represents the reinforcing stimulus and is read "leads to").

1 b. EXTINCTION

When an operant response fails to produce reinforcement, or when a conditioned stimulus is repeatedly presented without the usual reinforcer, the response undergoes a gradual decrement known as extinction. The term extinction is usually applied to the operation of withholding reinforcement following the emission of some response that has received reinforcement in the past, and it is important not to confuse this gradual decay with forgetting, since conditioned responses show only a slight tendency to diminish with the passage of time. In fact conditioned responses seem to be particularly resistant to decay. Conditioned flexion reflexes in the dog have shown little decrement after a period of thirty months, (Wendt, 1937) and eyelid reactions have been retained for sixteen months, (Marquis and Hilgard, 1936). Skinner, (1938) in a carefully controlled study in which drive level was held as constant as possible for all subjects, conditioned rats to press a lever in order to obtain food. Original conditioning took place when the rats were 100 days old and extinction curves were obtained 45 days later. A second group of animals then underwent the identical procedure except that they were placed on extinction one day after the training regimen. The total number of reinforcements received during the acquisition phase was the same for both groups. (approximately 100). Skinner therefore compared the effect of the time interval between conditioning and extinction. Fig.1 shows the averaged curves for the two groups. During the extinction period of approximately one hour and twenty minutes there is very little difference in the number of responses emitted by the two groups, and one may conclude that the rats in the forty five day delay group showed very little forgetting.

FIG. 1.



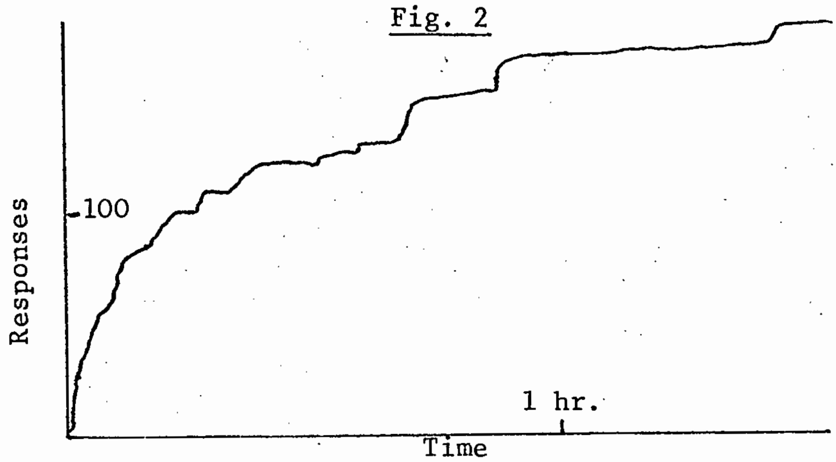
Averaged Extinction Curves Showing Only Slight Loss of Reserve During Forty-five Days

Skinner (1950) provides additional evidence for the assertion that conditioned responses in fact decay very little with the mere passage of time. A group of pigeons was trained to peck a key in order to obtain reinforcement. Once the operant response had reached a stable rate the birds were returned to the usual living quarters. Four years later the animals were returned to the conditioning apparatus and they immediately pecked the key and in fact emitted hundreds of responses in extinction. In another experiment (Skinner, 1956) pigeons were trained on a variable ratio schedule of reinforcement. After spending six years in living cages the animals still emitted hundreds of responses in extinction. The above examples should make it clear that extinction in no way implies "forgetting" of the operant response.

1 c. THE PROCESS OF EXTINCTION.

Contrary to expectation, the immediate effect of the introduction of an extinction schedule is not necessarily a decrease in the response rate but may in some cases result in an increase. If a response rate increase is elicited, it is usually only observed at the onset of extinction, and the overall rate can be said to decline gradually, the typical extinction curve showing negative acceleration. Fig. 2 shows such a curve.

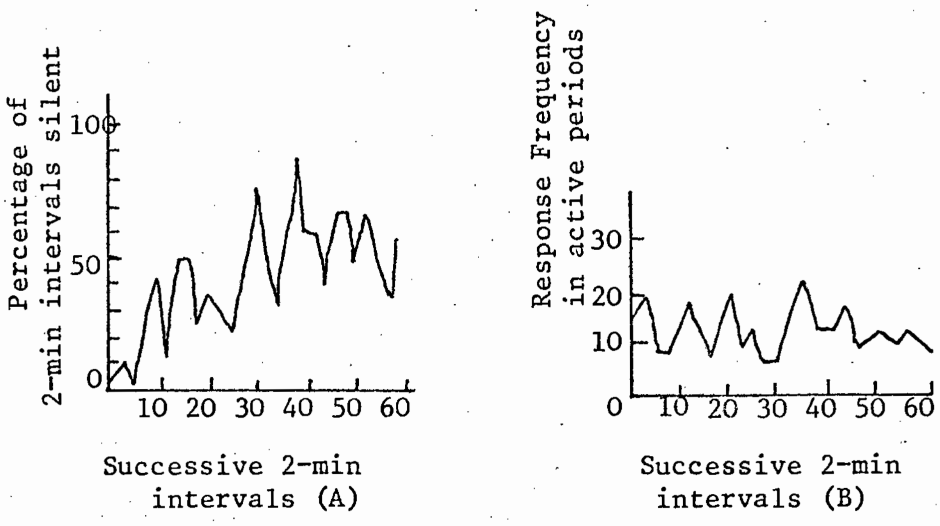
Fig. 2



An extinction curve for a previously food-reinforced lever press. (From Skinner, 1939, data of F.S. Keller and A. Kerr.)

It can be seen that the first 100 responses occur at a fairly high rate but that subsequent responses are emitted at a much lower rate. The curve becomes increasingly irregular and longer periods of no responding occur. Eventually after an hour and a half the rate is only slightly above operant level. Hurwitz, (1957) proposes that extinction is due primarily to an increase in the number of inactive/active periods; when the animal does respond, it does so at the usual high rate. Hurwitz analysed extinction records of rats previously trained on a continuous reinforcement (CFR) schedule, in order to determine whether the overall rate of response could be described as the outcome of two independently acting factors, i.e. rate of response during "active" periods and rate of "silent" periods, the latter being defined as 2 minute periods during which no response was recorded. Hurwitz's analysis showed that the response rate during "active" periods did not in fact decline as extinction progressed but that increasing numbers of intervals became "silent".

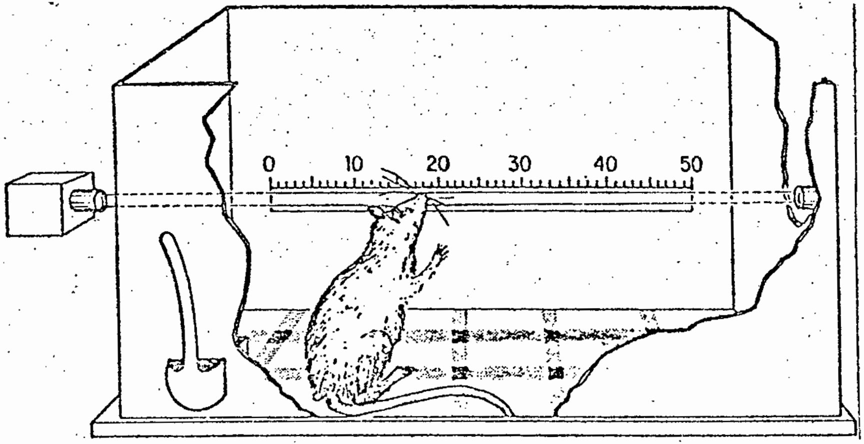
FIG. 3.



Analysis of responding during extinction
(After Hurwitz, 1957)

In summary it can be said that whether or not one draws the conclusion that response rate increases, decreases, or remains roughly the same during extinction as compared with acquisition, is dependent on the time sample drawn. Immediately after extinction is instated a rapid burst of responding often occurs, (response rate increase). Thereafter if extinction sessions are analysed as a whole, (usually periods of at least thirty minutes) the overall response rate deacreases, but if smaller time segments are analysed, (eg. 2 minute periods) then response rate can be shown to in fact remain approximately the same as during acquisition phases ("active periods") or decrease sharply, ("silent" periods). Another characteristic feature of behavior during extinction is the change in response topography. The extent to which behavior becomes stereotyped during strengthening has already been discussed. During extinction the opposite process occurs. Antonitis, (1951) investigated the relationship between degree of variability of some measurable aspect of the operant response and the number of reinforced responses during acquisition. Response variability was measured (a) during operant level determinations, (b) during conditioning and extinction sessions, (c) during successive extinction and reconditioning sessions following extended regular conditioning. The subjects (Ss) were male Albino rats approximately 100 days old and the operant under investigation consisted of a nose poking response. Across the rear wall of the experimental chamber was a horizontal slot 50 c.m.'s long. Whenever the S thrust its nose through the slot a beam of light from a spotlight to a photoelectric cell was interrupted and the position of the animal's nose with respect to the horizontal dimension of the slot was photographically recorded. On completion of the required operant, the animal could obtain a food pellet from the feeder tray at the rear of the chamber.

FIG. 4



Pictorial representation of the response studied by Antonitis (1951).

Results showed that during operant level determinations behavior was extremely variable. The Ss would run back and forward from one end of the slot to the other engaging in repeated nose thrusting. During the conditioning phases of the experiment, however, the response variability was substantially reduced, response position and angle being extremely stereotyped. When the extinction schedule was introduced behavior closely resembled that emitted during operant level, ie. variability increased once more. During successive restrengthening phases response stereotypy increased and even exceeded the level obtained during original strengthening.

Frick and Miller (1951), also investigated response topography during various phases of conditioning and extinction. They assert that reliance on rate as the principle datum and the assumption that successive behavioral events are independent often leads to ignoring sequential dependencies. In order to investigate behavioral patterns they developed a special apparatus in which the rat had to press a lever to obtain food from a tray which was situated at the rear of the chamber. They categorized the behavior into two main classes; Ra, approaching the food tray, and Rb, pressing the bar. A sample transcription from one of the records during operant level runs as follows: RaRaRaRaRbRbRbRbRb-RaRaRaRaRbRb..... etc. It may be noted that a certain amount of patterning is exhibited in this data- Ra's tend to follow Ra's and Rb's tend to follow Rb's. To a certain extent this result is a function of the design of the apparatus. If the S wanders to one end of the box he will tend to make several responses at that end before he leaves. During conditioning the pattern alters fairly abruptly and tends to follow the sequence RbRaRbRaRbRaRb..... etc. After the Ss had received 300 reinforcements a 24 hour record of extinction was obtained for each rat. The immediate effect of the extinction schedule was a disruption of the pattern. As extinction progressed the following pattern emerged:

RbRbRaRaRbRbRbRaRa....etc.

Thus during extinction the tendency was not for the behavior to become random, but rather the operant level pattern tended to reappear. This finding may appear "obvious" but it is in fact not necessarily so. The result of the extinction procedure could have been merely to produce a decline in <u>frequency</u> of the RbRa pattern and not a disruption of the pattern itself.

Two other aspects of operants which have been subjected to investigation during strengthening and extinction are response duration and force. Margulies (1961) investigated the variability of force emisions during operant level, regular reinforcement and extinction. Conventionally an operant is recorded as having occurred or not occurred, but each response, for example a bar press may be seen as consisting of subcategories, (such as presses of 0.02- 0.2 seconds, 0.2- 0.4 seconds etc). Using subcategories of this nature Margulies found that response duration was high during operant level, declined to an asymptote during regular reinforcement and then returned once again to high values during extinction. Once again we see that the operant level pattern reappears during extinction.

One of the earliest studies investigating force emissions was performed by Skinner (1938). After the conventional conditioning procedures he tested the force with which rats pressed the lever over short periods on several successive days. The average force exerted was somewhere in the region of 35-40 grams, and except for local minor deviations each rat maintained a constant mean force for up to five days. When the extinction schedule was introduced there was a tendency for greater forces to be emitted, especially at the beginning of the schedule, but subsequent to this initial increase in force, the tendency was towards responding with much reduced force.

In a more recent study, Notterman, (1959) studied variability of force emissions during operant level, regular reinforcement and extinction, He found that during operant level, force exertion tended to be uniformly high but during regular reinforcement there was a significant drop in magnitude of response. As soon as the extinction schedule was introduced both force magnitude and variability showed a sharp increase. The trial by trial extinction data conflict with Skinner's original observation that the strongest responses occur at the beginning of extinction. The Notterman study reveals a clear tendency for emission of fairly high magnitude of forces well into extinction. The most likely interpretation of this discrepancy concerns the number of reinforcements given during the acquisition phases and the duration of the extinction sessions. Unfortunately Skinner does not give sufficient detail in his report to enable a clear interpretation. In one important aspect, however, the two studies give very consistent results. It has already been noted that Skinner's Ss came to respond with a force of some 35-40 grams for a lever which required 20 grams for activation. Notterman's Ss typically responded with a force of approximately 5-6 grams, the critical force required being 3 grams. A possible interpretation of this finding is that over a fairly large range Ss will stabilize during regular reinforcement at a force magnitude which is roughly twice the critical threshold. Additional parametric data is however needed in order to clarify this interpretation.

2 a. RESISTANCE TO EXTINCTION

When the relationship between an operant response and reinforcement is weakened by the introduction of an extinction schedule, the subject does not immediately stop emitting the operant, in fact as has already been illustrated the response rate may increase. The number of responses emitted during extinction is a function of a number of variables. In everyday life we are often concerned with the phenomenon of extinction. Basically the problem encountered is one of persistence. How many responses will an organism emit in the face of no reward? Whether or not a person "gives up too easily" in the face of a difficult problem is often said to be a matter of temperament or character. Numerous experimental studies however, have clearly shown that the number of responses emitted is a function of certain clearly defined parameters, the most important of which being the schedule of reinforcement on which the behavior was acquired. In the practical situations of the clinic it is important to know what schedules or reinforcement to use if maximum resistance is to be induced. If, for example, positive reinforcement is being used in an attempt to elicit cooperation from an emotionally disturbed child we would not wish the behavior to be always dependent on extrinsic rewards. The ideal goal would be to arrange the contingencies in such a way that the behavior would persist long enough outside the therapeutic setting so that the intrinsic advantages of cooperation can then take over the maintenance of the behaviour. Laboratory analysis of those factors responsible for persistence after the termination of reinforcement and for the generalization of this persistence to other situations, is consequently of general significance.

Skinner, (1938) looked on operant strengthening as creating some sort of reserve, the size of this "reflex reserve" being a measure of the extent of the conditioning. He was quick to point out however, that there is no simple relation between these two measures. He maintained that maximum response rate can be built up very quickly, further reinforcement serving mainly to enlarge the reserve. Skinner in fact describes an experiment in which only one response was reinforced. Approximately fifty responses were emitted in extinction.

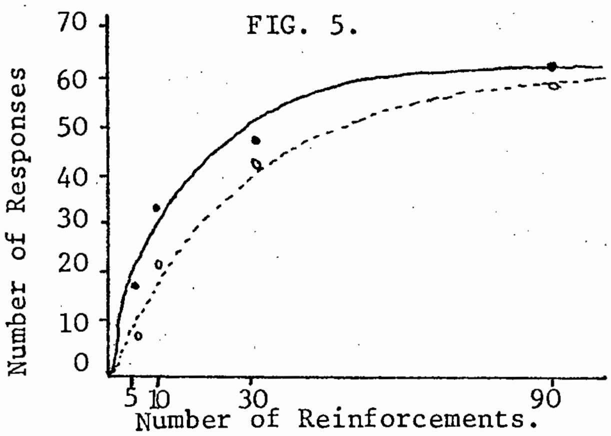
The size of the reserve is, however, also a function of the extinction criterion used. If the extinction process were allowed to continue to "completion", operant level should theoretically be reached. But in practice operant level is rarely recovered. If during acquisition we create a schedule of reinforcement which is so similar to the conditions that will prevail during extinction, no decline in response rate will appear for a long period of time, and the reserve can be made "infinitely" large. As a consequence of such a "doomsday" schedule the major limiting factors controlling reserve size and rate will be fatigue and the organism's need for food. (Skinner, 1950).

For experimental purposes various fairly arbitary criteria of extinction are used, the most common being number of responses emitted in a fixed period of time, for example, half an hour after the introduction of the extinction schedule. The use of different criteria may of course affect the resistance to extinction result.

2 b. NUMBER OF REINFORCEMENTS AND RESISTANCE TO EXTINCTION

As is the case with much research in operant behavior, B.F. Skinner was the first person to investigate the relationship between the number of reinforcements given during training and resistance to extinction. He claimed that the number of responses emitted in extinction was a direct monotonic function of the number of reinforcements given during acquisition and he expressed this fact in the form of a ratio between reinforcement and extinction responses- according to his data every reinforcement should produce 20 extinction responses i.e. a ratio of 1:20. (Skinner, 1936), Williams (1938) performed a mammoth study which has become a classic in the field. Using 140 (!) Albino rats as Ss he studied behavior during extinction of a bar pressing response acquired at 4 different levels of reinforcement. Four groups of 35 rats were given 5, 10, 30 and 90 reinforcements respectively and 22 hours later were extinguished. When no responses had occurred in a five minute period, extinction was regarded as complete. William's basic finding was a positive and consistent relations between resistance to extinction and number of reinforcements. However, the ratio of non-reinforced responses to reinforcements becomes progressively smaller with increasing numbers of reinforcements. The ratios were 3,8:1, 3,5:1, 1,6:1, and 0,7:1. It will be noted that in the light of these findings, Skinner's results seem optimistic indeed. Figure 5 below summarises William's findings.

FIG. 5.



In a study which attempted to replicate Williams' results and included the additional independent variable of motivation level, Perin, (1942) investigated "behavior potentiality" after varying numbers of reinforcements. The results indicated that behavior potentiality (resistance to extinction) was "a simple growth function of the number of reinforcements..." (Perin, 1942, p.107).

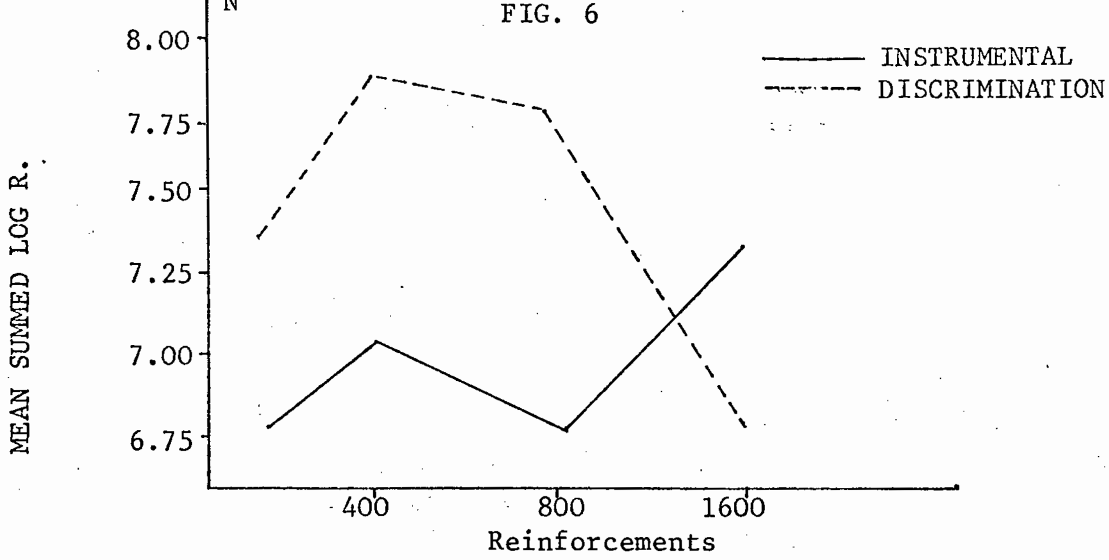
The above relationship was fairly widely accepted for a number of years, but more recent studies indicate that under certain conditions resistance to extinction may not be monotonic. ie. large numbers of reinforcements increase resistance to extinction up to a certain level, but further reinforcements actually decrease resistance to extinction. This finding is however not a consistent one and consequently only a few representative studies will be reviewed.

North and Stimmel (1960) rewarded rats in a straight runway 45, 90 or 135 times and the response was then extinguished. Ss in the 45 reinforcement group showed greater resistance to extinction (running speed) than Ss in the other two groups. Ison (1962) and Siegel and Wagner (1963) also found that above a certain level added reinforcements decreases resitance to extinction. Along with the Williams and Perin studies cited above, a more recent study (Hill and Spear, 1963) does not support the hypothesis that resistance to extinction is an "inverted U" function of number of reinforcements. Groups of rats were given 8, 16, 32, 64, and 138 training trials and were then given 28 trials of massed extinction on one day and 12 on the next. They found that running speed was an increasing function of number of training trials. (One possible interpretation of these results could be that the function had not yet reached its asymptote at 128 trials, thus the failure to produce non-monotonicity.) Bacon (1962) varied reinforcements from 10 to 300 and obtained results very similar to Hill and Spear (above).

One could add many studies to the list, most of which do show monotonicity but many clearly indicating non-monotonicity. There is, however, a study which appears to have given this rather confused area some consistency. D'Amato, Schiff and Jagoda (1962) hypothesised that whether or not non-monotonicity is obtained is a function of the kind of task employed. Where discrimination training is involved a significant decline in resistance to extinction is expected with prolonged acquisition training but monotonicity will be observed where non-discriminative training is involved. Their rationale is as follows. During the initial stages of discriminative training Ss are essentially on a partial reinforcement schedule (ie. they are reinforced during S+ but not during S-), until the discrimination is finally acquired (ie. no responses occur to S-). When this latter phase is reached, however, they are on continuous reinforcement, (CRF). Thus in extended acquisition training the Ss spend most time on CRF and can be expected to extinguish faster than a group of Ss not having experienced CRF for such long periods. There is a vast body of literature to support the contention that resistance to extinction is greater after partial reinforcement than after CRF. (See below). Where discrimination training is not employed, however, this partial reinforcement effect will naturally not occur.

To test this hypothesis 4 groups of Ss were trained on a simple instrumental response (a bar press) and allowed 200, 400, 800, or 1600 reinforced responses. The same number of reinforced responses were given to four corresponding groups of discriminatively trained Ss, the procedure employed differing only from the former in having occasional S- periods. All groups were exposed to 1 x 10 minute extinction periods on each of five successive days. Ss receiving extended acquisition training emitted fewer responses in extinction than Ss receiving only a few reinforcements on a discrimination task, but as a group emitted more responses than the non-discriminatively trained group. There results are summarised below.

FIG. 6



One may conclude, therefore, that discrimination training coupled with a large number of reinforcements are the critical variables essential to a non-monotonic relationship between number of reinforcements and resistance to extinction. (In passing, it is worthwhile mentioning a technique which lends itself to the more direct testing of this hypothesis. Terrace (1963) has developed a special training technique known as "errorless discrimination". With the use of this technique Terrace has demonstrated that if S- is introduced gradually, it is possible to establish a discrimination without any S- responding at all. It is not necessary to go into the procedural complexities here, but suffice it to say that if D'Amato et al, above, were to use this procedure for two groups of animals giving one group many more reinforcements than the other, the controbution of S- responding to the non-monotonicity effect could be adequately analysed).

2 c. DEPRIVATION LEVEL AND RESISTANCE TO EXTINCTION.

Drive level during acquisition and extinction has been studied in three major ways. In the first, response measures during acquisition are compared for groups of Ss, drive differing for each group. The other two methods look to measures taken after acquisition for evidence that drive strength during acquisition made a difference. In the first of these other two methods Ss are trained under different drive strengths, then the strength of what was learned is studied under extinction during which all Ss perform under the same drive strength. The second of these methods uses a factorial design in which a number of groups are trained under several drive strengths but during extinction each group is divided so that there is one subgroup which is extinguished under each drive level utilised during acquisition. The latter two methods are of relevance to extinction and will be briefly discussed here.

Extinction and drive during acquisition.

The earliest experiments on this problem used the procedure of training animals under different drive strengths and then testing all the Ss for resistance to extinction under identical drive. Thus Finan (1940) gave his Ss 30 reinforcements in a bar pressing situation under either 1, 12, 24 or 48 hours of food deprivation and then later put them all on extinction under 24 hours deprivation. He found that animals extinguished under 12 hours deprivation produced most responses in extinction. Other workers, however, (eg. Strassburger, 1950, and Carper, 1953) using similar procedures did not find extinction differences as a function of drive strength during acquisition. There is one important weakness with this kind of design. For many Ss acquisition drive strength and extinction drive level are different. Different drive levels undoubtedly have associated with them different stimulus patterns- whether an animal has been deprived for 2 or 24 hours will produce different sets of internal stimuli arising from various degrees of stomach distention and other physiological factors. If we change drive level we are simultaneously changing the stimulus pattern under which the animals were trained. On the basis of stimulus generalization, therefore, one would naturally expect a decrease in response strength as we go from the stimulus pattern associated with the drive level used during acquisition to another stimulus pattern associated with a new drive level during extinction. Consequently changes in drive between acquisition and extinction do not produce pure tests of the effect of drive level during acquisition. There is also the additional possibility that a change from low to high drive may not be the same as a change from high to low. While this latter quibble is a difficult one to eliminate an improved method for studying the general problem is afforded by factorial experiments.

In the typical factorial design groups of Ss are trained under different drive levels, but during extinction subgroups of animals trained on varying drive levels, are extinguished on all of the levels used during acquisition. This design is best illustrated in the following diagramatic form.

TABLE 1

Table 1. Factorial design for studying the effects of drive on habit strength.

Drive during test (eg. extinction) >	0	6	12	24	
Drive during acquisition (hours of deprivation)					Mean values for habit strength
0					X
6					X
12					X
24					X
Mean value for extinction >	X	X	X	X	

It can be seen from the table that the mean value of the rows show the influence of drive during acquisition on extinction. The column means show extinction at various drive levels with all drive levels during acquisition represented.

Using the above design, Kendler, (1949b), Hillman, Hunter and Kimble (1953) and others found no influence of drive during acquisition on resistance to extinction. Campbell and Kraeling (1954), Lewis and Cotton (1957) and Barry (1958) however, found that drive during acquisition did have an affect on the early extinction trials. Even the use of factorial designs is obviously insufficient to produce consistent results. The "quibble" mentioned above may be at the root of the trouble. Davis (1957) noted that little effect on performance was achieved by shifting drive from high to low but he did find marked effects when drive was shifted from low to high. Factorial designs inevitably involve shifts in drive both ways and in some cases these shifts may not cancel each other out. Prima facie it does not seem easy to control for this aspect. Another explanation goes as follows. When the operant under investigation is examined in more detail, it is noticeable that animals may in fact learn different things under different levels of motivation. The conventional all-or-none approach misses these subtleties. Cotton (1953) trained groups of rats to run a runway, then tested the groups at different times under 0, 6, 16 or 22 hours deprivation. Cotton did not just look at runway speeds in extinction but broke the trials into classes- (a) those in which Ss ran directly to the goal box. (b) Those in which competing responses appeared (e.g. grooming, retracing etc.) Using this dual analysis he found that on trials categorised as (a) running times did not vary with deprivation level, but in trials categorised as (b) increased deprivation lead to increased resistance to extinction. In other words, low drive does not cause Ss to run slower but merely to engage in more competing responses. (This result is analogous to the data on response rate during extinction noted earlier. When the animal responds the rate is just as high as in acquisition; pauses however, become progressively longer).

Ferster and Skinner (1957) support this contention. Pigeons were maintained on a fixed ratio schedule where every 110th response was reinforced

(FR110) for several months, during which their body weights were varied over a wide range. The principle effect was on the pause after reinforcement. As the deprivation level increased the length of the pause decreased. The local rates of responding showed very little sensitivity to even wide ranges of deprivation (68% - 90% of ad libitum weight). Unfortunately (for our purposes) Ferster and Skinner do not give extinction data for these Ss.

In a minor experiment on this topic carried out in the writer's laboratory 4 pigeons were trained to peck a key for reinforcement on a FR10 schedule of reinforcement. Deprivation level for all birds was 80% of ad lib weight, and the number of responses and reinforcements during acquisition was held constant for all Ss. Immediately before extinction was instituted, two birds were reduced to 70% and two allowed to reach 90%. The extinction criterion used was number of responses emitted in 2 x ½ hour sessions. No significant differences were found between the two groups. Although the results of this small study cannot be taken as difinitive when viewed alone, when seen in the light of the literature they seem to be fairly representative of a somewhat confused field. Perhaps one could conclude by saying that obviously during acquisition phases some motivation is necessary to get Ss to behave, work for food, etc., but above this minimum requirement drive level does not appear to affect simple operant responses. Where such effects are found they can often be explained (though perhaps not explained away) in terms of some of the additional factors mentioned above. (In passing it is interesting to note an observation made in the writer's own laboratory. Once animals have acquired an operant they will often emit it even at apparently "zero" motivation. There is one particular bird in the pigeon colony that can be placed in a Skinner box without any deprivation procedure at all. He will often emit hundreds of responses at a very high rate (5 responses/

second) under such conditions).

2 d. THE EFFECT OF DIFFERENT INTER-TRIAL INTERVALS (ITIs) ON EXTINCTION

Pavlov stated that "The shorter the pause between successive repetitions of the stimulus without reinforcement, the more quickly will extinction of the reflex be obtained, and in most cases a smaller number of repetitions will be required". (Pavlov, 1927, pp. 52-53). He made this statement on the basis of an experiment on conditioned salivation. Using ITIs of 2, 4, 8 and 16 minutes he noted that extinction of the response took 15, 20, 54 and over 120 minutes respectively. In other words massed trials produced faster extinction than spaced trials. Hilgard and Marquis (1935) produced additional evidence for this contention while studying conditioned eyelid responses in dogs. They found that when ITIs varied between 20 and 40 seconds extinction was rapid, but when trials were given on alternate days, little decrement was shown. One of the first studies on the relationship between ITIs and the extinction of an instrumental response appears to have been performed by Gagne (1941). Using a runway, he found that extinction was speeded up when ½ and 1 minute ITIs were used, but slowed down significantly with an ITI of 2 minutes. The one confusing aspect of this study, however, is that extinction was also speeded up if ITIs of <u>more</u> than 2 minutes were used. Although these results oppose Pavlov's notion to a certain extent, they are complicated by the fact that only five extinction trials were used. Subsequent studies often show that significant differences only reveal themselves after 5 trials.

Rohrer (1947) used a modified Skinner box apparatus which enabled the use of discrete trails. The rat was placed in a moveable stock which held its head firmly in place and allowed it access to a food cup and a lever. When the stock was in position below the lever the animal could activate the lever and obtain food. The results of this study must be viewed with caution, because they were complicated by the fact that deprivation and number of training trials were varied, but if we use the data of animals that match previous studies in terms of number of training trials and drive level, they show that massed trials produce faster extinction.

As in the area of drive and extinction, increasing use of factorial designs helped to bring greater clarity to this area. Sheffield (1950) using a simple factorial design trained rats to run down an alley in order to obtain food. Half the animals were trained on a 15 second ITI and half with a 15 minute ITI. For the extinction trials these groups were further sub-divided: half were extinguished with a 15 second ITI and half with a 15 minute ITI. Surprisingly enough extinction was more rapid when extinction trials were spaced, but this result must be attenuated by the fact that the spaced group had been trained on a 15 second ITI. For the group trained on massed trials, spaced extinction was faster. The factor of overriding importance in this study is obviously the relationship between training and extinction trials. The account of extinction using notions from stimulus generalization is obviously as relevant here as it was in the previous section. But a result which cannot be explained in this way is the fact that the group trained on spaced trials did not show differences in extinction regardless of the extinction ITI.

A study which produced more consistent results is that of Teichner (1952). He also investigated the course of extinction as a function of the ITI during acquisition and extinction. Two experiments were conducted each involving the training of a group of Ss with a single ITI and then subjecting subgroups of these Ss to extinction involving different ITIs. The results indicated that (1) acquisition is more rapid with longer ITIs. (2) Resistance to extinction is greater when the same ITI is used during acquisition and extinction; (3) holding other variables constant, massed trials produced more rapid extinction than spaced trials. Point (2) is, of course consistent with the stimulus generalization interpretation mentioned earlier. One group of researchers paid special attention to this aspect since they wished to minimise the effects of a change in ITI by exposing all Ss during acquisition in a Y maze to a sample of the ITIs they would experience during extinction. All animals experienced ITIs in acquisition varying from 20 seconds to 24 hours and subgroups of Ss were also extinguished on these same intervals. Animals in the 24 hour group (1 trial per day) showed the greatest resistance to extinction. (Cole and Abraham, 1962). Thus although there are a few contradictions in this area it can be stated with a fair degree of reliability that extinction will be more rapid, all other factors held constant, if trials are massed together than if they are spaced. But the exact empirical values of "massed" and "spaced" are yet to be established.

2 e. EFFORT AND RESISTANCE TO EXTINCTION

It would seem logical that a response requiring a great deal of effort would be more easily extinguished than a response needing less effort. But is the "logical" necessarily the empirical in this case? Is there a direct relationship between degree of effort and resistance to extinction? Mowrer and Jones (1943), using a modified Skinner box in which bar pressures could be varied, investigated this relationship. Rats were trained to press the bar in order to obtain food and the pressure needed to activate the feeder varied: ie. day 9-5 grams, day 10-30 grams, day 12-55 grams, day 13-80 grams, etc. Thus all animals experienced a variety of pressures during training. On the 19th day Ss were randomly divided into three groups, and each group extinguished on either 5 grams effort -

42,5 grams or 80 grams. The extinction criterion used was number of responses emitted during 3 x 20 minutes daily sessions. Results clearly indicated that effortfullness of the task is inversely related to the number of responses. The group extinguished on 5 grams made the greatest number of responses; the group extinguished on 80 grams the least number and the middle group an intermediate number.

These results are certainly "logical" but unfortunately they are also unreliable. A careful examination of the Mowrer and Jones procedure reveals that many more reinforcements were given to animals in the two lower groups (5 grams and 42,5 grams) than in the high effort (80 grams) group. One would certainly expect therefore, the last mentioned group to emit fewer responses in extinction because the 80 gram response had received the fewest reinforcements in acquisition.

Like the above study many of the more recent studies on effort and extinction are open to alternative interpretations because there are confounding variables such as number of reinforcements (Solomon, 1948); variable complexity of the operant response (Applezweig, 1951; Montgomery, 1951) and different reinforcement delays (Thompson, 1944). One study which controlled for most of these factors is that of Capehart, Viney and Hulicka (1958). They utilized an experimental design in which all Ss received the same experience during acquisition on each of the effort levels of which the response was subsequently to be extinguished. Bar loadings scheduled were (in sequence) 5, 40, 70, 5, 70, and 40 grams, so that after acquisition each S had performed a total of 90 responses, 30 responses on each bar loading. Ss were then randomly assigned to three groups and each group extinguished on either 5, 40 or 70 grams. The results clearly indicated that resistance to extinction is a function of the amount of effort required to make the response. Incidentally, the results obtained conform almost exactly to those of Mowrer and Jones

(1944) indicating that the criticisms levelled at this study may be irrelevant.

However, there are other criticisms which cannot be treated as lightly. During conditioning an animal does not merely learn to press a lever for food, but learns to press it in a particular way. In an earlier section on response changes in acquisition and extinction we elaborated on this point. According to this reasoning, the animal learns to press the lever with, say, a certain force. If we require the animal to make forceful responses in acquisition then forceful responses will be emitted in extinction. Conversely, if we require the animal to make responses needing little effort in acquisition then responses of a similar force will be emitted in extinction. However, and this is the important point, weak responses in extinction will not activate the counting mechanism if strong responses are required. Consequently Ss in this category will be seen to be less resistant to extinction, whereas they could be making many incomplete responses. Stanley and Aamodt (1954) attempted to get around this difficulty by measuring both complete and incomplete responses in extinction. Half the Ss were trained with a 50 gram force requirement and half with a 100 gram requirement. Before extinction these groups were further sub-divided and then extinguished on either 50 or 100 gram. The results are reproduced below.

TABLE 2.

Median Lever Presses during Extinction
(Stanley and Aamodt, 1954)

Group+	Complete R's	Incomplete R.s	Total R's
50-50	79.0	10.0	89.0
100-50	88.0	5.0	93.0
50-100	44.5	35.5	74.0
100-100	49.0	14.5	62.0

+ The first number in the designation for each group stands for the force, in grams, required to press the lever during conditioning; the second number is the force required during extinction.

It can be seen from the table that the most responses in extinction were produced by the group trained on 100 grams but extinguished on 50. Logically enough they also produced fewer incomplete responses. However, the group trained on 50 grams and extinguished on 100 grams produced the most incomplete responses. Ss trained and extinguished on 100 grams showed the best resistance to extinction which tends to indicate that work required <u>is</u> an important aspect of resistance to extinction. But it is nevertheless clear that including incomplete with complete responses tends to attenuate this effect.

However, another study which indicated that increasing work requirement does not always decrease resistance to extinction is that of Lawrence and Festinger (1961). Using a runway they trained rats to run on either a 25 degree or a 50 degree incline to get to the goalbox. Extinction was regarded as complete when Ss had run four trials of more than 90 seconds duration. Results showed that Ss trained on the 50 degree incline ran faster in extinction than Ss trained on 25 degrees and emitted more runs before the extinction criterion was met. Surprizingly enough, this experiment indicated that the more work required, the greater resistance to extinction will be! Evidently this is one (?) area where much additional research is needed.

3 a. REINFORCEMENT SCHEDULES AND RESISTANCE TO EXTINCTION

The one variable which has possibly the greatest effect on the number of responses emitted in extinction is that of the reinforcement schedule. Traditionally acquisition is an all-or-none affair- the desired response is either rewarded or it is not. But there are of course numerous possibilities for the way in which reinforcements may be scheduled. Possibly the most fundamental criterion separating the effect of reinforcement schedules on resistance to extinction is the answer to the question: Is reinforcement given 100% of the time? The answer normally leads to a two-fold division of schedules:

(1) continuous reinforcement (CRF) and

(2) partial reinforcement (PRF).

(1) refers to cases where every trial or every correct response is rewarded and (2) to cases where reinforcement is given at least once but omitted on one or more of the trials, or after one or more responses in a series. It is the effect of these two categories on (3) extinction (EXT) which is of interest to us here. Extinction, as has been mentioned earlier, refers to cases where an operant that has been reinforced at least once is followed by prolonged non-reinforcement.

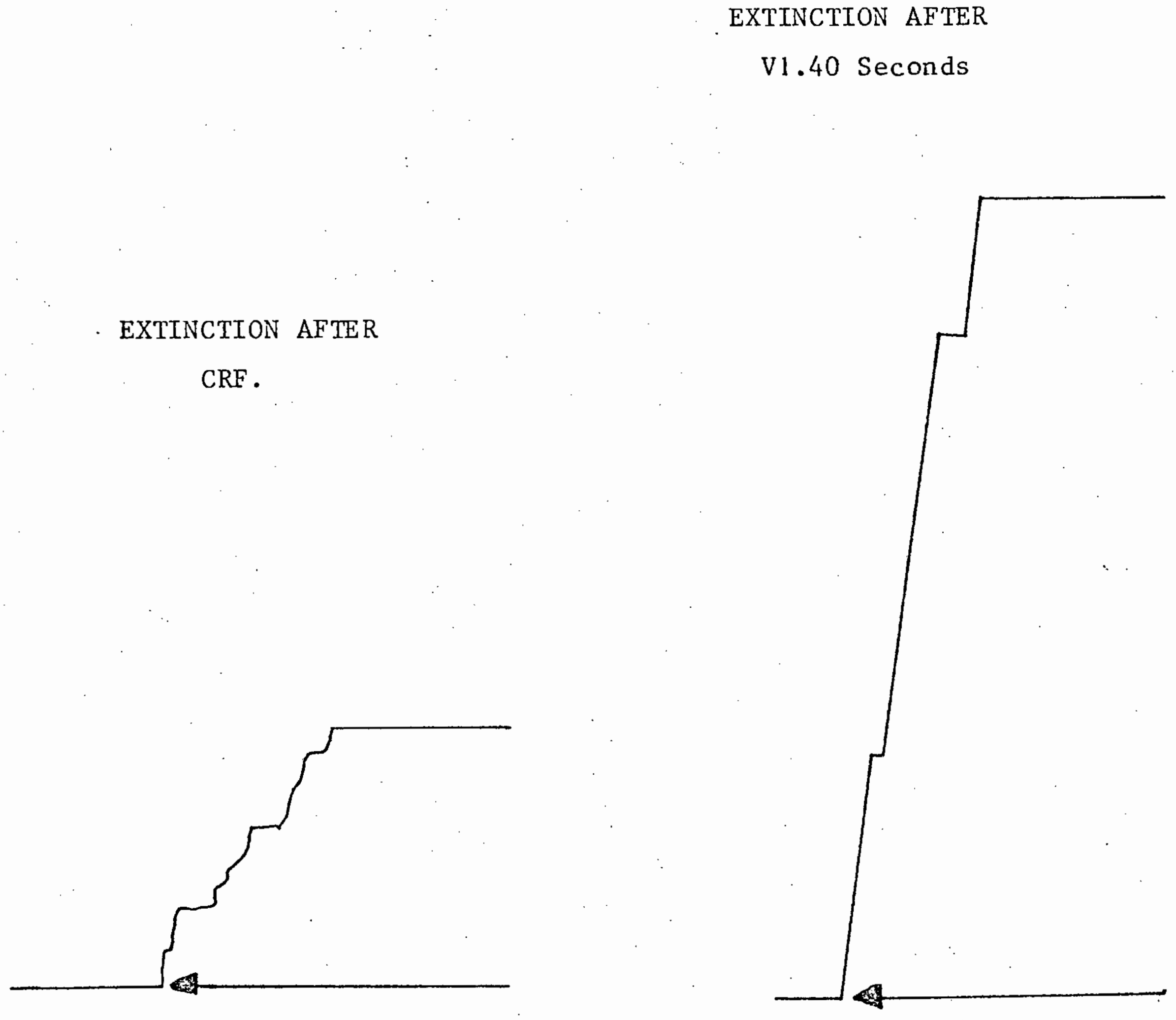
The development of ideas regarding reinforcement scheduling can be traced back to Platonov (in Razran, 1934). In an experiment performed in 1912 he found that after a conditioned response (CR) had been established, the unconditioned stimulus (UCS) had only to be applied to the first trial of each day to maintain the CR. He makes the important additional point that reinforcements should be scheduled on "optimal distributions" because many experimenters do not realize the inefficiency of CRF. Considering the immaturity of learning theory in 1912 these points were advanced indeed.

Pavlov (1927) was far from ignorant of the effects of reinforcement scheduling. He in fact performed an experiment in which three different patterns of PRF were used. In the first the CS was applied with food on every second trial (Fixed Ratio (FR) 2) and it was noted that conditioning occurred no less rapidly than in the usual procedure (CRF). In the second an FR3 schedule was used and once again conditioning occurred rapidly, but it is of interest to note that the dog became quite "excited". Here is possibly one of the first indications that PRF schedules may have aversive properties - a finding of central importance to the present work. When, however, an FR4 schedule was used no conditioning occurred even after 240 trials. If, however, Pavlov had slowly increased the response requirement from 1 to 4, this effect would probably have not occurred.

It was Skinner (1933), however, who firmly established reinforcement scheduling as one of the central areas in learning theory. He conceived of the idea of "periodically reconditioning" Ss by giving reinforcement to the first response that was emitted after a fixed time interval had elapsed. It was this procedure which was later called "periodic reinforcement" (presently Fixed Interval, FI). In a slightly later paper (1936) he studied behavior as a function of the number of responses per reward, calling this regimen "reinforcement at a fixed ratio". (Presently fixed ratio (FR) reinforcement). Mainly as a result of Skinner the 1940's saw a spate of work on the effects of reinforcement scheduling on resistance to extinction. It is not indended to give a comprehensive review of this and subsequent literature, but merely to pick out those studies which have made a substantive contribution to the field. An excellent broad over-view of the area may be obtained in Jenkins and Stanley (1950) and Lewis (1960).

It was through the study of extinction that Skinner came upon the phenomenon of "periodic reconditioning". He reports on an experiment in which extinction was instituted but shortly followed by reinforcement. A second extinction curve appeared but with a steeper slope than the first. If a further reinforcement followed after a 5 minute delay an even steeper curve ensued. After numerous such reconditionings the successive curves summated until a complete fusion occurred and responding was maintained at a constant value. The rate is so stable under periodic reconditioning that it will continue unchanged for as long as 24 experimental hours covering 47 days. The effects on extinction of such a periodic schedule are numerous. Unlike the curve produced after CRF the curve after periodic reinforcement is absent of cyclic deviations. Skinner feels that this difference is due to the adaptation of the emotional effects which normally occur at non-reinforcement. Another difference produced by periodic reinforcement is a reduction in the rate of decline. Normally after CRF the extinction curve is initially very steep but tapers off rapidly. After periodic reinforcement the initial rate is fairly low but it continues at this rate for protracted periods so that the animal shows great resistance to extinction. In figure 7 (below) the effects of CRF and periodic reinforcement on extinction are shown. The rate reduction, persistence and absence of fluctuations after periodic conditioning are obvious. Skinner concludes by saying "In my experience no amount of continuous reconditioning will yield an extinction curve of the height obtained through even small amounts of periodic reconditioning". (Skinner, 1938, p. 138).

FIG. 7.



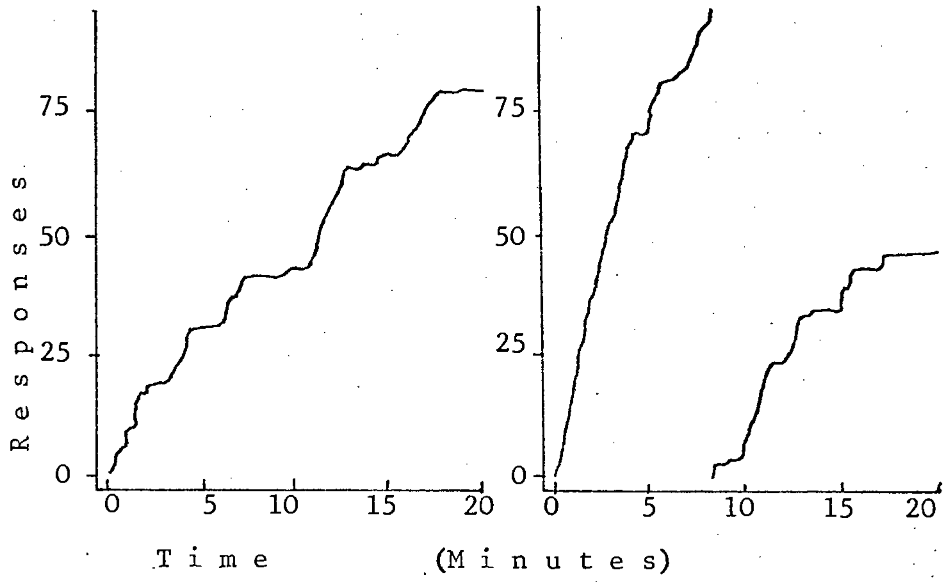
EXTINCTION AFTER CRF.

EXTINCTION AFTER VI.40 Seconds

Surprizingly enough, however, although Skinner had clearly stated the effects of PRF on extinction, it was the work of Humphreys (1939), which stimulated interest in this particular area. He performed three experiments using human Ss each producing the same basic result. The first utilized a conditioned eyelid response, the second a verbal response and the third a conditioned psychogalvanic skin response. The experimental design was the same in each case; Ss were divided into 2 groups: The first group received the UCS after the CS 100% of the time (CRF) and the second 50% of the time (FR2). The results showed quite clearly that the group reinforced only 50% of the time showed greater resistance to extinction than the 100% group. This effect which was temporarily labelled the "Humphrey's Effect" led to a considerable amount of research on partial reinforcement. Mowrer and Jones (1945) trained groups of rats on five different schedules, FR1, FR2, FR3, FR4 and variable ratio 2,5 (VR2,5 reinforcement on average every 2,5 responses). The results showed that the higher the ratio employed the greater resistance to extinction.

The cumulative records for day 1 of extinction (below) show the greatly increased rate of response in the FR4 group, the relative absence of fluctuations and the increased height of the curve.

FIG. 8.



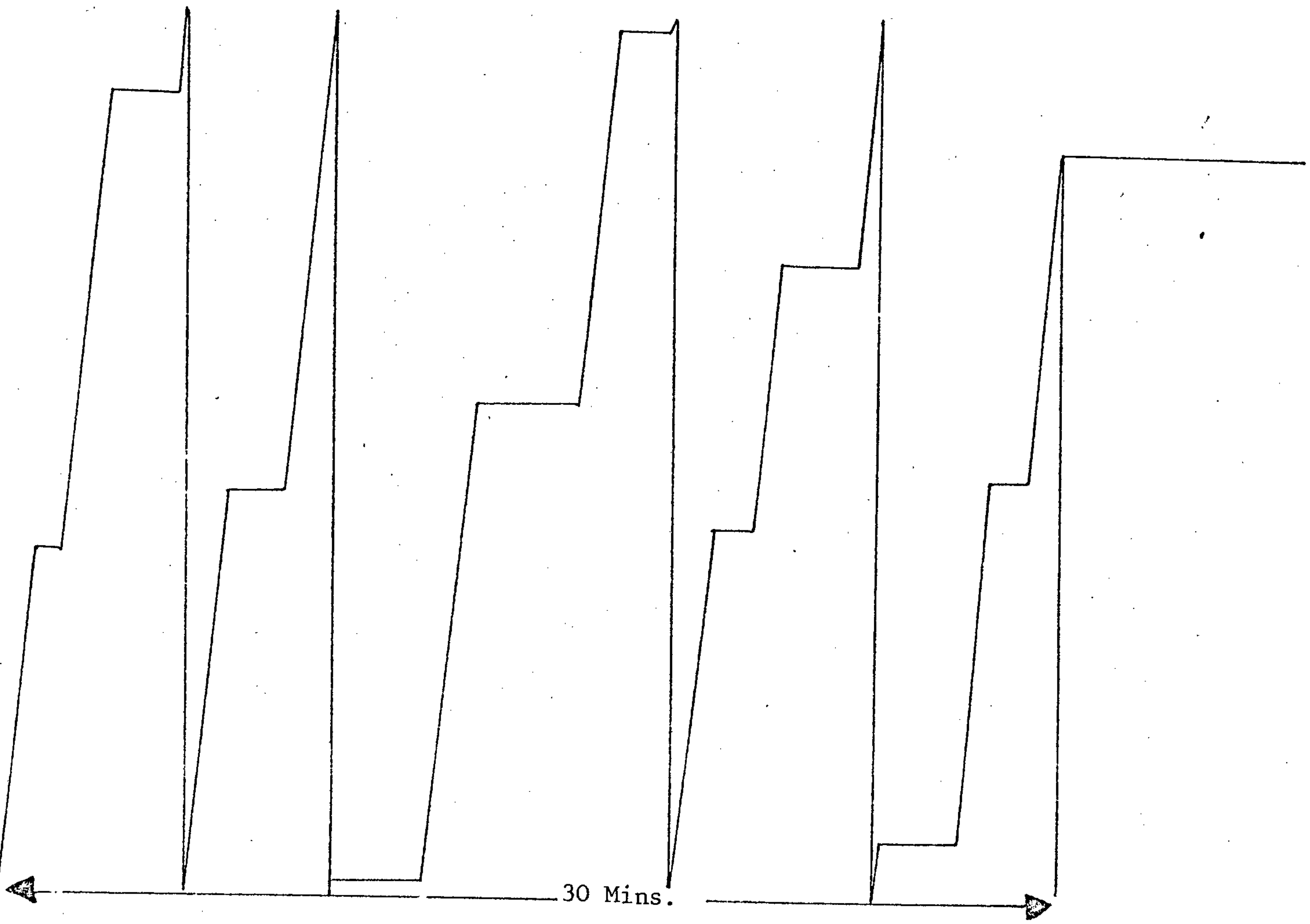
Extinction after FR1.   Extinction after FR4.

The results for the VR2,5 group are interesting because they conform to expectations. Under this schedule Ss will be reinforced sometimes on every 5th response, sometimes every 2nd response etc. giving an average of every 2,5th. It follows, therefore, that they should show greater resistance to extinction than the FR2 group but not as much as the FR3. This was in fact the case. Unfortunately the authors do not give cumulative records for this group; it would be interesting to compare their form with those of the other groups.

During the 1940's over 30 studies were performed to test the relative effectiveness of partial reinforcement as opposed to continuous reinforcement. In an extensive review of this work by Jenkins and Stanley (1950) it was concluded: "all other things being equal, resistance to extinction after partial reinforcement is greater than that after continuous reinforcement when behavior strength is measured in terms of single responses" (p. 222). Well over 20 years later this conclusion is still a valid one.

The following section will concentrate on Ratio schedules since they are of central importance to the present thesis. Extinction after FR shows clearly the controlling effects of the schedule. Under Fixed Ratios the faster the animal responds the greater the reinforcement frequency. Consequently in extinction responses are emitted at the high rate shown in acquisition. The figure below shows extinction after a history of

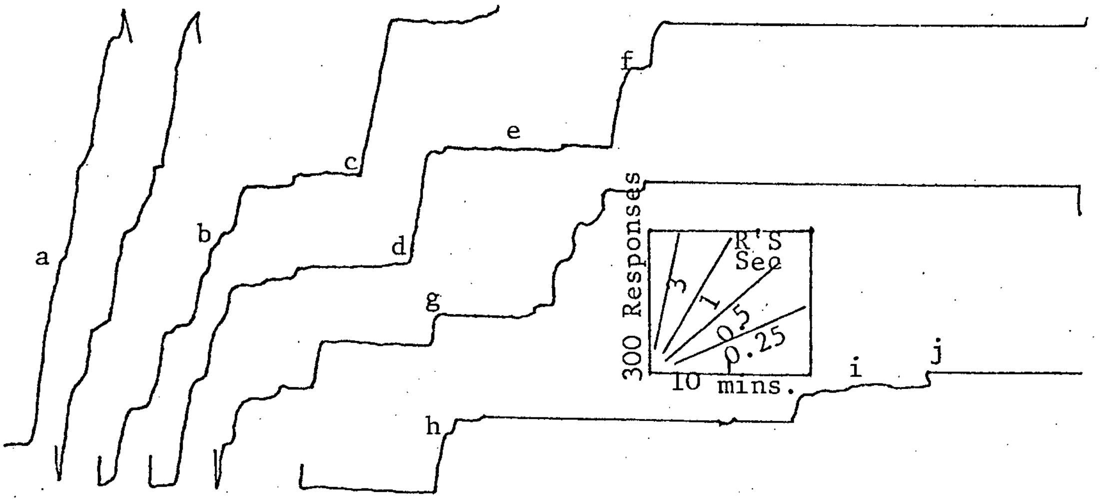
FIG. 9.



12000 reinforcements at FR50. The average rate of response is approximately 5 responses/second even at the end of the session. Transitions from high rates to pausing occur abruptly and medium rates are rarely seen.

Figure 10, taken from Ferster and Skinner (1957) shows the effect of a very long history of FR60. The bird concerned has been given 14000 reinforcements on this schedule with a total history of 35000 reinforcements on various FR schedules. The basic features of the curve are the same as in Figure 9. The terminal rate is as high as that during acquisition but negative acceleration soon sets in and pauses become progressively longer. However, because of the longer history the total number of responses emitted is much greater.

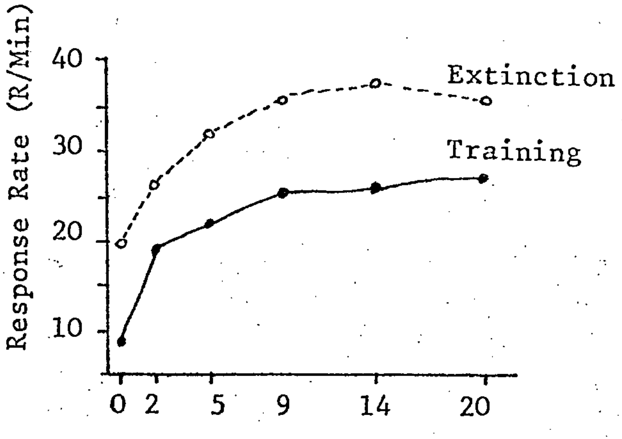
Fig. 10.



Extinction after FR 60

Boren (1961) studied resistance to extinction as a function of the fixed ratio value employed in acquisition. He divided his 36 Albino rats into groups of 6 and after the usual CRF training procedure assigned an FR value of either 1, 2, 5, 9, 14 or 20 to each group. The results are graphically represented below.

Fig. 11



The average response rate for each fixed ratio schedule. The solid curve represents the rate at the end of training while the dashed curve shows the rate for the first 2 minutes of extinction.

The figure compares rate at the end of training with the rate for each group during extinction and shows that as the size of the FR was increased from group to group the rate increased in a negatively accelerated way. During extinction the rate also increased with the size of the FR used in acquisition and the curve was also negatively accelerated. The criterion of extinction used was number of responses emitted in 5 daily extinction sessions. The rank order of the size of the FR correlated exactly with the rank order of the number of extinction responses on day 1 and 2. Boren maintains that the extinction function reaches a maximum at a ratio "somewhat greater" than 20 and then declines as the ratio is increased to very high values. Determining the empirical values necessary to support this contention will obviously come from additional research.

In a study using variable ratios, Hearst, (1961) showed that resistance to extinction is a function of the number of responses per reinforcement in acquisition. This study is of additional interest because of the experimental design. One difficulty in studying extinction is that each animal can yield only one extinction curve. After retraining definite changes occur in subsequent extinctions. Consequently groups of animals are usually trained, each group experiencing a different value of the independent variable. The problem with this type of design is that no single S experiences all the values of the independent variable. Generalization to individual subjects from such group data is often said to be of dubious value, but as will be shown the risk involved has probably been over-estimated. Hearst's design overcomes the difficulty regarding generalization because each S does experience every value of the independent variable. He used 4 pigeons as Ss, training them to peck a lighted response key with various VR schedules programmed to be operative during the prescence of different key colours. When a particular colour was on a VR4 was operative and when a third a VR10. Responses were never reinforced in the prescence of a fourth colour. These four schedules were correlated with different colours for each S so as to control for individual colour preferences. Each colour remained on until 5 reinforcements had been obtained and the experimental chamber was then darkened for 1 minute between different colour presentations. After responding had stabilized under this regimen extinction began. Each of the colours was presented in random sequence for 30 second periods followed by 10 second periods of darkness. In an analogous way to the Boren (1961) study Ss experienced the same number of reinforcements in the presence of each colour and had equal time available for responding during extinction. Hearst's results were quite clear. Each S exhibited an increasing function relating the number of responses to a particular colour during extinction to the value of the VR schedule correlated with that colour during training. The greater the value of the VR the greater resistance to extinction. From an experimental design point of view, the substantial agreement between these latter two studies suggests that in a free-operant situation the function for individual Ss trained on each of several schedules is virtually identical to that based on averaged data for independent groups.

4 THEORIES OF EXTINCTION

a. INHIBITION THEORIES.

Experimental extinction probably provides the most basic form of inhibition. Successive non-reinforcement of a previously reinforced operant according to this view produces a negative reaction potential. The response produced inhibition theory is in a sense the major classical theory of extinction nad has been virtually extinguished by contrary evidence. It is the theory, however, which has been used extensively in building better theories and deserves detailed attention. Since Hull (1943) has given the clearest statement of the theory we will concentrate on his views though at the same time noting the development of concepts regarding inhibition.

Whilst studying conditioned salivation in dogs, Pavlov (1928) came across a number of phenomena which he felt could only be explained by fairly elaborate notions regarding cortical functioning. Basically, afferent stimulation causes an area of excitation in the cortex which then spreads throughout the cortical "analyser" system. The UCS will produce an area of stronger excitation than the CS and the latter's excitatory area will consequently be attracted to that of the former. A link is therefore formed between the two areas. However, when the CS is repeatedly presented without the UCS (extinction) inhibition is produced which spreads through the cortex weakening the previously formed stimulus bond. Pavlov, (1930) originally believed that the strength of either excitation or inhibition was positively correlated with the intensity of the stimulus, but when it was noted that weak stimuli sometimes elicited stronger responses than more intense stimuli, he postulated the notion that cortical cells might have different excitability capacities depending on factors such as age and fatigue (Kimble, 1960). Consequently the fact that very intense stimuli sometimes had a disrupting effect could be "explained" by the view that the capacity of the cells had been reached and that a protective inhibition had occured to limit the spread of excitation.

Thus far we have looked at Pavlov's notion of internal inhibition, ie. inhibition intrinsic to stimulation. Pavlov introduced the concept to explain the following phenomena (1) extinction (2) spontaneous recovery (showing that the effect is not an abolition but merely a suppression) (3) the stimulus to which a response is inhibited (extinction) becomes a conditioned inhibitor since it can weaken the effects of other stimuli with which it is paired (4) if extinction is continued below zero (ie. well after the CR no longer appears) the conditioned inhibitory effects are further enhanced and spontaneous recovery of the extinguished response is delayed.

One other kind of inhibition needs to be dealt with here. Pavlov noticed that during conditioning distractions from outside the laboratory would induce orienting or defensive reactions from the Ss and consequently the CR would be weakened. Pavlov called this external inhibition. If the distractions occured during extinction, however, the effect would be to inhibit the inhibition and increase the strength of the response. This process Pavlov called disinhibition. External inhibition acted on whatever process was dominant at the time.

Later workers, however, tended to shy away from these neurological speculations and dealt with extinction in terms of stimulus-response relationships. Hovland, (1936) found that when trials were spaced closely together in training retarded performance often resulted. He called this a process of "inhibition of reinforcement" maintaining that the omission of reinforcement at the onset of extinction produced such stimulus change that disinhibition ocurred. On the basis of this assumption he predicted that extinction curves after massed and spaced training should differ. The response he investigated was the galvanic skin response (GSR) and his predictions were confirmed. Extinction after widely distributed reinforcements showed the usual rapid decline but after massed reinforcements there was an initial <u>increase</u> in response strength (suggesting to Hovland disinhibition) followed by the usual decline.

These developments in learning influenced Hull very strongly. However, his particular notion of inhibition also took the work of Miller and Dollard (1941) and Mowrer and Jones (1943) into consideration. The former authors analysed the role of muscle fatigue and pain in extinction. They use the example of a child crying. Prolonged crying produces stimulation from soreness and tenseness in the throat and fatigue. Stopping crying reduces the strength of these stimuli and in this way responses involved in stopping crying are rewarded. Muscle strain and fatigue are therefore drives constantly motivating the subject to stop the response he is making, and the authors conclude "....mere repetition does not strengthen a habit..... Instead non-rewarded repetitions progressively weaken the strength of the tendency to perform a habit" (P42)

Mowrer and Jones (1943) investigated the role of effort in extinction (reviewed earlier) and showed that the greater the effort demanded in extinction the lesser the resistance to extinction. Although this view has subsequently been challenged it formed an essential aspect of Hull's notion of inhibition.

Hull, (1943, 1952) attempted to develop a comprehensive behavior theory. One important aspect of the theory dealt with extinction and spontaneous recovery in a very similar manner to that of Pavlov. Hull assumed that whenever an organism makes a response it generates some inhibition to future responding - ie. a response produced <u>reactive inhibition</u>.

> "Whenever a reaction (R) is evoked from an organism there is left an increment of primary negative drive (IR) which inhibits to a degree according to its magnitude the reaction potential

(SER) to that response" (Hull, 1952, p.9).

Each response produces reactive inhibition whether reinforced or not, as an increasing function of the rate of response elicitation and the effortfulness of the response. When the response is reinforced the positive effect of reinforcement overcome the negative effects of reactive inhibition. When, however, trials are massed together in a long series there is little time for the dissipation of reactive inhibition and response strength might decline despite reinforcement. Although there is some evidence for this view besides the already discussed work of Hovland (1937), (eg. Kendrick, 1958), the bulk of evidence tends to oppose this notion. The literature of the experimental analysis of behavior abounds with examples where experimental animals have emitted responses at the rates of up to 15 responses/second non stop for periods of up to 2 months. (eg. Ferster and Skinner, 1957). No decrement in performance is noted under these circumstances. Perhaps it is during extinction that the predictions of response-produced inhibition theory are slightly more fruitful. During extinction there will be no counter-active effects of reinforcement and so inhibition tends to build up rapidly, the organism eventually ceasing to respond altogether. But since reactive inhibition dissipates over time a recovery of strength would be predicted after a time delay. (ie. spontaneous recovery). However, spontaneous recovery is never complete and so Hull postulated a second factor, conditioned inhibition. According to Hull the reduction of reactive inhibition will be reinforcing (ie. drive reducing). The "activity" most closely associated with drive reduction is "not responding" and consequently a new habit will be formed on the first occasion of this association and will be strengthened on each suceeding sequence of: (a) response, (b) reactive inhibition, (c) reduction of reactive inhibition by response cessation, (d) reinforcement of this cessation. Hull called this new response conditioned inhibition. (SIR).

> "Stimuli or stimulus traces closely associated with the ceasation of a given activity, and in the presence of appreciable IR from that response, become conditioned to this particular non-activity, yielding conditioned inhibition (SIR) which will oppose SER's involving that response, the amount of SIR generated being an increasing function of the IR present" (Postulate IX, corollary IX).

Extinction, therefore, according to this theory is due to an active inhibition of the response. The inhibition has two ARs - reactive inhibitionwhich is temporary and dissipates with rest, and conditioned inhibition which is permanent. Spontaneous recovery occurs becuase the former has dissipated, and is never complete because the latter has not.

Because reactive inhibition develops even when responses are reinforced its effects should be prominent in a variety of situations. For example, extinction should be more rapid when trials are massed closely together than when they are spaced apart. Generally speaking, most experiments support this prediction.

Another prediction on the basis of the IR concept would be that extinction should be more rapid in an effortful task than in a relatively effortless task. As has been noted earlier the relationship between effort and extinction is still largely uncertain and for every experiment that supports Hull's notion, there is one that does not.

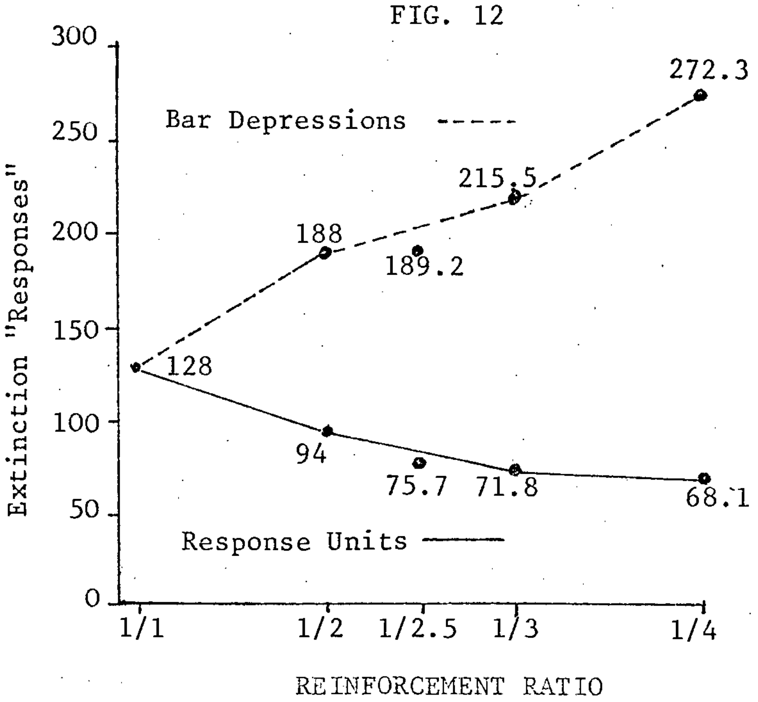
Even though the effects of effort and trial spacing on extinction are unclear, some of the data could still be held to support the inhibition notion. But the data from reinforcement schedules places the theory into insuperable difficulty. We have already shown that resistance to extinction is greater after partial reinforcement than after continuous reinforcement. According to Hull an animal on a CRF schedule should experience

IR as a function of response emission but that much of this IR will be cancelled out by SER produced by reinforcement. Consequently on a CRF schedule the rate of inhibition build up should be low. On say an FR5 schedule however, 1 response will be strengthened by reinforcement (and slightly weakened by inhibition) whereas 4 responses will produce nothing but inhibition. The net effect of this regimen should be rapid build up of inhibition, and performance decrement. However, an FR5 schedule will show a rapid response rate (up to 8 responses/second in the pigeon) without any evidence of decrement over a period of many months. In extinction the effects are even more striking. The animal trained on FR5 will emit thousands of responses more than the CRF trained animal. From the point of view of effort, the FR5 animal certainly had to do much more work for each reinforcement and should have built up for greater inhibition. If we regard each response as a trial then certainly much greater "massing" of trials occurs under the FR5 condition as compared with CRF. Yet according to inhibition theory massed trials in acquisition should decrease resistance to extinction.

There are numerous other criticisims of inhibition theory but its inability to predict the effects of schedules of reinforcement is sufficient to place the theory in serious difficulties. There is one possible explanation of these findings however. Mowrer and Jones (1945) have put forward the <u>response unit hypothesis</u>. It will be recalled that in their study Mowrer and Jones rewarded animals according to four fixed ratio schedules, varying from FR1-FR4. They maintain that even when responses occur which are not reinforced by food (eg. the second response on an FR3 schedule) the gradient of reinforcement is such that such responses still have reward value. In other words instead of thinking of reinforcement as being restricted to the response which occurred just before the reward, reinforcement should rather be seen as applying in decreasing amount to other preceding responses as well. If their data is reanalysed in these terms then the animals in the higher FR groups did not in fact emit more "responses" in extinction. During extinction the animals in the FR1 group repeated their response unit 128 times (128 ÷ 1), those in the FR2 group 94 times (188 ÷ 2), those in the FR3 group 71,8 times (215,5 - 3) and those in the FR4 group 68,1 times (272,3 ÷ 4). If response is defined as the total unit of behavior necessary to produce reinforcement then the apparent advantage of intermittent reinforcement is lost. Skinner, (1938) had in fact already noted the arbitrariness of the term "response". This is fundamentally a problem in the definition of a unit of behavior. "As a rather general statement it may be said that when a reinforcement depends upon the completion of a number of similar acts, the whole group tends to acquire the status of a single response, and the contribution of the reserve tends to be in terms of groups". (P.300).

Mowrer and Jones graphically represented their data in the following way.

FIG. 12



Curves showing the average number of bar depressions as contrasted with response-units made by Groups I-IV (reinforcement ratio of 1/1 to 1/4) on all three days of extinction.

The average number of response units becomes progressively smaller as we go from the FR1 - FR4 group. One could utilize the role of effort here to explain why the function is as it is. A response unit of 4 bar pressings or key pecks obviously requires more effort than a response unit of only one depression or peck. Consequently one would expect the former unit to extinguish more rapidly than the latter.

Another explanation of this effect is based on the fact that although all bar depressions involved in a response unit of 4 receive some reinforcement they do not all receive the same amount since the one nearest the reward gets most, the preceeding one somewhat less and the first response least of all. However, if we are dealing with a response unit, of 1 the reinforcement received is always the same, maximal amount. Assuming that every response has reinforcing properties, the FR4 group will receive more reinforcement than the FR1 group, but certainly not four times as much, because of the reinforcement gradient. Consequently when we analyse extinction in terms of response units we would expect the FR1 group to show greatest resistance to extinction and the FR4 group the least.

Whether or not one accepts the response unit analysis is a function of ones resistance to the conception of a "response" as a sequence of behaviors. Is the response that which activates the reinforcing mechanisms or a chain of behavior leading to the final act? There has been and still is much concern with the "units" of behavior, (see Schick, 1971) but the Mowrer and Jones analysis seems to have had little influence. It is stretching a point somewhat to insist that an animal on a FR1000 schedule is only emitting one response unit, and the data from controlled responding situations (e.g. runways) is difficult to analyse in these terms. One is inclined to think that Mowrer and Jones altered the response class merely to fit the response-produced inhibition theory.

4 b. EXTINCTION AND THE GENERALIZATION DECREMENT

As a result of numerous difficulties with their theory, inhibition theorists were forced to introduce various additional concepts to make the theory viable once more. These additions have generally been placed under the heading of generalization decrement. This view stresses the introduction of stimulus change in extinction. Naturally all extinction procedures involve such change because the feedback loop R SR+ is broken, and various proprioceptice consequences of reinforcement no longer occur. The degree of resistance to extinction will depend on the magnitude of the differences in stimulation between acquisition and extinction. Since Hull's concept of reactive inhibition suggested an effector localized mechanism due to its similarity to fatigue, the role of feedback in response maintenance is obviously important. Spacing of trials is one situation in which the predictions of this view may be tested. Assuming that a given distribution of trials will produce a particular level of response-produced feeback, changing the distribution either in training or extinction will change the feedback level and consequently the response strength. This view has a fair amount of experimental support. Teichner's (1952) experiment involved training groups of Ss at intertrial intervals of 30, 45 or 90 seconds. These groups were then sub-divided and the resulting subgroups extinguished at intervals of either 30, 45, 60 or 90 seconds. The results indicated that (1) the acquisition of response strength is more rapid, the longer the time between trials (2) resistance to extinction is greater when the same intertrial interval is used during training and extinction than when the intertrial interval during extinction is not the same as the one used during training.

It is, however, the analysis of partial reinforcement effects that is the most valid contribution of the generalization hypothesis. The analysis of the partial reinforcement effect hinges around similarities between the training and extinction phases of the experiment. When a response is reinforced intermittently similarity between these two phases is increased and generalization decrement is reduced. Each response leaves stimulus traces. When an animal is reinforced on a CRF schedule these traces will always include traces of reinforcement, but when an animal has been trained on an intermittent schedule traces of non-reinforcement will be included. Consequently, during extinction (continuous non-reinforcement) there will be less stimulus change for the PRF animals, and greater resistance to extinction. But these stimulus traces do not exist ad infinitum, they obviously disappear over time. Consequently where trials are massed their effect from trial to trial will be felt, but in widely distributed trials the influence of stimulus traces will be minimal. It follows therefore, that partial reinforcement effects should be minimized where distributed trials were used in training. In an experiment specifically designed to test these predictions Sheffield (1949), trained 72 rats to run down an alley for food. Half were continuously reinforced and half reinforced on every second trial. These groups were further sub-divided and each subgroup trained with either a 15 second intertrial interval or with a 15 minute ITI. For the extinction trials these subgroups were further divided and half extinguished with a 15 minute ITI and half with a 15 second ITI. The results were as follows. After massed training resistance to extinction was greater for the 50% reinforcement group than for the 100% but after spaced training the difference in resistance to extinction between these two groups was not significant. Consequently Sheffield concludes that the differential effect of partial reinforcement depends on whether acquisition is massed or spaced, thus supporting the generalization decrement hypothesis.

In the above experiment the effect of trial spacing on the partial reinforcement effect seems quite clear cut and the findings are handled neatly by the theory. However, as is to be expected there is much evidence contrary to this view. Weinstock (1954) used an ITI of 24 hours during training - a period sufficiently long for all treaces of reinforcement/ non-reinforcement to have disappeared. Ss were either reinforced 100%, 80%, 50% or 30% of the time and the extinction ITI was 24 hours.

During extinction group differences were significant beyond the ,01 level, with an inverse relationship between percentage of reinforcement and resistance to extinction. Obviously with such a large ITI, the generalization decrement hypothesis has difficulty in handling these partial reinforcement effects.

In another experiment a detailed analysis was made of the role of stimulation from food particles in the mouth present on trials immediately following reinforced trials but not on any extinction trial. Wilson, Weiss and Amsel (1955) assumed that the degree of persistence of mouth cues depends on the kind of reinforcer used. In Experiment I dry food was substituted for the wet mash used in the Sheffield study in an attempt to increase the persistence of traces and enhance the Sheffield effect. Experiment II used water reinforcement in an attempt to minimise the duration of the reinforcing stimulus trace since it was presumed that water does not persist as a mouth cue as long as food. Besides these changes in reinforcers the experimental design duplicated Sheffield's; Results, however, differed substantially. The partial reinforcement group was more resistant to extinction than the continuous reinforcement group regardless of ITI in acquisition or reinforcement used. In one way, however, the results support a stimulus generalization view since the effect of distribution of extinction trials on resistance to extinction depends on the distribution of acquisition trials: the switched groups were less resistant to extinction than the unswitched groups.

One may conclude this section by noting that although there are experiments producing evidence contrary to the stimulus trace aspect of the generalisation decrement hypothesis, the basic theory seems to receive support in most experiments. Obviously the extent to which non-reinforcement can be discriminated by a S will dictate the strength of the behavior. On schedules where acquisition and extinction hardly differ we may expect, and in fact do find, greater resistance to extinction. But for many researchers extinction is regarded as not only the loss of a particular response but as the learning of new responses. These researchers propose that extinction occurs because of interference or competition from other stimuli.

4 c. COMPETITION THEORY.

The competition theory of extinction is largely the work of Guthrie (1952, 1959) and Estes (1950, 1959). No special assumptions are needed regarding the nature of extinction for these authors since extinction is merely the acquisition of new responses. Guthrie believes that learning occurs by contiguity and not because of reinforcement.

> "A combination of stimuli which accompanied a movement will on its recurrence tend to be followed by that movement" (1952, p.23).

The rather weak word "tend" is used purposefully by Guthrie because the probability of the response recurring will not reach unity on a second trial because of the impossibility of duplicating exactly stimulus conditions. When we omit reinforcement in operant extinction the S is then able to make new (competing) responses to the stimuli present at the time.

> "A stimulus may thus be unconditioned by the very simple means of becoming a condition for an incompatible movement ...."
>
> 1952, P.56.

Consequently one of the few differences between acquisition and extinction is that in acquisition the experimenter may decide what responses the organism can make (eg. key peck, alley-run, etc.) either because of forced occurrence or because of the arranged contingencies between response and reinforcement. In extinction the S decides what response(s) will be emitted. Naturally if there are numberous opportunities for alternative (competing) responses then extinction should be hastened. If competing responses cannot be made no response decrement will be seen. Guthrie did not elaborate much further on the acquisition of competing responses except to say that they were acquired by contiguity. Estes, however, introduces probabalistic notions in his explanation of extinction. For Estes the organism is faced by a stimulus situation which consists of small independent "elements" of which only a sample are active at any one time. On any given trial of a learning experiment the stimulation which affects the organism is a sample of elements chosen from the population of stimuli. The consequent "Urn" model assumes independent random sampling where all elements have the same probability of being sampled. Learning therefore consists of connecting all the elements sampled on a given trial to the last response and is all-or-none because the response is in that trial conditioned completely. Learning appears to be incremental because different stimulus elements are sampled from trial to trial until eventually all the elements from the population are sampled. Extinction proceeds in exactly the same manner

> ".....from the present point of view, conditioning and extinction are regarded simply as two aspects of a single process".
>
> (Estes, 1950, p.105).

In a later publication the view is stated more clearly.

> "Suppose a particular element........of S is connected to response (R1); if now this element becomes connected to a different response (R2) on some learning trial, it is at the same time disconnected from (R1).....given an association principle and a probability model.....a principle of <u>un</u>learning by interference follows....." (Estes, 1959, p.400).

In other words, the experimenter defines the contingency as "extinction" of (R1) but in fact it is really only acquisition (of R2).

If this analysis is extended to the conventional runway situation in which groups of animals have either been partially reinforced or continuously reinforced it produces a number of predictions. If we go through the procedure step by step we note that according to contiguity theory reinforcement is a signal conditioning the response that immediately preceeded it to the stimulus elements sampled. In extinction the S makes other competing responses which also become conditioned to a stimulus sample by contiguity. Authors such as Weinstock (1954) go on to assume that the competing responses the S makes on non-reinforcement habituate after a number of such trials. Thus partially reinforced animals which have experienced non-reinforcement during acquisition will have their competing responses habituated to a fairly low level. Once habituation occurs there will be little decrement in response strength when non-reinforcement is experienced again. Consequently during extinction the Ss reinforced on the lowest partial reinforcement schedule will have had the greatest number of non-reinforced responses and consequently their competing responses will have most completely habituated. In extinction therefore, few competing responses will occur compared with a CRF group of Ss where no habituation has taken place. These predictions are of course supported by most of the literature.

But like inhibition theory there are problems in the competition theory camp as well. If conditioning and extinction are merely the same process then extinction should respond in the same way to certain variables known to influence acquisition. Take trial spacing for example. If trials are massed together in acquisition learning is usually retarded. In extinction, however, massing of trials speeds up the loss of a particular response class (and according to the theory acquisition of competing responses). Spaced trials in extinction often increases resistance to extinction but according to competition theory response strength should be reduced because there is more time for competing responses to occur. Extinction also reflects other changes such as initial response rate increase, increased emotionality and a source of motivation, the latter aspects normally listed under the heading of "frustration". The next section shall be devoted to these aspects.

4 d. EXTINCTION AS FRUSTRATIVE NON-REWARD

The emotional-motivational effects of non-reward had been noted in the 1930's. Miller and Stevenson (1936) noticed that during extinction rats showed "agitated" behavior and they explained this as the effects of non-reinforcement carried from one trial to the next.

Skinner (1938) noticed this effect in extinction records which showed coarse grain with rapid periods of responding interspersed with pauses. He regarded these effects as the result of "emotionality" in the animal. Later Skinner wrote:

> "When we fail to reinforce a response that has previously been reinforced.....we set up an emotional response - perhaps what is often meant by frustration". (Skinner, 1950, p.203).

The concept of a frustrative event was originally regarded by Hull (1943) merely as an occasion on which there is no reinforcement; non-reinforcement of a previously rewarded response was not assigned any special role in the theory. However, in his later works (Hull, 1951, 1952) he referred to "frustration of an anticipation" and stated that "abrupt cessation of a customary reinforcement will lead to a slight initial rise in $S^{E}R$ (reaction potential) due to emotion (D)". Thus we can see that Hull was beginning to realize that non-reward had motivational properties.

Amsel (1952, 1958, 1962) adopts the position that all learned instrumental responses depend to some extent on classically conditioned implicit responses. These responses are the learned couterparts of responses elicited by frustrative events. This type of response along with the response produced stimulation associated with it has been designated $r_G - s_G$ the fractional anticipatory (antedating) goal reaction and a construct of this kind has been extensively employed in connection with the development of positive excitatory tendencies. In the present terminology $r_G - s_G$ is a general term covering all types of antedating conditioned responses. Separately these might be designated $r_R - s_R$ fractional anticipatory reward; $r_P - s_P$ fractional anticipatory punishment usually termed fear or anxiety; and $r_F - s_F$ fractional anticipatory frustration.

Conceptually, the anticipatory reactions, that have been designated are conditioned forms of goal or consummatory responses (secondary reinforcing reactions) which through stimulus generalization and higher order conditioning come to be elicited by stimuli in an instrumental response sequence which antedate the goal. The fractional anticipatory frustration reaction may then be conceptualized as resulting from higher order conditioning and generalization of secondary reward.

Amsel's basic position may be characterized as follows:

(a) under certain conditions non-reward is an active factor which is termed frustrative non-reward.

(b) such frustrative events are antecedents to a primary aversive motivational condition, frustration.

(c) a secondary (learned) form of this primary aversive condition termed fractional anticipatory frustration $r_F - s_F$ develops through classical conditioning and is the inhibitory mechanism in non-reward.

Frustrative non-reward events determine activating (drive) effects which can be measured as an increase in the vigour of behavior which immediately follows the frustrative events and are also responsible for inhibitory effects which are at least partly responsible for decreases in strength of the instrumental behavior which is terminated by the frustrative event.

Frustration is regarded as a hypothetical implicit reaction elicited by non-reward after a number of prior rewards. Amsel has been interested in certain active properties of non-reward following reward and no more than this is meant by frustration in this context.

There are many experiments which establish the motivational properties of non-reward. In all of them the situation is virtually the same: two instrumental (running) responses are elicited in series, the apparatus consisting of a start box, a first runway (Runway I) a first goal box (BI) and a second runway (Runway II) and a second goal box (GII). The major dependent variable in these experiments is running time (speed) in Runway II. The independent variables are manipulations of reward and non-reward in GI and also certain variations of the stimulus properties of Runway I.

The original experiment by Amsel and Roussel (1952) asked the question: Does non-reward following consistent reward have any motivational properties? Does it invigorate responses which follow it? Deprived rats were trained to run down Runway I into GI where they found food, then leave GI and run down the second runway into GII where they found food again. Their running time between GI and GII was measured and then a series of test trials was run on half of which Ss were not rewarded in GI prior to transversing Runway 2. Results showed that Runway 2 was transversed quicker when reward had been omitted in GI. This increased vigour following non-reward as compared with reward has been called the <u>frustration effect</u> (FE).

The second problem tackled was the role of partial reinforcement in this effect. Was continuous reinforcement necessary for the production of the FE? Roussel (in Amsel, 1958) showed that FE slowly developed under 50% reinforcement after about 20 trials. But what actually is developing as a function of rewarded trials which makes non-reward frustrating? Amsel and his co-workers guessed $r_R - s_R$. This hypothesis can be tested by varying those factors which by definition would affect the strength of r_R.

Amsel and Hancock (1957) tested this relationship in two experiments. In each experiment the similarity between Runway 1 and GI was the variable defining differential strength of r_R in Runway 1 and upon entry to GI. Experiment 1 gave reward continuously in GI before non-reward was introduced while in experiment 2 reward was given in GI 50% of the time from the start of training. The results confirmed those of previous experiments but with the important additional finding that the magnitude of the FE was greater in each case when the conditions for r_R arousal were better.

Amsel assumes that the FE only occurs after non-reward has been preceeded by several rewarded trials permitting the development of r_R. Before this regimen non-reward is not frustrating. This former procedure occurs in two situations, partial reinforcement and discrimination learning. Where there is inconsistent reward frustrative factors are involved - in discrimination learning they in fact facilitate the stimulus selective process and in partial reinforcement they account for the enhanced resistance to extinction compared with continuous reinforcement.

But this far we have only dealt with one of the frustration concepts - primarily motivational in character. The second concept is the classical conditioned, anticipatory form of F which operates during an instrumental sequence after the sequence has been non-rewarded and rewarded a number of times. This factor is termed fractional anticipatory frustration $r_F - s_F$.

Hull's two factor theory of inhibition had been successful in helping to explain many phenomena of response decrement (eg. experimental extinction, spontaneous recovery, disinhibition, etc.). But the theory is largely unable to deal with certain aspects of response decrement in what could be called goal oriented learning situations, for example, discrimination learning. Amsel believes that this latter kind of learning situation can be better understood by including the notion of goal events as determining response decrement and the important inhibitory factor fractional anticipatory frustration ($r_F - s_f$). Primary motivation cannot be regarded as inhibiting the response which preceeded it; conditioned frustration could be regarded as having inhibitory properties because it could move backward from the goal region to cause weakening of the response.

Because frustration is regarded as an aversive condition, S_F should be associated with avoidance response tendencies which would compete with movement toward the previously rewarding goal region.

The sequence of events occuring in partial reward situations or in discrimination training are outlined by Wilson, Weiss and Amsel (1956) as follows:

(1) The development of $r_R - s_R$ with early rewards, non-reward being

ineffective at this stage.

(2) With the development of $r_R - s_R$, non-rewards elicit more and more frustration.

(3) When non-rewards elicit frustration the instrumental sequence cues previously evoking the r_R now also evoke r_F, and these antedating goal responses are temporarily in competition. (This produces temporarily increased variability in the instrumental response and decreases vigour).

(4) Since r_R and r_F cannot be elicited spearately by differential cues in partial reinforcement as they can in the latter stages of discrimination learning, and since partial reinforcement training is such that running to the goal box is reinforced more than is avoiding it (the animal is removed from the situation at the end of the trial if it runs to the goal box, reducing conflict and frustration as well as the relevent needs on rewarded trials) s_F becomes associated with the instrumental approach response in the latter stages of partial-reinforcement training.

(5) When Ss are placed on extinction, the partial reinforcement groups have been trained to respond in the presence of antedating frustration stimuli, whereas the consistently reinforced Ss have not.

FRUSTRATION AND PARTIAL REINFORCEMENT

The Amsel and Hancock study (reviewed above) showed that the frustration effect was greater when better secondary reinforcing stimuli (r_R eliciting stimuli) were present in Runway 1. Under the partial reinforcement regimen of the Runway 1 response, frustration developed more strongly when the stimuli in Runway 1 were like those in G1 than when they were not, ie. under partial reinforcement the relative presence or absence of secondary rewarding cues on non-reward trials should enhance or reduce resistance to extinction. The reason for this is because when on non-reward trials secondary reinforcing cues are minimal, there is less r_R evoked, therefore, less frustration and less r_F. Consequently in acquisition there is less conflict and ultimately less connection of s_F to the rewarded response, therefore, less resistance to extinction. Rubin (1953) found that when secondary reinforcement was minimized during partial reinforcement acquisition continuously reinforced groups were more resistant to extinction than partial reinforcement groups. Hulse and Stanley (1956) in a similar manner, found that resistance to extinction was greater after partial reinforcement training when secondary reinforcement was present in every trial during acquisition but not when secondary reinforcement was omitted on the non-rewarded training trials.

Another study which supports the role of secondary reinforcing stimuli is that of Tyler (1956). Ss were randomly assigned to one of three acquisition conditions:

Consistent - 100% reinforcement with same colour goal box on every trial in acquisition and extinction.

Same - 50% reinforcement, with same colour goal box on every trial.

Reversed - 50% reinforcement, with for example, a black goal box on reward and white goal box on non-reward trials, followed by extinction in the black goal box ie. the box in which the S was rewarded during acquisition.

Results showed that the 100% group extinguished more rapidly than either of the 50% groups, but the "Same" group was more resistant to extinction than the "Reversed" group. In other words the omission of the stimulus which accompanies reward on non-reward trials in partial reinforcement in acquisition reduces the usual effect of partial reinforcement.

Two further predictions can be made from Amsel's frustration interpretation of partial reinforcement and extinction. The effect of partial reinforcement should only be present after some critical number of training trials ie. only after s_F becomes conditioned to running, the absolute number of trials depending on the training situation. Secondly, partial reinforcement acquisition should be more variable than CRF acquisition in the early stages of training when r_R and r_F are in competition.

Amsel trained Ss to run a straight runway under various acquisition conditions - 100% reinforcement, or 50% reinforcement, with either 24 or 84 acquisition trials. The apparatus consisted of a closed straight runway and measures were made of (a) response latency and (b) running time. After the Ss had run their requisite number of training trials, 18 extinction trials were run. Performance of the partial and continuous reinforcement groups did not differ until day 4 of acquisition. This, interestingly, corresponds to the stages of the Roussel and the Amsel and Hancock data (above) where the frustration effect begins to appear with partial reinforcement of the runway response. A further point of interest is that on the last 5 days of acquisition the groups receiving 84 trials showed few differences comparing partial reinforcement with continuous reinforcement Ss. The extinction data are, however, of greatest interest. Whether Ss were reinforced partially or continually had no significant effect on resistance to extinction after 24 trials. After 84 acquisition trials however, the partial reinforcement group is significantly more resistant to extinction than the CRF group,the size of the difference increasing on successive days.

An indication of the aversiveness of the extinction contingency can be gained from the record of urination in the experimental apparatus. None of the 24 trial Ss urinated in the apparatus either during acquisition or extinction. Amsel regards this as indicating that conflict had not yet developed in training. Regarding the 84 trial Ss, urination was fairly frequent from the 50th trial onward and tended to occur more often in the partial reinforcement group than in the CRF group. During extinction nearly all Ss urinated regardless of acquisition schedule.

The above data are interpreted as indicating the development in the partial reinforcement situation of frustration and $r_F - s_F$ with the resultant conflict between goal (food) oriented behavior (running) and the incompatible frustration motivated responses. The enhanced effect of partial reinforcement after 84 as compared with 24 trials is also consistent with the notion of frustrative non-reward factors.

Although many of the notions developed from the $r_F - s_F$ mechanism are of direct relevance to the present work it must be noted that Amsel was dealing with discrete trial learning of a highly spaced character. This "controlled responding" situation obtains when the experimenter administers discrete trials one by one and usually measures behavior changes within trials (eg. response latency or speed) in an attempt to determine the effects of various independent variables. This regimen should be differentiated from the "free-responding" situation of the Skinner box, where the S may distribute its responses as it chooses. In the former situation partial reinforcement consists of reinforcing a particular percentage of trials, whereas in the latter, or reinforcing apercentage of responses. (ie. under an FR schedule). Amsel (1958) makes the very important point that different principles and explanations may be required in the two types of situation. The discrete highly spaced trial situation involves primarily consideration of certain developing associative tendencies, whereas the chained type of responding involves consideration of effects of stimulus traces from previous responces and goal events. Nevertheless it is felt that some of the notions developed under the discrete trial regimen are of value when applied to free responding situations.

4 e. THEORIES OF EXTINCTION: SUMMARY AND CONCLUSIONS.

Thus far we have looked at the process of extinction, analysed the major variables affecting this process and reviewed the more important theoretical interpretations of the relationships between the variables. As yet very few experimentally supported principles have emerged excepting perhaps for the role of partial reinforcment on resistance to extinction. The fact that partial reinforcement increases resistance to extinction is undoubtedly one of the most solidly founded facts in psychology. Each of the theories covered has contributed a great deal to the field and each has also been subjected to much criticism.

Prima facie, the theories covered appear to be mutually exclusive but closer analysis shows that there are many concepts which re-appear under different guises in each interpretation. Although theories of extinction exemplify some of the most elaborate and abstract theorising in psychology it is in fact their simpler notions which make the greatest contribution. The Law of Parsimony is as valid in this field as in any other. If one is faced with two alternative explanations of a particular phenomenon the one with the fewest assumptions is likely to offer the best solution. Most theorists agree that during extinction the operant class under investigation undergoes a gradual weakening. Hull, Guthrie and Skinner all agree that this weakening must take place before some new class becomes prominent. The fact that competing responses occur in extinction is rarely argued today, but which operant class will tend to predominate, and by what process it is learned is another issue. The "controlled responding" (vs) "free operant" experimental situations often produce different notions about which variables will affect competing responses. The effects of partial reinforcement are generally attributed to what the S learns after non-reinforcement during acquisition, and naturally theorists whose Ss are in runways and those whose Ss are trained in Skinner boxes will tend to see the situation differently.

Finally we have the role of "emotionality" in extinction. The extent to which theorists admit that such a notion contributes much to our understanding of extinction usually depends on their philosophical biases, but even an extreme positivist will admit that the concept of frustration can be a useful one if properly used. The motivational properties of non-reward have been amply illustrated by Amsel and his co-workers, though it must be remembered that the definition of the term used by Amsel is not really akin to lay conceptions of frustration. When goals are blocked organisms are often said to be "frustrated" and much more is meant when the term is used in this way. The weaknesses of such a conception are discussed in the next section.

5 a. THE CONCEPT OF FRUSTRATION

Marx, (1963) has suggested that psychological terms evolve through three basic stages.

1) pre-scientific definitions; 2) definitions in the form of hypothetical constructs; 3) definitions in the form of intervening variables. The trend is toward the increasing operational specificity of terms with a corresponding decrease in surplus meaning. This three stage process is clearly illustrated in the development of ideas about frustration.

But what is meant by "frustration"? The term is certainly not used in the descriptive sense ie. it is not used in the same way as one uses the word "running" to describe the movements of certain muscle groups at a particular rate. The term usually denotes a certain state of arousal. In fact it also carries implications about what has happened to the organism in the recent past. In other words the term goes will beyond description, implies a motivational state and even gives a hint regarding the "causes" of the behavior. Thus the term as used in common parlance is heavily overloaded with surplus meaning and is in need of clarification.

For scientific purposes the term "frustration" must be related to specific observations and/or manipulations. If one reported that "S was frustrated for n experimental sessions" other researches would have great difficulty in replicating the procedure. Ultimately any definition of frustration will have to be tied to certain experimentally manipulative variables. Naturally increasing operational specificity is a gradual process and researchers have used various approaches in an attempt to achieve it. Some have jumped directly from the commonly held view of frustration to an experimental analog and then produced a "theory" to cover the findings. Others use this same process but prefer to leave theoretical formulations to others.

Earliest notions of frustration grew out of psychology's concern for so called "inner processes". According to this view frustration was a state of the organism and related to its "experiences" or "feelings". But since one never has direct access to "feelings" (even one's own - Skinner, 1957, 1963) the study of frustration as an inner state is really a pseudo problem. When the subjectivity of this notion became apparent many psychologists realized that only by objective study of the "other one" (Meyer, 1921) could psychology make a satisfactory contribution to science.

The scientific study of frustration demands the identification of antecedent events and behavioral consequences and ultimately making generalizations about their relationship. If we follow this procedure we convert a pre-scientific problem into a scientific one. (Lawson, 1965).

But before the latter phase was reached psychologists were concerned with frustration as a hypothetical construct. This view is somewhat more satisfactory than the "inner state" view because although it posits mediating processes it does aim to specify specific antecedent and consequent conditions. Mediation is "hypothetical" because the means of measuring or identifying the process is unstated. Although some psychologists have supported their use, (eg. Tolman, 1949) hypothetical constructs have had an undistuinguished record in psychology. The writer prefers an approach where psychological variables are sufficient to an understanding of behavior. One agrees with Marx (1963) that psychological terms should be defined exclusively in terms of the kinds of measurements psychologists can make. The intervening variable approach is to be favored where psychological constructs are defined solely in terms of relationships between operationally defined events. However, researchers on this topic have not always heeded Marx's advice and various strategies have been used in the investigation of frustration. Although many researchers combine the following strategies in various ways the following categories cover some possibilities.

(1) In this strategy an arbitrary "frustration" procedure is utilized and its consequences measured. For example the effect of non-reward either through lack of food in the goal box or because of an obstruction to obtaining the food. The experimenter relies on this basic "frustration" procedure while he manipulates various variables. If an experimenter uses this procedure and discusses his results in terms of a general concept of frustration the implication is that there is a "thing" which can be labelled "frustration" regardless of the procedure used to induce it. An implicit theory of frustration is evident in this view.

(2) The second strategy involves hypothesising a dependent variable consequent on frustration and investigating the independent variables which produce it. Once again an implicit theory is involved here since selection of relevant independent variables implies that one knows what is relevant. Although these strategies have been used in the study of frustration *per se*, it is not intended to review the studies which have had this sole objective. It is rather assumed that the lessons of pre-scientific conceptions have been learned, and the writer will concentrate on research which has moved away from a concept of frustration *per se* especially work which examines related issues in terms of more technically defined dimensions. Our primary concern here is with certain aversive contingencies and more specifically with one particular operant class which they tend to induce, that of aggression. The studies to be reviewed have not found it necessary to invoke the concept of frustration but rather prefer to manipulate various independent variables across wide dimensions measuring the dependent variable with increasing precision.

6 AVERSIVE CONTINGENCIES

a. PAIN INDUCED AGGRESSION

The earliest studies of aggression generally involved naturalistic observations of fighting amongst animals of a variety of species. The observer would hide behind a blind and from a safe distance attempt to record the sequence of behavior. The factors increasing the likelihood of aggressive behavior were generally found to be territorial encroachment, limited space, shortage of mates, competition over food etc., (Scott, 1958). Observation of animals in their natural habitat is a necessary prelude to experimental analysis, because it is a rich source of relevant variables and hypotheses. But the nature of the situation is such that all variables are beyond the control of the viewer and consequently no generalizations about causality can be made.

Experimental studies have, however, substantially increased our knowledge about aggression and its necessary and sufficient causes. The role of male hormones in aggression is well documented (eg. Bevan, Davis and Levy, 1960) and Bond, (1950) has shown the importance of the hypothalamus in the investigation of aggressive behavior. Other independent variables in studies of aggression have been food deprivation of the animal (Seward, 1945) and previous fighting experience (Scott, 1958).

One less obvious variable affecting aggression is that of pain. Common sense notions indicate that when an organism is experiencing pain the probability of aggression increases. The respect that hunters show for a wounded animal is testimony to this notion. Earliest experimental studies noticed the relationship between pain and aggression whilst studying other variables. In one early study (O'Kelly and Steckle, 1939) six rats were placed in an experimental chamber and periodic schocks were given through the grid floor. Although no aggression had been observed prior to the shock, when it was introduced the animals immediately

adopted the aggressive posture (standing upright on hind legs, forepaws outstretched and mouth open) and even attacked vigourously. Few studies gave the problem of pain induced aggression detailed analysis, however, until Ulrich, Azrin and their associates investigatedthe problem in detail in the 1960's. In the early studies (eg. Ulrich and Azrin, 1962) the primary stimulus used to elicit fighting was electric shock and most of the research analysed the important parameter of the shock. One of the first findings was that fighting was not monotonically related to shock intensity. Increasing the shock intensity from 0-2 m.a. increased fighting frequency but at higher intensities (3-5 m.a.) the rate of fighting decreased. This finding was partly due to the debilitating effect of shock and partly as a consequence of competing behavior.
A second parameter investigated was that of shock frequency. It was found that the more often shock was presented the more often the Ss fought. When shock was continuous, however, fighting decreased since most of the rats' behavior seemed to be centred around getting out of the experimental apparatus. The value of shock which produced the optimum rate of fighting seemed to be about 30-40 shocks per minute (Ulrich and Azrin, 1962).

An important technical aspect of this work concerns the method of shock, presentation. Early investigators used a type of shock circuit in which alternate bars of the floor grid were wired in parallel. When this design is used the animal is able to avoid the shock by standing on bars of the same polarity and this may account for the contradictory findings of some of the early work. (eg. Miller, 1948; Richter, 1950). Ulrich et al used a system whereby the polarity of the electified grids is scrambled and thereby alleviated this difficulty.
These authors went on to investigate a number of other factors that were related to this "reflexive fighting", including the sex and the strain of the rats. It was found that fighting occurred regardless of sex and strain

except that the Wistar strain appeared to be more sensitive to shock intensity. Similar results were also found in other species, (guinea pigs, hamsters, opossums, raccoons, marmosets, foxes, cats, turtles, squirrel monkeys, bantam roosters, alligators and several species of snake).

A further variable which these investigators studied was the characteristics of the attacked animal. Ethological studies have shown that certain behavior patterns are often "triggered" by eliciting "sign stimuli". The male robin attacks any object which enters his territory in the mating season which has the characteristic "red breast" of other males. A small bunch of red feathers will be just as vigourously attacked as an invading male robin. Ulrich _et al_ wanted to find out whether the shock-attack reaction was similarly related to specific physical attributes of the "target" or whether it is the expression of a general tendency to destroy. If the attack reaction was triggered by the combination of shock and physical characteristics of the target, then slight changes in the appearance of the target should reduce the amount of aggression. To test the possibility a series of studies was conducted in which various animals were paired with target animals of a different species. For example, a rat would be caged with a guinea pig, a monkey with a mouse, a rat with a rooster, etc. In every instance the shocked animals would attack each other, showing the characteristics of the target to be irrelevant. Eventually even a stuffed doll was placed in the cage with various animals and shock still produced the same attack reaction. (Azrin, Hutchinson and Sallery, 1964). It seems, therefore, that almost any "attackable" object in the environment will suffice - animate or inanimate - regardless of its attributes.

The studies on pain-induced aggression reviewed so far have two basic problems. Firstly, the method of recording aggression is open to error.

Human observers would depress a microswitch for any striking or biting movements of either of the animals toward the other. Although reliability checks were run with various observers inter-rater reliability is not as adequate as an automated recording device. The second difficulty concerns the problem of counter-aggression. When an animal was attacked it often fought back thus contaminating the results. When for example, a snake and a rat were paired, on receiving the first shock the rat would attack the snake, but the frequency of attack could not be recorded because the snake's counter attack would be fatal.

Both these problems were subsequently solved, however. Since pain elicits aggression even against inanimate objects it is possible to use this apsect to advantage. One initial technique of recording consisted of suspending a tennis ball from a cord attached to a switch. Whenever the animal struck at or bit the ball the switch would be closed and would in turn activate a recording device. This enabled attack to be recorded objectively and allowed the recording of attack responses of very destructive animals. A significant improvement on this technique was introduced with the development of the "bitometer". This device consists of a plastic tube inflated with air which can be bitten by the shocked animal, thus giving a direct measure of the number of bites as well as their duration and forcefulness. Using this method the shock-attack reaction could be studied using single animals over a period of many months, without injury to subject or target and eliminated the problem of counter aggression and reliance on human recording.

Thus far the only painful stimulus used was shock, in itself a novel sensation never experienced by the animal in its natural habitat. Would attack result from every aversive stimulus? Azrin, Hake and Hutchinson (1965) used a physical blow as the painful stimulus and were able to elicit aggression. Monkeys restrained in a chair were subjected to a blow on the tail. It was found that attack occured as a direct consequence of the blow. In another investigation Ulrich (in Kimble, 1967) paired rats were placed in an experimental chamber with a preheated thin metal floor. The heated floor elicited aggression in a similar manner to shock. Evidently aggression is a reaction to many types of painful stimulation and is not distinctly related to electric shock. Situations which the animal finds aversive are reacted to vigourously and instantly in a way which is likely to terminate them. From the standpoint of evolution therefore, pain induced aggression has survival value.

The work of Ulrich, Azrin and their co-workers stands as a model for the systematic exploration of a vitally important behavioral phenomenon. Thus far only pain has been analysed; might not other "psychologically" painful experiences have the same effect; For example, is withdrawal of reward a sufficiently painful experience to elicit aggression? The following section examines schedule induced aggression.

6 b. EXTINCTION

We have already noted in previous sections how at the onset of extinction animals appear to become "emotional" and agitated. Defaecation and urination tend to increase and rats sometimes bite part of the apparatus. (Mowrer and Jones, 1943). Amsel and Roussel (1952) showed that running speed tended to increase after omission of a food reinforcement for running. However, there is more direct data on the aversive properties of extinction.

Ferster, (1958) analysed some of the properties of behavioral control by stimuli which are aversive because positive reinforcement is discontinued. A "time-out" (TO) from positive reinforcement is used as the aversive event. In a series of 5 experiments chimpanzees and pigeons were reinforced on various variable interval schedules. This schedule generally produces sustained responding at fairly high rates thereby providing a performance base line on which to assess the effects of TO. To generate this aversive event extinction was introduced in the presence of one stimulus but terminated in the presence of a second stimulus. When the rate of responding was zero in the presence of the second stimulus (TO stimulus) it could be used as an aversive event. A third stimulus was also used which signalled that a TO stimulus was about to be introduced. The experiment of interest in the present context is Experiment III. In this experiment a procedure was used whereby the pre-TO stimulus could terminate without extinction if the rate of responding were low enough toward the end of pre-TO stimulus. Under this regimen the rate during the pre_TO fell to zero. Subsequent exposures to the same procedure produced a performance in which the rate of responding in the pre-TO stimulus was negatively accelerated. Eventually TO never occurred because the rate of responding always reached zero by the end of the pre-TO stimulus. The aversive properties of TO are evident in this study.

Experiment IV generated avoidance behavior based on the postponement of the TO. The VI schedule of reinforcement on one key was interupted periodically by a TO unless a second key was pressed. If the second key was pressed the TO was postponed. Substantial levels of avoidance behavior were generated once again illustrating the aversive properties of TO. Experiment V used TO as a punishment where inter-response times fell below or exceeded specified values. In this way it was possible to decrease or increase the inter response times at will.

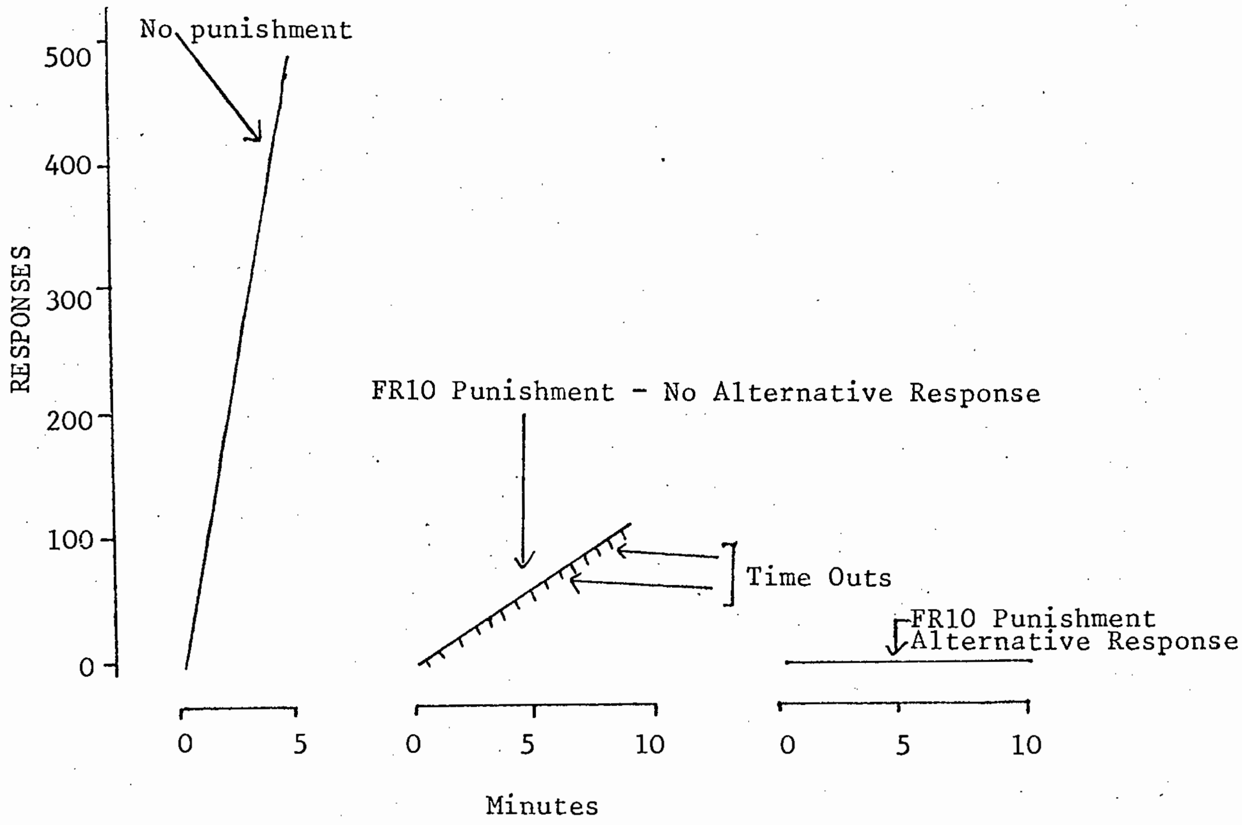
Ferster and Appel (1961) used TO as a punishment in a matching to sample task with pigeons. Matching to sample involves a chain of responses consisting of pecking the centre key first and then one of the side keys. This response sequence is reinforced with the bird responds to the side key and is unreinforced when the response is to the non-corresponding colour (S-). Ferster and Appel were able to speed up the acquisition of matching by punishing S- with TO on a continuous reinforcement schedule (every S- peck followed by TO). They used various values of TO however, varying from 0,5 seconds to 60 seconds and found that generally the longer the TO the fewer S- responses were produced.

In an experiment involving 5 year old thumbsucking nursery school children, Baer (1962) used filmed cartoons which could be made contingent on thumb withdrawal. Using a yoked control procedure, two Ss sat side by side and watched the same cartoons projected on the screen before them. A small room divider was placed between them so that they could not observe each other as they watched the film. Two observers watched the Ss each recording the thumbsucking of one S on separate cumulative recorders. The Ss were shown cartoons for 30 minute sessions and in the first three sessions no experimental manipulations were introduced so that operant level of thumbsucking could be recorded. In the first experimental session S1 experienced alternating 5 minute periods of continuous cartoons and contingent withdrawal/re-presentation of the cartoons. S2 experienced the same contingency but in his case it was randomly related to his thumbsucking behavior. In the second session this situation was reversed so that S2 now experienced contingent withdrawal/re-presentation whereas the procedure was non-contingent in the case of S1. In either session the S undergoing the contingent procedure was promptly controlled by the schedule whereas the non-contingent S was unaffected by the schedule. Thus in a different setting and using human Ss the aversive aspects of withdrawal of positive reinforcement are shown.

Can TO periods be used to eliminate behavior in adult Ss? Holz, Azrin and Ayllon (1963) make the important point that the experimental investigation of TO as punishment has special relevance for the control of human behavior since TO periods such as social rejection, physical isolation, job dismissal etc. are amongst the most widely used techniques of behavioral control.

Mental patients classified as "psychotic" were used as Ss and cigarettes were used as reinforcers. The cigarettes were dispensed by a vending apparatus which could be activated either by pulling a knob or pressing a pushbutton switch. Initially every response produced a cigarette but in later sessions an FR10 schedule was gradually introduced until responding had stabilized at a high rate. Finally a variable interval schedule was introduced and the experiment proper began. Initially only one manipulandum (R1) was available to the S (R2 being present but immovable). Responses on R1 were reinforced according to the VI schedule but every 10th response produced a 30 second TO. This procedure was in operation for 10 sessions after which the TOs were omitted and responding on the VI recorded once again. The second procedure then consisted of unlocking the second manipulandum and giving the Ss the following instructions "You can either push the button or pull the knob or both". Ss generally responded with the highest rate on R1 and consequently every 10th response on R1 produced a 30 second TO. After about 10 sessions of this procedure the TO contingency was changed to the other manipulandum, so that responding on one lever was punished with a TO, but the other was not. The results indicated that with the TO contingency responses were reduced to about 20% of the original rate. When the alternative response (R2) was available the punished responses (on R1) were reduced to a near zero level for all patients. The figure below graphically illustrates the data showing the importance of providing an alternative response.

FIG. 13. TIME OUT WITH AND WITHOUT ALTERNATIVE RESPONSE



TO is therefore comparable to punishment by electric shock since it can be used to eliminate behavior. The one important difference however, concerns the gradualness with which TO suppression in contrast with the immediate suppression produced by even mild intensity of shock (see Azrin, 1959). However, the strongly aversive properties of TO from positive reinforcement have been adequately illustrated.

Extinction after a history of reinforcement appears to be so aversive that aggressive behavior often results. Azrin, Hutchinson and Hake, (1966) in a series of experiments analysed the role of alternating periods of continuous reinforcement and extinction. In Experiment 1 18 pigeons were each paired with a "target" bird. The apparatus consisted of an enlarged Skinner box with the conventional translucent key at one end with food aperture below it. At the other end of the chamber was a specially constructed apparatus for recording attack on the target bird. The target was restrained in a box by a metal band fastened on each wing; the bird being able to move its head freely but being unable to move its body. This restraining box was mounted on an assembly wuch that as soon as a force exceeding 100 grams was exerted against the target a micro-switch and various timers were activated. Normal spontaneous movements of the target did not activate the recording devices.

The procedure followed an ABAB design consisting of: no reinforcement, reinforcement-extinction, no reinforcement and reinforcement-extinction. An initial phase of at least five sessions was given in which the target bird was present but the food dispenser inoperative in order to provide a measure of attack prior to any experimental history of food reinforcement. Then the experimental pigeons were trained to peck the key for food on a CRF schedule without the presence of the target bird. 15 sessions were then given in which periods of CRF were alternated with five minute periods of extinction, a tone signalling the beginning of CRF. This procedure remained in effect until responses occurred immediately upon sounding of the tone, but few responses were made during the extinction period. The tone onset was delayed for 5 seconds by any preceeding responses in order to prevent superstitious reinforcement (Skinner, 1948) of the responses by the tone.

The target pigeon was then placed in the restraining box and the alternating reinforcement-extinction contingency continued. To prevent superstitious reinforcement of attack a 5 second delay was imposed between occurrence of attack and the onset of the tone.

The results of this experiment were as follows. In the CRF condition the pigeons pecked the key soon after the onset of the tone with a latency of less than 1 second. When extinction was introduced the characteristic burst of responding occurred. After the target bird was introduced, however, the usual burst of responding occurred but in addition the target was vigorously attacked. Occasionally the attack was preceeded by a period of pacing up and down in front of the wall on which the key was mounted or by a swaying approach to the target bird with the head lowered. The data show clearly that pigeons attacked more during the reinforcement-extinction procedure than during the no reinforcement condition.

Experiment II investigated whether the key peck was essential for producing attack. Two naive pigeons were subjected to the same procedure as in Experiment 1 except that food was available for 1 second as soon as the tone sounded. Every 10 presentations of food were followed by 5 minutes of extinction. Results showed that little or no attack occurred when food was not made available, but when the free food deliveries were interrupted attack increased considerably. The temporal pattern of attack was similar to that in Experiment 1, the critical similarity being that attack occurred at the termination of the food delivery. Evidently on the basis of this experiment the response requirement is not essential to attack induction, although studies to be reviewed later tend to oppose this notion.

Experiment III compared signalled with unsignalled extinction. The previous experiments had shown that after the food delivery the animals often lingered around the food aperture. Azrin et al hypothesised that this might be due to the absence of any discriminative stimuli signalling the start of the extinction period. Pavlov (1927) noted that when animals have to make a difficult discrimination they often become "emotional". Was the aggression due to the absence of a clearly defined extinction period? Could the aversiveness of the contingency be reduced by providing a clear signal of its occurrence?

To test this conception basically the same design as previous was used except that in the signalled condition the tone sounded continuously during the CRF condition terminating immediately after the last food delivery that preceeded each 5 minute extinction period. As regards aggression induction, however, the discrimination of extinction does not appear to be important since extinction onset produced attack whether or not the period had been signalled. Unsignalled extinction did tend to produce slightly more attack but the difference was slight. Azrin _et al_ used only one animal in each of the conditions studied and perhaps the relative effects of signalled (vs) unsignalled extinction would have been clearer had more Ss been used.

Preceeding results showed that attack was at a maximum immediately after termination of a food delivery, and that it then decreased fairly repidly. Could this be due to competing responses, such as returning to the response key to await the following reinforcement period? _Experiment IV_ evaluated this possibility by programming only one reinforcement period during each session and by allowing a longer period of extinction. The procedure was the same as the signalled extinction procedure described above, but the period of continuous reinforcement began 30 minutes after the start of the 60 minute session and consisted of a single period of 60 food deliveries.

During the initial 30 seconds of each session some attach did occur but no attack occurred during the reinforcement period. However, when the reinforcement period terminated (extinction) consistent attack occurred. Because only one period of reinforcement was given during each session the gradual fall off in attack cannot be attributed to competing behavior associated with the onset of the next reinforcement period. (This of course does not rule out the possibility that other competing behavior eg. preening may account for the attack reduction). The fact that no attack occurred <u>during</u> the reinforkement period indicates that it is not the delivery of food, but its termination that is mainly responsible for the attack.

<u>Experiment V</u> This experiment investigated the possible role of competition over food in eliciting aggression. According to this line of reasoning the termination of a food delivery may have reinstated the conditions for competitive attack. Consequently Azrin <u>et al</u> reared 4 pigeons in "isolation" for nine months (apart from the first 5 weeks when they were reared by their respective parent birds). Food and water were available at all times. At 10 months the pigeons were divided into 2 pairs, one animal acting as the target, the others as the experimental animal, and the reinforcement-extinction procedure programmed. Substantial attack accurred with the expected temporal pattern- attack occurring mainly at the onset of extinction. The absolute duration of attack was comparable to that of non-isolated pigeons used previously. Evidently schedule induced attack is not a result of competition over food.

<u>Experiment VI</u>. This experiment investigated which aspect of the food delivery produced the attack - did the food have to be eaten, or was the mere sight of food sufficient? Secondly, would the experimental pigeon attack a taxidermically prepared bird? If the answer to this latter question was in the affirmative then some of the apparent variability that seemed to arise from counter-aggression by live target birds would be eliminated. Thirdly, how would food satiation affect the attack responss?

Using a stuffed White Carneaux pigeon as a target 40 experimental pigeons were exposed to the general reinforcement-extinction procedure. However, only 10 birds attacked the target and 5 of these were selected at random to undergo the following procedure: (1) inaccessible food; (2) reinforcement-extinction; (3) inaccessible food; (4) reinforcement-extinction;

(5) satiation. The stuffed pigeon was present throughout the procedure. In the inaccessible food condition the food tray was covered by a thin plexiglass shield and was raised for 1 second, lowered for 1 second, raised for 1 second, etc. for a total of 10 presentations. During the reinforcement-extinction procedures, the plexiglass shield was removed and the food could be eaten. The satiation procedure was identical to the reinforcement-extinction procedure except that food was continuously available to the animals in the living cages.

Results showed that the same temporal sequence of attack occurred under the reinforcement-extinction procedure as when a live target bird had been used. Attack occurred mostly within 30 seconds after termination of food reinforcement and this procedure produced substantially more attack compared with the inaccessible food or satiated conditions. Obviously the mere sight of food is not enough to produce attack. Why only 25% of birds attacked the stuffed pigeon is difficult to ascertain. Variations were made in size, posture, degree of movement etc. but still most pigeons would not attack. Varying characteristics of the experimental animals such as age, strain and degree of food deprivation still failed to produce attack.

Experiment VII. It has already been seen that interupting the eating of a hungry pigeon is a prerequisite condition for producing attack, the implication being that food has been delivered for some period before its termination. This study aimed at determining how the number of food deliveries affected duration of attack. Apparatus and procedure were the same as in the reinforcement-extinction period except that either 0, 1, 3, 5, 10 or 30 reinforcements were given during each reinforcement period. It was found that attack was a direct function of the number of food deliveries reaching an asymptote at 10 reinforcements.

Azrin, et al (1966) have analysed extinction induced aggression in an admirable series of methodologically sound studies. Their development of an objective measure of attack has facilitated work in this field especially since the pecking response of birds is less destructive than the biting attack of many animals, thus facilitating long term study. An important aspect of this study is that it provides a technique for measuring the aversiveness of a schedule of reinforcement - one would expect attack to be at its greatest when the schedule is most aversive. The Azrin et al study revealed a high frequency of attack at the moment of transition from continuous reinforcement to extinction, indicating that this transition is an aversive event. Another aspect of this study which is of major importance is that schedules of reinforcement produce aggression as a by-product that is not apparent when Ss are studied in isolation. Evidently extinction has a far greater effect than merely reducing the number of responses.

We have already noted in an earlier section that one of the characteristic changes at the onset of extinction is a noticeable response rate increase. Thompson and Bloom (1966) examined the covariation between the duration of fighting and the tendency for response rate to increase at the onset of extinction. In addition the changes in both these variables as a consequence of repeated exposure to non-reinforcement were explored. Food deprived rats were conditioned in a regular reinforcement schedule (CRF) and a satiated rat subsequently introduced into the test chamber. Training sessions were continued until the presence of the satiated animal had no discernable effect on lever pressing performance. Then a series of 5 minute extinction periods and 50 reinforcement reconditioning periods were run and response frequency changes and duration of fighting recorded. Duration of fighting was recorded by visually observing the two animals and operating a microswitch during fighting. Inter-observer agreement varied from 83% to 100% of the total fighting duration per session. The results of this study wer as follows. During the first few sessions following the introduction of the satiated animal responding was intermittently disrupted by social interaction between the two animals. Eventually responding stabilized once more and the satiated S tended to remain on the side of the experimental chamber opposite the food hopper, while the food deprived S occupied the side near the lever and hopper. During the first extinction session the satiated S was substantially attacked and suffered lacerations on the back and neck. Subsequent extinction sessions did not elicit aggression to such an extent although vocalizations and what appeared to be biting about the neck and back continued to take place.

As regards the rate increase, rate was greatest during the first minute of extinction diminishing over each 5 minute extinction period, whereas attack was greatest during the second and third minute of extinction. As with the lever pressing Ss attack duration decreased over successive extinction sessions, eventually almost returning to the base-line duration by the fifth extinction period.

These data indicate therefore, that extinction increases the probability of aggressive behavior, but that there is a relationship between the increase in response rate and the tendency for attack to occur. The temporal relationship between the two suggests that the previously reinforced operant (ie. lever press) has an initially higher probability of occurrence but that this is followed by an increased tendency for aggressive behavior.

6 c. RATIO SCHEDULE INDUCED AGGRESSION

So far we have seen that aggression can be elicited by a number of unconditioned stimuli such as electric shock, heat, a physical blow and extinction. Various schedules of intermittent reinforcement should also elicit aggression since they involve some kind of extinction period. Fixed ratio schedules would appear to have aversive properties since it has been noted (Azrin, 1961) that Ss will initiate "rest periods" before making the required number of responses on an FR schedule. Hutchinson, Azrin and Hunt (1968) wished to determine the effects of intermittent reinforcement on attack and discover if extinction induced aggression could be elicited in primates. Squirrel monkeys were seated in a restraining chair in front of an operandum panel and a food cup - opposite the Ss head was a "bitometer" which enabled recording of attack responses. Ss were trained to press a lever in order to obtain food pellets and the ratio requirement was gradually increased to a variety of values up to a maximum of FR200. Extinction sessions were in some cases as long as 8 hours.

When extinction was instigated after FR2 the Ss emitted approximately 750 responses and then started biting the bitometer. After biting had started it continued at a frequency of 20-30 responses per minute for the next 20 minutes. FR2 was then introduced and biting ceased immediately. Different Ss then had response requirements increased to FR50, 75, 150 and 200 and biting attacks recorded. The major result of increased response requirement was to increase the duration of attack and alter its distribution. FR50 induced most aggression during the post-reinforcement pause and very occasionally during the execution of the ratio. However, as the ratio requirement was increased more and more attacks occurred during the ratio run until under an FR200 schedule attack occurred throughout the ratio run.

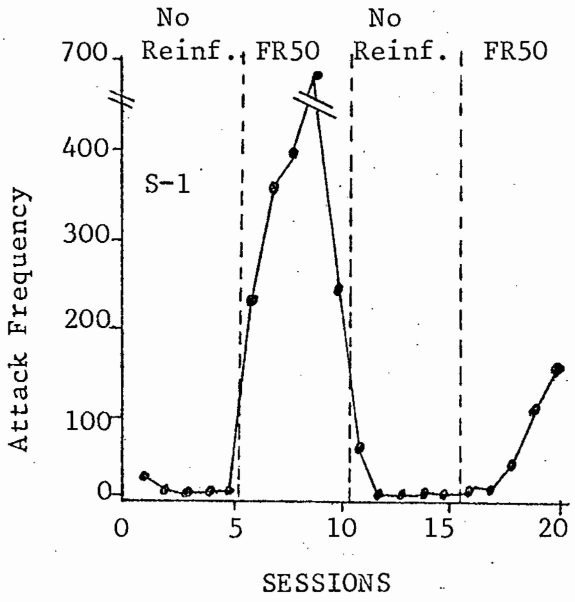
During the experiments apparatus failure sometimes occurred such as when one S failed to receive reinforcement whilst on an FR20 schedule. In previous experiments this S had been exposed to a variety of FR schedules up to FR35 and fixed intervals up to 3 minutes. The inadvertent extinction carried on for an extra long period (8 hours) and then continued for 40 x 4 hour daily sessions. The onset of extinction showed a rapid increase in biting attacks compared with the FR20 regimen and only decreased after the sixth daily session. Attacks gradually decreased and over the course of the 40 extinction sessions a total of 25,729 bar presses and 75,090 bites occurred. The extreme resistance to extinction provided by the history of intermittent reinforcement appeared to contribute to the lengthened display of biting.

This study is important because it extends the findings of Azrin et al (1966) showing extinction induced aggression occurs in primates as well as pigeons. The study also shows the aversiveness of FR schedules though whether it is the large response requirement or the large interfood intervals which induced the aggression is not clear. The amount of attack emitted by the S extinguished over 40 days is remarkable and it suggests that a history of intermittent reinforcement produces greater attack than a history of continuous reinforcement. This is contrary to expectation since one would expect extinction to be more aversive for an animal trained on a CRF schedule and consequently elicit more aggression than a S trained on a partial reinforcement schedule who would have had a chance for "emotional" responses to adapt out.

Gentry (1968) attempted to replicate the previous findings on FR schedule induced aggression using pigeons as subjects. The apparatus used is identical to that of Azrin et al (1966) and an ABAB design of no reinforcement, fixed ratio 50 reinforcement, return to no reinforcement and return to FR50 was used. During the initial period of non reinforcement the experimental and target birds were both placed in the chamber with the reinforcing mechanism inoperative in order to obtain a baseline level of attack before any history of FR reinforcement. The target bird was then removed and the experimental bird trained on an initial CRF schedule and then the response requirement was progressively increased until Ss were responding on an FR50 schedule. The target bird was then reintroduced and the second phase of the experiment began (ie. FR50 reinforcement). In the third phase the response key was taped over and the feeder was inoperative. A final phase of FR50 followed.

The results of this study are graphically represented in Figure 14 below.

Fig. 14.



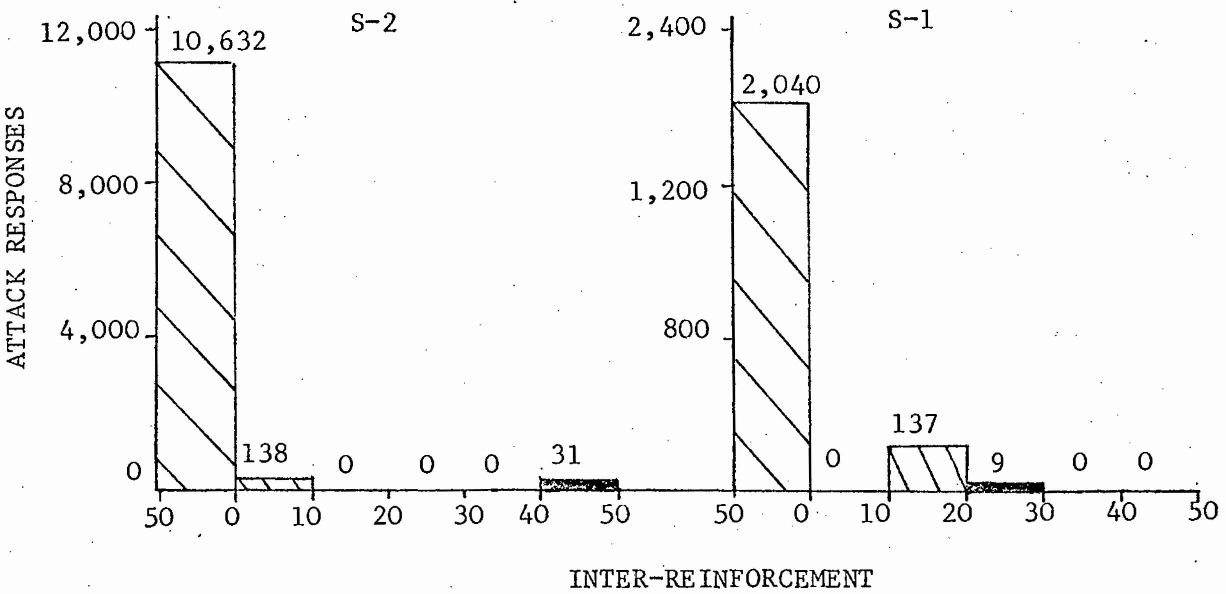
Frequency of aggressive responses made against a target pigeon by Pigeon No. 1 in alternated no-reinforcement and FR-50 sessions. Under no-reinforcement, the reinforcement mechanism was inoperative. Under FR-50, the pigeon received food reinforcement on a FR-50 schedule.

During phase A there was usually a fair amount of attack but this attack decreased to virtually zero by the end of the baseline period. During the second (FR50) phase of the experiment, however, a marked increase in attack occurred. The experimental bird would peck the FR50 response requirement, eat from the food magazine and then at the termination of reinforcement attack the target before returning to the key. Attack occurred after the very first episode of FR50 and followed nearly every instance of reinforcement thereafter. Attack tended to take place almost exclusively during the post-reinforcement pause, confirming the findings of Hutchinson et al (1968).

In the third phase attack decreased markedly. Typically the experimental bird paced back and forth in front of the response key apparently very "agitated" and occasionally attacked the target bird briefly. On subsequent days of this phase the experimental bird would sit quietly in front of the response key.

There was a return to a fairly high rate of aggression during the second FR50 phase but there was evidence of much more "ritualized" aggression in the form of aggressive postures, pecking movements without actually coming into contact with the target bird etc. Once again attack tended to occur only during the post-reinforcement pause. The inter-reinforcement distribution in Figure 15 below makes this point clearer.

FIG. 15.



Interreinforcement distribution of attach responses. Attack responses in the first interval occurred during the post-reinforcement pause. The pecking ratio requirement was divided into five intervals.

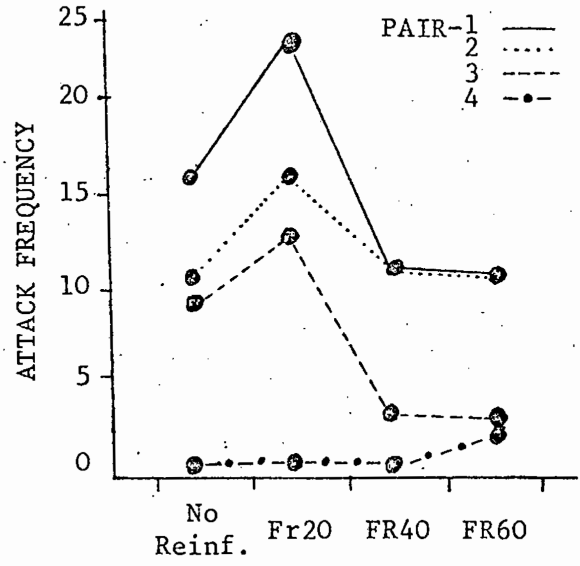
It can be seen that the interval 50-0 contains ± 98% of all aggressive responses. Almost all the remaining attacks occurred during the early part of the response sequence (0-20).

Thus it is evident from this study that FR schedules definitely have aversive properties and are capable of eliciting aggression. Whether this is due to the reinforcement schedule itself or to the periodic delivery and withdrawal of food is, however, unclear.

The obvious next stage in the investigation of ratio schedule induced aggression is to ascertain the effect of response requirement on amount of attack behavior in rats. Gentry and Schaeffer (1969) are responsible for this analysis. Using the conventional procedure of having a target and experimental animal in the test chamber a four phase procedure was carried out: a baseline of no reinforcement condition, an FR20 condition. an FR40 condition and an FR60 condition. The no reinforcement condition provided a measure of aggression before any conditioning history. Before the second phase the target animal was removed and the experimental S trained to drink from a water dipper and press the lever. Once the response requirement had been increased to FR20 and responding stabilized at this value, the target animal was re-introduced. 5 Sessions were then given during each condition of FR20, FR40 and FR60.

Figure 16 shows the mean number of attack responses for each pair of Ss during all four phases of the experiment.

FIG. 16



Mean number of attack responses for the four pairs of Ss in all four phases of the experiment: baseline (i.e. no-reinforcement), FR20, FR40, FR60.

Three of the four pairs displayed the same pattern of aggression but pair 4 showed a completely different pattern and will be dealt with separately. During the baseline condition a moderate amount of aggression was exhibited but a great deal of exploratory behavior, grooming etc. occurred as well. In subsequent baseline sessions however, aggression decreased substantially. Relative to the baseline condition aggression increased markedly during the FR20 condition. The attacks were, however, not associated with any particular segment of the FR response sequence, such as the post-reinforcement pause. (Gentry, 1968, Hutchinson, 1968). Under the FR40 and FR60 conditions aggression <u>decreased</u> compared with the FR20 as Ss spent most of their time pressing the response lever. There were no significant differences in amount of aggression induced by FR40 and FR60 and as in the FR20 condition, attack was unrelated to any particular segment of the schedule. The fact that increased response requirement reduced the amount of aggression is difficult to accept especially in the light of Hutchinson's (1968) findings. The lack of temporal relationship between attack and the FR schedule is also difficult to understand. The fact that pair 4 showed very little aggression throughout the study except when FR60 was introduced tends to discredit this study in general since, the study tends to oppose previous work and is also inconsistent. The inconsistencies are difficult to explain as it is doubtful that the unusual reinforcer used (water) could produce these effects.

The effect of response requirement on attack was further investigated by Flory (1969) using a multiple fixed ratio schedule. This study follows the same basic design as previous studies except that a taxidermically prepared pigeon was used as the target. Procedure consisted of the usual no reinforcement condition in the presence of the target to establish that no aggression occurred before any conditioning history. The target was then removed and the experimental Ss trained to use the feeder and peck the key. Gradually Ss were exposed to increasing ratio requirements until they responded on an FR25 schedule in the presence of a red key and on an FR100 schedule when the key was blue. The key colours were alternated after each reinforcement. When responding had stabilized on the multiple FR25/FR100 schedule the target bird was re-introduced. Results showed that no attacks were made during the baseline period but when the multiple schedule was introduced attacks began. Such attacks however, occurred only when the response key was blue ie. the colour correlated with FR100. No attacks occurred during the FR25 component. Attacks occasionally occurred during the ratio run but such instances were infrequent. Thus this study supports most of the previous work and indicates that a minimum response requirement and/or minimum reinforcement frequency per unit time if necessary for attack. The fact that the Ss attacked a stuffed target is noteworthy since previous researchers (eg. Azrin et al, 1966) found that Ss would not attack a taxidermically prepared bird. If researchers could establish in pilot studies that their particular breed of animal would attack a taxidermically prepared target then some of the difficulties associated with live targets, eg. damage and counter-aggression, could be overcome.

Knutson, (1970) is responsible for a detailed analysis relating amount of aggression to a wide variety of FR schedules varying from FR1 to FR120. In addition he wished to ascertain whether the schedule of reinforcement immediately preceding periods of extinction would affect the amount of extinction induced aggression. 5 White Carneaux pigeons were used as Ss and 5 as targets. All Ss were tested with a stuffed pigeon as target but only one would attack it. The stuffed target was paired with this S throughout the study. Apparatus was the same as that used by Azrin et al, (1966).

The experiment consisted of 5 stages. After the preliminary stages in which the target and experimental Ss were placed together before any history of conditioning and the experimental Ss then trained to use the feeder and peck the key in the absence of the target, the target was returned to the apparatus and the Ss placed on a multiple sch-dule consisting of 10 reinforced key pecks followed by 5 minutes of extinction (mult FR1 EXT). When the frequency of aggression had stabilized during the extinction component the target was removed and an FRN (N [illegible] 1) schedule introduced.

On this schedule the animal was trained to peck the key when it was red on an FR1 schedule and to peck the key when it was green on an FR15 schedule. Each session consisted of a multiple schedule alternating three FR15 and three FR1 periods of 10 reinforcements each - all reinforcement periods being separated by 5 minutes of extinction. (Mult FR15 EXT FR1 EXT). When responding had stabilized on this schedule the target was reintroduced. When aggression had stabilized during extinction after both FR1 and FR15, the FRN requirement during the presence of the green light was increased. The FRN requirement was changed successively from 15 to 25 to 40 to 60 to 120 responses when the amount of aggression had stabilized at each value. A 5 second changeover delay was included whenever the S attacked during the FRN component in order to delay reinforcement for at least 5 seconds after an attack. This measure prevented superstitious reinforcement of aggression.

Once these procedures were completed the final stage of the experiment was performed. Ss were placed in the apparatus daily for one week in the absence of the target with the feeder inoperative and the key unlit. The pigeons were then placed in the chamber with the target present with the key and feeder again inoperative for 7 daily sessions.

Results were as follows. No aggression occurred during the baseline condition although one S displayed cooing, head bobbing and ruffling of the feathers. During the extinction components of the multiple reinforcement schedules Ss attacked the target. Aggression occurred during extinction after both FR1 and FRN. Within sessions and between sessions of the same multiple schedule there was no difference in the amount of attack that occurred after FR1 and FRN. In other words the immediately preceding schedule of reinforcement did not differentially effect the rate of attack displayed by Ss during the extinction component of the multiple schedules, but did appear to have an effect on extinction in general.

There were some fairly large individual differences in the amount of aggression accompanying changes in FR requirements. For 3 of the Ss the amount of aggression was high during extinction in mult FR1 EXT and decreased with increases in the FRN requirement of mult FRN EXT FR1 EXT. One S showed a low rate of aggression after lower FRN requirements but then decreasing when the mult FRN EXT schedule was introduced. Another S aggressed very little during extinction throughout the entire study. For most Ss attack occurred at a higher rate during the first minute of extinction than during the total 5 minute extinction component.

During the FRN components of the mult FR1 EXT FRN EXT schedule only 2 birds attacked the target during FR15 and FR25, but on the introduction of FR40 all birds attacked the target. With the exception of one S all Ss displayed increased aggression with increased FRN requirements. In all Ss, however, the introduction of the mult FRN EXT schedule resulted in a decrease in the amount of aggression during FRN as compared to the aggression during the same FRN in mult FRN EXT FR1 EXT.

As regards the temporal relationship between attack and key responding, when the lower FRN requirements were used most attack occurred during post-reinforcement pauses. With the higher FRN requirements (FR60 and FR120) proportionately more aggression occurred during the ratio run. If during the attack the discriminative stimulus for FRN (red) was projected on to the key the attack was immediately terminated.

In the final stages of this experiment Ss were placed in the apparatus with key and feeder inoperative and no target present. When the target was introduced only one of the 5 pigeons briefly attacked during two sessions.

Most of the findings of this study are in agreement with previous studies. Hutchinson et al, (1968) tentatively concluded that a history of intermittent reinforcement would result in greater attack during extinction than would a history of CRF. However, Knutson (1970) shows in this study that only one of five Ss showed an increase in aggression during extinction with increased FRN requirement, 3 Ss in fact displayed less extinction induced aggression with increased FRN requirements. This failure to support the Hutchinson et al, (1968) finding could be due to the use of multiple schedules or to species/specific differences, since Hutchinson et al used primates. It is evident that the effect of various schedules of reinforcement upon extinction induced aggression merits additional research. Knutson (1970) makes the important point that the introduction of the target bird led to extremely strained performance on the higher FRN requirements compared with performance in the absence of the target. Although previous researchers have not noted this effect it is important since it indicates that data obtained from single subject situations should not be compared with data obtained from multiple organism studies.

6 d. AVERSIVE PROPERTIES OF INTERVAL SCHEDULES

Richards and Rilling (1972) investigated a fixed interval schedule (FI) as an elicitor of aggression. On an FI schedule the S reinforced for the first response that follows a set time period. 5 White Carneaux pigeons were used as Ss and a further 5 served as targets. The apparatus used was similar to that used by Azrin et al (1966). Ss received 10 sessions in the presence of the target in order to measure the operant level of attack. Following this, three sessions of CRF were given in the absence of the target and then a further three were given with the target present. Following this procedure the schedule was changed to FI 90 seconds and a 5 second changeover delay contingency introduced to prevent superstitious reinforcement of attack.

Most of the Ss showed a fair amount of attack at the beginning of the operant level phase but this diminished towards the end of this phase. No attack occurred during the sessions of CRF in which the target bird was present. When the FI schedule was introduced most Ss showed a large and consistent increase in attack rate and this rate was sustained throughout 20 sessions of FI reinforcement. For one S the FI schedule produced only a small increase in attack rate above the final operant level session.

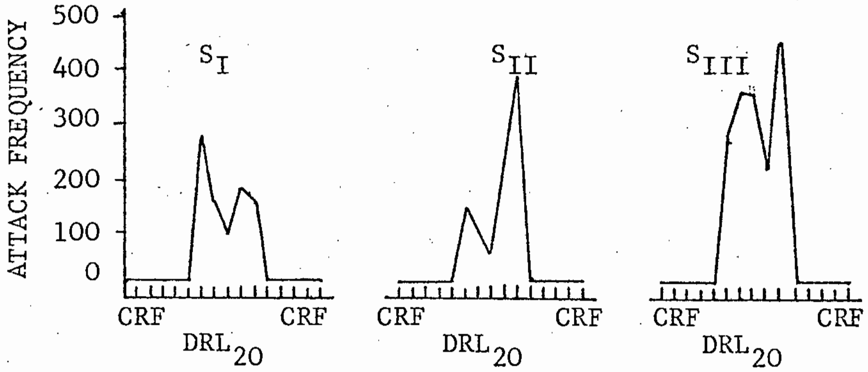
As reported in previous studies using ratio schedules, the attack for each S was higher during the post reinforcement pause than during the remaining portion of the interval. Ss would typically pause after reinforcement, move to the rara of the chamber, and attack the target bird, then return to the key and peck for the remainder of the interval.

Using aggression as an index of aversiveness the present study shows that an FI schedule of reinforcement posesses aversive properties, the most aversive of which being located during the post reinforcement pause. But since Ss still pecked the key during the interval the issue of whether aggression is a function of the response requirement or the inter-food interval remains unclear.

In an attempt to clarify this issue Knutson and Kleinknecht (1970) sought to determine if an intermittent schedule characterized by infrequent reinforcement and low response requirement would result in elicited aggression. Differential reinforcement of a low rate of responding (DRL) was utilized to achieve this result. According to this schedule only those responses which are preceded by a period of nonresponding of at least t seconds are reinforced.

Apparatus was similar to Azrin et al (1966) and the procedure consisted of the following phases:- operant level; key peck training in the absence of the target; CRF with target present; DRL without target; DRL with target; CRF without target; CRF with target. When Ss were first submitted to the DRL contingency for the first time the DRL requirement was gradually raised from 2 seconds to 20 seconds. To reduce the frequency of short inter-response times and consequently improve DRL performance IRTs of less than 20 seconds resulted in a 10 second time out (TO) in which houselight and key light were extinguished. Once this TO procedure had produced an improvement in DRL performance it was discontinued. When the DRL 20 performance had stabilized the target pigeons were reintroduced and the usual changeover delay contingency included. Results showed that no attacks occurred either during the initial training session or during the CRF session. When the target birds were introduced during DRL20 attack occurred in all 4 Ss. Figure 17 (below) shows the frequency of attack during each session for 3 Ss.

Fig. 17



The variability across Ss was quite great and in fact one S displayed so much aggression that some of the sessions had to be terminated to avoid serious injury to the target bird. Unlike previous research, this study shows that attack during DRL20 occurred throughout the entire session and it was not associated with any particular aspect of the schedule. Knutson and Kleinknecht concluded on the basis of their study that density of reinforcement is an important factor in attack behavior elicited by intermittent reinforcement. The caution with which they draw this conclusion is warranted since the DRL performance was never perfected by their Ss. In other words numerous unreinforced responses still occurred indicating that extinction was probably the elicitor of attack. Since Ss often responded <u>within</u> the 20 second period it is difficult to separate the response requirement aspect of the schedule from the inter-food interval aspect. Only if the DRL performance had been perfectly maintained could these two aspects be isolated.

6 e. AVERSIVE PROPERTIES OF DISCRIMINATION TRAINING

It has been assumed by several theorists that the negative stimulus S-, which is correlated with extinction in a successive discrimination actively controls the behavior of not responding. In a successive discrimination the subject is alternatively presented two stimuli: S+ in the presence of which responses are reinforced and S- in the presence of which responses are not reinforced. The negative stimulus has been interpreted as inhibitory (Pavlov, 1927), frustrative (Amsel, 1962) or aversive (Terrace, 1966a). It is the work of Terrace which is of particular interest to us in this context. Terrace (1963) has developed a technique known as "errorless discrimination", in which S- is gradually introduced during the very first session of training. Pigeons were trained to peck a red key (S+) for food reinforcement on a variable interval (VI) schedule of 30 seconds. As soon as key pecking was established the key was darkened for 5 seconds (S-) at regular intervals. Reinforcement was not given if the pigeon pecked during this time but since they do not tend to peck dark keys no response occurred. The duration of the dark key (S-) was gradually increased to 30 seconds. The next stage involved decreasing the duration of S- to 5 seconds and the intensity of a green light during S- periods was gradually increased until it was as bright as S+. Finally the duration of S- at full brightness was increased to 30 seconds. Following this training subjects were still responding at a moderate rate in the presence of S+ and had rarely if ever, responded during S-.

This procedure differs in several fundamental respects from the traditional procedure in which S- is introduced abruptly at full duration and intensity after several sessions of non-differentially reinforced responding to S+. Unlike Terrace's procedure, the traditional method produced many responses to S-. Although these unreinforced responses to S- eventually disappear it has been found that S- also acquires non discriminative functions as by-products of the discrimination learning. These by products include (inter alia) the following:

1) Behavioral contrast. Reynolds (1961a) noted that after discrimination training on a multiple schedule, the rate of responding to one discriminative stimulus (S1) may change as a result of a change in the schedule associated with another discriminative stimulus (S2). The important point is that the schedule correlated with S1 remains unchanged and that the change in responding to S1 is solely the result of a change in the schedule in a different component of the multiple schedule. The interaction is called a contrast if the change in rate in the first (constant schedule) component is in a direction away from the rate prevailing in the other (changed schedule) component.

2) Peak shift: Hanson (1959) reported on an experiment in which pigeons were trained to discriminate between two successively

alternating monochromatic stimuli, one correlated with reinforcement (S+) and the other with extinction (S-). The peak of a subsequently obtained generalization gradient of wavelength did not occur at S+ but was instead shifted away from S-.

3) Response to an "escape key" (Rilling, Askew and Ahlskog, 1969) and S- induced aggression (Rilling and Caplan, 1973). It is this final category of by-products which is particular interest in this context. What are the reasons for these by-products and what ways can S- be compared with the other aversive contingencies reviewed earlier?

Terrace (1972) maintains that these non-discriminative functions of discriminative stimuli are neither universal nor permanent. Under certain conditions the phenomena listed above do not occur at all. If the "errorless" discrimination technique is used (ie. if no responses to S- occur) none of the by-products of discrimination learning are observed (Terrace, 1963a, 1963b, 1964, 1966, 1971b). If an "errorful" discrimination technique is used these phenomena inevitably occur but disappear with extended training.

Terrace (1972) is particularly concerned with emotional responses to S-. In comparing behavior at the onset of S- of pigeons who learned to discriminate a horizontal line from a vertical one, he provides evidence to support his claim that there is a clear difference between pigeons who learned the discrimination with errors and those who did not. He provides photographs showing pigeons who have learned with errors. These Ss react with wing flapping, striking the key with their wings and turning away from the key ie. typical "emotional" responses. Pigeons trained with the errorless technique usually settle down in front of the key and wait for S+ to appear again. These findings indicate that S- is acting as an aversive stimulus but more direct evidence of this aversiveness would be provided by a demonstration that S- affects behavior in a similar manner to the way a primary negative reinforcer affects behavior. Could a response be conditioned and maintained by using removal of S- as the "reinforcer"? The problem with this avoidance paradigm is that to maintain the strength of the behavior primary psoitive reinforcement would have to be used as well (eg. food). Removing S- would therefore increase the frequency of positive reinforcement thereby contaminating the result. The use of an escape response, however, obviates this difficulty.

Rilling, Askew and Ahlskog (1969) extended an experiment of Terrace's (1966) in which behavioral contrast was observed early in discrimination training but decreased when the training was extended. Terrace proposed that contrast was a by-product of frustration or emotional responses and that these reactions adapt out after extended exposure to S-. Terrace, however, only inferred these aversive properties of S- not measuring them independently. Rilling et al employed a procedure in which the subject was given an opportunity to produce a time-out (TO) from the discriminative stimuli. A multiple schedule in which S+ alternated with S- was arranged on one key. A peck on a second key produced a TO during which the box was dark and the contingencies on the multiple schedule were removed. To avoid the confounding of TO from S- with the frequency of reinforcement in S+, the procedure was designed so that TOs during S- had no effect on the reinforcement frequency during S+. In order to -etermine if the TO response was controlled by its consequences a control group was given the same multiple schedule as the experimental group, but although pecks on the TO key were counted, they had no scheduled consequences.

In experiment 1 S+ was correlated with a variable interval 30 second schedule (VI 30 second) and S- with extinction. Results showed that TOs from S- increased rapidly for each subject during the early sessions of the discrimination training. But after reaching a peak, TOs from S-declined with extended training, thereby supporting Terrace's ideas on the subject. In experiment II S+ was correlated with VI 5 seconds and S- with VI 5 minutes. Generally TO responses occurred mainly to VI 5 minutes but for some Ss TO behavior was extremely weak and substantial individual differences were present. TOs were also recorded in a multiple VI 30 second VI 5 minute schedule in which the TO response removed the stimulus correlated with the VI 5 minutes in exchange for a stimulus correlated with extinction.

But why did TOs occur? There are at least 3 alternative explanations. (1) Extinction (S-) increased the variability of behavior (eg. Antonitis, 1950) so the occurrence of TOs on the "escape" key could be attributed to increased variability in responding due to extinction of responding to S-. (2) Following the work of Azrin et al (1966) pecks on the TO key could be interpreted as extinction induced aggression onto inanimate objects. (3) The TO response could be an escape response from a conditioned aversive stimulus.

The increased variability explanation of TO behavior implies that TO is not controlled by its consequences. However, in Experiment I, a comparison of the control group, where responses on the escape key had no contingency, with the experimental group, where a response produced a 30 second TO, showed a higher rate of TO behavior for the experimental group for all but the first session of discriminative training. Subsequent sessions showed increased responding to the escape key indicating that escape from S- was reinforcing.

The aggression interpretation of Azrin et al (1966) has considerable support since for the majority of Ss in the Rilling et al (1969) study the discrimination of TOs paralleled the distribution of attacks reported by Azrin et al, thus suggesting that transition from VI 30 seconds to extinction or VI 5 minutes may be considered as an aversive event. Rilling et al, although supporting this explanation, feel that the role of S- as a conditioned aversive stimulus is better able to explain their findings. Why TO responses occasionally occurred to S+ is, however, difficult to explain. The most important aspect of this work, however, is in its analysis of S- as an aversive event producing "escape" responses.

The procedure used by Rilling et al (1969) can be classified as "errorful" in as much as numerous responses occurred to S- until the contingency was properly learned. Would escape responses occur if an "errorless" technique were used? Terrace (1971) compared the number of escape responses from S- when S- was gradually introduced during the first session of training ("errorless" technique) with the escape behavior obtained when S- was introduced abruptly after 21 sessions of non differentially reinforced responding to S+. Excape from S- was not obtained for the first group, but a substantial number of escape responses were obtained from the second group. Terrace concluded that "....the occurrence of non-reinforced responding to S- is the crucial factor in rendering S- aversive" (Terrace, 1971, p.160). Rilling, Richards and Kramer (1973), however, showed that errors during S- may not be the only factor responsible for the by-products of discrimination learning. Rilling et al (1973) used a procedure utilizing 4 groups of pigeons, each group differing in the time and manner in which S- was introduced and also differing with resepct to errors. S- could be terminated by pecking a TO key. Generally speaking groups that differed with respect to errors did not differ with respect to the number of TOs produced; in fact the correlation between errors and TOs for the 4 groups was only +0,06.

Escape from S- was more likely when S- was introduced late in training. In once case, escape from S- was obtained from an errorless bird after S- was introduced gradually following several sessions of non-differentially reinforced responding to S+, but few escape responses were obtained from errorless birds when S- was introduced gradually during the first session of discrimination training. One could conclude on the basis of this finding that it is the procedure for introducing S-, that is the major factor determining the aversiveness of S-.

Could this explanation be applied to aggression induced by S-? Is aggression at the onset of S- unrelated to the number of responses to S-? Rilling and Caplan (1973) used an ABAB design in which A was the presentation of S- alone without S+, and B was discrimination training. To obtain errorless learning stimuli that are easily discriminated by pigeons were used: S+ being a green key correlated with a VI 30 second schedule and S- being a dark key, correlated with extinction. The question of primary interest was whether the attack rate would increase during discrimination training when S+ and S- were alternately presented. 45 sessions of discrimination training were provided during condition B in an attempt to determine if aggression would disappear with extedned training. A seven phase procedure was used.

Phase 1: operant level of attack in the presence of S- was obtained before key training began.

Phase 2: after shaping, responses on a green key (S+) were reinforced on a VI 30 seconds schedule, whereas a dark key indicated extinction.

Phase 3: target birds reintroduced and S+ and S- alternated in random manner. If attack occurred during S+ the first peck on the key following the attack delayed reinforcement on the VI schedule until a subsequent response occurring at least 5 seconds after the first response.

Phase 4: the baseline rate of responding to S+ was obtained, S+ being alternated with S+ for 25 presentations. S- was not presented.

Phase 5: the discrimination training of phase 3 was re-introduced.

Phase 6: S+ was omitted and the baseline rate of attack to S- was again determined. Conditions were identical to phase 1.

Phase 7: discrimination training as in phase 3 repeated.

Six of the seven Ss did not attack the target bird at all during phase 1. The remaining S had an attack rate of 0,3 attacks per minute. Discrimination training in phase 3 increased the rate of attack during S- over the rate prevailing in phase 1 when S+ was not presented. When discrimination training was resumed (phase 5) attack during S- was observed in all Ss. When S- was again presented alone (phase 6) the attack rate during S- dropped considerably. During discrimination training (phase 7) each bird showed an increase in rate of attack during S- compared with the base rate obtained in phase 6.

The rate of attack during S- was not reduced with extended training since the rate of attack was just as great in phase 7 as it was in phase 3. Although there were large individual differences in rates of attack during S-, attack occurred even though many of the birds were errorless in most phases of the experiment. As regards the temporal relation of attack in discrimination training, for each of the 7 birds the rate of attack was highest in the first 20 seconds after S+ terminated and decreased monotonically to the lowest rate during the last 20 seconds of S-.

In conclusion it may be said that the generalization made by Terrace (1966, 1971) that by-products of discrimination training are only observed when an "errorful" training technique is used is not supported by the data of this experiment. Aggression during S- is obviously an exception to the generalization. The fact that aggression did not disappear with extended training is also contrary to Terrace's notions. Evidently errors during S- (extinction) are not the essential requirements needed for by-products to occur. The distribution of attacks during S-, in which the probability of attack was highest after S+ terminated, was similar to that of Azrin _et al_ (1966) and also paralleled the distribution of escape responses from S- obtained by Rilling _et al_ (1969). These data taken together indicate that positive reinforcement during S+, is one of the factors responsible for attack during S-. The fact that attack frequency declines during S- indicates that the aggression inducing properties of S- are not primarily due to the contingencies prevailing during S-.

7 a. REINFORCING PROPERTIES OF AGGRESSION

So far we have seen that aggression is elicited by a wide variety of aversive situations. What is the function of aggression under these circumstances; Is it merely "reflexive" or does it in fact have reward value? Could the opportunity for aggression be used to reinforce an arbitrary response?

Azrin, Hutchinson and McLaughlin (1965) using squirrel monkeys as Ss investigated this problem. Ss were restrained in a special chair to prevent extraneous movement and aversive stimulation consisted of tail shock of 100 m sec. duration. The top of the experimental chamber had an opening through which a canvas-covered ball, 2 inches in diameter, could be lowered by activating a motor. The ball could be withdrawn by removing the motor. "Reinforcement" in this study refers to the lowering of the ball through the opening to a distance of 4 inches away from the Ss face where it remained for a duration of 2 seconds. While the ball was in the lowered position, the monkey could grasp a flexible cord attached to the ball and bring it to its mouth. The cord was attached to a microswitch facilitating recording of the response.

The manipulanda for the conditioned response consisted of 2 easily discriminated chains suspended through separate openings in the ceiling of the chamber. The manipulandum on the right of the S is designated Rr and that on the left Rl. One important aspect of the chamber was that there were no projecting objects that could be attacked easily other than the indended object of attack, which was the ball.

The procedure consisted of the following phases:

<u>Phase 1</u>: Reinforcement continuously available, but no manipulanda available and no shock given, in order to measure the base level of attack.

<u>Phase 2</u>: Identical to phase 1 except that brief shocks were

delivered every 15 seconds.

Phase 3: Rr was made available and brief shocks were delivered at 15 second intervals. The ball could be lowered only by pulling Rr - ie. an attempt was made to ascertain whether the response of pulling Rr would be learned if that response were followed by the reinforcement of having the ball lowered for 2 seconds.

Phase 4: Rl was available and Rr was absent. When Rl was pulled the ball was lowered for 2 seconds.

Phase 5: Both Rl and Rr were available but only Rl was reinforced. This procedure was continued until response to Rl constituted more than 80% of the total responses to Rl and Rr.

Phase 6: The reinforcement contingencies were reversed, responses to Rr only being reinforced.

Phase 7: Contingencies again reversed such that Rl was reinforced and Rr unreinforced.

Phase 8: Contingencies again reversed.

Phase 9: Identical to phase 8 except that no shock was delivered.

Results showed that no attacks occurred when no shocks were delivered in phase 1. When the shocks were delivered while the ball was lowered (phase 2) attack occurred consistently and immediately after each delivery of the shock. When the availability of the ball was made contingent on the chain pull (phases 3 and 4) chain pulling responses occurred consistently after each shock.

When both manipulanda were present (phases 5 - 8) the monkey responded to that chain which produced the ball - for all Ss over 85% of the chain pulling responses were emitted on the chain that resulted in reinforcement.

This successful conditioning of the chain pulling response offers a way quantify the strength of aggression-motivation without the need to adapt the recording apparatus to unique modes of attack. The chain pulling response was itself not merely the result of blind attack since responses occurred almost esclusively only on the chain which produced opportunity for attack. Azrin et al, conclude that opportunity to attack appears to be a reinforcement for a subject exposed to aversive stimulation, in a very simmilar manner to the way in which eating is a reinforcement for a food deprived organism. One difference between the two types of motivation may concern the persistence of the drive being investigated. In this study, as in previous studies, attack reached its highest level during the period immediately after the shock, diminishing rapidly thereafter. Hunger motivation, however, is far more persistent. But this difference could be due to the fact that shock is only given very briefly. If it were given continuously then perhaps attack would be more persistent. Data provided by Azrin, Ulrich, Hutchinson and Norman (1964) lends some support to this contention, since they noted that when continuous footshock was given for short durations attach was observed for a major portion of the shock delivery. Perhaps one could conclude that when an animal is experiencing shock opportunity for aggression is reinforcing both during the shocking experience and for a short period of time thereafter..

Supporting the notion that aggression is reinforcing in a similar manner to food or water, is a study by Tellegen, Horn and Legrand (1969). Male mice trained to be reliable fighters were run in a modified T maze in which a correct position choice was follows by an opportunity to fight with a docile mouse placed in the "correct" goal box. The procedure for all Ss followed three stages: (1) acquisition, (2) reversal - in which the "correct" and "incorrect" goal boxes were interchanged, (3) extinction - in which regardless of which arm of the T maze was chosen the experimental

S did not receive the opportunity to aggress.

The data showed that all Ss acquired a preference for the aggression reward side of the maze both during acquisition and reversal. Ss chose the side rewarded with aggression approximately 72% of the time, results being statistically significant. (p .05). These results clearly show that the opportunity for aggression functioned as a reinforcer. In addition extinction as well as reversal of the location of the reinforcer produced comparable effects to those observed with other reinforcers such as food or water.

Addtional support for this notion would come from studies which could show that aggression as a reinforcer could be scheduled in various ways and produce similar reactions to schedules of food reinforcement. For example, would a partial schedule of aggression reinforcement produce greater resistance to extinction than a continuous schedule?

Legrand (1970) used a technique similar to Tellegen et al (1969) in which opportunity to attack was used as a reinforcer. Ss were run in a straight runway and were rewarded 0%, 50% and 100% of the time. All Ss received the same number of rewards during acquisition, however, since partially reinforced Ss were given a compensatory number of reinforcements in a special apparatus completely unlike a straight runway.

Results showed that opportunity for aggression served as a reinforcer in an analagous way to food or water since reinforced groups performed signifcantly better than unreinforced groups. Evidence for a partial reinforcement effect, however, fell just short of the .15 level of significance.

Van Hemel (1972) explored the use of the opportunity to attack and kill mice as a reinforcer. Hooded rats were used as Ss, each rat having killed at least 20 mice in a previous study. The apparatus consisted of an experimental chamber with two easily discriminable keys and the reinforcement mechanism consisted of a 14 inch diameter motorized wheel with small wire mesh compartments. When the wheel was turned mice were delivered through an opening in the chamber. In Experiment I Ss were shaped to press either lighted key in order to be presented with a mouse on a CRF schedule. Ss were then given discrimination training in which for two rats mouse presentation followed only presses on the key preffered during the three previous daily sessions, and for the other two rats reinforcement followed presses on the non-preffered key only. Responses on the incorrect key were consequently extinguished. For the next seven days of training this reinforcement contingency was reversed for each rat. Results clearly showed that Ss rapidly learned to press a key for reinforcement. When a mouse was presented it was usually instantly attacked and killed. During the discrimination procedure Ss learned to press the correct key for reinforcement and then reversed their preference during the reversal procedure.

Experiment II investigated the role of motor feedback from the performance of the act of killing the mouse. Variations in the amount of consummatory behavior involved in a reinforcing activity had been shown to affect the reward value of the activity. (Sheffield and Roby, 1950). Van Hemel varied the amount of consummatory activity by using normal mice, anethetized mice, dead mice and rat pups as reinforcers.

Rats underwent pretraining tests to select those that would attack mice with consistently short latencies, but would not attack rat pups. After they had learned to press a key for mouse presentation on a CRF schedule, an interval schedule was gradually introduced until responding had stabilized on a VI 1 minute schedule. The Ss received 20 days of training on this schedule, and three rats were assigned to each of two groups, matched on the basis of median response rate on the last 9 days of training. For one group of three rats responding was first reinforced with presentation of normal mice, then with anaesthetized mice, next with dead mice and finally with 14-25 day old rat pups. For the other group of rats the stimulus animals were presented in reverse order. Control periods in which the reinforcer consisted of normal mice, were interspersed with varied reinforcement periods to re-establish baseline responding. When this procedure had produced stable responding a 6 session extinction period was introduced. Sessions were identical to those of previous test periods but the compartments of the reinforcement wheel were empty.

Results indicated that Ss responded at a fairly high rate on the VI schedule of reinforcement. When the stimulus animals were introduced normal mice were attacked and killed. Anaesthetized mice were treated in exactly the same way even though they did not move in response to the attack. Dad mice also elicited vigorous attacks, but when rat pups were used as reinforcers they were merely pulled from the wheel and licked but in not one case were they injured.

Response rates were quite variable within test periods when various reinforcers were used, but the only consistent effect of type of reinforcer was the sharp reduction in rate of responding when the reinforcer consisted of ratpups. When extinction was instituted the response rate dropped to almost zero over the 6 session period.

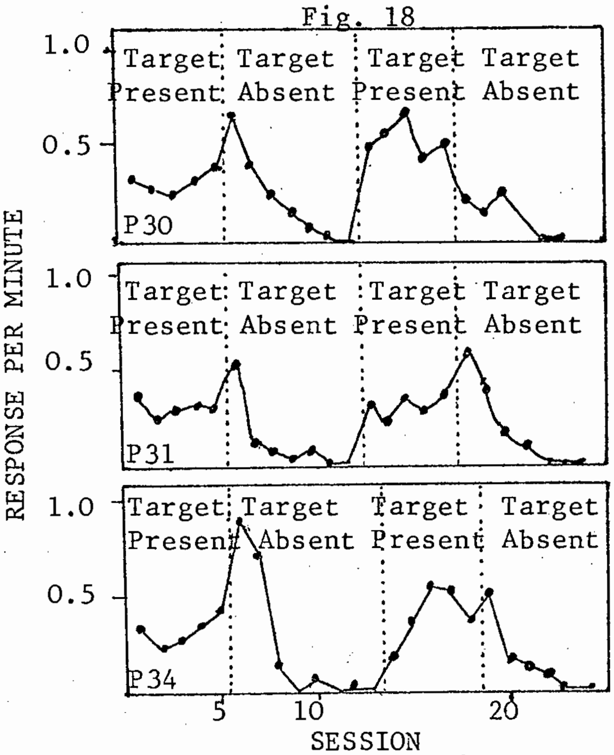
This study shows clearly that opportunity for aggression can be used to reinforce a lever pressing response. The fact that anaesthetized mice and dead mice were attacked as readily as normal mice provides support for the notion that the aim of the aggression is not destruction. The actual act of attacking is obviously in itself rewarding.

In a series of experiments Cherek, Thompson and Heistad (1973) investigated whether opportunity for aggression would be reinforcing during concurrent food reinforced responding. The apparatus used was similar to that of Azrin _et al_ (1966), except that the target bird was placed behind a plexi-

In Experiment II the target bird was successively removed and returned to the apparatus in an attempt to extinguish and recondition responding on the target key. Three Ss from Experiment I underwent an ABAB procedure in which the target bird was either present (A) or absent (B). Two responses on the target-key were necessary to activate the shield motor and responses on the food key were reinforced according to the FI schedule which produced the highest response rate for each bird in Experiment I. Under condition B responding on the target-key produced all the usual stimulus changes associated with availability of the target, except for the actual presence of the target bird.

The results of the study are graphically represented below. (Figure 18).

Fig. 18



The rate of responding on the target key in the presence and absence of the target

It can be seen that for all three Ss when the target was first absent response rate on the target-key increased but then subsequently decreased to zero. When the target bird was reintroduced response rates returned to almost the same level as in the previous target accessible condition. Cherek et al conclude (cautiously) that this experiment suggests that responding on the target-key was maintained by the presentation of the target animal. They do not claim that opportunity for aggression was reinforcing the response. In order to make this additional claim the opportunity to attack itself would have to be manipulated in some way.

Experiment III investigated the effect of response dependent versus response independent reinforcement on taget-key responding. In the response dependent condition Ss were reinforced on the response initiated FI schedule that produced the highest rates in the previous experiment. In the response independent condition the food key was covered and food was delivered independently of behavior. The interval used for each of the three Ss was equal to the mean inter-reinforcement interval calculated from the previous five sessions of the response dependent condition. Food was not presented, however, until 15 seconds after each response on the target key or 15 seconds after the termination of target availability. The response-dependent and response-independent conditions were both scheduled twice.

There were fairly large individual differences in the results of this experiment. For subject P17 rate of responding on the target key decreased accross the four sessions regardless of whether food was response dependent or independent. For Subject P30 target key responding was maintained in both conditions and rate showed no change across the four sessions. As regards Subject 41, however, response rate on the target key decreased in the response independent condition but increased again in the response dependent condition. Because of the large individual differences in this experiment it is impossible to assess the effects of response-dependent versus response independent food reinforcement on target key responding.

The results of Experiment IV are, however, more easily interpreted. Azrin et al (1966) had shown that attack ceases when Ss are no longer exposed to alternating reinforcement and extinction conditions. This experiment attempted to determine if responding on the target key would be maintained in the absence of a concurrent food reinforcement schedule. The procedure consisted of an ABAB design of response initiated FI food reinforcement (A) and no reinforcement (B) conditions. Five sessions of concurrent FI food reinforcement FR2 target presentations were given followed by the no reinforcement condition in which the food key was covered and food never presented. (This condition was not extinction because the food reinforced response could not be emitted). Condition A was then reinstated followed by condition B.

During the FI phase response rates on the target key increased for all Ss. When the nopreinforcement condition was introduced rats on the target key increased briefly but then decreased to zero for all Ss. When the FI condition was reinstated response rates on the target key increased once more and then dropped to zero rapidly in the no-food condition. Actual attack rates on the target bird also followed this pattern indicating that attack is a function of the concurrent food schedule, consequently supporting the findings of Azrin et al (1966).

SYNOPSIS

Thus far we have looked at the strengthening of an operant response and noted that when such a response is followed by reinforcement the rate increases, a behavioral loop develops and the response becomes highly stereotyped. When this response fails to be reinforced it undergoes a gradual decrement known as extinction. Extinction is characterised by an initial response rate increase but gradually the incidence and duration of pauses increases and eventually very few responses are emitted. Behavior does not become random during extinction but rather the operant level patterns tends to re-appear.

The number of responses emitted in extinction is a function of a number of variables. Generally speaking, the more reinforcements given in acquisition the greater the resistance to extinction although this function appears to reach a limit rather early and is dependent on the presence or absence of discrimination training. Drive level appears to have relatively little effect on the number of extinction responses and when extinction trials are massed ("controlled operant" situations) less resistance to extinction is usually shown.

Reinforcement schedule affects resistance to extinction more than any other variable. Basically the more unreinforced responses the S makes in acquisition the greater the resistance to extinction. When a fixed ratio schedule is used during training the extinction function reaches a maximum at a ratio above about FR20 and then declines as the ratio is increased to very high values.

The major theories of extinction have been reviewed and it was concluded that notions regarding competing responses, stimulus generalization and motivational properties of frustration perhaps provide the most productive solutions to the numerous problems.

Extinction was then classed as an "aversive contingency" and compared with various other aversive contingencies such as pain from electric shock, a physical blow, heat, etc. and it was noted that the probability of a particular operant class (aggression) increased tremendously under such conditions. It was then shown that schedules of reinforcement and discrimination training, where unreinforced responses occur, also induce aggressive behavior.

But why does aggression occur during aversive contingencies? Is aggressive behavior providing the S with some kind of reward? Various studies were reviewed showing that aggression does indeed have considerable reward value.

The following series of experiments was undertaken to investigate the relationship between fixed ratio value, opportunity for aggression and resistance to extinction.

EXPERIMENT 1: THE EFFECT OF RESPONSE REQUIREMENT ON RESISTANCE TO EXTINCTION

RATIONALE.

In section 3a (above) studies investigating the influence of schedule of reinforcement on resistance to extinction were reviewed. It was noted that in studies where FR schedules were investigated the general finding supported the notion of a monotonic relationship between FR value during acquisition and resistance to extinction. Mowrer and Jones (1945) trained rats on FR values from 1 to 4 and noted this monotonic relationship, and Hearst (1961), using a completely different experimental design, found the same result with pigeons and response requirements of up to 10 responses per reinforcement. Boren (1961), however, studied the effect of FR values as high as FR20 using rats and noted that his Ss were unable to sustain high rates of responding above a response requirement of 20. He sheds doubt on the monotonic relationship conception stating that:

> ".... considered over a much wider range of fixed ratios than was covered in the present experiment, it is likely that the extinction function reaches a maximum at a ratio somewhat greater than 20:1 and then declines as the ratio is increased to very high values". (Boren, 1961, p.307).

Ferster and Skinner (1957) did, however, investigate extinction after Fixed Ratios as high as 160 but their data are contaminated by the fact that number of reinforcements during acquisition was not controlled. Ferster and Skinner were not interested in resistance to extinction *per se* and so they did not supply the detailed data necessary to draw adequate conclusions, but analysis of their cumulative records indicates support for a monotonic relationship between FR value during acquisition and resistance to extinction. Experiment 1 attempts to overcome the difficulties associated with the Ferster and Skinner data and investigates FR values from FR10 to FR80. Since all Ss received the same number of reinforcements during acquisition the influence of response requirement per se on resistance to extinction could be assessed.

SUBJECTS:

Sixteen experimentally naive male Homing pigeons varying in age from 18 months to 36 months served as subjects for this experiment. Ad Libitum weights varied from 350 grams to 490 grams.

Pigeons make ideal subjects for the experimental analysis of behavior because their characteristic mode of responding, the peck, can be emitted for many hours at a very high rate (up to 15 responses per second have been recorded) without undue fatigue. Response rates are also extremely stable enabling the experimenter to introduce independent variables and easily measure the consequent changes in responding.

The sensory capacities of the pigeon also enable the experimenter to utilise various stimuli to signal experimental conditions. Chard and Gundlack (1938) note that the eye of the pigeon is large (half the weight of the brain as compared with one fiftieth in humans), that the retina is thicker than in man, and that there are no retinal blood vessels that might interfere with vision. Measures of the acuity of the pigeon's vision have often produced equivocal results but most authors agree that the pigeon equals man in this respect. (Chard, 1939; Hamilton and Goldstein, 1933). The near-point of accommodation appears, to be approximately 40 cms and acuity is reduced at closer distances. (Chard, 1939). The large number of cones in the pigeon retina would suggest good colour vision and Hamilton and Coleman (1933) claim that the colour vision of the pigeon is equal to man's. Additional details on the sensory capacities of pigeons may be found in Reese, (1964).

APPARATUS

During pilot studies a Ralph Gerbrands Company Skinner box for pigeons model G5610 was used. The chamber measured 42 x 47 x 49 cms. For a number of reasons, however, the original chamber proved to be unsuitable for the present study. A one-way mirror viewing aperture was provided to enable visual monitoring of the S, but the aperture was placed in a position in which all the corners of the chamber were not visible. As a result of this the S would often be out of sight. Because a one-way mirror was used the S was able to see its reflection and as a result a variety of social behaviors such as aggressive postures, sexual behavior etc. resulted. Naturally the ongoing operant performance was disrupted by such activities. An added difficulty was the small size of the chamber because this precluded the use of additional apparatus, for example a stabilimeter, inside the chamber. For the above reasons it was decided to construct a Skinner box which would obviate these difficulties.

The new Skinner box measured 90 x 45 x 35 cms and was of wooden construction. (See Figure). The chamber was lined with aluminium and the space between the box and the aluminium filled with polystirene. A full length forward hinging door provided easy access to the chamber and a Television camera was focussed through the aperture at the far end of the chamber. Because a special wide angle lense was used the S never went out of sight of the experimenter. The camera was a Pie "Lynx" automatic wired to a National monitor.

The intelligence panel from the Gerbrands Skinner box (above) was mounted in a slot so that it could slide into and out of the chamber thus facilitating maintenance and repair of the response keys and the feeder. Three standard pecking keys (Ferster and Skinner, 1957) were mounted approximately 24 cms above the wire mesh floor. The keys which were 1,8 cms in diameter, were adjusted so that the switches were activated when a force of 15 grams was exerted against the plexiglass. (15 gramms is the value used by most researchers in the field.) (See Figure). Throughout all the experiments, however, the two outer keys were taped over leaving only the centre key accessible.

Directly behind each key was mounted an in-line digital display (projector). The displays enabled the experimenter to project the following symbols/colours onto the keys:- triangle, square, circle, cross, plus sign, minus sign, vertical line, red, turquoise, green, white and yellow. 12,5 cms. below the centre key was a feeding aperture which, during reinforcement, gave the S access to grain provided by the solenoid operated feeder. The S stood on a wire mesh floor and a removable stainless steel tray was mounted immediately below it to facilitate cleaning.

The chamber was illuminated by 4 x 2,5 watt globes- two mounted directly above the intelligence panel behind a perspex panel and two behind a similar panel in the ceiling of the chamber. When the feeder was raised a 2,5 watt globe illuminated the feeder aperture. The globes in the in-line digital displays were 2,5 watts each. Readings taken with a general purpose illumination meter (Salford Electrical Instruments Ltd. Model M904) indicated that the luminance level was approximately 6,5 lumens per square metre. Readings were taken in various parts of the chamber but no detectable variation was recorded.

An extractor fan was mounted on the wall of the chamber opposite the television camera. The fan, which operated throughout all experimentation, helped to keep the temperature inside the chamber at a moderate level. The humming sound which it produced also helped to mask extraneous noises.

A Grason Stadler model 901B noise generator provided white noise of 86 db through a speaker attached to the rear of the intelligence panel. White noise was used as a masking sound throughout all experiments.

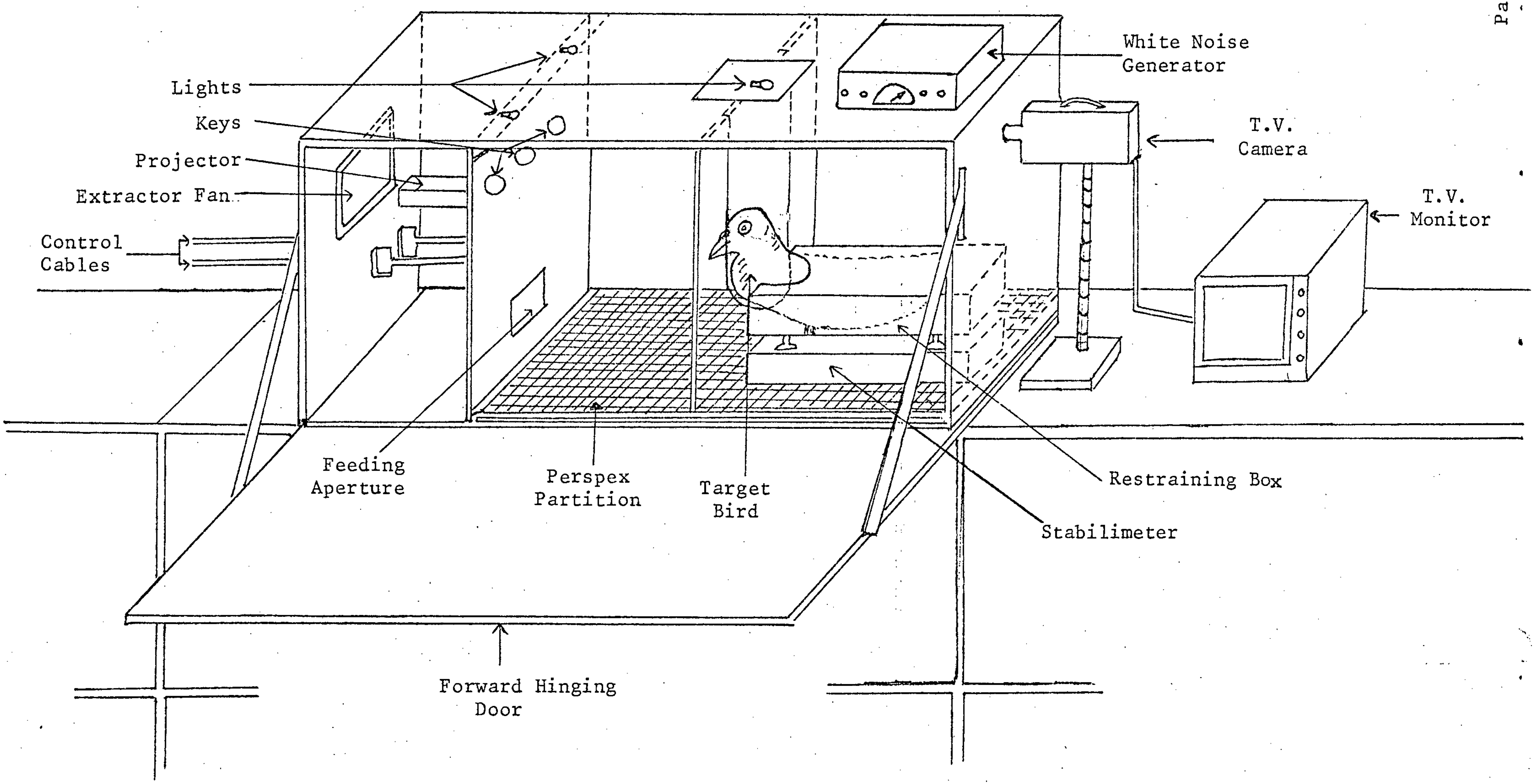
Approximately 28 cms from the intelligence panel a removable clear perspex partition divided the chamber roughly in half. The partition had a "u shaped" cut out, and depending on how it was mounted, either allowed or prevented the S access to the rear half of the chamber.

All experiments were programmed by a system of buss-bar mounted clocks, predetermining counters, digital counters and relays. The relay rack and all other equipment in the chamber was powered by a 28 volt, 10 amp power supply.

The main data from each experiment was provided by a scientific Prototype model CR3F cumulative recorder. Paper speed was 30 cms per hour and the pen stepped 100 times every inch. A clock timed the duration of each experiment while a timer controlled reinforcement duration. Other digital counters recorded reinforcements and responses.

(In Experiment I the apparatus was as in Figure 19 except that the target bird was not present).

FIG.19 APPARATUS USED IN EXPERIMENTS I, II AND III.
(Experiment I TS Absent)
(Experiment II and III TS Present)



PROCEDURE

(a) DEPRIVATION SCHEDULE

Pigeons were obtained from a variety of sources throughout the city. When they were first brought into the Department colony their numbers were recorded in the colony log book and they were then housed in individual cages measuring 30 x 35 x 45 cms. Mixed pigeon grain and water were freely available for one week after which time all Ss were weighed and experimental weights established. The experimental weight chosen was 80% x *ad libitum* weight as pilot studies had shown that at this figure food became a highly sought after reinforcer. This weight was however not so low as to make the Ss debilitated - the fact that they remained in perfect health throughout month long experimental phases adds support to this contention.

The deprivation procedure followed Ferster and Skinner (1957). Ss were given no food for the first two days and were then weighted and given 5 grams of mixed grain per day until their weights reached 80%. Ss were fed by hand during this phase because this helped to tame the animals facilitating later handling. Water was freely available at all times. When all the Ss had reached their experimental weight training began.

(b) TRAINING

The initial phase of training consisted merely of adapting the S to the apparatus, teaching the use of the feeder, and key peck training. On day 1 of this phase each S was placed in the apparatus with the house lights, key light and white noise on. After half an hour had elapsed t the bird was returned to its home cage.

On day 2 conditions were the same as in day 1 except that the feeder was raised for 30 seconds every 30 seconds. As the feeder was raised the key light was extinguished automatically and the feeder light came on. By the end of day 2 all Ss were eating from the feeder without hesitation as soon as it was raised. After the session Ss were returned to their home cages after being weighed. It was always necessary to weigh each S before and after every session in order to ensure that they were not gaining too much weight during each session which would have affected motivation.

On day 3 key-peck training began. The feeder was raised by the Experimenter (E) for 10 seconds whenever the S raised its head in the direction of the pecking key, ie. the method of successive approximations was used. This process was speeded up by programming the equipment so that whenever the feeder was raised the key light was simultaneously extinguished. This procedure seemed to draw the Ss attention to the light. Most Ss pecked the key within half an hour of this procedure and when they did so the feeder was automatically raised for 5 seconds. Each S then received 50 x 5 second reinforcements on a CRF schedule.

On day 4 Ss were placed on a multiple schedule of reinforcement enabling the E to progressively raise the response requirement for each component in a systematic manner. On day 4 a multiple Fr1 FR2 schedule was in effect and table details the procedure for each subsequent day of the experiment. When the Ss had responded on an FR10 schedule 4 were non-

EXPERIMENT 1. DAILY SCHEDULE

DAY	SCHEDULE	REINFORCE-MENTS	RESPONSES
1	–	–	–
2	Feeder Training	–	–
3	Shaping (CRF)	50	–
4	*Mult.* FR1FR2	100	150
5	*Mult.* FR2FR4	100	300
6	*Mult.* FR4FR6	100	500
7	*Mult.* FR6FR8	100	700
8	*Mult.* FR8FR10	100	900
9	*Mult.* FR10FR12	50	550
	Mult. FR12FR14	50	650
10	*Mult.* FR14FR16	50	750
	Mult. FR16FR18	50	850
11	*Mult.* FR18FR20	50	950
	Mult. FR20FR22	50	1050
12	*Mult.* FR22FR24	50	1150
	Mult. FR24FR26	50	1250
13	*Mult.* FR26FR28	50	1350
	Mult. FR28FR30	50	1450
14	*Mult.* FR30FR32	50	1550
	Mult. FR32FR34	50	1650
15	*Mult.* FR34FR36	50	1750
	Mult. FR36FR38	50	1850
16	*Mult.* FR38FR40	50	1950
	Mult. FR40FR42	50	2050
17	*Mult.* FR42FR44	50	2150
	Mult. FR44FR46	50	2250

DAY	SCHEDULE	REINFORCE-MENTS	RESPONSES
18	*Mult.* FR46FR48	50	2350
	Mult. FR48FR50	50	2450
19	*Mult.* FR50FR52	50	2550
	Mult. FR52FR54	50	2650
20	*Mult.* FR54FR56	50	2750
	Mult. FR56FR58	50	2850
21	*Mult.* FR58FR60	50	2950
	Mult. FR60FR62	50	3050
22	*Mult.* FR62FR64	50	3150
	Mult. FR64FR66	50	3250
23	*Mult.* FR66FR68	50	3350
	Mult. FR68FR70	50	4830
24	*Mult.* FR70FR72	50	3550
	Mult. FR72FR74	50	3650
25	*Mult.* FR74FR76	50	3750
	Mult. FR76FR78	50	3850
26	*Mult.* FR78FR80	50	3950
	FR80FR80	50	4000
27	Each S on appropriate schedule	100	-
28	Each S on appropriate schedule	100	-
	TOTAL:	2550	
29	EXT.	0	
30	EXT.	0	

systematically chosen to remain on this schedule for the remainder of the experiment. The remainder of the Ss were then subjected to the procedure outlined in the table until they had all responded on a FR20 schedule. Four Ss were then non-systematically chosen to remain on this schedule for the remainder of the experiment. The remaining Ss then followed the procedure as outlined in the table until they had all responded on a FR40 schedule. Once again 4 were non-systematically chosen to remain at the value for the duration of the experiment and the rest followed the procedure as outlined in the table.

Following this procedure, by the end of day 26 there were 4 SS on each of the FR values to be investigated: FR10, FR20, FR40 and FR80. However, by this stage Ss responding on the FR80 schedule had not yet stabilised on this schedule so a further 2 sessions of 100 reinforcements each were given to <u>all</u> Ss on their respective schedules. By the end of this procedure each S had received exactly the same number of reinforcements and had undergone an identical procedure except for the reinforcement schedule.

On day 29 each S was placed on extinction. The feeder mechanism was disconnected but all other secondary reinforcing stimuli present during acquisition were in effect during extinction. The key light remained on throughout the 30 minute extinction period and response counters and a cumulative recorder kept record of the data. After the extinction period had elapsed Ss were returned to the colony, weighed and given the same amount of grain as they normally ingested during the acquisition phases. For most Ss this amount was approximately 15 grams.

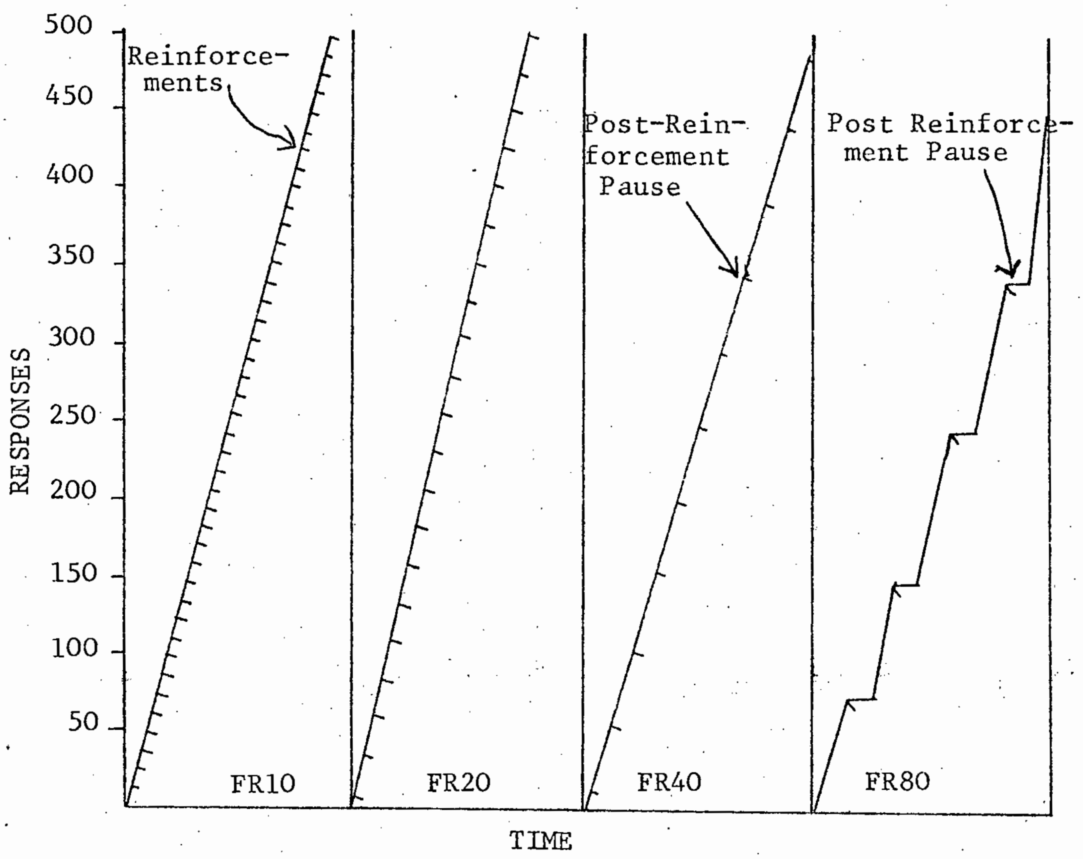
On day 30 Ss were again weighed and then returned to the apparatus.

A further 30 minutes extinction period followed during which the apparatus conditions were as in day 29. When 30 minutes had elapsed Ss were returned to the colony and allowed free feeding for one day after which they were given 15 grams per day.

EXPERIMENT I - RESULTS.

Each experimental animal stabilised on its respective ratio very rapidly and the figures below show typical stabilised performances on each of the ratios investigated.

FIG. 20 STABILISED RESPONDING ON FR10, FR20, FR40 AND FR80.



Response rates, once performance had stabilised, appeared to reach a peak at FR40 where approximately 5 responses per second were emitted. The major factor distinguishing performance among the four ratios studied was the post-reinforcement pause. Ss in the FR10 condition rarely exhibited a post-reinforcement pause whereas in the higher ratios studied (FR40 and FR80) a post-reinforcement pause characterised the performance of all the Ss studied. A timer had been so programmed as to be activated immediately after reinforcement and de-activated when the S responded on the pecking key. The times recorded were analysed for each ratio and the following table depicts the results.

TABLE 3 MEAN POST-REINFORCEMENT PAUSE FOR Ss ON FR10, FR20, FR40, AND FR80.

	FR10				FR20			
Ss	S13	S10	S8	S17	S1	S5	S11	S16
Mean Post-Reinforcement Pause (Seconds)	.60	.65	.40	.70	.75	.90	.40	.35
Overall Mean =	0.58				0.60			

	FR40				FR80			
Ss	S4	S14	S2	S7	S15	S19	S9	S6
Mean Post-Reinforcement Pause	3.5	6.3	4.3	5.2	5.7	5.9	7.3	6.6
Overall Mean =	4.82				6.4			

The mean post-reinforcement pauses for Ss on FR10 was 0.59 seconds and for Ss on FR20, 0.60 seconds. FR10 and FR20 schedules therefore appear to be virtually identical as far as the duration of the post-reinforcement pause is concerned.

FR40, however, showed a marked increase in the duration of the post-reinforcement pause with an overall mean of 4,82 seconds. The overall mean for the duration of the post-reinforcement pause was 6.4 seconds for the FR80 Ss showing a large increase over FR40. The following diagram illustrates the relationship between ratio requirement and duration of post-reinforcement pause.

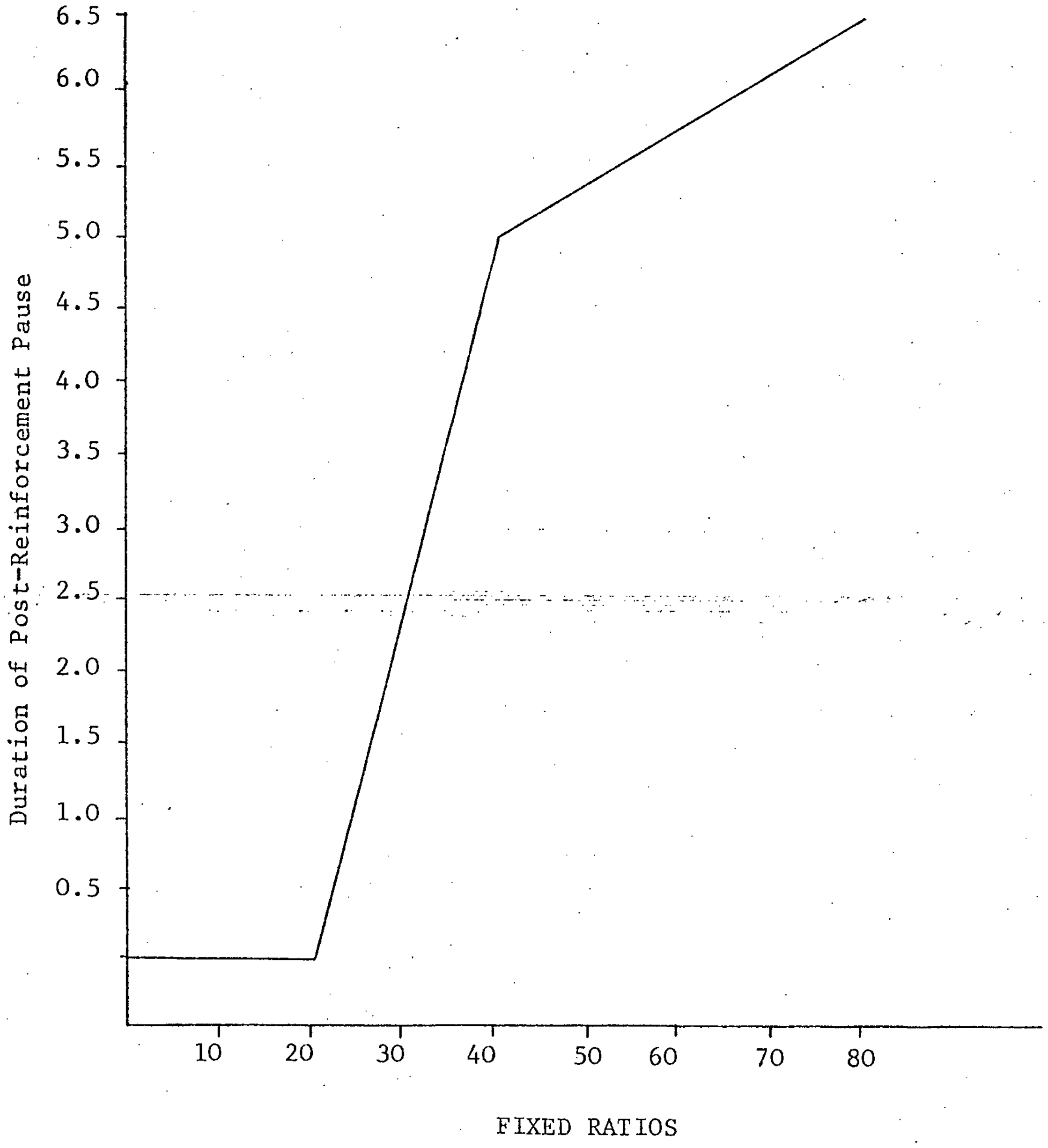


Fig. 21 Relationship between Ratio Requirement and Post-Reinforcement Pause

There can be little doubt from the results depicted that increasing the ratio requirement increases the post-reinforcement pause but the relationship does not appear to be a monotonic one. A wider range of ratios and more Ss would be needed, however, before a firmer conclusion could be drawn.

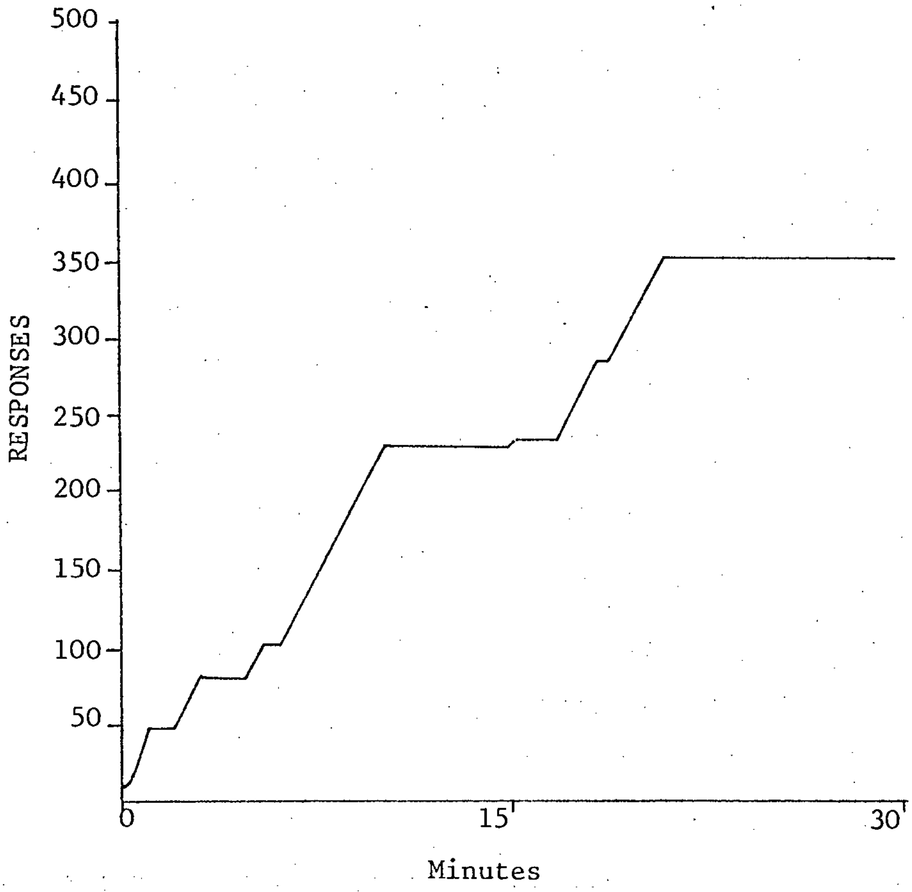
BEHAVIOR DURING POST-REINFORCEMENT PAUSE.

On FR10 and FR20 during the post-reinforcement pause Ss would normally only swallow the grain obtained from the feeder and then immediately resume pecking. Occasionally an S would briefly preen its breast feathers and then continue pecking. Whilst responding on FR40 and FR80, however, a number of "ritualistic" behaviors tended to occur. Ss, during the post-reinforcement pause would preen their wing tips, bow and coo or briefly walk around the chamber. Occasionally Ss would peck at other parts of the intelligence panel or at the sides of the experimental chamber, but this tended to occur only rarely. One particular S (bird S19) would adopt an almost catatonic posture during the post-reinforcement pause but at the end of an approximately six second period would suddenly resume responding. The behaviors listed above often tended to be ritualistic since in preening, for example, the Ss would only "go through the motions" without any real effect. The term "displacement activities" may be relevant here since the activities discussed only occurred during the period when the probability of obtaining reinforcement was zero. In all Ss and for all ratios studied, once responding began it was rarely interrupted, even by the occasional external noise which penetrated the experimental chamber.

RESISTANCE TO EXTINCTION.

FIXED RATIO 10

Fig. 22 Extinction After FR10 (Bird S10)



Ss extinguished after FR10 showed the controlling effects of the contingency. Responding began immediately after the Ss were placed in the chamber and the key light and house lights turned on. Since all secondary reinforcing stimuli present during acquisition were present during extinction the Ss had no way of telling that they were undergoing extinction. This aspect of the present study differentiates it from the majority of previous extinction studies. In most previous studies the response key is conventionally taped over. Consequently Ss are unable to respond in the same way as they responded during acquisition. Secondary reinforcing aspects of the key peck such as motor and auditory feedback are therefore lost.

In the present study, however, the only aspect differentiating extinction from acquisition was the absence of food reinforcement.

Ss would respond at the rate normal for FR10 (± 3 responses per second) until they reached the point where they were accustomed to receiving reinforcement. At this stage a pause would generally occur. During this stage, which corresponds to the point where a brief post-reinforcement pause would occur during acquisition, Ss would pace to and fro in front of the intelligence panel and would occasionally lunge toward the key without actually making contact. After the pause, pecking would continue at the normal rate until a further pause intervened. The duration of these pauses tended to become longer as extinction continued. When responding occurred little change in rate was observed but the "response rhythm" tended to be lost. Ss showed increased hesitancy to respond as extinction continued and the "grain" of the cumulative records became coarser.

The number of responses emitted during extinction varied to an unusual degree among Ss. The table below shows data for each S studied.

TABLE 4 NUMBER OF RESPONSES EMITTED AFTER FR10.

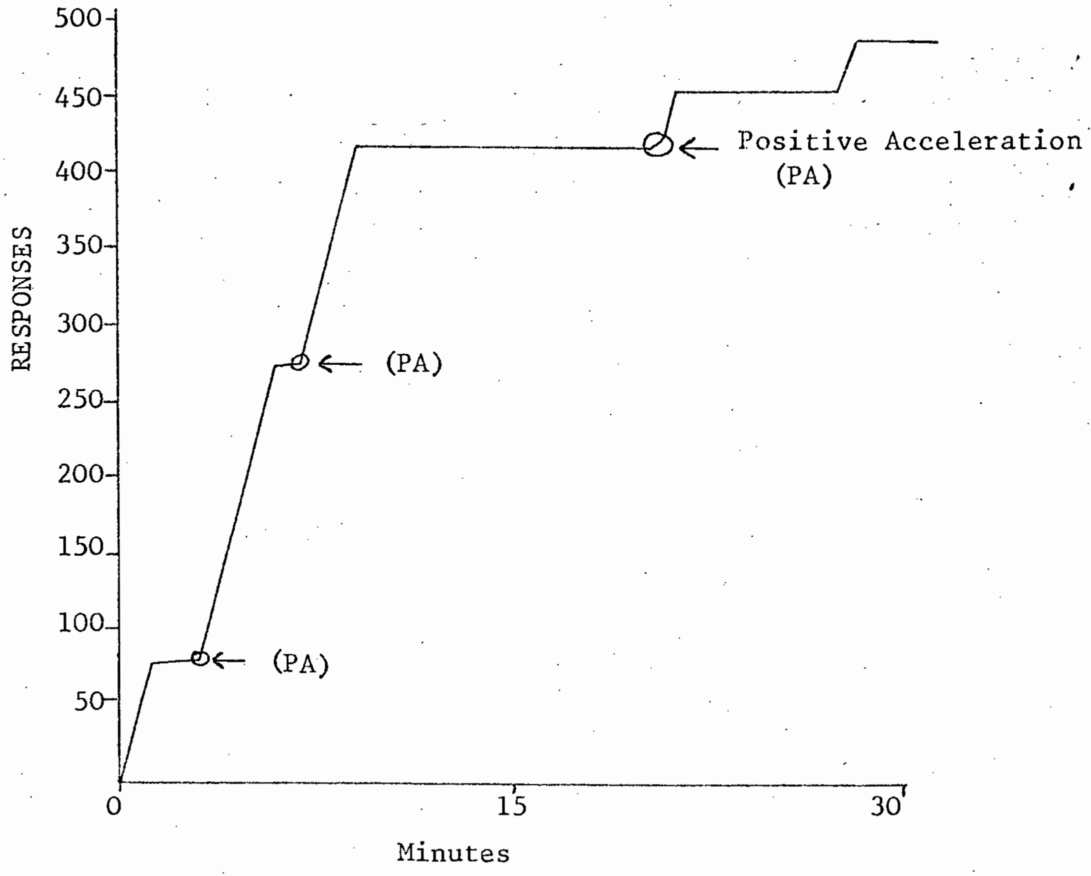
S13	360
S10	381
S8	466
S17	409
Mean Rs	404

The relatively large variation in number of responses experienced is difficult to explain. Since all training procedures were identical for each S one can only assume that factors operative prior to the experiment may account for the variation.

An animal's resistance to extinction will be a function of its total prior reinforcement history both within and outside the experimental situation. Some degree of generalisation from prior extinction experiences in the extra-laboratory environment may play a role in laboratory experiments but the Experimenter (E) feels that the extra-laboratory environment is so different from that of the laboratory in terms of contingency consistency that any generalisation effect would be immeasurable. Consequently one can only account for the variation under the rubric of "individual differences". Only by rearing Ss under identical environmental conditions could these individual differences be reduced. This would, however, be beyond the scope of the present study.

EXTINCTION AFTER FR20.

FIG. 23 EXTINCTION AFTER FR20 (BIRD S11)



Consistency in performance characterised the performance of the FR20 Ss. Ss would characteristically enter the chamber and begin responding as soon as the houselights were turned on. Responses were emitted at a high rate (± 4 responses per second) and the records showed very little coarse grain. One interesting feature which emerged during extinction after FR20 was the existence of positive acceleration immediately after pauses. Ss would begin responding at a relatively low rate after a pause and the rate would then suddenly increase to a level which would be maintained until the next pause occurred.

The number of emotional responses which occurred showed an increase compared with FR10 Ss. During pauses behaviour exhibited included bowing and cooing, wing-flapping, ritualistic preening, attempts to escape the experimental chamber, pecking at the intelligence panel, lunges at the pecking key which stopped just short of the key and almost catatonic postures which would be maintained for several seconds. Defaecation/urination also showed an increase compared with the FR10 Ss.

Another important difference between FR20 and FR10 Ss concerned the "urgency" or rapidity with which behaviour during pauses occurred. Whereas FR10 Ss engaged in "displacement activities" the "strength" of the behaviour could not be regarded as excessive. FR20 Ss, however, seemed to find non-reinforcement more aversive since "emotional" responses increased in both frequency and intensity. When, at the end of the 30 minute extinction period, the E removed the S from the chamber the FR20 Ss would struggle and attempt to escape the grasp of the E.

This behaviour very rarely occurred during acquisition for any Ss regardless of the ratio, and did not occur at all after the extinction period for FR10 Ss.

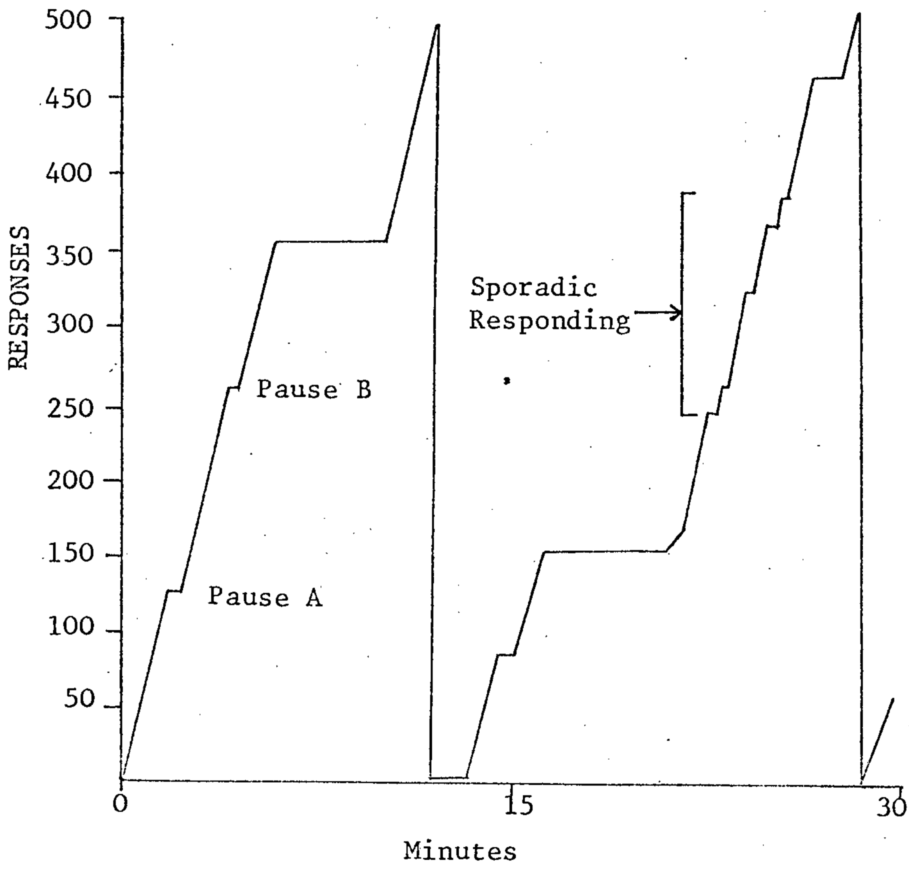
TABLE 5 NUMBER OF RESPONSES EMITTED AFTER FR10 AND FR20.

FR10		FR20	
	S13 : 360 S10 : 381 S8 : 466 S17 : 409		S1 : 519 S5 : 547 S11 : 493 S16 : 529
Mean Rs : 404		Mean Rs : 522	

Whereas the mean number of responses emitted by the FR10 Ss in extinction had been 404, FR20 Ss emitted 522 responses.

FIG. 24 EXTINCTION AFTER FR40.

EXTINCTION AFTER FR40 (BIRD S7)



The record for S7 was chosen to illustrate extinction after FR40 because S7 typified the performance of the FR40 Ss. Once the houselights were turned on S7 would begin pecking the key at a very high rate. No pauses occured until approximately 125 responses had been emitted. Another 125 responses were then emitted until a short pause of approximately 20 seconds interrupted the performance. During these first two pauses all the "displacement activities" mentioned under FR20 extinction occurred but Ss appeared to be panicky or extremely agitated. During the second pause (Pause B) S7 attempted to escape the chamber. The intelligence panel was subjected to a flurry of blows with the wings and feet. The next pause was much longer (± $2\frac{1}{2}$ minutes) and S7 displayed every emotional behaviour mentioned thus far. Catatonic postures, however, never occurred in S7 or in any of the FR40 Ss.

The section of the record marked "sporadic responding" is of interest. S7 would pace up and down the intelligence panel, respond rapidly for about 20 responses, pace up and down the intelligence panel once more and then resume responding once more. This behaviourial sequence was repeated four times. One interesting feature of this behaviourial sequence was that the S would feint responding as it passed the response key - the beak would just touch the plexiglass but without sufficient force to close the contacts. The casual observer would almost assume that the animal feared the response key.

The number of responses emitted during extinction after FR40 showed remarkably little variation across Ss. The following table compares the FR40 Ss with results of FR10 and FR20 schedules.

TABLE 6 NUMBER OF RESPONSES EMITTED IN EXTINCTION AFTER FR10, FR20 AND FR40 SCHEDULES

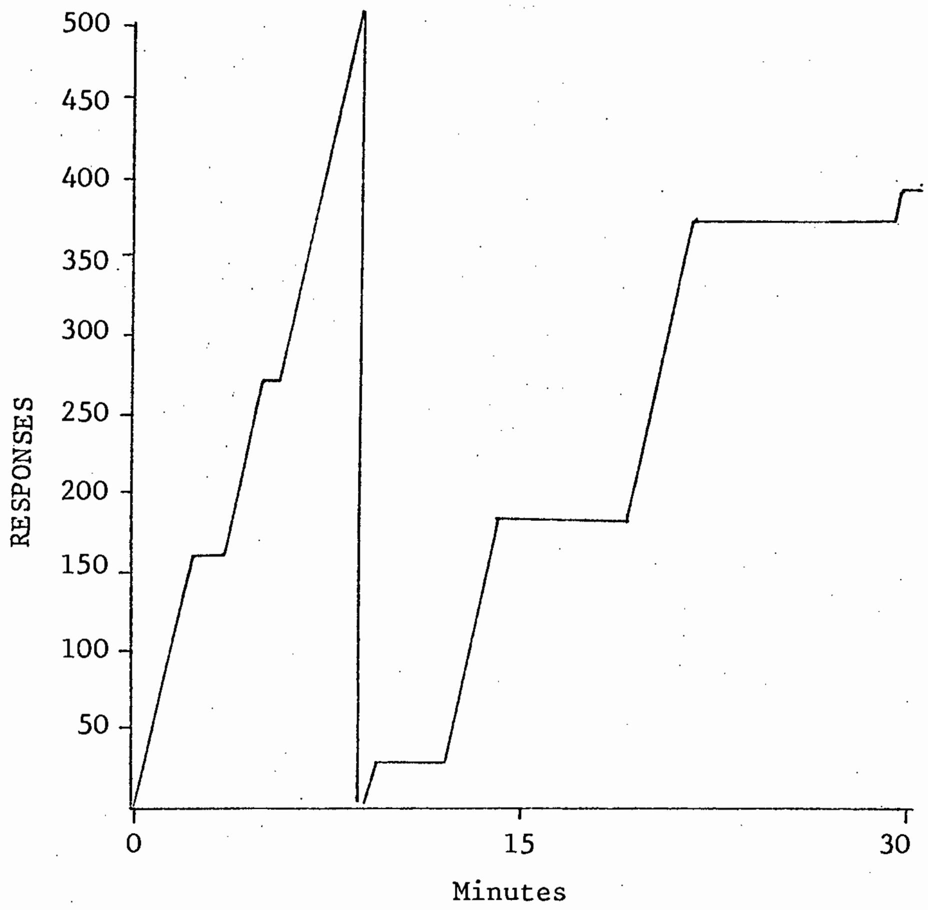
FR10		FR20	
S13	360	S1	519
S10	381	S5	547
S8	466	S11	493
S17	409	S16	528
Mean Responses	404	Mean Responses	522
FR40			
S4	1010		
S14	1209		
S2	973		
S7	1058		
Mean Responses	1062		

The table shows that FR40 Ss produced a mean number of 1062 extinction responses. It is interesting to note at this point that although Ss trained on FR20 emitted during acquisition twice as many unreinforced responses as Ss trained on FR10, they emitted nowhere near twice as many responses in extinction as their FR10 counterparts. FR40,Ss, however, emitted twice as many unreinforced responses in acquisition as FR20 Ss and maintained this relationship during extinction. Evidently the "reflex reserve", to use an outdated term, is significantly enhanced in ratios above FR20 in the pigeon.

EXTINCTION AFTER FR80.

The extinction record for Bird S9 is reproduced below:

FIG. 25 EXTINCTION AFTER FR80 (BIRD S9).



Bird S9 responded without pause when placed in the experimental chamber and emitted approximately 160 responses before pausing for approximately two minutes. During this pause the S paced up and down the intelligence panel in an upright posture. Wing-flapping and the characteristic "bowing and cooing" also occurred. Responding then continued once more at the same initial high rate for approximately 100 responses until a further pause occurred. During this pause similar behaviour occurred to that emitted in the first pause except that the S now tried to escape the chamber by clawing at the wall opposite the intelligence panel and beating the same wall with its wings.

Defaecation and urination also occurred during this pause. When responding on the pecking key began the S did not pause for almost 300 responses. When a pause did occur it was four times as long as the previous pause. The first portion of the pause was spent in behaviours mentioned above but these gradually diminished in duration and became sporadic. At the end of this pause the S appeared to be involved in exploratory behaviour - pecking at the floor of the chamber and at spots on the walls. Occasionally preening was noticed .

When responding was resumed the same high rate and consistency was maintained. Once response rhythm was attained the S did not pause at all until that particular response sequence was completed. Pauses then became longer and longer and the behaviour during pauses altered. In the final pause before the end of the extinction session the S showed very few signs of "emotion" and merely walked around the chamber, occasionally pecking at the floor. Much of the time was spent in the S sitting relatively still in a corner of the chamber.

To interpret the behaviour of this subject to some extent, it appeared as if non-reinforcement was particularly aversive in the early part of the extinction session (the first 15 minutes) but became less so as extinction continued. Behaviour was less "wild" and "emotional" in the latter half of the extinction session almost as if the S had resigned itself to non-reinforcement. This contrasted strongly with behaviour emitted by the Ss extinguished after FR40 since their behaviour remained "emotional" throughout extinction.

The number of responses emitted in extinction by Ss trained on FR80 is included in the table which follows:

TABLE 7 NUMBER OF RESPONSES EMITTED DURING EXTINCTION AFTER FR10, FR20, FR40 & FR80 (SESSION 1).

	FR10		FR20
	S13 : 360		S1 : 519
	S10 : 381		S5 : 547
	S8 : 466		S11 : 493
	S17 : 409		S16 : 529
Mean Rs	: 404	Mean Rs	: 522
	FR40		FR80
	S4 : 1010		S15 : 1190
	S14 : 1209		S19 : 1126
	S2 : 973		S9 : 896
	S7 : 1058		S6 : 988
Mean Rs	: 1062	Mean Rs	: 1050

It can be seen that the mean number of responses emitted in extinction was 1050, compared with 1062 (FR40); 522 (FR20) and 404 (FR10). Very little additional resistance to extinction was achieved in the Ss studied by raising the response requirement from FR40 to FR80. It would appear that FR40 or a ratio fairly close to FR40, provided the Ss with the maximum resistance to extinction. Additional comment on this fact will be included in the "Discussion" section below.

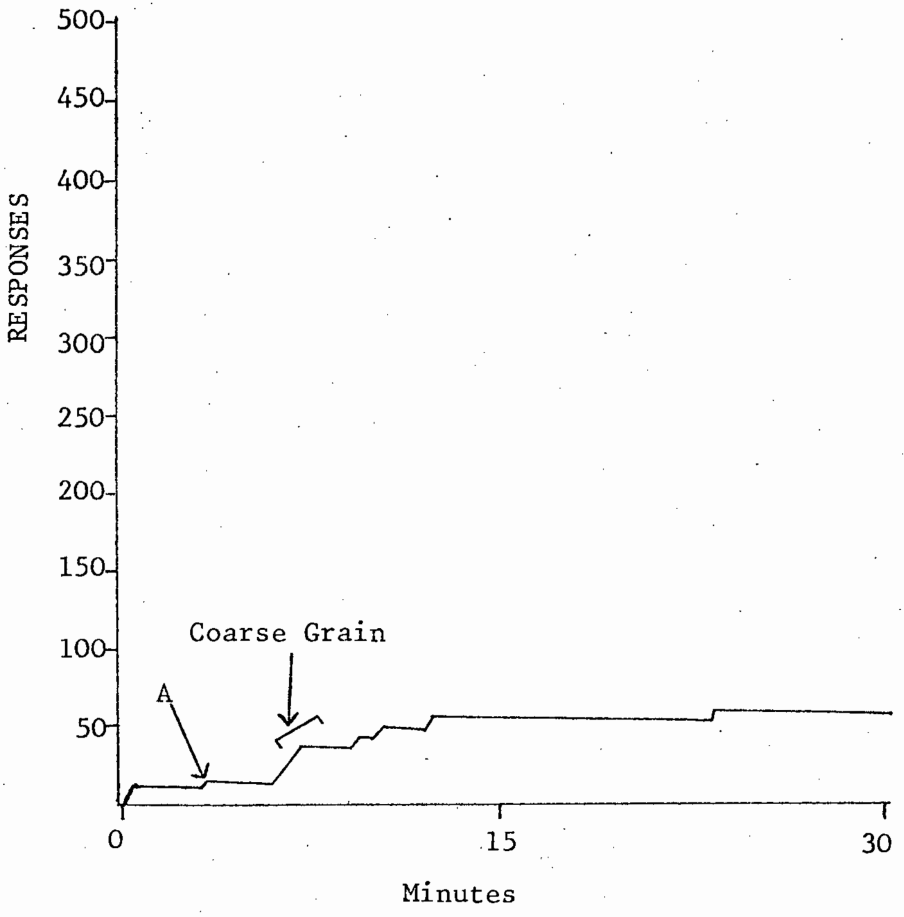
RESULTS: EXTINCTION SESSION TWO.

a) FIXED RATIO 10.

An immediately apparent difference between extinction session one and extinction session two emerged. In session one Ss began responding as soon as the houselights were turned on, whereas in session two, Ss remained perfectly still in the chamber for at least one or two minutes. When key-peck responding began it was extremely sporadic with numerous pauses and weak pecks, which failed to activate the key contacts.

Very few responses were emitted in extinction by all Ss in the second session. The following record is typical.

FIG. 26 EXTINCTION AFTER FR10 (BIRD S10)



Bird S10 began responding approximately three minutes after the houselights were turned on but the rate was very slow albeit fairly consistent. Behaviour during pauses consisted mainly of attempts to escape the chamber. Very little pacing up and down the intelligence panel occurred although occasionally the S would approach the panel, respond once or twice as in "A" above, and then continue attempts at escape. From approximately the 13th minute onward the S merely sat quietly in a corner of the chamber, occasionally preening its feathers. The section of the graph marked "Coarse Grain" occurred when the S pecked the key with just sufficient pressure to actuate the key and the cumulative recorder - almost "as if" the S feared the key. An interesting point in this context was the behaviour of the Ss on being removed from their home cage for the second extinction session. Ss who have been trained on a particular schedule generally behave in a reasonably calm manner before a training session. When the E removed the Ss from their cages for the second extinction session, however, the Ss struggled to escape the grasp of the E and attempted to escape from the container used to transport them from the home cage to the experimental chamber. This aspect will be analysed below in the "Discussion" section.

The total number of responses emitted by Ss in session two is detailed below.

TABLE 8 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR10 SESSION TWO.

S13	63
S10	56
S8	79
S17	58
Mean Rs	64

The variation across Ss was very small with a mean of 64 responses compared with a mean of 404 responses in the first extinction session.

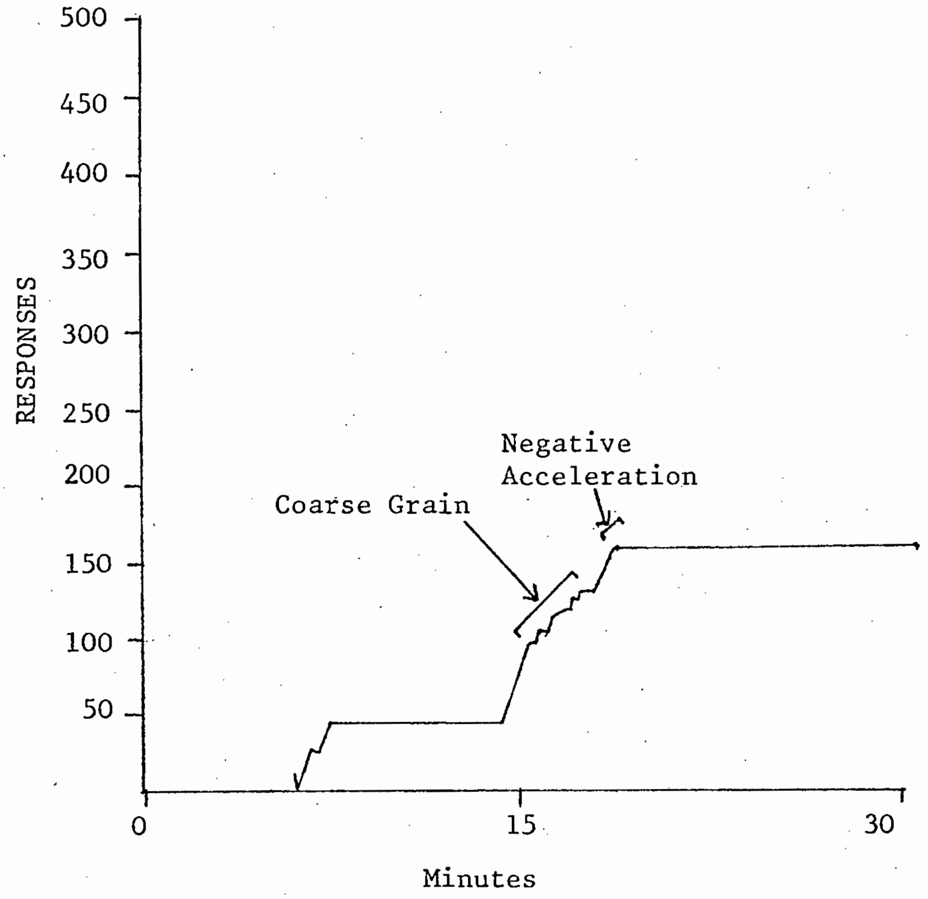
b) FIXED RATIO 20.

On being removed from their home cages for the second extinction session Ss exhibited the same escape reaction mentioned above. In contrast with the FR10 Ss, however, FR20 Ss defaecated and urinated whilst in the transporting container.

When placed in the experimental chamber Ss rushed around the cage, flapped their wings and pecked at the walls of the chamber. Key-peck responding did not begin for three of the Ss until 5 minutes had elapsed. The fourth S responded after 4 minutes 26 seconds.

The following graph is illustrative of the Ss' performance.

FIG. 27 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR20 - SESSION TWO (BIRD S11)



When responding occurred the rate was as high as that emitted during the stabilised acquisition phases but a pause occurred after approximately 35 responses. The next pause was a long one (approximately 7 minutes) during which time the S paced around the cage flapping its wings, occasionally even flying around the cage.

If the "intensity" of the behaviour could be measured it could be justifiably said that the FR20 Ss were "more emotional" than the FR10 Ss.

The number of responses emitted by the Ss is included in the table below.

TABLE 9 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR10 AND FR20 - SECOND SESSION.

	FR10		FR20
	S13 : 63		S1 : 197
	S10 : 56		S5 : 209
	S8 : 79		S11 : 158
	S17 : 58		S16 : 143
Mean Rs	: 64	Mean Rs	: 177

The mean number of responses emitted in session two by the FR20 Ss was 177 compared with 522 responses in session one.

c) FIXED RATIO 40.

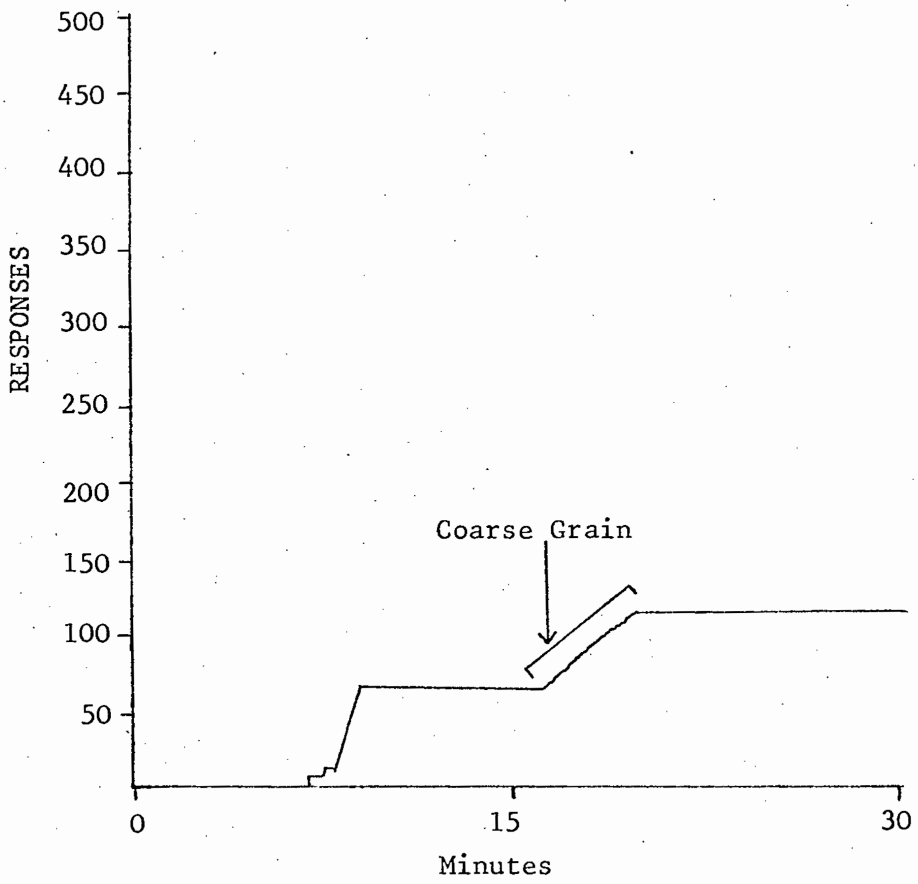
On being removed from the home cages and placed into the transporting container FR40 Ss were extremely active. They struggled to be free of the grasp of the experimenter and emitted a low "cooing" sound continually. Handling of the Ss was in fact extremely difficult due to the struggling, wing-flapping, and clawing of the Ss. The E was pecked on the hand by three of the Ss upon removal from the home cage. This behaviour had very rarely been experienced in Ss accustomed to a training regimen.

When placed in the experimental chamber S flapped their wings continually and persisted in attempts to escape the cage. In most training sessions pigeons will very rarely move about in a darkened chamber since their scotopic vision is so poor that movement often results in injury.

FR40 Ss, however, were exceptions to this rule - they rushed around the cage even before the houselights were turned on.

Extreme emotional behaviour continued when the houselights were turned on and Ss renewed their attempts to escape with increased vigour. After a few minutes, however, Ss sat quietly - possibly due to exhaustion. The behaviour of S14 can be discussed as typical of the FR40 Ss. Once S14 stopped rushing about the cage it sat passively for about 3 minutes and then approached the intelligence panel with its beak in an upright position. Eventually the S feinted pecking at the response key, a few times and then pecked the key with insufficient force to activate the contacts. After a few weak pecks of this sort the S began pecking in the trained stabilised fashion for approximately 60 responses. When the S paused it ran around the cage, flapping and cooing agitatedly. The S persisted in flying into the wall of the chamber further away from the intelligence panel. Although post-experimental examination revealed no damage, it appeared as if the S was sustaining injury during this behaviour. Responding which occurred after this "injurious" behaviour was extremely sporadic resulting in a very coarse grain on the recorder. Between key pecks the S would move its head from side to side in an apparently "ritualistic" manner. The record below graphically illustrates the behaviour just described.

FIG. 28 EXTINCTION AFTER FR40 - SESSION TWO (BIRD S14)



The section of the graph above marked "coarse grain" also shows negative acceleration, typical of an extinction record - the extremely coarse grain is, however, atypical and indicates extreme "agitation".

The total number of responses emitted in extinction by the FR40 Ss is affected by the number of extremely weak key-pecks emitted. Since these pecks did not close the contacts on the key or activate the counter they were not classified as "a response". Had the E attempted to count these "head lunges", a different category of behaviour would have been under investigation compared with Ss trained on FR10 or FR20. These "weak pecks" possibly accounted for approximately 10% of the key peck responses made and might explain the comparatively low number of responses emitted in session two by FR40 Ss.

The table below includes these results.

TABLE 10 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR10, FR20 AND FR40 - SESSION TWO.

FR10	FR20
S13 : 63 S10 : 56 S8 : 79 S17 : 58	S1 : 197 S5 : 209 S11 : 158 S16 : 143
Mean Rs : 64	Mean Rs : 177
FR40	
S4 : 179 S14 : 108 S2 : 184 S7 : 146	
Mean Rs : 154	

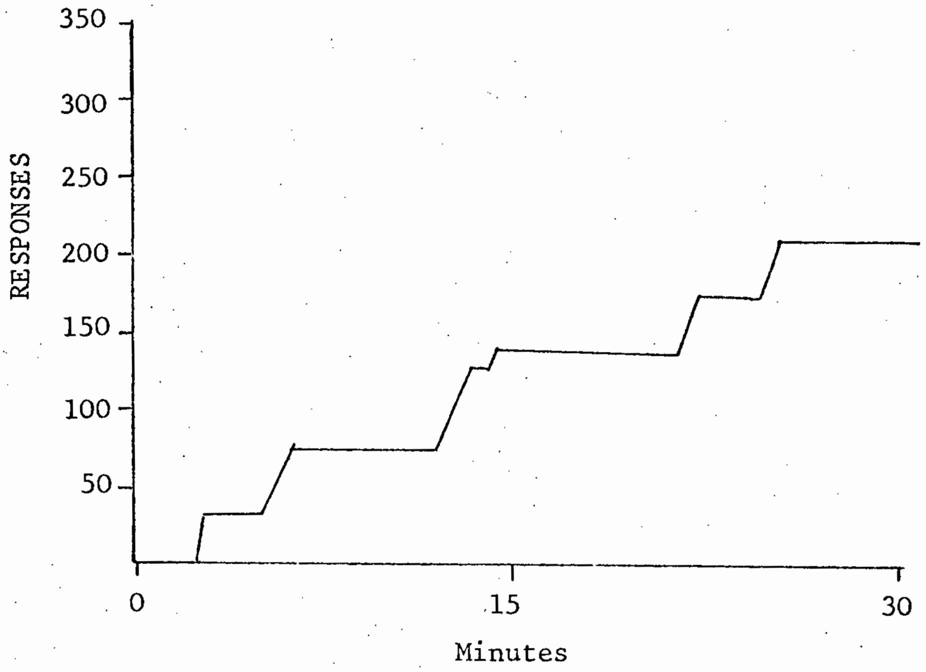
As can be seen in the table the mean number of extinction responses emitted by FR40 Ss was 154 in session two, compared with 177 for FR20 and 64 for FR10. Possible explanations of this result will be covered in the discussion section.

d) FIXED RATIO 80.

On removal from their home cages FR80 Ss were as agitated as FR40 Ss. The usual struggling, wing-flapping and cooing characterised their behaviour. When placed in the experimental chamber they flapped around even before the houselights were turned on. When the lights were turned on they continued their agitated behaviour ignoring the response panel completely for at least 3 or 4 minutes. The behaviour of S6 will be described as representative of the FR80 Ss.

The record which follows depicts its behaviour.

FIG. 29 EXTINCTION AFTER FR80 - SESSION TWO (BIRD S6)



S6 did not begin responding until approximately 4 minutes of the extinction session had elapsed. During this time the S had walked about the cage, flapped its wings, attempted to escape the chamber etc. It paced up and down the response panel, head in an upright position, but it seemed to avoid the response key. It would then return to a far corner of the cage flapping its wings excitedly. When key peck responding eventually began the S emitted 25 responses without pausing. When the pause occurred the S bowed its head as if to feed from the feeder aperture and then rushed to the far side of the chamber bowing and cooing.

After approximately two minutes the S returned to the response panel and began responding. 35 responses were emitted during this segment without pausing. When the pause occurred the S flapped its wings for approximately 20 seconds and then sat passively for the rest of the pause.

This pattern was repeated in the next segment but the S appeared to become more passive during the later pauses. During the last pause in the 30 minute session, for example, the S merely sat quietly in a corner having emitted altogether 153 responses. The table below includes results for the FR80 Ss.

TABLE 11 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR10, FR20, FR40 AND FR80 - SESSION TWO.

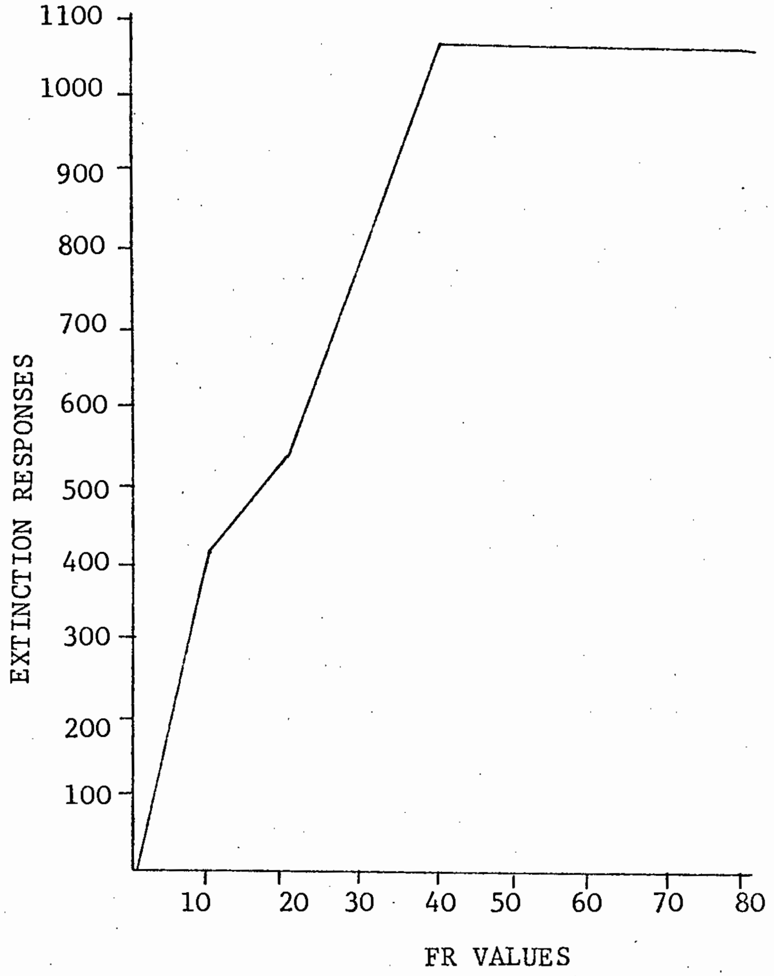
FR10		FR20	
S13	63	S1	197
S10	56	S5	209
S8	79	S11	158
S17	58	S16	143
Mean Rs	64	Mean Rs	177
FR40		**FR80**	
S4	179	S15	193
S14	108	S19	217
S2	184	S9	211
S7	146	S6	153
Mean Rs	154	Mean Rs	193

DISCUSSION.

a) MONOTONICITY OF RESPONSE REQUIREMENT DURING ACQUISITION AND RESISTANCE TO EXTINCTION.

The range of FR values investigated in this study enabled a relatively clear statement to be made regarding the relationship between response requirement during acquisition and resistance to extinction. The following graph depicts this relationship.

FIG. 30 RELATIONSHIP BETWEEN FR VALUE AND RESISTANCE TO EXTINCTION.



As can be seen from the graph above large increases in resistance to extinction one obtained as the FR value is increased from 10 up to 40. The function, however, appears to reach its maximum at 40 and continues at that level until FR80. Boren's statement that "the extinction function reaches a maximum at a ratio somewhat greater than 20:1 and then declines as the ratio is increased to very high values". (Boren, 1961, P.307) was not supported in this study. Boren, however, had used rats as Ss whereas pigeons were used in the present study. Pigeons do tend to be more easily trained under operant conditions and emit responses at a far higher rate than rats.

Their ability to respond for sustained periods at high rates is well documented (Ferster and Skinner, 1957). This ability seems to have some carry-over effect into extinction since pigeons appear to be more resistant to extinction in general compared with rats.

Propounding possible reasons for this difference undoubtedly places the E firmly into the area of speculation, but some possibilities are apparent. Perhaps one could argue that the key-peck is a "more natural" response for the pigeon than is the bar-press for the rat. Pigeons both in the wild state and domesticated can be observed pecking at spots on a wall or on a tree. Since the peck is the means whereby the pigeon obtains its food, the muscular development and control necessary for its execution are well advanced. The peck is also the only means the pigeon has to physically explore its environment, for example, uncovering grains of food.

The rat in its natural state is very unlikely to have to press a lever in order to obtain food, though the forepaws are used in gripping items of food. Consequently fewer components of the bar-press response are already in the rat's repertoire when it comes into the operant experimental situation. The pigeon, however, already has every component of the key-peck response in its repertoire before operant training. All operant training does is to shape the <u>direction</u> of the response.

Given the above differences it is probably not surprising that the pigeon emits more extinction responses since the "pecking" component of the key-peck response is the response which <u>has always</u> been correlated with food in the animal's past. Pressing a bar for a rat, however, only has a history as long as its Skinner Base experience.

The correlation between bar-press and food is small compared with its entire food ingestion history. Consequently, therefore, the E feels that the differences between Boren's results and his own are due to the species used as Ss in the two studies.

But why does the extinction function reach a maximum at FR40 in pigeons? The following section discusses this issue.

b) BY-PRODUCTS OF EXTINCTION.

The degree to which by-products of extinction emerge is undoubtedly a function of the training procedure used. If during the training procedure the Ss are gradually accustomed to emitting non-reinforced responses they are in fact being exposed to small doses of extinction during their training. Consequently one would expect Ss with a long history of continuous reinforcement to exhibit every by-product of extinction whereas Ss with a history of many unreinforced responses should exhibit very few by-products during extinction. The results of the present study did not, however, support this formulation.

Ss trained on FR40 and FR80 schedules exhibited the greatest variety and degree of "emotional" behaviours - precisely those Ss which had been exposed to the greatest number of "extinction doses" during training. FR40 appears to have been a fairly critical value for the Ss studied since this schedule elicited both the greatest resistance to extinction and the greatest number and variety of emotional behaviours. The increased resistance to extinction was apparent only in the first session however. In the second extinction session there was little difference between Ss trained on FR20, FR40 and FR80. Why had the "behaviour potential" built up during training shown up in session one but apparently dissipated completely by session two?

If, as occurs in extinction, however, reinforcement does not occur, the aversive effects of non-reinforcement continue to build up as the fractional anticipatory reward undergoes extinction due to non-reward. The extinction of this fractional anticipatory reward, however, probably only begins after a number of non-rewarded ratio runs. For example, the S trained on FR80 will probably experience extinction of its fractional anticipatory reward only after a few hundred responses, since at ratios as high as this it will take a pigeon a few hundred responses to discriminate that extinction is occurring. An S trained on FR10 is very quickly, however, able to discriminate acquisition from extinction. Consequently such an S has all fractional anticipatory reward extinguished very early in an extinction session and resistance to extinction of the operant under study is low.

The S trained on a much higher ratio, however, for example FR40 and FR80, will have the fractional anticipatory reward component extinguished only much later in an extinction session, especially if extinction is continued into a second session. In other words, increased fixed ratio requirements during acquisition only increase resistance to extinction by making it difficult for the S to discriminate between acquisition and extinction. Once this discrimination occurs, extinction is as rapid as for an S trained on any other ratio schedule.

All Ss in this study were accustomed to receiving reinforcement at some stage during a training session. When the first extinction session was over and the Ss had not received reinforcement this would have clearly led the FR40 and FR80 Ss to discriminate a contingency change. Consequently when the second extinction session began fractional anticipatory reward came under extinction immediately and fractional anticipatory punishment began accelerating.

The behaviour of the Ss trained on the FR40 schedule was characterised by a hesitancy to peck the key. As was mentioned earlier the casual observer would have thought that the Ss feared the key. In extinction of course every key peck will extinguish further fractional anticipatory reward thereby leading to fractional anticipatory punishment. Consequently pecking the k ey was equivalent to punishment. The S would find itself in an approach-avoidance conflict situation - approach for the anticipated reward - avoid for the anticipated punishment. Since anticipated punishment increases in extinction, the S approaches less and less. The "coarse grain" of the extinction records supports this notion as does the number of key pecks emitted of insufficient strength to activate the counter. Ss also tended to feint responding during extinction. Could this have been related to the fact that the movement of lunging the head at the key without actually touching the key will provide very similar sensori-motor feedback to an actual key peck - thereby enhancing fractional anticipatory reward but reducing fractional anticipatory punishment?

What is needed is an objective measure of the punishing effects of extinction and its various stages. Emotional behaviour is characteristic of aversive contingencies but in general is very difficult to measure especially in the pigeon. Aggression, however, is the most easily measured component of emotional behaviour, and can be used as a measure of aversiveness of a particular schedule.

EXPERIMENT II - INVESTIGATION OF RELATIONSHIP BETWEEN ACQUISITION SCHEDULE AND AGGRESSIVE BEHAVIOUR IN EXTINCTION.

RATIONALE

Experiment I had provided the E with essential baseline data regarding the resistance to extinction of a number of fixed ratio schedules.

Only the vaguest analysis of these aversive properties of these schedules was possible, however, because of a lack of objective measures. Detailed "naturalistic observation" methods had been employed to good effect, however, and behaviour categories such as wing-flapping, defaecation, preening etc., had been recorded. On the basis of these "data" it appeared that FR40 and FR80 schedules during acquisition produced the most "emotional" behaviour in extinction, especially in session two. Session two seemed also to equalise the role of the various schedules since different schedules hardly produced differentiated performance as regards resistance to extinction in session two. Experiment II therefore, set out to firmly establish the degree of aversiveness experienced in extinction as a function of four fixed ratio schedules.

SUBJECTS

24 male Homing pigeons were used as subjects. Ages ranged from 18 months to three years. All Ss were experimentally naive and ad libitum weights varied from 385 to 450 grams.

APPARATUS.

The experimental chamber used in Experiment II was identical to that used in Experiment I except that the rear compartment was now opened. In this rear compartment a stabilimeter was mounted on the wire mesh floor. This stabilimeter was especially designed for this study since conventional stabilimeters could not be fitted into the space available and were generally not suitable for use with pigeons. The stabilimeter constructed consisted of a 0.5mm thick sheet metal base, 20cms x 100cms x 4cms onto which was mounted two roller bearings to act as bearing surfaces for a top plate. This top plate pivoted on the bearings in a similar way to a see-saw. (See Fig. below).

FIG. 31 STABILIMETER (Side View)

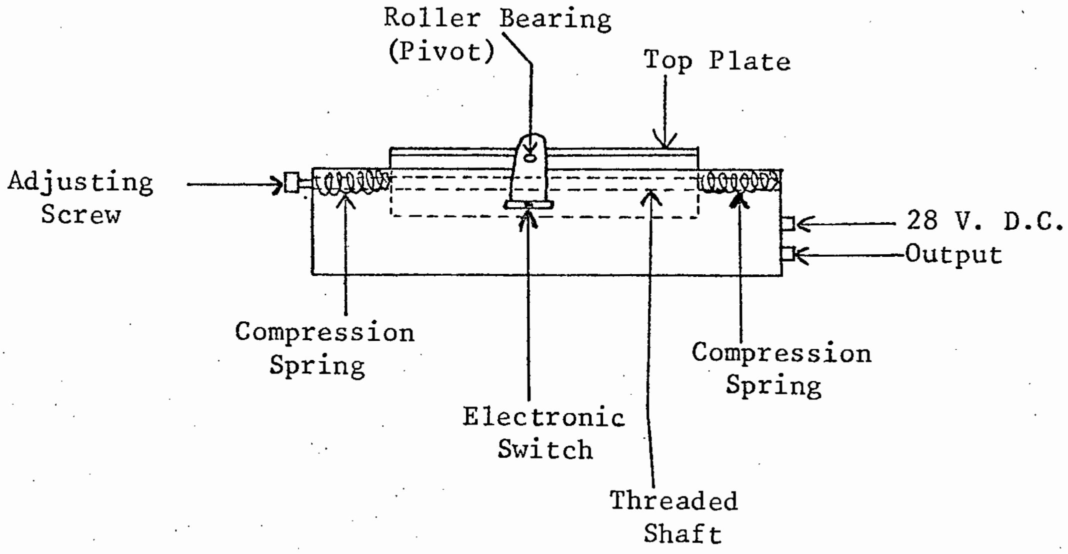


FIG. 32 RESTRAINING BOX (Top View)

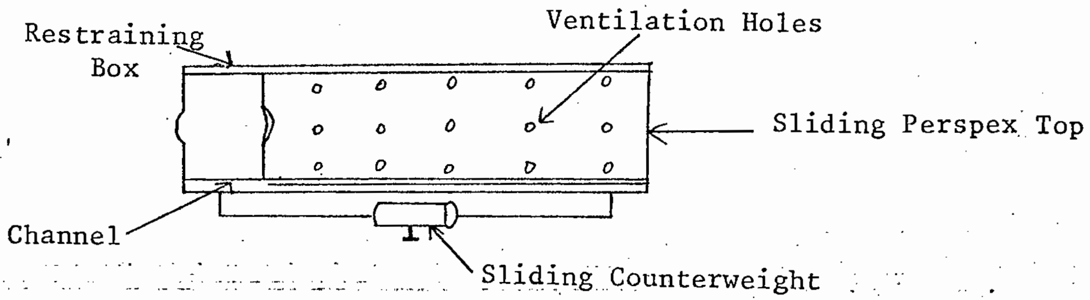
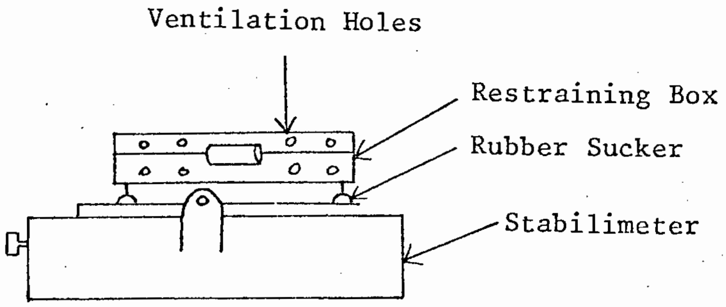


FIG. 33 RESTRAINING BOX MOUNTED ON STABILIMETER (Side View)



Beneath this top plate an electronic switch was mounted. By an arrangement of springs and levers, the switch was activated when a certain degree of movement on the top plate was exceeded. An adjusting screw enabled the E to set the apparatus so that accidential movements (e.g. spontaneous movements of the "target-bird" mounted on the top plate) would not be recorded.

The switch was powered by a 28 Volt D.C. supply compatible with the rest of the apparatus and connected to a counter, a timer and an additional event market on the cumulative recorder. Closure of the switch, therefore, resulted in the counter and timer being activated as well as the event marker.

Once the stabilimeter had been designed some means of restraining a target pigeon on top of the stabilimeter had to be found.

N.B. The decision to use a live target bird had not been taken lightly. Azrin et al (1966) had attempted to use a taxidermically prepared bird but found that regardless of age, sex or strain many experimental birds would not attack a stuffed pigeon. The E therefore decided to use live pigeons as targets but to place the bird in such a position that the full force of any attack would be abated, i.e. the target bird was placed just within reach of the experimental S. Much pilot work established the optimum distances involved. Pilot work had also shown that:

1. the problem of counter-aggression mentioned by Azrin et al (1966) could be avoided if the restraining apparatus was so designed as to prevent the target bird from excessive movement;

2. even under extremely violent attack target birds later examined showed very few signs of injury;

3. Even in the natural state pigeons are often subject to sustained attack for prolonged periods (for example, when fighting over nesting space) yet little serious damage is sustained.

An additional factor considered was that most previous studies had used live target birds - could any results obtained from a stuffed target bird situation be generalised to these studies?

After a number of attempts a restraining box was designed. The box was constructed from 0.5mm thick sheet metal and measured 17cms x 8cms x 7cms. (See Fig.32 p.155).

The top portion of the box included a channel which enabled a perspex lid to slide along the box thereby facilitating access. The perspex lid had a bevelled and curved front edge to fit snugly around the target bird's neck, serving the functions of:

1. Preventing the target bird from escaping, and
2. Sustaining injury. Numerous large holes were drilled through the perxpex lid and through the sides and bottom of the box to facilitate ventilation.

Attached to the side of the box was a shaft along which slid a machined counterweight. By moving the counterweight to the appropriate position the stabilimeter could be set to "zero" before each session.

Partially separating the stabilimeter portion of the chamber from the experimental Ss portion a large sheet of perspex measuring 45cms x 35cms was mounted. A large section of the perxpex was cut out leaving a "U" shaped opening between the stabilimeter and experimental portions of the chamber.

A number of pilot studies had dictated this shape. This opening had to be sufficiently large to allow the experimental S access to the target bird. If the opening was too large however, the experimental S would cross into the stabilimeter portion of the chamber-stand upon the stabilimeter and thereby upset the readings. In addition the target bird would sustain injury if this situation was allowed to occur.

Pilot studies also allowed the E to adjust the stabilimeter so that it operated only when movement occasioned by an attack occurred. When target birds were first placed in the restraining box they tended to struggle a great deal but after a number of experimental sessions this struggling stopped and very few spontaneous movements occurred.

Besides the above, the apparatus was as for Experiment I.

PROCEDURE.

a) DEPRIVATION SCHEDULE.

Initially Ss were assigned to one of two roles:

a) as target bird;

b) as experimental Subject.

Experimental weights of each experimental S were then determined (i.e. ad lib weight minus 20%) and Ss were then matched with target birds as far as possible on the basis of weight. The E believed that matching on the basis of weight in this way would help reduce any damage that might be inflicted on the target bird.

b) TRAINING.

Once the experimental Ss had reached 80% of ad lib weight they were placed in the experimental chamber with the houselights, key light and white noise on and the target bird in place in the restraining box.

After half an hour the Ss and the target birds were removed to the home cage and the Ss fed. This phase which lasted for three days was essential as it provided a lease-time level of attack before any experimental manipulations occurred.

In all remaining phases of the experiment the target bird was present at all times. On day four feeder training began. The feeder was raised for 30 seconds every 30 seconds, i.e. once every minute. As the feeder was raised the key light extinguished automatically and the feeder light came on. By the end of day 5 all Ss were eating from the feeder as soon as it was raised. At the end of each session all Ss were weighed and returned to their home cages. On day 6 key peck training began using the identical procedure to that employed in Experiment I. On day 7 Ss were placed on a multiple schedule of reinforcement enabling the E to progressively raise the response requirement for each component in a systematic manner. On each day the response requirement was raised systematically until all Ss were responding on a FR20 schedule. At this stage four Ss were randomly assigned to stay at this FR value. For the remainder of the acquisition phase of the experiment they responded according to an FR20 schedule.

The remaining 8 Ss continued daily experimental sessions where the response requirement was systematically raised until all 8 were responding according to an FR40 schedule. 4 Ss were then assigned to remain at this level for the remainder of the acquisition phase of the experiment.

The remaining four Ss continued on a multiple schedule with the response requirement being gradually increased until they were responding on an FR80 schedule. Unfortunately one S would not exceed an FR50 response requirement and had to be discarded leaving 3 Ss at the FR80 value.

Two additional days of training were allowed the FR80 Ss so that their performance could stabilise. On the final two days of the experiment all Ss experienced a 30 minute extinction session. The table below details the procedure.

EXPERIMENT II - DAILY SCHEDULE.

DAY	SCHEDULE	REINFORCEMENTS	RESPONSES
1	No training	-	-
2	No training	-	-
3	No training	-	-
4	Feeder training	-	-
5	Feeder training	-	-
6	Key peck training	-	50
7	Mult. FR1 FR2	100	150
8	Mult. FR2 FR4	100	300
9	Mult. FR4 FR6	100	500
10	Mult. FR6 FR8	100	700
11	Mult. FR8 FR10	100	900
12	Mult. FR10 FR12	50	550
12	Mult. FR12 FR14	50	650
13	Mult. FR14 FR16	50	750
13	Mult FR16 FR18	50	850
14	Mult. FR18 FR20	50	950
14	Mult. FR20 FR22	50	1050
15	Mult FR22 FR24	50	1150
15	Mult. FR24 FR26	50	1250
16	Mult. FR26 FR28	50	1350
16	Mult. FR28 FR30	50	1450
17	Mult. FR30 FR32	50	1550
17	Mult. FR32 FR34	50	1650
18	Mult. FR34 FR36	50	1750
18	Mult. FR36 FR38	50	1850
19	Mult. FR38 FR40	50	1950
19	Mult. FR40 FR42	50	2050
20	Mult. FR42 FR44	50	2150
20	Mult. FR44 FR46	50	2250

DAY	SCHEDULE	REINFORCEMENTS	RESPONSES
21	Mult. FR46 FR48	50	2350
21	Mult. FR48 FR50	50	2450
22	Mult. FR50 FR52	50	2550
22	Mult. FR52 FR54	50	2650
23	Mult. FR54 FR56	50	2750
23	Mult. FR56 FR58	50	2850
24	Mult. FR58 FR60	50	2950
24	Mult. FR60 FR62	50	3050
25	Mult. FR62 FR64	50	3150
25	Mult. FR64 FR66	50	3250
26	Mult. FR66 FR68	50	3350
26	Mult. FR68 FR70	50	3450
27	Mult. FR70 FR72	50	3550
27	Mult. FR72 FR74	50	3650
28	Mult. FR74 FR76	50	3750
28	Mult. FR76 FR78	50	3850
29	Mult. FR78 FR80	50	3950
29	FR80	50	4000
30	FR80	100	8000
31	FR80	100	8000
32	Extinction	-	-
33	Extinction	-	-

RESULTS

a) ACQUISITION PHASE.

Once the experimental S (to be referred to in future as ES) and the target bird (to be referred in future as TS) were placed in the chamber and the houselights turned on a variety of social behaviours occurred. Initially many of the ESs sat quietly without responding to the TS in any way but after a few minutes the conventional social rituals occurred. Bowing and cooing, turning in a semi-circle, puffing up of the chest and strutting up and down the cage were behaviours common to all the ESs.

This behaviour would usually last a few minutes and was generally followed by behaviour best described as exploratory. ESs would walk around the cage pecking at spots on the floor and at the walls of the chamber. This exploratory behaviour generally continued for the rest of the half-hour session and very few individual differences were noticed across ESs. Throughout this period no observable reactions were noted regarding the TSs.

On day two the ESs and TSs were once again placed in the chamber for a half-hour session. The essential difference between day 2 and day 1 concerned the proportion of time spent on certain behaviourial categories. In session 2 much less time was spent in social behaviour and much more on exploratory behaviours. Most ESs started the session with perhaps 1 or 2 minutes exploration, followed by 1 or 2 minutes social behaviour, the remainder of the time being spent on exploratory behaviour. In neither session 1 nor session 2 was any behaviour which could be described as "aggressive" observed.

In session 3 the ESs seemed to ignore the TSs completely in all but two cases. In these two cases (Bird ES116 and Bird ES127) social rituals occurred for probably two minutes at the most, the rest of the time being spent in exploration. Consequently one could conclude that the base-line level of attack was zero.

During the feeder training sessions ESs ignored the TSs completely. All behaviour appeared to be focussed on obtaining food from the food hopper.

Session 6 involved key-peck training and it was here that an effect of the presence of the TSs was observed. Key-peck training was made more difficult by the presence of the TS since the TS seemed to provide distracting stimuli.

Shaping of the key-peck took the E slightly longer than usual because some of the ESs would occasionally face the TS for fairly long periods thereby providing no behaviour approximating a key-peck. By the end of session 6 and in some cases 7, all ESs were key-peck trained.

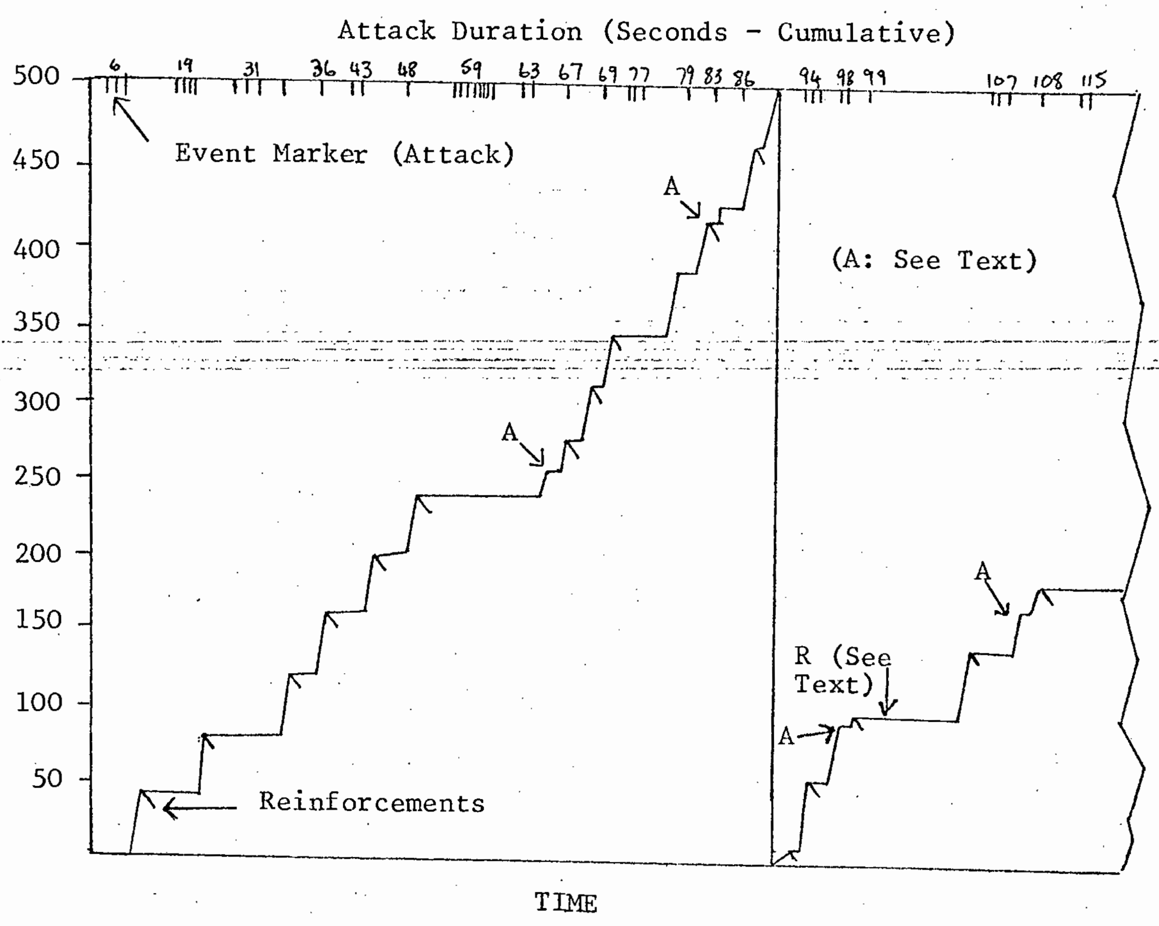
Once the ESs were responding consistently on lower FR schedules no social or exploratory behaviour was observed. At the higher ratios, however, a distinct change was noted. In certain ESs responding on the FR20 schedule, social behaviour was noted at the start of a session. Up to this point all ESs would begin responding as soon as the houselights were turned on but certain ESs stabilised on FR20, began experimental session with bowing and cooing and head-dipping. This head-dipping response is normally only observed in pigeons during approach-avoidance conflict situations, for example, in competitive male-male encounters as in sexual male-female encounters. This behaviour normally lasted only a few minutes and once stabilised FR20 responding began, the TSs were ignored. The ESs concerned, however, (ES134 and ES137) continued this behaviour at the beginning of each session throughout their acquisition phase.

The remaining 8 ESs began to show a variety of social behaviours once the ratio levels were raised above FR20. Once FR25 was reached by all ESs social behaviour occurred at the onset of each experimental session and occasionally immediately after reinforcement. By FR30 aggressive postures and rushing at the TSs would occur both at the beginning of the session and after reinforcement. The ESs would rush at the TSs stopping just short of physical contact and then bow and coo vociferously. Physical contact between the TS and the Es began at FR37 when bird ES121 pecked at the head of the TS during a post-reinforcement pause.

This behaviour occurred 12 times during a session. The ES would peck its ratio-requirement, eat the available food and then immediately turn around and peck the target bird.

During FR40 training 5 out of 8 ESs were pecking the target bird at the beginning of a session, after reinforcement, and in one case (ES146) during the ratio run. The cumulative record below, shows the behaviour of ES146 in session 27.

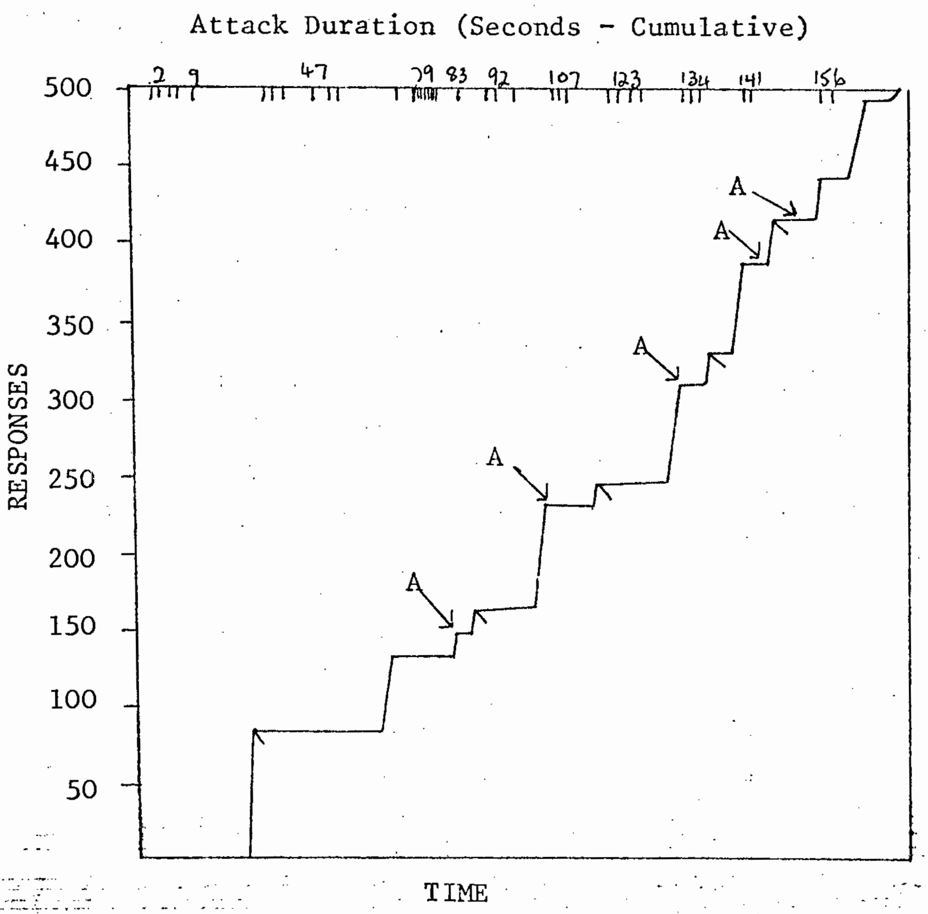
FIG. 34 KEY PECK AND ATTACK BEHAVIOUR DURING STABILISED FR40 SCHEDULE (BIRD ES146)



As can be seen from the record above attack began for this ES immediately the session started. The event market indicates exactly when the attack occurred and the figures above the markers indicate the cumulative time attacks occurred. This time was recorded by E for the previous "bout" of attack whenever key-peck responding resumed. It can be seen therefore that attacks occurred at three points at the beginning of the session and lasted a total of six seconds. These attacks generally consisted of pecks at the breast and neck of the TS. The majority of attacks generally occurred after reinforcement except for attacks during the ratio run. These attacks are marked "A" on the graph and generally occurred at the middle or in the latter half of the ratio. At one point, marked "R" on the graph, only "ritualistic" aggressive postures occurred without any physical contact. Between actual attacks a variety of intention movements also occurred.

As the ratio requirement was raised above FR40 ESs began attacking to a greater and greater extent during the ratio run itself. Attacks also became far more vigorous and extended. In many instances attacks were sufficiently prolonged to keep the event marker in the "on" position for as long as 30 seconds. During such attacks the ES would grasp a clump of feathers in its beak and pull downwards. When such attacks ended the ES would run about the cage flapping its wings. This behaviour characteristic of the extinction sessions of Experiment I, rarely occurred below FR60. The record below illustrates a typical stabilised FR80 performance.

FIG. 35 KEY PECK AND ATTACK BEHAVIOUR DURING STABILISED FR80 SCHEDULE (BIRD ES160)



As can be seen from the record above attacks began right at the beginning of the session and were of 29 seconds duration. When responding began however, the complete ratio requirement was met without interruption. Every other ratio run was interrupted with attack as marked by the "A's" on the record. Interruptions inevitably occurred in the latter half of the ratio run. The number of attacks was far greater than for Ss responding on the FR40 schedule and the duration of attacks was much greater.

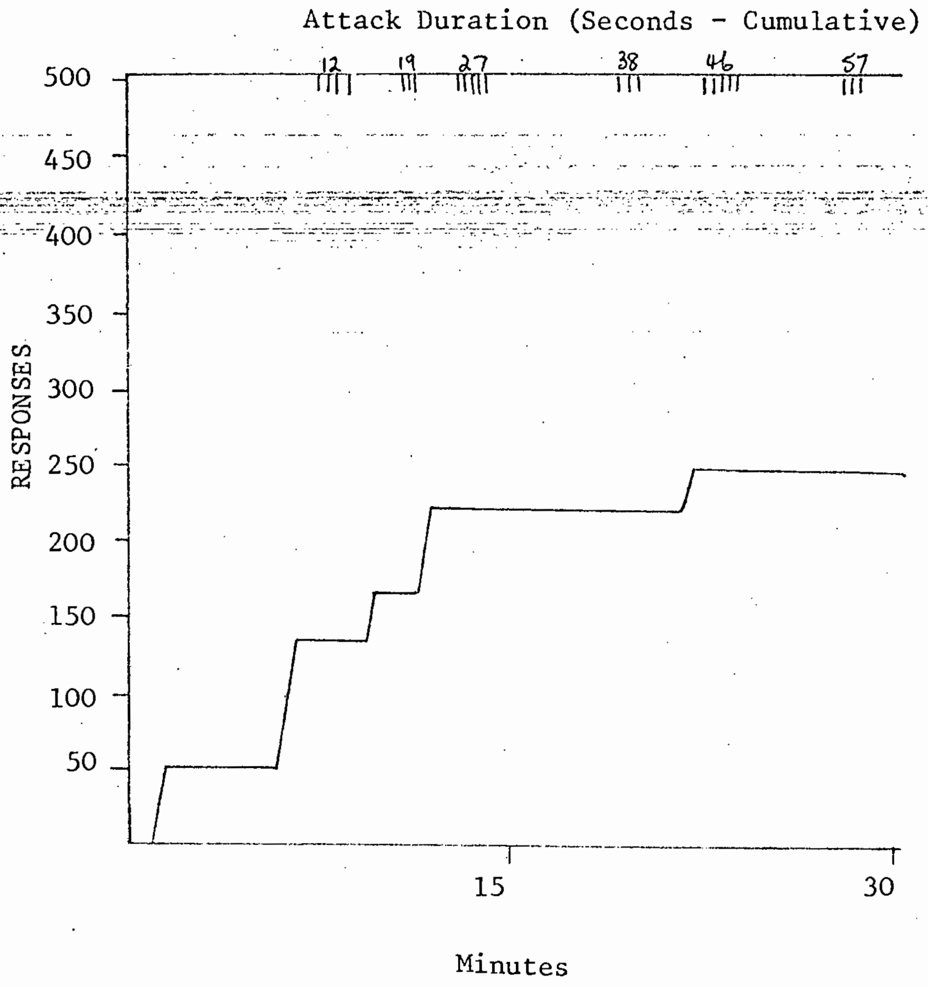
RESULTS.

b) EXTINCTION - SESSION ONE.

FR20.

During session 32 and 33 each ES underwent a 30 minute extinction period. ESs trained up to FR20 exhibited the expected social behaviour at the onset of the session. When key-peck responding began all 4 ESs emitted above 20 responses before any attack behaviour was emitted. During the acquisition phase none of the FR20 ESs had physically attacked the TSs although a number of aggressive postures had been observed. During extinction, however, actual attack occurred. The following record is representative of performance of the FR20 ESs.

FIG.36 EXTINCTION AFTER FR20 AND ATTACK BEHAVIOUR (BIRD ES137 - SESSION ONE)



Bird ES137 began the session by bowing and cooing and rotating in a semi-circle. This behaviour did not continue for long, however, when key-pecking responding began. Approximately 45 responses were emitted before the first pause occurred. During this pause the ES flew around the cage, preened itself and displayed aggressive postures (head-dipping, rushing) towards the TS. No physical contact occurred, however. After this pause the ES began responding and emitted 75 uninterrupted responses. During this pause physical attack occurred, albeit of short duration (12 seconds). The remainder of the pause was spent in strutting around the cage, wing-flapping and aggressive postures. This pattern of key-pecking, aggressive postures, physical attack, aggressive postures and key-pecking continued for the remainder of the session. Other "emotional behaviours" such as defaecation and pecks stopping just short of the key which occurred in Ss extinguished after FR20 without a TS present, were absent in this experiment, however.

The numbers of extinction responses emitted by FR20 Ss is included in the table below.

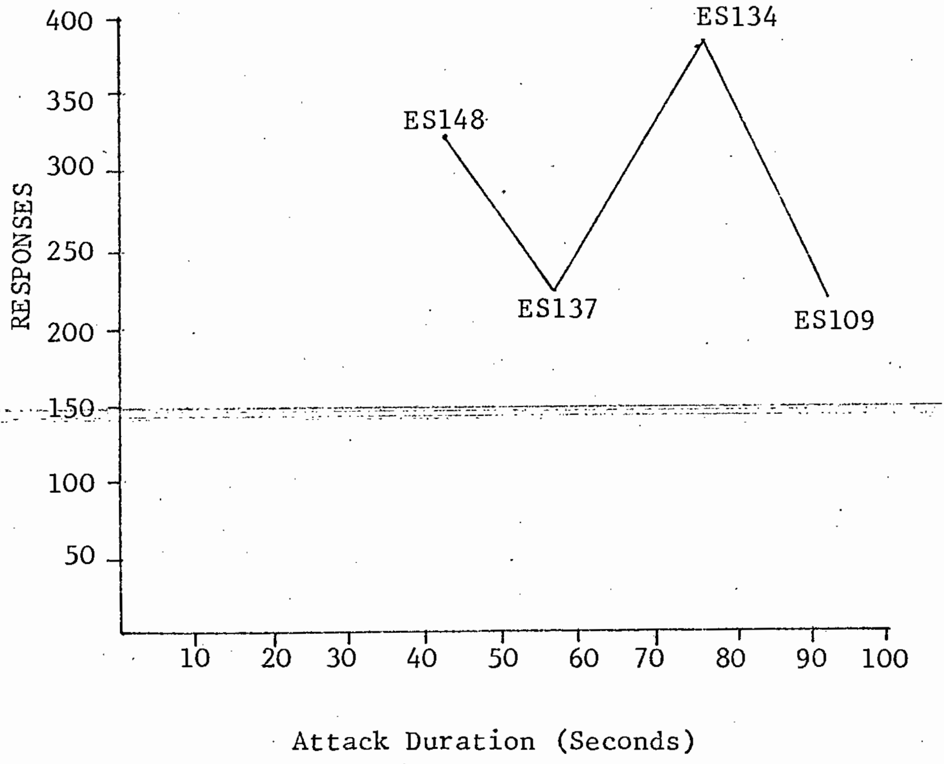
TABLE 12 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR20 (SESSION ONE).

TS PRESENT			TS ABSENT		
Bird ES134	:	361	Bird S1	:	519
Bird ES137	:	238	Bird S5	:	547
Bird ES148	:	327	Bird S11	:	493
Bird ES109	:	230	Bird S16	:	529
Mean Rs	:	289	Mean Rs	:	522

As can be seen from the table above Ss extinguished with a target bird present emitted fewer responses in extinction than Ss extinguished without presence of the target bird.

The E believed that there might have been a relationship between duration of attack in extinction and resistance to extinction. The two sets of data are graphically represented below.

FIG.37 RELATIONSHIP BETWEEN ATTACK DURATION AND RESISTANCE TO EXTINCTION (FR20 - SESSION ONE)

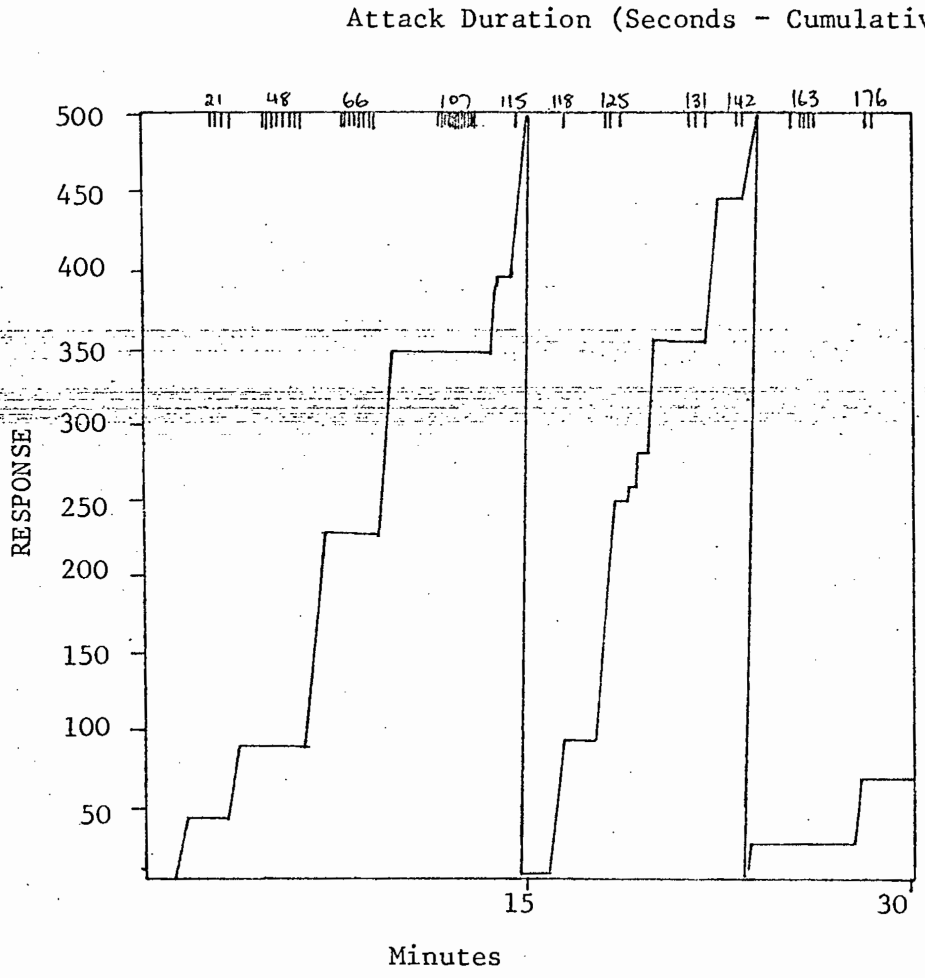


From the above graph one can see that no direct relationship exists for FR20 between duration of attack and persistance to extinction.

FR40.

At the onset of extinction ESs trained on an FR40 schedule exhibited a wide variety of social/aggressive behaviours. In only one case did actual physical contact occur between the ES and the TS. The longest delay between onset of the extinction schedule and key-peck responding was 4 minutes 26 seconds. The record below illustrates typical extinction behaviour of ESs trained on FR40.

FIG. 38 EXTINCTION AFTER FR40 AND ATTACK BEHAVIOUR (BIRD ES131 - SESSION ONE)



ES131 began the extinction session by strutting around the chamber head-dipping in the direction of the TS. No physical contact occurred in the initial pause. Once key-peck responding began approximately 50 responses were emitted. During the following pause 21 seconds of attack on the head and chest of the target bird occurred. A series of long period of responding followed by attack then occurred. Attacks were the most vigorous yet experienced by the E - at one stage the event market remaining in the "on" mode for 41 seconds. Between attacks the ES flapped its wings and rushed around the cage. An interesting aspect of these results is that in the first 500 responses 115 seconds of attack behaviour had occurred, whereas in the second 500 responses only 27 seconds of attack occurred.

The number of extinction responses emitted by FR40 Ss is included in the table below.

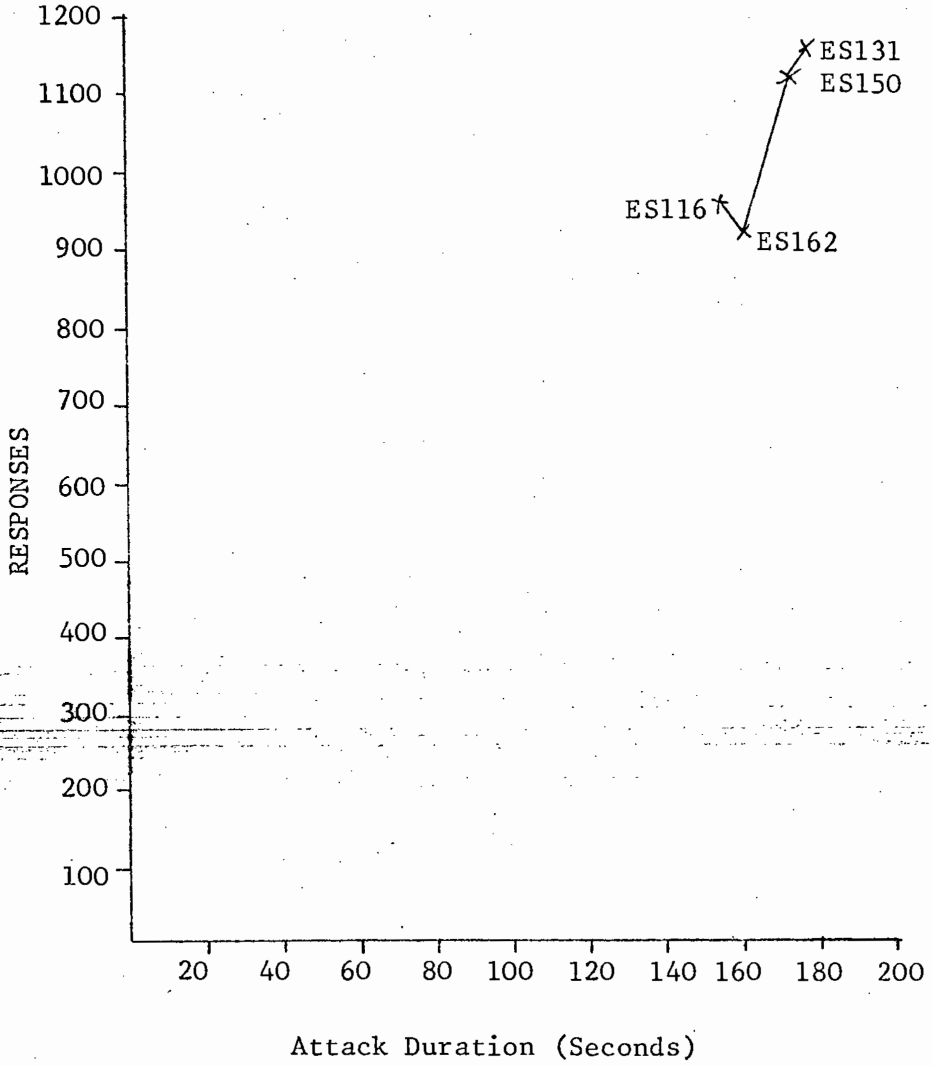
TABLE 13 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR40 (SESSION ONE)

TS PRESENT			TS ABSENT		
Bird ES131	:	1070	Bird S4	:	1010
Bird ES116	:	982	Bird S14	:	1209
Bird ES162	:	941	Bird S2	:	973
Bird ES150	:	1142	Bird S7	:	1058
Mean Rs	:	1034	Mean Rs	:	1062

The table indicates that the target bird appears to have little, if any, effect on extinction performance after FR40.

The following graph describes the relationship between resistance to extinction and duration of attack.

FIG. 39 RELATIONSHIP BETWEEN RESISTANCE TO EXTINCTION AND DURATION OF ATTACK AFTER FR40.

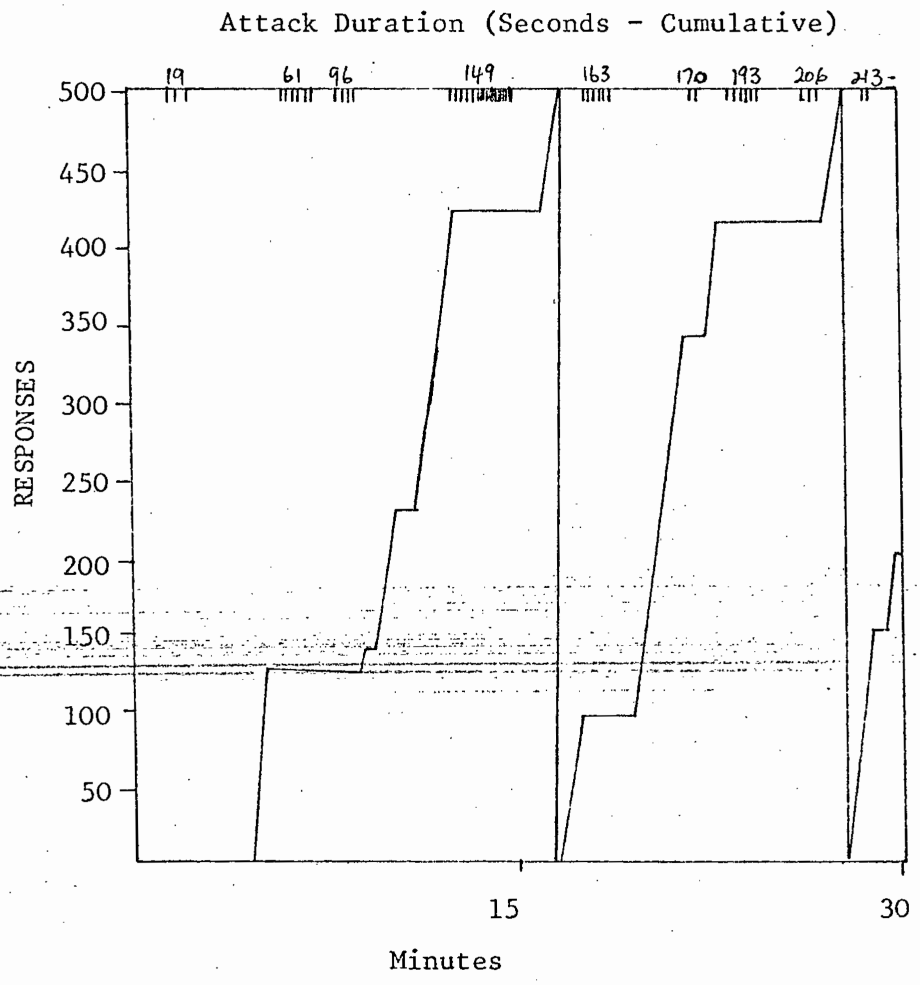


The E wondered on the basis of this data if there was not a positive relationship between duration of attack and resistance to extinction. The design used and the number of Ss involved would not of course warrant such a conclusion.

FR80

Extinction after FR80 followed closely the pattern of extinction after FR40, the one major difference being that FR80 ESs physically attacked the TS before key-peck responding had begun. Behaviour of ES127 illustrated below is typical.

FIG. 40 EXTINCTION AFTER FR80 AND ATTACK BEHAVIOUR (BIRD ES127 - SESSION ONE)



Attack began after a short delay at the beginning of the session and lasted for 19 seconds. A large burst of responding then ensued, followed by a sustained attack for 61 seconds. After this attack the ES bowed, coo'd, flapped its wings and attempted to escape the chamber.

After this outburst approximately 200 responses were emitted almost without pausing. One of the most vigorous attacks experienced then occurred lasting altogether 53 seconds. This was the only case where the E observed the ES actually pull out feathers from the chest of the target bird. In this case altogether 213 seconds of actual attack duration occurred in a 30 minute session. It is also interesting to note that upon removal of the ESs from the chamber, ESs seemed unusually calm compared with the performance experienced in Experiment I. The following table compares extinction responses of FR80 Ss with and without the TS.

TABLE 14 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR80 (SESSION ONE)

TS PRESENT		TS ABSENT	
Bird ES127	1198	S15	1190
Bird ES121	1433	S19	1126
Bird ES133	1347	S9	896
Es Discontinued		S6	988
Mean Rs	1326	Mean Rs	1050

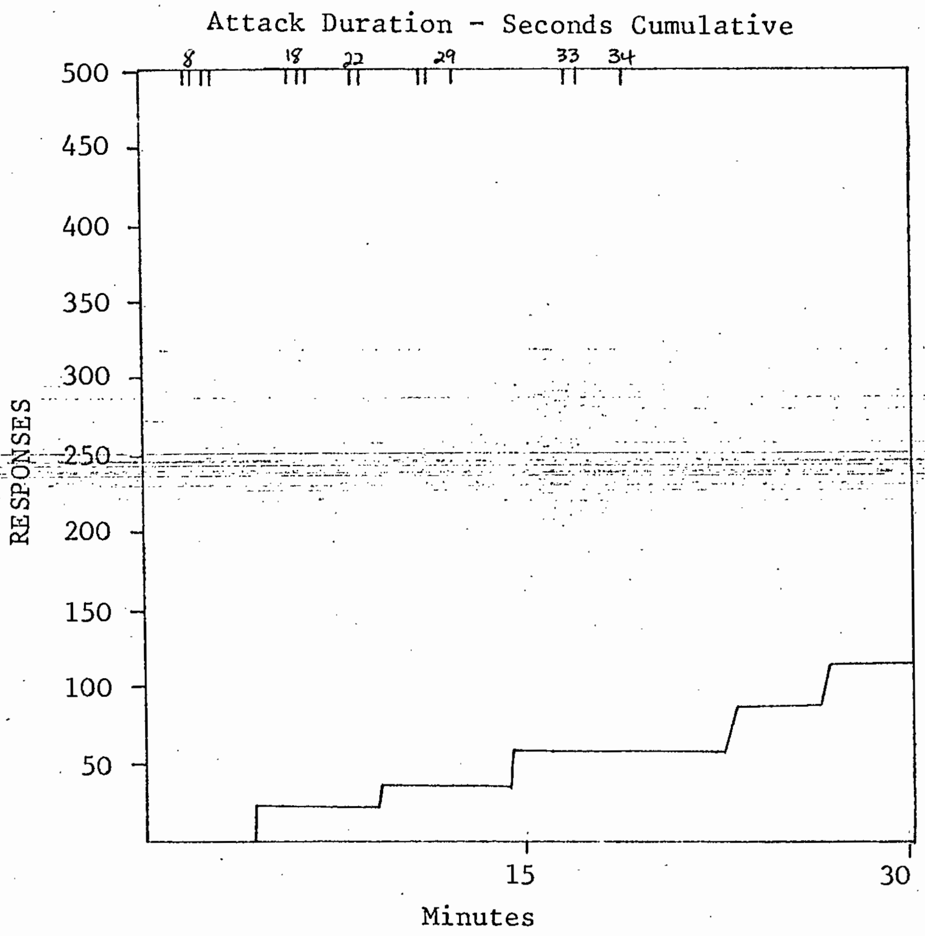
It was regrettable that one S was unable to sustain high FR values and had to be discontinued. However, the data indicate that the target bird might have had a facilitatory effect on extinction since the mean number of extinction responses emitted was actually greater in Ss allowed opportunity for aggression. This issue will be covered in greater detail in the Discussion session.

EXTINCTION - SESSION TWO.

FR20.

Behaviour exhibited by ESs in session two was essentially similar to that experienced in session two of Experiment I. ESs were agitated on removal from the home cages and ran about the experimental chamber wildly as soon as the houselights were turned on. Attack behaviour occurred before key-peck responding began and sporadic attacks occurred throughout the session. Record of Bird ES137 is illustrative.

FIG.41 EXTINCTION AFTER FR20 AND ATTACK BEHAVIOUR (SESSION TWO) BIRD ES137



Attacks began with this S before key peck responding ensured but lasted for only 8 seconds. Attacks were not particularly vigorous, however, and tended to be of short duration. More time was spent in aggressive postures than in actual attacks. Key-peck responding occurred in short bursts followed by mild attacks on the TS. No attacks were recorded after approximately the 17th minute of extinction. An interesting feature is that the cumulative records did not show the coarse grain characteristic of extinction after FR20 without the target bird. Rate fluctuations were also absent.

The total number of extinction responses emitted varied to a fair degree across the ESs studied. The following table includes these results and the relevant results of Experiment I.

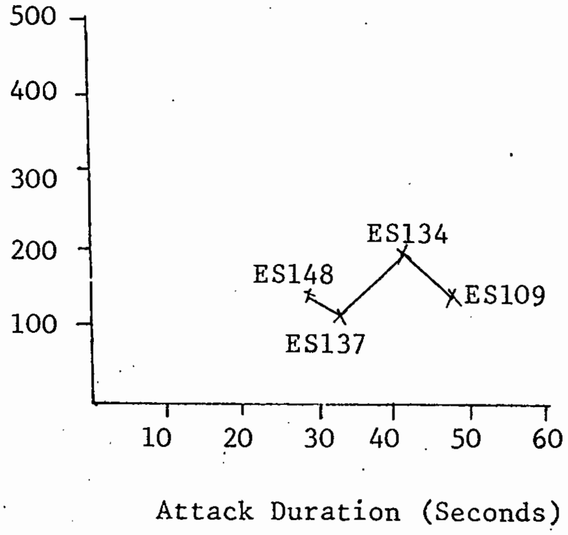
TABLE 15 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR20 - SESSION TWO.

TS PRESENT		TS ABSENT	
Bird ES134	173	S1	197
Bird ES137	121	S5	209
Bird ES148	139	S11	158
Bird ES109	146	S16	143
Mean Rs	144	Mean Rs	176

Mean responses emitted in extinction with the TS present was 144 and with the TS absent 177.

The following graph describes the relationship between the duration of attack and the number of extinction responses.

FIG. 42 RELATIONSHIP BETWEEN EXTINCTION RESPONSES AND DURATION OF ATTACK AFTER FR20.

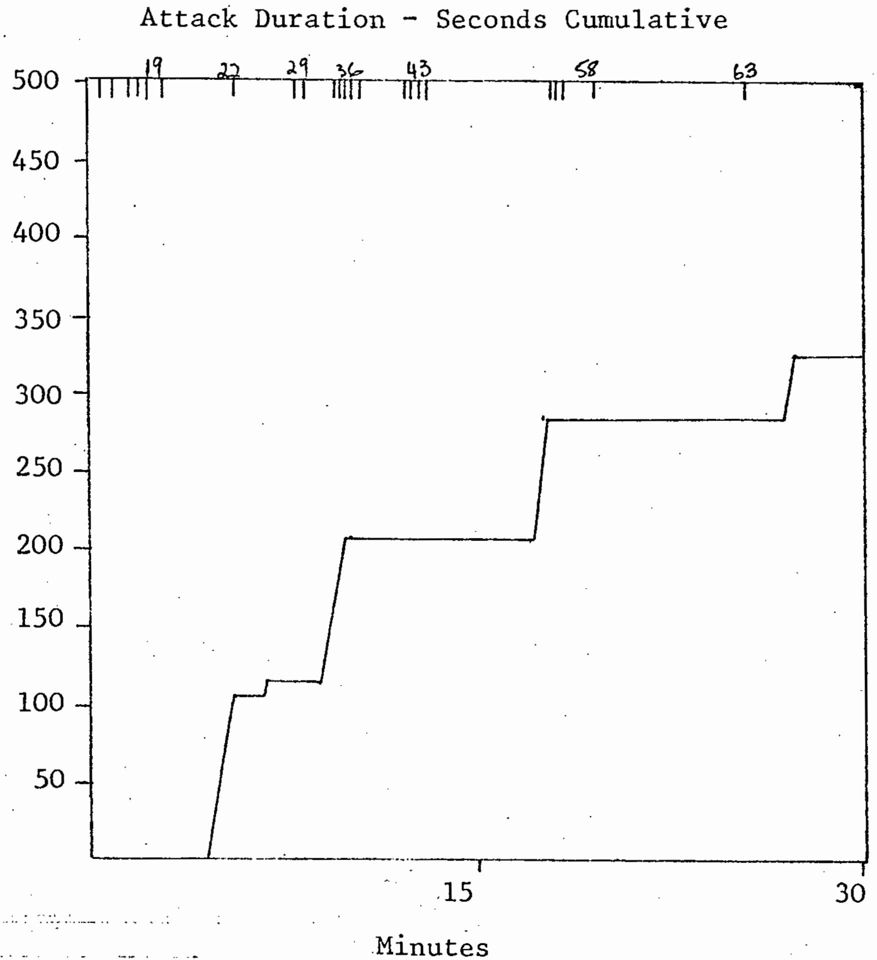


On the basis of the Ss studied there appears to be no direct relationship between attack duration and resistance to extinction after FR20.

FIXED RATIO 40.

At the onset of the session FR40 ESs generally showed a variety of aggressive postures culminating in physical attack. In three out of four cases attack occurred before any key-peck responding. The behaviour of ES131 can be regarded as typical and the record below describes its behaviour.

FIG. 43 EXTINCTION AFTER FR40 AND ATTACK BEHAVIOUR BIRD ES131 - SESSION TWO.



Aggressive postures were followed almost immediately by attack in the case of this ES. Once responding began, however, a burst of 120 responses was emitted. This was followed by a brief attack, a short burst of responding and then a longer attack. Another long burst of responses then occurred. As the session continued, however, the key-peck response bursts became progressively shorter and the pauses longer. Once again most of the attacks occurred in the first half of the session - aggressive postures and other social behaviours taking the place of attack as the session ended.

As in the FR20 condition the graph shows a remarkable lack of coarse grain and only the overall negative acceleration and progressively longer pauses distinguish the curve as depicting extinction.

The remarkable feature of session two is the very large number of extinction responses emitted compared with Experiment I. This aspect which characterised all ESs is depicted in the table below.

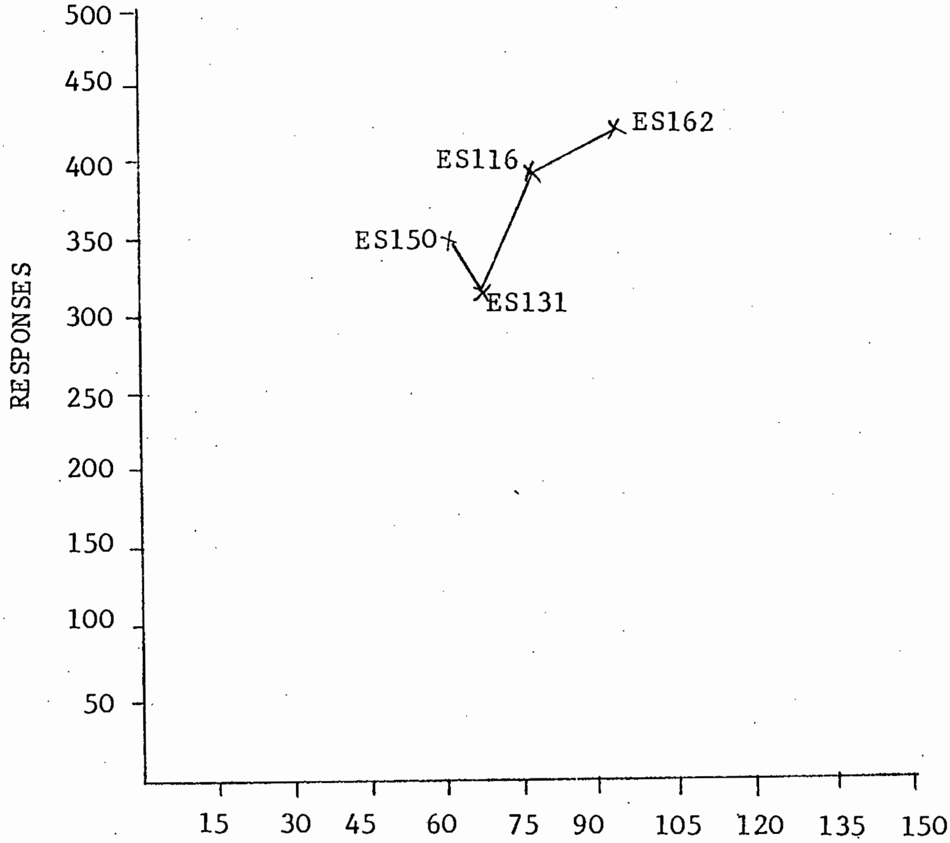
TABLE 16 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR40 - SESSION TWO.

TS PRESENT	TS ABSENT
ES131 : 338	S4 : 179
ES116 : 371	S14 : 108
ES162 : 419	S2 : 184
ES150 : 347	S7 : 146
Mean Rs: 369	Mean Rs : 154

It can be seen that more than twice as many responses were emitted in session two after FR40 when the TS was present compared with Experiment I where the TS was absent.

The graph below depicts the relationship between the duration of attack and the number of responses emitted in extinction.

FIG. 44 RELATIONSHIP BETWEEN EXTINCTION RESPONSES AND ATTACK DURATION AFTER FR40.



Attack Duration - Seconds

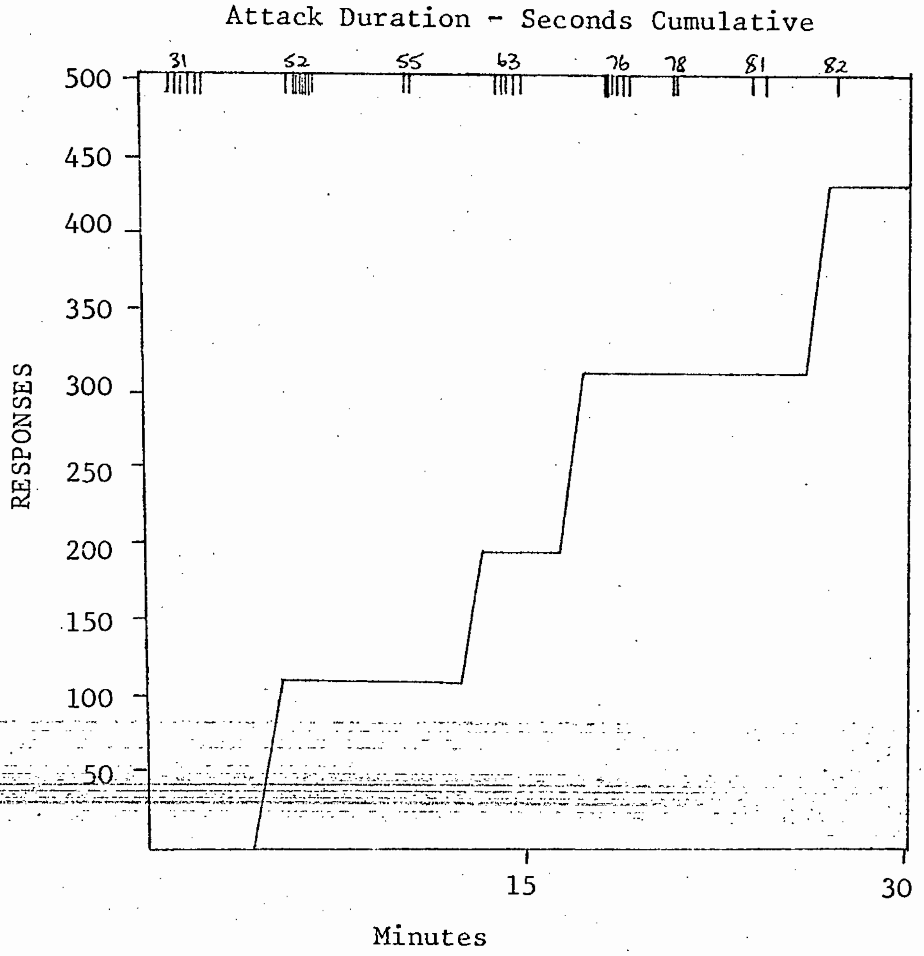
Although ES150 does not support this statement the E wondered on the basis of this data whether there could not be a positive relationship between attack duration and resistance to extinction.

FIXED RATIO 80.

Session two of extinction after FR80 was characterised by a great deal of attack at the onset of the session before key-peck responding began. When key-pecking started long bursts of responses were followed by aggressive postures and attacks.

As in previous cases most of the attack behaviour occurred at the beginning of the session. The record of ES127 is typical.

FIG. 45 EXTINCTION AFTER FR80 AND ATTACK DURATION (BIRD ES127 - SESSION TWO.



Attack behaviour in the case of ES127 was followed by extremely regular and sustained responding at very high rates. The graph illustrates the complete absence of indications of "emotionality" commonly found in extinction curves.

The number of responses emitted by the three Ss studies is included in the table below.

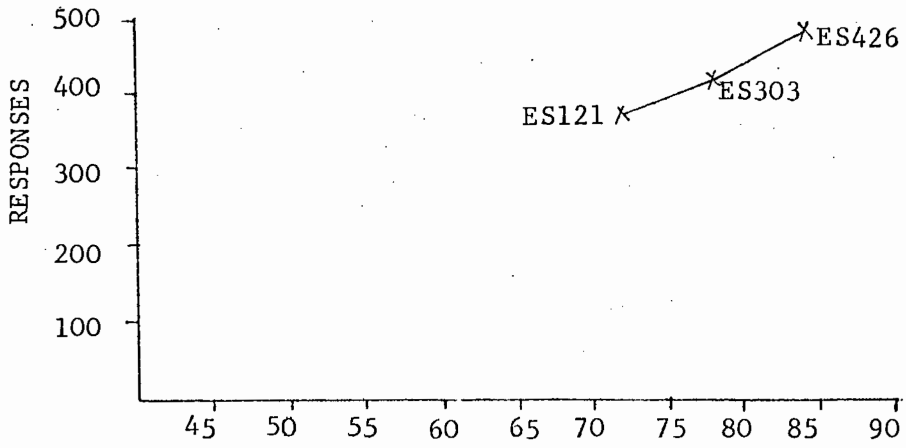
TABLE 17 NUMBER OF EXTINCTION RESPONSES EMITTED AFTER FR80 - SESSION TWO.

TARGET PRESENT	TARGET ABSENT
ES127 : 426	S15 : 193
ES121 : 387	S19 : 217
ES133 : 405	S9 : 211
E Discontinued	S6 : 153
Mean Rs : 406	Mean Rs : 193

As in FR40 more than twice the number of responses was emitted in session two when the target bird was present. It is regretted that only three ESs were available for study in the FR80 target present condition.

The following graph depicts the relationship between the number of extinction responses and attack duration.

FIG.46 RELATIONSHIP BETWEEN EXTINCTION RESPONSES AND ATTACK DURATION AFTER FR80



On the basis of the three ESs studied it would appear that the greater the attack duration the greater the resistance to extinction after FR80 in session two.

EXPERIMENT II - DISCUSSION.

Experiment II clearly supported much of the literature reviewed earlier concerning the aversive aspects of fixed ratio schedules. The aversiveness appeared to be in direct proportion to the ratio requirement. At the lower ratios aggressive postures and intention movements predominate but as the ratio requirement is raised these ritualistic behaviours give way to actual attack.

Attack tends to occur during the post-reinforcement pause at lower ratios but as the response requirement is raised more and more attacks occur during the ratio run. The target bird has the effect of disrupting the ongoing key-peck behaviour completely at FR values of 80 so that a complete ratio run is rarely achieved. In this respect the target bird provides opportunity for competing responses - opportunities which are absent when the target bird is not present. The "drive" to participate in competing activities therefore seems to increase as the aversiveness, of the schedule increases. Since no attack behaviour occurred during the base-line conditions of the experiment one must assume that the aggressive behaviour was solely a function of the experimental contingencies. The results of the acquisition phase of the experiment produced few surprises, but this deficit was certainly compensated for in the extinction phase.

Ss extinguished after FR20 showed the normal aversive effects of extinction and attacked the target bird during pauses throughout the extinction session. An immediate difference was noted, however, between an extinction curve with a target present and without the TS. The normal rate fluctuations, and minor pauses characteristic of extinction appeared to be absent. Could this be because the ES had the opportunity of releasing the "emotional build-up" onto a "scapegoat?". Normally in extinction, the apparatus is the object of aggression but the operant class under investigation still shows emotional effects. When a target bird is provided these emotional signs appear to be absent. Could it be that attacking a live target bird is more rewarding than attacking a piece of apparatus?

Although the fluctuations were absent from the graphs the total number of responses emitted in extinction appears to be reduced by the presence of the target bird. Evidently in this respect the target bird provides a powerful competing activity which detracts from the emission of the operant under study. In general Ss extinguished after FR20 appeared to be less "driven" than Ss at the higher ratios consequently emitting fewer attack and key-peck responses.

Extinction after FR40 and FR80 provided the most interesting data of the experiment. ESs engaged in a great deal of attack behaviour for long durations especially in the first half of the extinction session. Their extinction graphs showed complete absence of fluctuations and were it not for the absence of reinforcement pips and the long pauses it would be difficult to identify the graphs as depicting extinction.

Evidently the higher ratios generate a high drive to engage in competing activities and if these activities are provided an outlet the operant under investigation (the key-peck) is unaffected from the point of view of fluctuation.

The almost contradictory aspect is that resistance to extinction appears to be <u>increased</u> under these conditions. According to Competition theory competing responses inhibit the operant class originally acquired. In extinction competing activities are said to "displace" the original operant until eventually it is displaced almost completely (theoretically, operant level). Results of the FR40 and FR80 ESs oppose this notion completely. According to Guthrie (1959) if there are numerous opportunities for alternative (competing) responses extinction should be hastened. If competing responses cannot be made no response decrement will be seen at all. Estes (1959) maintains a similar view when he discusses his principle of unlearning by interference.

Attacking a target animal has been shown to be an extremely rewarding event (Tellegen et al, 1969, Legrand, 1970). Consequently the behaviour which enables this reinforcement should increase in frequency and probability of occurrence. Yet in the extinction of FR40 and FR80 Ss in the present study most of the aggression occurs in the early part of the session and then diminishes in frequency. Consequently one could say that the reward value of attack diminishes as extinction progresses. This attack behaviour does not surprisingly enough, detract from the performance of the original operant and at high FR values appears to enhance it.

The implications of the above are significant for extinction theory. Consequently the E felt that the findings should not only be replicated or supported but attacked from a different viewpoint. Consequently Experiment III was undertaken.

EXPERIMENT III.

RATIONALE.

It is traditional in much of experimental psychology to use large numbers of subjects in order to "cancel out" individual differences. Since many designs prevent a large degree of control over the Ss individual differences are often great. The experimental analysis of behaviour approach, however, generally studies a very closely defined operant class under extremely controlled experimental conditions. Consequently individual differences tend to be very low. Single subject designs can therefore be used - numbers of subjects merely acting as replications of an original finding. In Experiment I and II of the present study each FR value investigated was virtually studied four times (with the exception of FR80). The E, however, feels that the variation across Ss prevented a really solid conclusion from being drawn. Consequently in Experiment III design was chosen whereby each S was its own control.

The experiment set out to establish clearly whether providing opportunity for aggression in extinction would enhance or detract from the performance of the operant under study.

DESIGN.

Since results of FR40 and FR80 were essentially the same from an extinction and aggression point of view it was decided to study two extreme values in order to accentuate the differences between a high and a low FR requirement. Consequently FR20 and FR80 were chosen. In order for each S to act as its own control it was decided to use a "multiple" schedule of reinforcement.

"Multiple" is put in inverted commas since the schedules used were not strictly multiple. Each schedule was trained with two components with a particular key colour present during one component and a different key colour present during the second component of the same schedule. For example, FR10 would be trained as MULT FR10, FR10 with a green key light in the first component and a red in the second. In the presence of the green light a target bird would be present in the presence of the red light the target bird would be absent. Apart from base level conditions, the criteria would apply throughout acquisition until responding had stabilised.

Extinction would be divided into 4 phases of 10 minutes each. Following on ABAB design, the target would be present for ten minutes and the green light on (A). The target would then be removed and the light changed to red (B). The target would be returned in the third segment and key light changed to Green (A) and finally the target would be removed and the key light changed to Red (B). This procedure would then be repeated in reverse for a second ES, i.e. BABA, in order to counteract any sequence effects. In this way the effect of opportunity for aggression on the number of responses emitted in the 10 minute extinction periods could be compared.

APPARATUS.

As for Experiment II.

SUBJECTS.

8 female Homing Pigeons; experimentally naive; ages: 1 year to 3 years. Weight range 385 - 500 grams. Four Ss were assigned to the role of target bird and the remaining ESs underwent the deprivation procedure.

DEPRIVATION SCHEDULE.

As for Experiment I.

PROCEDURE.

Initially a procedure identical to Experiment II was followed. When all ESs were responding according to an FR20 schedule two were allocated to remain at this value while the other two continued on a progressive multiple schedule in order to get them responding on an FR80 schedule. The target birds were present throughout this phase.

When the Ss had stabilised on their respective ratios the key lights were alternated between Red and Green to check for the existence of colour preferences.

The target bird conditions were then altered. From this stage onwards, each experimental session was divided into 10 minute segments. In the first segment (A) the key light would be green and the TS present. In the second segment (B) the TS was removed during a Time Out (chamber and laboratory in darkness) and at the start of segment two the key light was red. In segment three (A) the TS was returned and the key light changed to Green. In segment four (B) the key light was red and the TS was present. This procedure was reversed for the second ES at each FR value.

FR20:	ES209	A	B	A	B
	ES231	B	A	B	A
FR80:	ES221	A	B	A	B
	ES212	B	A	B	A

This procedure was adopted in order to counteract any sequencing or spontaneous recovery effects.

Once responding had stabilised for all ESs on extinction session was scheduled. The feeder apparatus was "disconnected" and the ABAB or BABA design adopted according to the ES concerned. ESs who underwent ABAB in acquisition experienced the same sequencing in extinction in order to maintain as many aspects of stimulus similarity between acquisition and extinction as possible. Extinction for each ES consisted of 4 x 10 minute segments.

RESULTS: ACQUISITION.

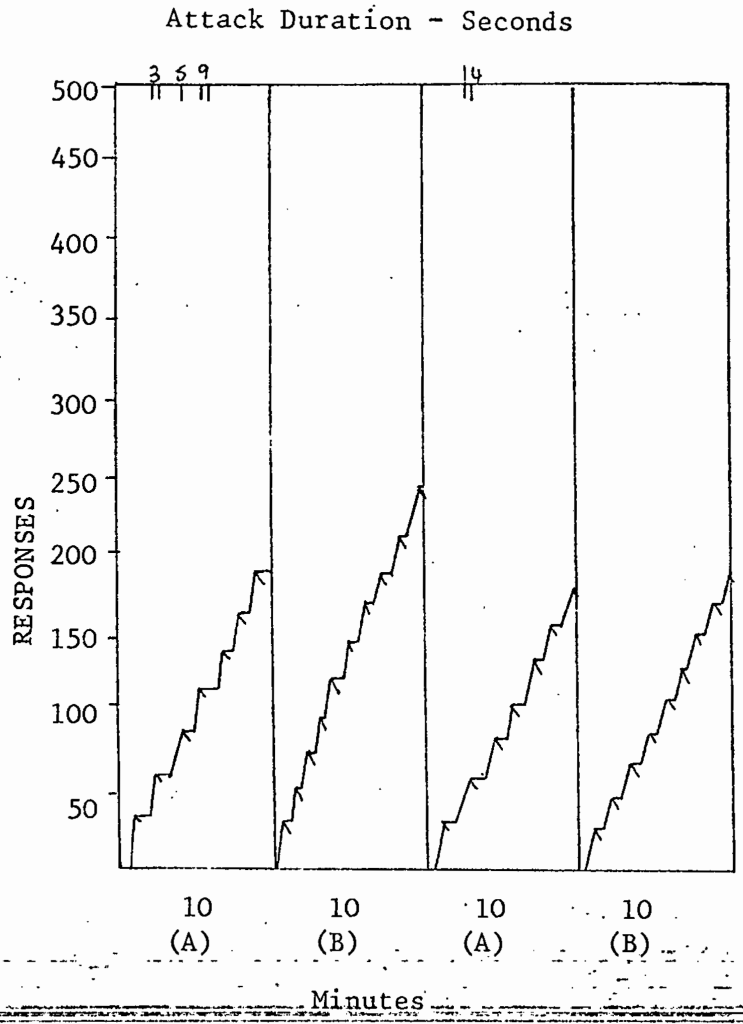
FR20

Stable FR20 responding was easily achieved by the Ss. When the key lights were alternated between Red and Green (10 minutes each) ongoing performance was at first disrupted, due to the stimulus change, but after three sessions responding had stabilised on each colour; no signs of a colour preference were detected.

When the alternating ABAB condition was introduced the ESs experienced a certain degree of "agitation" but eventually responding occurred immediately after termination of the intersegment TO.

The following record shows stabilised FR20 responding with the ABAB condition operative.

FIG. 47 STABILISED FR20 RESPONDING: ES209
(TS PRESENT: A) (TS ABSENT: B)



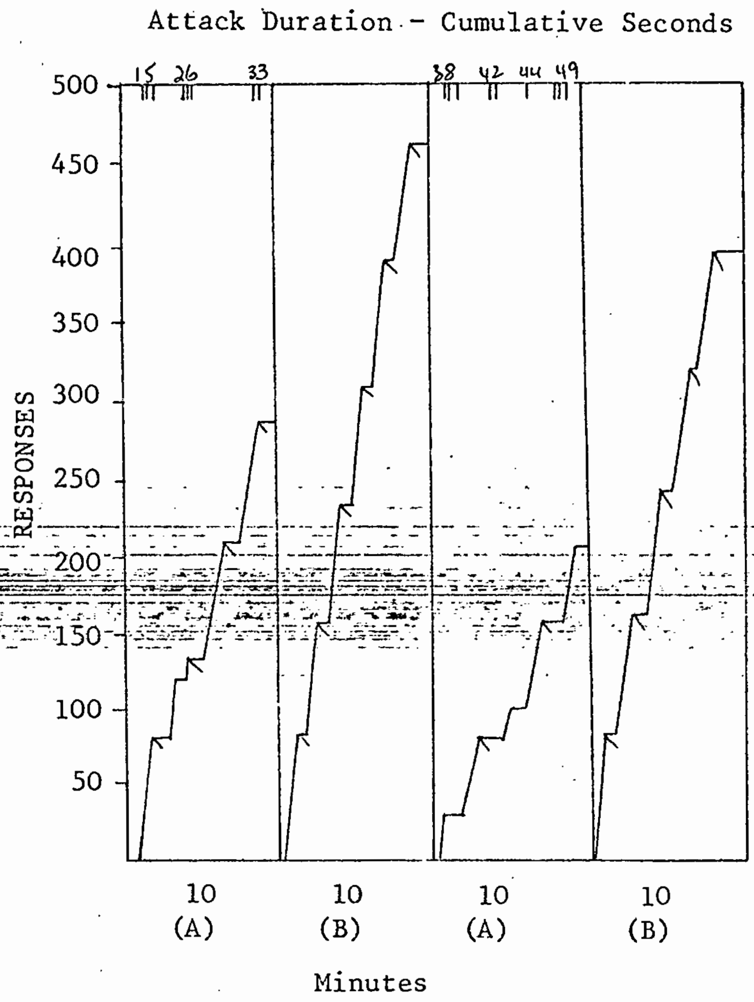
Very little attack behaviour was emitted during the FR20 condition. Any attacks emitted occurred only during the post-reinforcement pause and were of short duration. Consequently only a small difference in the number of responses emitted in each 10 minute segment occurred.

FR80.

Within 35 experimental sessions Bird ES212 and ES221 were responding stably on an FR80 schedule. The pattern of attack did not differ from that experienced in FR80 of Experiment II. When alternating red and green key lights were introduced (ten minutes of each) an initial response hesitation was noticed but after two experimental sessions no difference in responding between these two colours was detected.

The alternating ABAB and BABA conditions were then introduced. Initially the TO intersegment periods caused disruption of the ongoing behaviour beyond the TO periods themselves but within five or six experimental sessions the ESs were responding in a stable fashion as soon as TO terminated. The following graph shows stabilised responding on an alternating ABAB design for Bird ES221.

FIG.48 — STABILISED-FR80 RESPONDING (TS PRESENT: A)
TS ABSENT: B) (ES221)



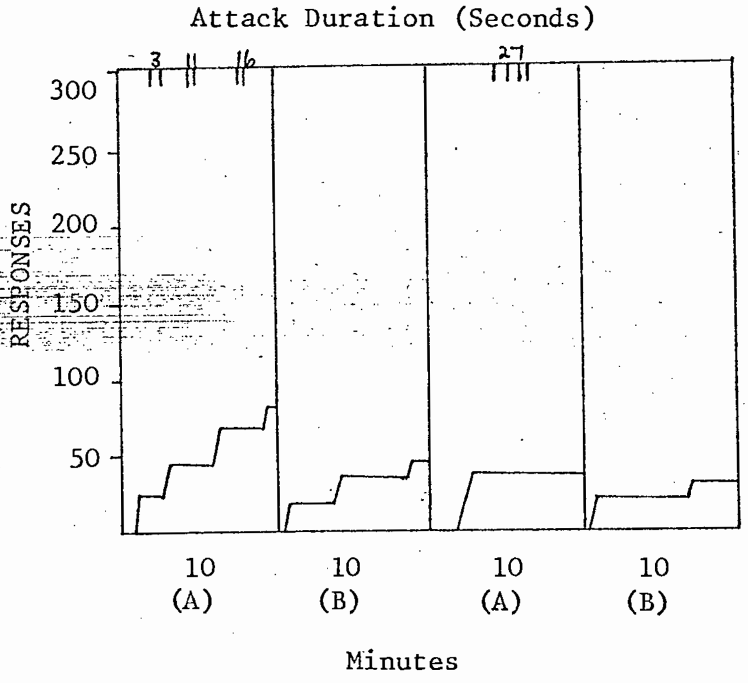
During Condition A most attack occurred during the post-reinforcement pause but attack also occurred during the ratio run. Many more responses were emitted in a 10 minute segment when the TS was absent. In the B conditions the ES merely pecked its ratio, paused briefly after reinforcement and then continued.

EXTINCTION.

FIXED RATIO 20.

At the onset of extinction Bird ES209 was undergoing the "A" condition (TS present, key light green). The ES began responding immediately pausing only after 30 responses. At this point the expected intention movements and aggressive postures occurred. The ES then continued responding and attack occurred in the next pause. The attack was not of long duration however, and the ES soon continued responding. This pattern of responding followed by brief attacks continued throughout the segment. The following record shows the complete 40 minute extinction session.

FIG. 49 EXTINCTION AFTER FR20 (ALTERNATING ABAB) (ES209)



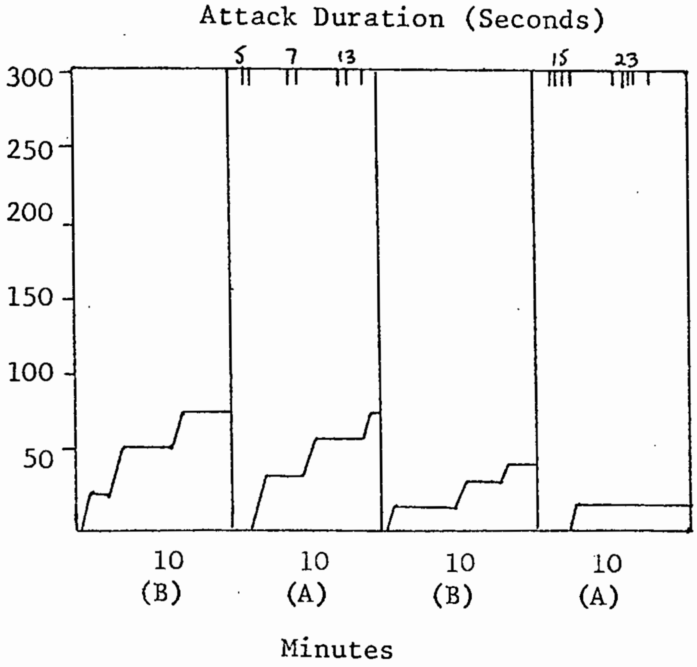
During the intersegment TO the ES sat quietly in a corner of the chamber. During the second segment responding began immediately but was followed by a pause during which the ES showed the normal "agitated" behaviour of "bowing and cooing" as well as wing-flapping. A burst of responding then occurred followed by a long pause - only 48 responses being emitted in this segment.

In the third segment the target bird was attacked as soon as the houselights were turned on after the TO. This behaviour was followed by a burst of responding but the rest of the segment was spent in a variety of aggressive behaviours and brief attacks.

Segment four began with a burst of responses but was followed by a long pause in which the ES flapped its wings and attempted to escape the chamber.

For ES231 the BABA condition occurred. The following record describes its behaviour.

FIG. 50. EXTINCTION AFTER FR20 (ALTERNATING BABA) (ES231).

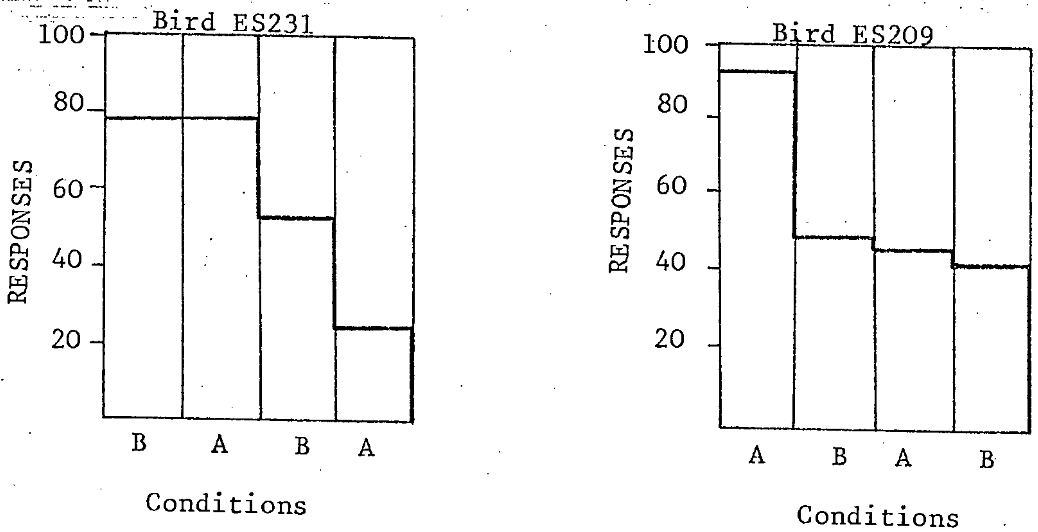


ES231 began responding as soon as the houselights were turned on at the onset of segment one of extinction. Pauses which were filled mainly with "emotional" behaviours of various sorts, became longer as the segment continued.

At the beginning of segment two the TS was attacked briefly and then key-peck responding resumed for a long burst followed by a pause in which brief attacks occurred. The segment continued the pattern of responding followed by brief attacks. Surprisingly as many responses were emitted in segment two as in segment one. In segment three negative acceleration set in and pauses were occupied mainly by rushing around the chamber and wing-flapping. In segment four attack occurred for a sustained period of 15 seconds followed by a brief burst of key-peck responding. The remainder of the attack was spent in sporadic attacks and pauses.

The following graphs show the number of responses emitted in each segment for each S studied.

FIG. 51 RESPONSES EMITTED IN EACH FR20 EXTINCTION SEGMENT.

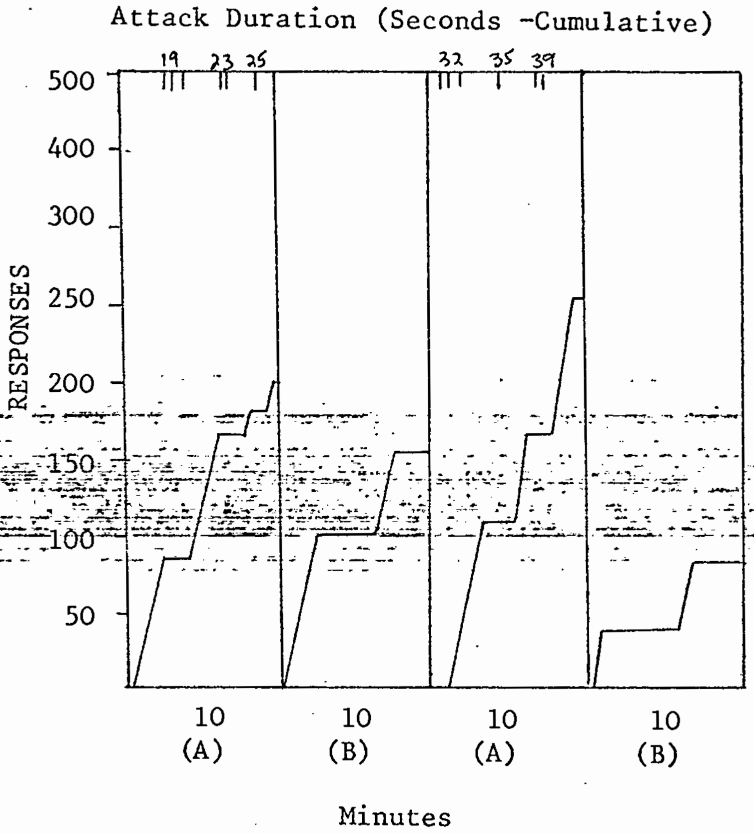


Regardless of the condition sequence the general trend is for a gradual response decrement typical of extinction curves. The opportunity for aggression after FR20 appears to have little effect on the extinction function.

EXTINCTION - FIXED RATIO 80.

The following graph illustrates performance of ES221 during the four phases of extinction.

Fig. 52 EXTINCTION AFTER FR80 (ABAB ALTERNATING) (ES221)



ES221 began the session by responding vigorously and consistently for about 90 responses. When a pause occurred it was filled with a number of strong attacks. After this pause another long burst of responses occurred followed by sporadic attacks and responding.

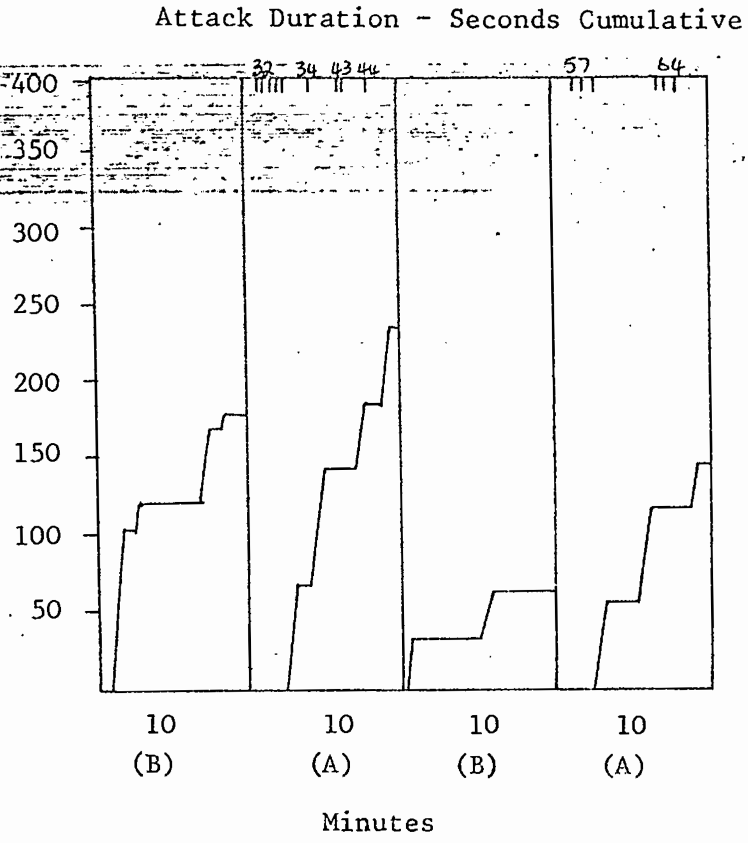
In segment B (target absent) the ES responded very consistently but followed this with a long pause, during which wing-flapping and attempts to escape the apparatus occurred. Another burst then occurred followed by a pause to the end of the segment.

The third segment (A) began with a long and sustained attack, followed by a long burst of responses (approximately 100). This pattern of long response burst followed by attack continued to the end of the segment. This segment showed a remarkable recovery of the operant under study.

In segment 4 no target was present and although two strong bursts of responding occurred long pauses occupied most of the segment.

The second subject (ES212) underwent the BABA sequence and the following record illustrates its behaviour.

FIG.53 EXTINCTION AFTER FR80 (BABA ALTERNATING) (ES212)



The session began with a short unaccountable pause during which the ES merely sat in a corner of the chamber. However, when responding began approximately 100 responses were emitted in a single burst. A short pause then occurred during which the ES paced up and down the intelligence panel agitatedly. Responding then resumed for a short while and was followed by a pause in which the ES became extremely emotional and rushed about the chamber. A long burst of responding then occurred and a short pause before the segment was terminated by the TO.

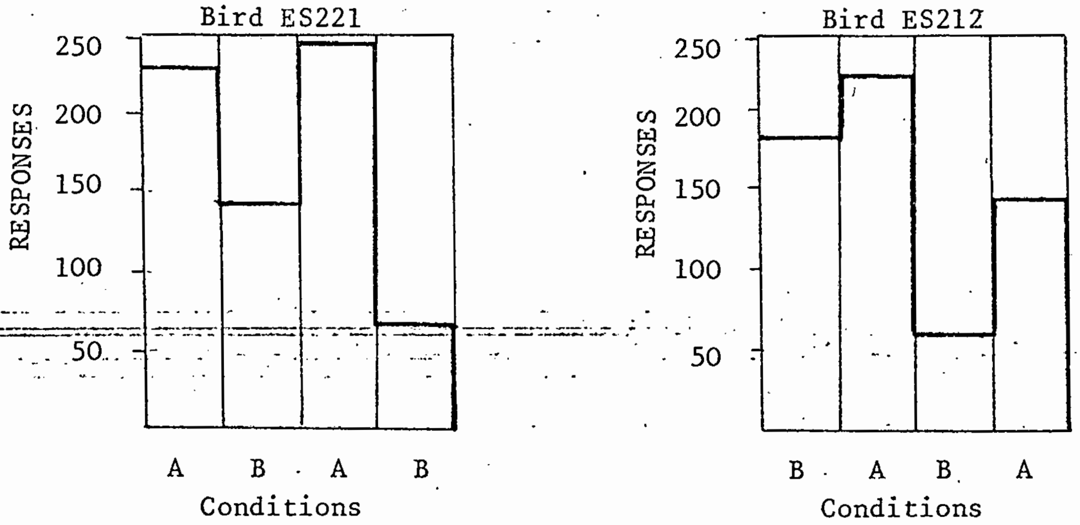
In segment two the target bird was introduced, and key light changed to green. The ES began the segment with an extremely vigorous attack on the target bird lasting 32 seconds. Following the attack, however, a sustained period of responding occurred which was only briefly interrupted by an attack. During the next pause more attack occurred but was followed by bursts of responding in two cases. More extinction responses were emitted in the second segment compared with the first.

In segment three the target bird was not present and almost nine minutes of the segment were spent in emotional behaviour directed at the floor and walls of the chamber.

The final segment began with a great deal of attack onto the target bird interspersed with aggressive postures. However, long bursts of key-peck responding occurred between attacks. More responses were emitted in segment four compared with segment three.

The following figure relates the number of responses emitted in each segment for both ESs studied.

FIG. 54 RESPONSES EMITTED IN EACH FR80 EXTINCTION SEGMENT.

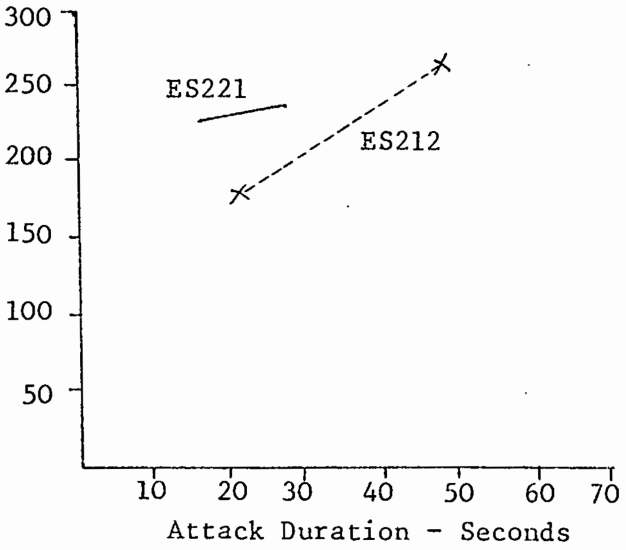


The figures above clearly indicate that more responses are emitted in the A (target present) condition than in the B (target absent) condition. The only exception to this is where the B condition occurs immediately after acquisition.

RESISTANCE TO EXTINCTION AND ATTACK DURATION.

The facilitatory effect which opportunity for aggression has on extinction is clear from the data above, but is there a relationship between the duration of the attack and the degree of this facilitation? The following graph relates this data.

FIG. 55 RELATIONSHIP BETWEEN ATTACK DURATION AND EXTINCTION RESPONSES



The graph above shows that for ES212 as attack duration increased so did the number of extinction responses. For ES221 much less attack occurred and there does not appear to be a differential effect of attack on extinction responses for this ES.

DISCUSSION.

Experiment III clearly indicates the relationship between an aversive contingency and the effect opportunity for aggression will have on this contingency. When a contingency is not particularly aversive (e.g. FR20) during acquisition extinction also appears to be less aversive. Consequently opportunity for aggression, although doubtless rewarding, seems to have no effect on the operant originally acquired.

Where a contingency is aversive during acquisition (e.g. FR80) extinction is also an aversive event. Providing opportunity for aggression under these circumstances appears to have a facilitatory effect on the operant originally acquired.

Opportunity for aggression (i.e. the presence of a target bird) undoubtedly provides the subject with many competing responses. Packing a target bird which is 180 degrees away from the pecking key is very definitely an incompatible response. Yet performance of this incompatible response facilitates performance of the original operant. But is attacking a target bird really "incompatible" with the originally learned operant? In Chapter 6a we discussed pain induced aggression and noted that aggression elicited under aversive contingencies appeared to be "reflexive" in nature. This reflex was seen to be so powerful that even if a rat and a snake were caged together and the rat experienced aversive stimulation, the snake would be violently attacked, almost as if the attack was completely automatic.

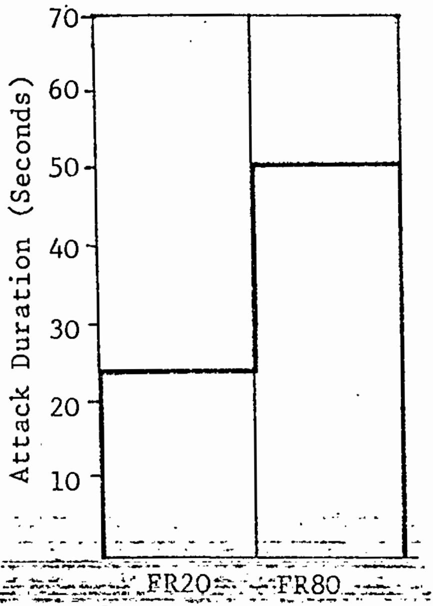
Under these circumstances the attack is not incompatible with the ongoing operant response; in fact attack may be necessary in order for the ongoing operant not to be disrupted completely. Preventing the reflex from occurring is therefore detrimental to the Ss ongoing performance.

Azrin, Hutchinson and Sellery, (1964) showed that no matter which species of animal was used as a target subject, shock produced the same attack reaction. Any attackable object in the environment seemed to suffice regardless of its attributes. This statement would not appear to hold true when pigeons are the subjects under study, however. The experimental chamber used in most operant studies is generally constructed in such a way that there are few objects protruding into the experimental space; the major exception to this statement being the lever characteristic of Skinner boxes used for rats. In the pigeon apparatus, however, there are generally no "attackable" objects in the experimental space. In extinction rats will often attack the lever (Mowrer and Jones, 1945) whereas pigeons attack the intelligence panel or walls of the chamber. These attacks may take the form of pecking with the beak, or beating with the wing. The pigeon's attacks are, however, generally self-injurious. Pecking an aluminium panel is bound to injure a pigeon to some extent. One could liken this injury to counter-aggression by the attacked object.

The E would hypothesise that for the pigeon the reward value of pecking, say, an aluminium panel would be low whereas pecking a restrained target bird would be high - since the latter does not counter-aggress in any way. Measuring the reward value, if any, of attacking say the intelligence panel, would be difficult to measure but some possibilities emerge. A design similar to Experiment III could be used but the attackable object used could be a piece of aluminium. In the no-attack condition the S could be restrained in a harness to prevent any attack occurring. The effect of these two conditions on extinction responding could then be measured.

An important issue highlighted by Experiment III is the degree of aversiveness experienced in extinction. Assuming that attack duration is a valid measure of aversiveness experienced, extinction after FR80 is definitely more aversive than extinction after FR20. The following graph compares the mean duration of attack during extinction for the 4 ESs studied according to acquisition schedule.

FIG. 56. RELATIONSHIP BETWEEN ACQUISITION SCHEDULE AND ATTACK DURATION.



There can be little doubt on the basis of the data above that extinction after FR80 is more aversive than extinction after FR20. Yet in this case why does FR80 generally produce greater resistance to extinction than FR20? Evidently Ss trained on high ratios adapt to high levels of aversiveness since the increase in aversiveness is gradual. According to the Discrimination Hypothesis, however, these same Ss should experience extinction as <u>less</u> aversive because during their training traces of non-reinforcement were included.

The finding that a history of intermittent reinforcement produces more attack in extinction than a history of continuous reinforcement is very difficult to explain. Hutchinson, Azrin and Hunt (1968) experienced the same result indicating that the finding is not fortuitous. Additional research will be needed in order to solve this apparent contradiction.

Assuming that a history of intermittent does produce more attack in extinction has wide implications. Most of human behaviour is maintained by intermittent schedules of reinforcement. Consequently anyone attempting to eradicate this behaviour should be cognisant of the by-products of the eradication procedure. Both punishment and extinction can produce aggression. Since extinction is a more protracted process than punishment its propensity to result in aggression should be seen as a serious limitation to its use in behaviourial control.

On the other side of the coin, however, the fact that provision of opportunity for aggression during aversive contingencies may increase the probability of the response undergoing extinction, also has significance. Could it not be that the provision of socially acceptable channels of aggression may enable individuals to continue unrewarded tasks for greater periods of time compared with a situation where no channels of aggression are available? Additional research using wide ranges of species and a wide variety of conditions should be able to answer this question.

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