A COMPARISON OF OMISSION TRAINING WITH CONSTANT OR CHANGING REINFORCERS VS. EXTINCTION: RESPONSE REDUCTION AND RECOVERY

by

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There are three procedures often used as response elimination techniques: punishment, extinction, and omission training. Punishment is the administration of an aversive stimulus when a specific response is made by a subject. Extinction occurs when a response-reinforcer relationship is broken, whereupon a response is no longer followed by a positive reinforcer. Omission training is a learning situation in which a previously performed act must be omitted in order to receive reinforcement (Grant, 1964). Omission training is also referred to as differential reinforcement of other behaviors or DRO (see Reynolds, 1961).

In the case of a child who is typically reinforced by attention when he or she performs an undesirable aggressive act, punishment by removal could be employed as a "time-out" procedure by requiring the child to stay in his or her room for a specified time after each occurrence of an aggressive act. Punishment by application could also be administered by spanking the child after performance of an aggressive act. Extinction could be used in this situation by requiring that those who gave attention to the aggression ignore such acts. With omission training, the child could be reinforced (perhaps by attention) for successfully passing a time criterion in which no aggressive acts occurred. Any acts of aggression would necessarily restart the time criterion after which reinforcement would occur. Thus reinforcement would never directly follow an aggressive response. The response elimination technique of omission training is used often in child rearing. For example, a parent may reinforce a child when the child has successfully slept through the night without wetting his or her bed.

One response elimination technique may be more feasible in a given situation than another technique. For example, if the response to be eliminated is a self-abusive behavior, there may be extensive physical harm to the subject before the behavior extinguishes. On the other hand, punishment has been shown to induce undesirable side-effects in the subject (Azrin & Holz, 1966). The feasibility of a technique can be assessed by consideration of the amount of time required for response reduction (efficiency), and of the lasting effects on response reduction (durability). In comparison with the other techniques, omission training has been found to be very durable (Uhl, 1973; Uhl & Garcia, 1969; Uhl & Sherman, 1971), and in some cases, quite efficient (Cross, Dickson, & Sisemore, 1978; Mulick, Leitenberg, & Rawson, 1976; Zeiler, 1971) in eliminating responses. Also, omission training is an attractive technique because it involves the more positive effects of reinforcement as opposed to the negative effects of punishment or extinction. The present experiment will compare omission training with extinction in terms of both efficiency and durability of response reduction. After a discussion of past research on omission training, an alteration in the typical omission training procedure will be presented, with the intention that this alteration may serve to make omission training more efficient, although not necessarily more durable.

Past results conflict as to whether extinction or omission training is more efficient. The different findings from these experiments may be attributed to the difference in the techniques used in performing or comparing omission training to extinction. The major procedural differences in past omission training research include the use of a within-group versus a between-group design, gradual versus non-gradual introduction of the final omission schedule, the use of differing time intervals in the parameters of the experiment, variable versus fixed omission schedules, type and length of baseline training, and the use of different subject populations.

Efficiency of Response Reduction

Between-groups vs. Within-groups Experiments. In a typical between-groups experiment in which one group of subjects receives omission training and another group receives extinction training, and when a non-gradual introduction of the omission schedule is used, extinction has been found to eliminate responses faster than omission training (Uhl, 1973; Uhl & Garcia, 1969, exp. #1). On the other hand, in a within-groups design,[1] omission training has either been found to eliminate responses as fast (Topping & Ford, 1975) or faster (Mulick et al., 1976; Zeiler, 1971) than extinction. A stimulus associated with omission training reduced responding as well as a stimulus associated with extinction when each of these stimuli were compounded with a VI associated stimulus in a within-groups design (Neven, Michaud, Keefe, & Scharff (1979). A comparison of omission, extinction, and yoked procedures each in a multiple schedule with VI training, where later subjects switched from omission training to extinction (and visa versa), found that omission training reduced responding more efficiently and to a lower terminal rate than the other procedures (Uhl & Homer, 1974).

In attempting to explain why omission training produces faster response elimination than extinction when a within-groups design is used, Zeiler (1971) suggested that it may be the case that some competing response is developed in the omission training condition. When omission training is used in a multiple schedule with extinction, the competing response is increased because of behavioral contrast. In other words, the theory of behavioral contrast would predict that responses made to the non-extinction (in this case omission) schedule would increase. If the responses learned with an omission training procedure are competing responses to key-pecking (such as turning in circles), then, assuming behavioral contrast, these competing responses would increase in a within-subjects design that compared omission to extinction training. This would then lessen the likelihood of key-pecking responses made during the omission training schedule. If Zeiler's (1971) hypothesis is correct, then it would not be accurate to assume that a subject learns how to withold reponses in a multiple schedule, within-groups design testing omission training, rather, the subject is merely developing a competing response to the initial learned response.

Gradual vs. Non-gradual Omission Schedules. A second procedural difference is the use of gradual versus non-gradual introduction of the omission training schedule. In experiments using a gradual omission training schedule, omission training might begin with a 6 s response-reinforcer interval, and a 2 s reinforcer-reinforcer interval.[2] These intervals are gradually increased until they reach, for example, a 30 s response-reinforcer interval and a 10 s reinforcer-reinforcer interval. With gradual omission schedules in between-groups designs, subjects stopped responding sooner than with non-gradual omission schedules (Topping, Larmi, & Johnson, 1972; Uhl, 1974). Cross et al. (1978) found that a gradual omission training schedule eliminated responding faster than extinction in mentally deficient individuals. In this study, extinction eliminated responding faster than a non-gradual omission schedule.

Possible explanations for the better efficiency of gradual omission training versus non-gradual omission training were mentioned by both Topping et al. (1972) and Uhl (1974). Topping et al. (1972) suggested that reduced responding in gradual omission training may occur because the gradual procedure provides more immediate reinforcement for not responding, which is also more frequent, yet still provides extinction for responding. Uhl (1974) explained the advantage of using a gradual omission schedule in a similar way. He believed that gradual omission training is most effective at the beginning of the training. This occurs because at the beginning of a non-gradual omission schedule, the first reinforcement does not occur until extinction has eliminated enough responding so that the response-reinforcer interval clocks out. Once this occurs, the reinforcement may serve as a discriminative stimulus to start responding (Uhl, 1974). Gradually introducing the omission schedule makes it more likely that reinforcement would occur at the beginning of the omission trials. Thus it can be seen from the above examples that the utilization of a gradual omission schedule increases the response elimination capacity of omission training.

Response-reinforcer and Reinforcer-reinforcer Intervals. The third major procedural difference which may account for possible variations in results is the use of different intervals in omission training. As mentioned earlier, there are two parameters that must be considered in omission training (see Uhl & Garcia, 1969). The first parameter is the response-reinforcer interval. This interval dictates how much time must pass after a response before reinforcement is available again. The second parameter is the reinforcer-reinforcer interval. This interval dictates how much time must pass after the last reinforcement, in the occasion that no response occurs, before the next reinforcement is made available. In other words, if no responses occur, the reinforcer-reinforcer interval is in effect. If a response does occur, the amount of delay before reinforcement is available is determined by the response-reinforcer interval. Smith and Clark (1972) found that very low rates of responding occur when the response-reinforcer interval exceeds 60 s, or when the response-reinforcer interval is equal to or longer than the reinforcer-reinforcer interval. Uhl and Garcia (1969) determined similar maximally efficient intervals. They found that subjects reduced responding faster when the penalty for responding (the response-reinforcer interval) was equal to or greater than the interval occurring when no responding took place (the reinforcer-reinforcer interval). Uhl and Garcia explained this finding in terms of maximizing reinforcement density.

Variable vs. Fixed Omission Schedules. Another possible explanation for the differing results found when comparing omission training to extinction concerns the use of variable interval omission training as opposed to fixed interval omission training. Uhl (1974) found that response elimination was slightly faster with a variable interval omission schedule than with a fixed interval omission schedule. In an experiment using college students (Topping & Crowe, 1974), there was no difference in telegraph-key pressing responses when using either a fixed or a variable interval omission training schedule. In the multiple schedule within-groups design used by Uhl and Homer (1974) in which omission training was compared to extinction, a variable omission schedule eliminated responding faster than extinction.

It is difficult to compare Topping and Crowe (1974) with Uhl (1974) because different intervals were used (variable 8-s interval schedule for both response-reinforcer and reinforcer-reinforcer intervals, and a variable interval 10-s reinforcer-reinforcer and a variable 30-s response-reinforcer interval, respectively). Also, Uhl used rats to test the effect of using a variable interval omission schedule, while Topping and Crowe used human subjects. In Uhl and Homer's (1974) experiment, the use of the multiple schedule within-groups design may have been the major reason why these researchers found a variable omission training schedule to be faster than extinction. Thus the effect of using a variable interval omission schedule versus a fixed interval omission schedule is somewhat inconclusive. However, it could be stated that a variable interval schedule eliminates responding at least as well as a fixed interval schedule, if not better.

Type and Length of Baseline Training. Possible effects of different kinds of baseline training on later performance have been investigated by some researchers (Topping & Crowe, 1974; Uhl, 1973). Uhl (1973) found no interaction between number of days of baseline training and differences between extinction and omission training. Likewise, using college students, Topping and Crowe (1974) found no later differences in behavior based on whether the initial baseline training was an FI or a VI schedule. It appears that the use of different baseline parameters is not critical in determining later performance by the subject.

Summary. With within-groups designs, omission training has been found to more efficient than extinction; on the other hand, with between-groups designs, extinction was found to be more efficient than a non-gradual omission training schedule. Gradually introduced omission training schedules appear to be more efficient than both extinction and non-gradual schedules. Omission training is more efficient when the penalty for responding (response-reinforcer interval) is equal to or greater than the interval between reinforcers (reinforcer-reinforcer interval). The use of a variable omission schedule has been found to be more efficient than extinction, and as efficient, or more efficient than a fixed omission schedule. Pretraining parameters (VI or FI schedule and length of pretraining) have not been found to affect omission training and extinction differentially.

Durability Tests

In attempting to assess the lasting effects of a response reduction technique, researchers usually employ one of several durability tests. Generally, it can be concluded that when a contingent VI schedule is used to test the durability of the different response elimination procedures, all different groups usually respond at the same rate (Mulick et al., 1976; Uhl & Garcia, 1969; Uhl & Sherman, 1971). However, when a VT (variable time) durability test is used, omission training is found to be more durable than extinction (Uhl, 1973; Uhl & Garcia, 1969; Uhl & Sherman, 1971), punishment (Uhl & Sherman, 1971), and yoked groups (Uhl & Homer, 1974).

Other researchers have choosen to test durability with other procedures. Parker, Yarbrough, and Hardy (1980) and Zeiler (1971) used a test of spontaneous recovery in their multiple schedule experiments. Parker et al. (1980) used an intertrial interval of 15-45 seconds in which the response key was darkened. The original omission key showed a constant light in which pecking produced no scheduled consequences, while new keys were introduced with colors associated with either extinction or omission. Fewer responses were made when the color associated with omission, as opposed to the color associated with extinction, was presented (Parker et al., 1980). In Zeiler's (1971) multiple schedule experiment, when stimuli were presented 72 hours after the prior presentation, more responses occurred to the stimulus associated with extinction than to the omission training stimulus. Generally, across different kinds of durability tests (except contingent VI schedules) omission training is usually found to be more durable than extinction.

Yoked Controls

Yoked controls have been used as a comparison to omission trained groups (Uhl, 1974; Uhl & Homer, 1974). These yoked controls are used to separate the effects of solely receiving reinforcement (in the yoked group) from the effects of reinforcement for not responding (in a typical omission training schedule) (Uhl & Homer, 1974). Uhl (1974) found no significant differences between the yoked subjects and the subjects in the omission schedule groups. In another experiment, Uhl and Homer (1974) found that omission training was faster in eliminating responses than both extinction and the yoked groups. Uhl and Homer also found that response elimination was equivalent for both the extinction and yoked groups. However, the yoked group was less durable as shown by the greater number of responses made on the variable time (VT) durability test. It appears that the results found from using yoked controls are not conclusive. In the present experiment, a yoked control will be used to hopefully clarify these previous results.

Rationale for the Present Experiment

Many researchers have suggested that the reinforcing event itself may play the role of a stimulus to the subject

(Bottjer, Scobie, & Wallace, 1977; Mulick et al., 1976; Reid, 1958; Uhl, 1973; Uhl & Garcia, 1969; Uhl & Sherman, 1971). Because the reinforcer is still present in omission training (as opposed to extinction) and this reinforcer is generally the same as that used in pretraining, some of the responding found in the beginning of omission training may be a result of the reinforcer serving as a stimulus to respond (Bottjer et al., 1977; Uhl & Garcia, 1969; Uhl & Sherman, 1971). Reinforcer presentations on a VT durability test may act as a stimulus to respond for extinction trained groups because reinforcement does not occur in extinction, thus the associations made with the occurrence of reinforcement do not change from pretraining to the treatment phase (Mulick et al., 1976; Uhl, 1973; Uhl & Sherman, 1971).

The present experiment was designed to change some of the associations formed in an omission training procedure between reinforcers and responding by changing the reinforcer in the treatment phase. This manipulation was intended to lessen the capacity of the reinforcer to act as a stimulus for responding. Uhl and Garcia (1969, exp. #2) used a technique of discrete trials with time-outs to break down the power of the reinforcer as a discriminative stimulus. They found that omission training eliminated responding as fast as extinction (whereas in non-discrete trials extinction was more efficient). Homer and Peterson (1980) suggested using different reinforcers for humans in omission training to avoid satiation effects and to increase interest. It is expected that by using different reinforcers in the pretraining and omission training phases, it is possible to reduce substantially the power of the reinforcer in omission training to act as a signal to resume responding, which would serve to increase the efficiency of omission training. It is also expected that the omission training groups who received the same reinforcer throughout the experiment would show more durable response reduction in the recovery phase than the omission training groups with different reinforcers and extinction. The durability of response reduction for the omission trained groups with switched reinforcers and extinction is expected to be similar because both groups had not learned to reduce responding in the presence of the reinforcer given during the recovery phase. In the present experiment, water or food was used as a reinforcer during pretraining (Phase 1), depending upon which condition the subject was in. In the treatment phase (Phase 2), birds were either given extinction training or omission training in which the reinforcer used was either the same as that used in pretraining, or birds were switched (from food to water or from water to food), or were yoked to the omission trained birds, receiving the same reinforcer as their omission partner. In the recovery phase (Phase 3), all subjects were reinforced with the same reinforcer used in pretraining on a VT schedule of reinforcement. The effect of changing the reinforcer in omission training was observed and compared with the omission trained groups with constant reinforcers between pretraining and treatment, the yoked groups, and the extinction groups. Differences in the durability of response reduction was assessed by group comparisons of responses made during the VT schedule recovery phase.

Method

Subjects

The subjects were 42 experimentally naive pigeons obtained from a local supplier. One subject with low pretraining response rates and another subject who would not eat from the hopper when reinforcers were switched in Phase 2, were dropped from the experiment. All subjects were deprived of both food and water, and were maintained at 80% free-feeding weight. Because it was necessary to deprive pigeons receiving a water reinforcer of both food and water (Bennett, 1982), depriving the recipients of food reinforcers of both food and water served to equalize these two groups. Subjects' weights were recorded daily, and the 80% weight level was maintained by regulating the amount of pigeon chow or grain given daily in the home cage. Birds were individually housed with a 16-hr light, 8-hr dark lighting schedule, and had free-access to grit.

Apparatus

Four home-made operant chambers with internal dimensions of 25 cm x 29 cm x 34 cm (h x w x l) were used. On one wall of each chamber was a key transilluminated by an IEE display cell equipped with a Kodak Wratton filter, which produced a 555 nm light. The key (approximately 2 cm in diameter), centered 19 cm from the wire screen floor, remained lit throughout each session. Directly below the key, 7 cm from the floor, was an opening (5.5 cm x 6 cm) which allowed access to the reinforcers. When water was used as the reinforcer, 35 cc of water was placed in the hopper from a syringe. The grain cover was removed from the hopper. A baffle made from peg-board, and secured in place with silicone, was placed 4.2 cm from the end of the hopper closest to subject. This was built to prevent some of the water from flowing towards the back of hopper (which would decrease the available water level) when the hopper rose. Subjects were allowed to drink water from the hopper for 2 s. The hopper held more water than the subject could drink in 2 s, and in an entire session. When food was used as a reinforcer, the grain cover was placed on the hopper and the hopper was filled with grain which was made available for 3 s. The tray of grain provided more food than the bird could eat in 3 s, and in an entire session. Located within the food or water hopper was a white light which was illuminated each time a reinforcer was available.

The front of the chamber was all wood, except for a 12 cm (in diameter) circle cut into the wood, and covered with plexiglass. The center of this window was located 11 cm from the roof of the chamber, and 17 cm from the left wall of the chamber. Because of this window, the light in the running room was always turned off during a session. The chamber was illuminated by a GE 7 W, 115-125 V houselight, covered by white styrafoam to diminish the brightness, which remained on throughout a session, except when a reinforcer was presented. The houselight was located in the upper corner in the back of the chamber, on the wall opposite the intelligence panel. A fan was in operation during each session to enhance air circulation, and also to serve as a masking noise. The presentation of food or water, the keylight, and the recording of responses were controlled by a standard relay rack located in an adjacent room.

Procedure

There were 10 experimental conditions in this experiment, with 4 subjects in each. There were 3 Phases in this experiment: A pretraining phase (Phase 1) with either food or water as the reinforcer; a treatment phase (Phase 2) of either omission training with the same or different reinforcer as in pretraining, or extinction; and a recovery phase (Phase 3) under a VT schedule with the same reinforcer as in pretraining. Subjects in Group A (WFW) had water reinforcement for pretraining (Phase 1), food reinforcement for omission training (Phase 2), and water reinforcement for the recovery (Phase 3) following omission training. Subjects in Group B (WWW) had water as a reinforcer throughout the different phases (pretraining, omission training, and recovery period). For subjects in

Groups C (FWF) and D (FFF), the reinforcers were reversed from what was used in conditions A and B, respectively. Groups E (WEW) and F (FEF) consisted of a water reinforcement and food reinforcement, respectively, for both pretraining (Phase 1) and the recovery period (Phase 3), but with extinction in Phase 2. In addition, each of the birds in Groups A-D (i.e., those that received omission training) had a yoked bird paired with it for Phase 2. Thus, subjects in Group A-Y had water reinforcement in pretraining (Phase 1), and in the recovery phase (Phase 3). Whenever a bird in Group A received a food reinforcer during omission training in Phase 2, the yoked bird received food independent of its behavior. Birds in Groups B-Y, C-Y, and D-Y, were similarly yoked to birds in Groups B, C, and D. For a summmary of these conditions, see Table 1.

Deprivation Schedule. Subjects who received food during pretraining were first deprived of both food (to 80% free-feeding weight) and water (one gulp per day) in their home cage. One gulp of water consisted of the subject emersing its head in water and drinking. No time limit was set for the gulp, however, when the bird raised its head from the water, the water tray was removed.

Birds who received water as a reinforcer during pretraining were deprived of both food (to 80% free-feeding

Table 1

Treatment Conditions Used With Corresponding Reinforcers

Group	Pretraining (Phase 1)	Treatment (Phase 2)	Recovery (Phase 3)
A	Water	Omission-Food	Water
A-Y	Water	Yoked-Food	Water
B	Water	Omission-Water	Water
B-Y	Water	Yoked-Water	Water
C	Food	Omission-Water	Food
C-Y	Food	Yoked-Water	Food
D	Food	Omission-Food	Food
D-Y	Food	Yoked-Food	Food
E	Water	Extinction	Water
F	Food	Extinction	Food

weight) and water in their home cage. Birds were given one gulp of water a day until magazine training began. Once a bird was receiving water in an operant chamber, water was no longer available in the home cage, except when the bird was more than 10 g underweight and had not eaten all the food from the previous day. In this case, because birds deprived of water lower their food consumption (Zeigler, Green, & Siegel, 1972), a subject was given the water tray and allowed to take one gulp. If difficulty in magazine training or shaping occurred, subjects were totally deprived of water for at least 48 hours. The birds were further deprived of water until successful magazine training or shaping occurred. If after 4 days of deprivation the subject still did not magazine train or shape, the subject was dropped from the experiment. These subjects were given grain in the home cage if additional food (beyond that received in the operant chamber) was required for weight maintenance.

Initially, birds receiving water as a reinforcer during pretraining were given pigeon chow in their home cage to maintain their 80% free-feeding weight. However, some birds began to eat very small portions of this type of food, and as a result, often weighed much less than 80% of their free-feeding weight. For this reason, pigeon grain (50% Milo, 50% Wheat), which was more preferred by these pigeons, was given to the birds to maintain weight. Some of these pigeons however began to require less grain to maintain their weight. In many of these cases, response rates during the pretraining phase also fell at this time. These birds were switched back to pigeon chow for weight maintenance. To simplify this procedure with other birds, pigeon chow exclusively was given in the home cages unless: An extra sip of water was required for weight maintenance (i.e., when a subject was more than 10 g underweight and had not consumed all of the food from the previous day) on a near daily basis; and receiving this extra water apparently interfered with the subject's response rate (i.e., some birds showed a great reduction in response rate when they had received an extra sip of water on the previous day).

Magazine Training. All subjects (including the yoked controls) were first magazine trained, and then trained to peck at the key by the method of successive approximations (with either food or water as reinforcement, depending on the eventual placement into pretraining groups).

A subject was placed in the operant chamber with food available. Initially, the subject was then left alone until it ate from the hopper. To facilitate this procedure with other birds, the subject's head was directed into the hopper (that had additional food added), and then left to eat alone from the hopper. Once some consumption had occurred, the house lights and hopper lights were very briefly flicked to adapt the subject to the change in lighting. The hopper was then briefly lowered and then raised again. This was continued (with longer durations of the food being unavailable) until the subject quickly approached the hopper when it was raised.

Initially, subjects were placed into the operant chamber with the hopper up (water available), and then left alone until drinking occurred. Later to facilitate this procedure, a clear plastic tray that had dimensions of 7 mm x 4.3 cm x 5.5 cm (h x w x l) was placed into the hopper, and the subject's head was directed into this tray through handling. Once drinking occurred in this situation, the tray was immediately removed from the hopper, with the water in the hopper remaining available. The subject was then left alone until drinking occurred from the hopper. If the subject happened to move away from the hopper and sit elsewhere, the subject was placed directly in front of it (which was intended to enhance the hopper's salience). In addition to the tray being used for the birds receiving water as a reinforcer, droplets of water were sprayed on the interior of the funnel that led to the hopper, so that the pigeons would possibly be more directed towards the water in the hopper. Once drinking occurred, subjects were gradually introduced to the flickering of lights and the movements of the hopper, until the subject quickly approached the hopper.

Shaping. When a subject approached the hopper consistently upon presentation of a reinforcer, it was shaped to peck the key through a method of successive approximations, and allowed to receive 30 reinforcements for key-pecking. Often if subjects were magazine trained and shaped in one session, subjects apparently became satiated before 30 reinforcers had been given. If this occurred, subjects were returned to their home cage and not given any additional access to the reinforcer until the next day in the operant chamber.

Phase 1 (Pretraining). The day after a subject successfully obtained 30 reinforcements, it was allowed to receive 30 more reinforcements on a continuous schedule. Food reinforcers were available to the subjects for 3 s, water reinforcers for 2 s. This difference in reinforcer presentations is due to the problem of satiation. Animals given the same amount of time to eat or drink satiate faster with water than with food (Astley, personal communication, February, 1983). On the next three days subjects received 30 reinforcements on a VI 10-s, VI 20-s, and VI 30-s schedules, respectively. Subjects remained on the VI 30-s schedule until their responses had stabilized.

Subjects were considered stable when their response rates showed neither an upward nor a downward distinctive trend for a period of 10 days.

Once a bird was magazine trained in a particular experimental chamber, it received all further training in that box. When a subject had stabilized on the VI 30-s schedule, it was placed into one of the different experimental groups (omission, yoked, or extinction). Because some birds stabilized more quickly than others, it was necessary to distribute the birds into the groups as they became stable. Attempts were made to equalize these groups such that each group contained some of the first and last birds to become stable.

When a bird was placed into any of the groups other than extinction, it was necessary to have the response rate of a bird in an adjacent box (receiving the same reinforcer) concurrently stable so that one bird could be placed on an omission schedule and the other bird yoked to it. If a partner with a stable response rate was not available, birds with stable response rates continued on the VI 30-s schedule until one was available. When the second bird's response rate had become stable, the first bird was reassessed for stability, and if it still met the criterion for stability, both birds were placed in the treatment phase.

Birds receiving food reinforcers during pretraining did not participate in a session if their weight was over or under 10 g of their 80% free-feeding weight. For the birds receiving water as a reinforcer during pretraining, an index of the extent of thirst present in a given session was not obtainable. However, if the bird was more than 10 g underweight, and if it had not consumed all of the food from the prior day, given the relation between food and water, the bird was given an additional gulp of water after it had completed a daily session.

Phase 2 (Treatments). Of the ten conditions used in this experiment, four of them involved omission training (see Table 1). Four subjects were placed into each of the omission training groups, with another four subjects serving as yoked controls for each of these four omission training conditions.

Subjects who received the same reinforcer in the treatment condition as in the pretraining phase, or who received extinction, were placed into their treatment phase directly after their last day of pretraining in Phase 1 (unless they were to receive a food reinforcer and their weight was more than 10 g over or under their 80% free-feeding weight). Birds switching reinforcers from pretraining to Phase 2 (Groups A, A-Y, C, and C-Y) entered the omission phase only after successful magazine training to the different reinforcer.

Those birds who received water as a reinforcer during pretraining and food during Phase 2 (Groups A and A-Y) were further deprived of food and given extra water on the day preceding magazine training. Birds who had not received grain in their home cage for weight maintenance were given grain during this phase when necessary for maintenance. They were magazine trained by the same procedure presented before, except that there was black electrical tape covering the key light to insure that no responses occurred. Also, once a subject drank from the hopper, less time (about 1 s) elapsed between hopper presentations since many birds seemed to approach the key at this time. This was done so that motions approximating key pecking were not reinforced (since not enough time elapsed for birds to make these motions towards the key between hopper presentations). Birds were magazine trained until they rapidly approached the hopper consistently, which took an average of 5.50 days for this group.

For the birds switching from a food reinforcer during pretraining to a water reinforcer during Phase 2 (Groups C and C-Y), the same procedure was used, except that these birds were not given any water in their home cage on the day before and of magazine training. Also, birds were switched from pigeon chow to pigeon grain in the home cage for weight maintenance. These birds continued magazine training until they rapidly approached the hopper consistently, which took an average of 1.50 days.

Regardless of the reinforcer, each subject in the omission groups was gradually introduced into the omission schedule. Initially these subjects were reinforced every 5 s for not-responding. This interval gradually increased to 30 s, increasing by 2 s every time the subject responded 3 or fewer times for 5 consecutive reinforcers in a specific interval. Hence the parameters in this case were a gradually introduced 30-s reinforcer-reinforcer interval (which occurred in the absence of a response), and a gradually introduced 30-s response-reinforcer interval. This latter interval dictated that when a response occurred, reinforcement was not available until a period of 30 seconds had elapsed with no additional responses occurring. If a response did occur, the response-reinforcer interval reset for another 30 s. Therefore, each bird was on a gradually introduced, fixed interval 30-s omission schedule, with the response-reinforcer and the reinforcer-reinforcer intervals increasing (from 5 to 30 s) at the same rate. Each session continued until 30 reinforcers were presented, or until 30 min had elapsed, which ever occurred first. Each subject continued omission training until, for 3 consecutive days, the subject's response rate was less than 10% of the averaged response rates from the last ten sessions during pretraining.

Yoked controls received the same reinforcer during pretraining that their partner in an omission training group received. During Phase 2, responding or not responding had no effect on the availability of reinforcers for the yoked subjects. Everytime a reinforcer was available to the omission subject, the same reinforcer was simultaneously made available to the yoked subject. Thus, number of reinforcer presentations and session length were identical for a bird receiving omission training and its yoked control. The yoked subject continued in this phase until its omission paired subject had reached the response elimination criterion.

Birds placed in the extinction conditions had daily sessions lasting 30 min. Extinction continued until response rates were less than 10% of the averaged response rates from the last 10 sessions of pretraining, for 3 consecutive days.

Phase 3 (Recovery). When a subject reached the response reduction criterion in Phase 2, it was placed on a VT (Variable Time) 30-s schedule during the next experimental session. All subjects received the same reinforcer they had during pretraining (see Table 1). Each session consisted of 30 reinforcer presentations. Subjects remained in this final phase of the experiment for 10 days.

Data Analysis. The total number of responses and session length were recorded daily and used to calculate response rates for each phase. Rate of responding in Phase 2 was also transformed in a manner suggested by Anderson (1963). Transformations were performed to assess the effect of each response elimination technique relative to the prior pretraining behavior. Transformed scores were determined by first finding the mean rate of responses for a subject from the last 10 sessions of pretraining. Responses made during Phase 2 were treated or transformed as a proportion of the mean of the responses made during the last 10 sessions in pretraining. Thus a transformed score of "1" represented responding that was identical to the mean of the last 10 days of pretraining, a ".50" represented a rate that was half of the pretraining rate, whereas a "0" represented no responding.

Results

Phase 1 (Pretraining)

Mean rates of responding from the last 10 days of Phase 1 were compared to assess equality of group assignment. Group means are presented in Table 2. A 2 x 5 (Reinforcer x Treatment) analysis of variance found no significant main effects for treatment groups, $F(4,30) < 1$, type of reinforcer (food or water) received, $F(1,30) < 1$, or a significant Reinforcer x Treatment interaction, $F(4,30) < 1$.

Phase 2 (Treatments)

Daily response rates were transformed to a score relative to the mean response rate from the last 10 days of pretraining for each bird. Subjects' mean relative response rates combined in groups as a function of days are depicted in Figures 1 and 2. The total number of subjects in each group for each day are presented in Table 3. A 2 x 5 x 4 (Reinforcer x Treatment Group x Days) analysis of variance was performed comparing relative response rates from the first four days of Phase 2. Only the first four days were considered in this analysis because some subjects reached the response reduction criterion on the fourth day and were placed in the recovery phase on the fifth day (see Table 3). There was no significant main effect of the type of reinforcer received in the pretraining phase, $F(1,30) =$

Table 2

Mean Response Rate During Pretraining as a Function of Group Assignment

Group	Mean
Water as a Reinforcer	
(A) WFW	49.22
(A-Y) WFW	36.98
(B) WWW	36.79
(B-Y) WWW	48.31
(E) WEW	48.65
Food as a Reinforcer	
(C) FWF	44.68
(C-Y) FWF	41.49
(D) FFF	55.15
(D-Y) FFF	41.37
(F) FEF	37.96

Figure Caption

Figure 1. Mean relative response rate over days during Phase 2 for subjects with water as a reinforcer in Phase 1. The letter enclosed in parentheses denotes group (see Table 1). Last three letters indicate reinforcer given in the three phases, respectively. See Table 3 for the number of subjects in each group for each day.

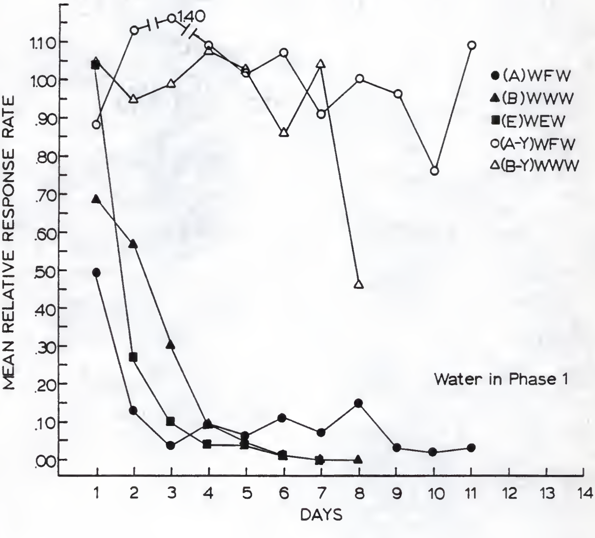

1.40
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.00
MEAN RELATIVE RESPONSE RATE
1 2 3 4 5 6 7 8 9 10 11 12 13 14
DAYS
● (A) WFW
▲ (B) WWW
■ (E) WEW
○ (A-Y) WFW
△ (B-Y) WWW
Water in Phase 1

Figure Caption

Figure 2. Mean relative response rate over days during Phase 2 for subjects with food as a reinforcer in Phase 1. The letter enclosed in parentheses denotes group (see Table 1). Last three letters indicate reinforcer given in the three phases, respectively. See Table 3 for the number of subjects in each group for each day.

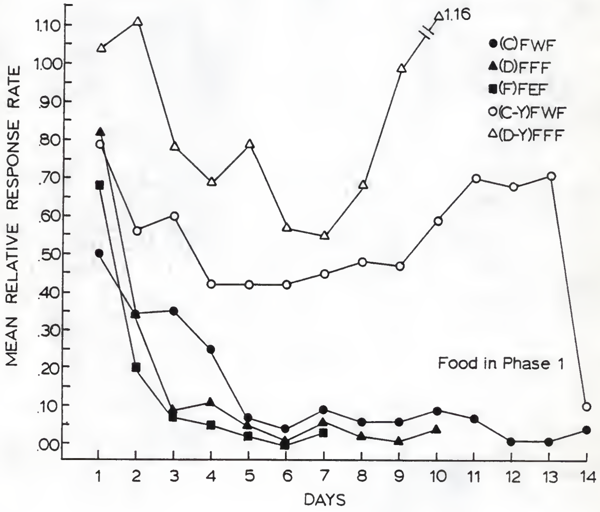

1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.00
MEAN RELATIVE RESPONSE RATE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DAYS
Δ1.16
●(C)FWF
▲(D)FFF
■(F)FEF
○(C-Y)FWF
Δ(D-Y)FFF
Food in Phase 1

Table 3

Total Number of Subjects in Each Group as a Function of Days

	Days									
Group	1-4	5	6	7	8	9	10	11	12	13	14
(A) WFW	4	3	1	1	1	1	1	1	0	0	0
(B) WWW	4	4	4	3	1	0	0	0	0	0	0
(C) FWF	4	4	4	4	3	2	2	2	2	2	1
(D) FFF	4	4	2	2	2	1	1	0	0	0	0
(E) WEW	4	4	1	1	0	0	0	0	0	0	0
(F) FEF	4	3	2	1	0	0	0	0	0	0	0

2.44. There were significant main effects of treatment group, $F(4,30) = 12.41$, $p<.0001$, and of days, $F(3,90) = 17.77$, $p<.0001$, with a significant interaction between these two factors, $F(12,90) = 3.32$, $p<.001$. There were no significant interactions of type of reinforcer received in pretraining and treatment group, $F(4,30) = 1.86$, of days and type of reinforcer received in pretraining, $F(3,90) < 1$, and of days, type of reinforcer received in pretraining, and treatment group, $F(12,90) = 1.50$.

Post hoc t-tests performed on the treatment groups collapsed across days showed that the yoked birds receiving the same reinforcer in Phase 1 and 2 had significantly higher mean relative response rates ($M=.96$) than the omission trained birds with the same reinforcer in Phase 1 and 2 ($M=.38$), $t(14) = 3.37$, $p<.01$. Likewise, the yoked birds with a different reinforcer in Phase 1 and 2 had significantly higher mean relative response rates (M=.86) than the omission trained birds who changed reinforcers ($M=.27$), $t(14) = 4.44$, $p<.001$. There were no significant differences of mean relative response rates between the extinction trained birds ($M=.31$) and omission trained birds with different reinforcers in Phase 1 and 2, $t(14) = .46$. There was no significant difference between mean relative response rates of the extinction trained and the omission trained birds that had the same reinforcer in Phase 1 and

2, *t*(14) = 1.50, or between the two omission trained groups, *t*(14) = 1.52.

Omission trained birds and their yoked partners who were switched from a water reinforcer in pretraining to a food reinforcer in Phase 2 took an average of 5.50 days (range = 1 to 12 days) to magazine train to the food reinforcer. Omission trained and yoked birds switching from a food to a water reinforcer took an average of 1.50 days (range = 1 to 2) to magazine train to the water reinforcer.

Efficiency of response elimination for the omission training birds with the same reinforcers between pretraining and treatment, or different reinforcers, and for extinction was indexed by total time spent in the treatment phase. The treatment phase ended when a subject responded at less than 10% of its pretraining mean for three consecutive days. Total time spent in the treatment phase was transformed into natural log (base e). This transformation was performed to normalize the distribution of these time scores. A 2 x 3 (Reinforcer x Treatment Group) analysis of variance found no significant main effects of type of reinforcer given in pretraining, $F(1,18) = 3.09$, or of treatment group, $F(2,18) = 1.02$. There was a significant interaction between type of reinforcer given in pretraining and treatment group, $F(2,18) = 3.81$, $p < .05$.

This interaction is depicted in Figure 3. Further tests of simple main effects showed that the effect of receiving water vs. food during pretraining was significant for the omission training group with different reinforcers between pretraining and treatment phases, $F(1,18) = 10.67$, $p<.01$, but not for the omission groups with the same reinforcer, $F(1,18) < 1$, nor for the extinction groups, $F(1,18) < 1$. The omission group switched from food in the pretraining phase to water in the treatment phase took longer to reach the response elimination criterion (M(log)=5.36) than the omission group switched from water to food in these phases (M(log)=4.56). There was a significant negative correlation between total log time in Phase 2 and the number of days required to magazine train to a different reinforcer for the omission training groups who changed reinforcers from Phase 1 to Phase 2, $r(6) = -.77$, $p<.05$; that is, subjects who took a longer time to magazine train tended to reach the response reduction criterion in Phase 2 more efficiently.

Phase 3 (Recovery)

The daily mean response rates during Phase 3 for each group are presented in Figure 4. A 2 x 3 x 10 (Reinforcer x Treatment Group x Day) analysis of variance found significant main effects for groups, $F(2,18) = 16.08$, $p<.001$, days, $F(9,162) = 3.00$, $p<.002$, and type of

Figure Caption

<u>Figure 3</u>. Mean time (log min) spent in Phase 2 for groups with either food or water as a reinforcer in Phase 1.

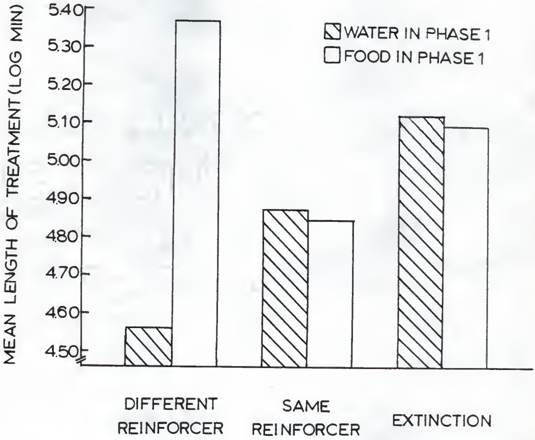
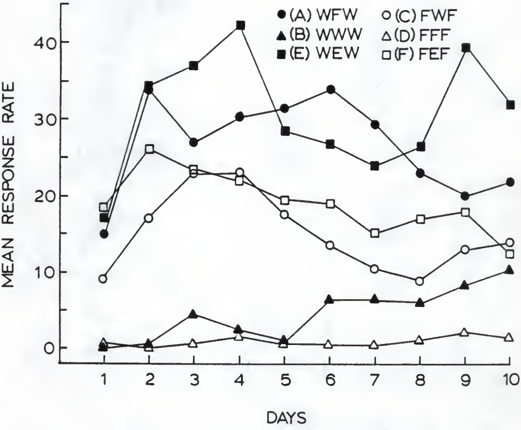

MEAN LENGTH OF TREATMENT (LOG MIN)
5.40
5.30
5.20
5.10
5.00
4.90
4.80
4.70
4.60
4.50
WATER IN PHASE 1
FOOD IN PHASE 1
DIFFERENT REINFORCER
SAME REINFORCER
EXTINCTION

Figure Caption

Figure 4. Mean response rate (per min) as a function of days during Phase 3. The letter enclosed in parentheses denotes group (see Table 1). Last three letters indicate reinforcer given in the three phases, respectively.


● (A) WFW
○ (C) FWF
▲ (B) WWW
△ (D) FFF
■ (E) WEW
□ (F) FEF
MEAN RESPONSE RATE
0
10
20
30
40
1
2
3
4
5
6
7
8
9
10
DAYS

reinforcer given, $F(1,18) = 7.13$, $p<.05$. There were no significant interactions. The groups that received water as a reinforcer during pretraining responded at significantly higher rates (M=20.69) than the groups that received food as a reinforcer (M=11.64). The mean response rate collapsed across days and reinforcers for the groups with the same reinforcer during the pretraining and treatment phases was 2.78. For the omission groups with a different reinforcer between pretraining and treatment, the mean response rate was 20.80, while for the extinction groups the mean was 24.92. Post hoc t-tests comparing groups across reinforcers revealed that the omission groups with different reinforcers in Phases 1 and 2 responded at a significantly higher rate than the omission groups with same reinforcers in these two phases, $t(18) = 3.75$, $p<.01$. There was no significant difference in mean response rates between the groups that received extinction during the treatment phase and the omission groups that received different reinforcers between the pretraining and the treatment phases, $t(18) < 1$.

Discussion

In the present study, there were no significant differences in the efficiency of both omission training procedures and extinction for reducing responding. Subjects yoked to the omission training birds did not reduce responding in the treatment phase as much as the experimental subjects. Efficiency of response reduction for the omission training groups with different reinforcers in pretraining and the treatment phase was affected by the order in which the reinforcers were presented. Birds switching from water in pretraining to food in the treatment phase reduced responding more rapidly than birds switching from food to water. The omission training groups with the same reinforcer in pretraining and the treatment phase showed greater durability of response reduction during the recovery phase than the omission training groups with changed reinforcers, and the extinction groups.

In the treatment phase, there were no significant differences in response elimination efficiency (time involved in reaching the response elimination criterion) between the omission groups receiving the same, or different reinforcers between pretraining and treatment phases, and extinction. This differs from past research using a between groups design (Cross et al., 1978) where a gradually introduced omission training schedule reduced responses faster than the use of an extinction procedure. This difference in the findings of the present and past research may be due to the use of different subject populations. Cross et al. used mentally deficient subjects while the present study employed pigeons.

It was hypothesized that the omission group with different reinforcers in pretraining and the treatment phase would show more efficient response reduction than the omission group with the same reinforcer in both phases. This hypothesis was based on the findings that reducing the capacity of the reinforcer to act as a stimulus to respond equalizes the efficiency of omission training vs. extinction (Uhl & Garcia, 1969, exp. #2). In the present experiment, not only was the omission schedule with different reinforcers in the pretraining and the treatment phases as efficient as omission training with the same reinforcer throughout the experiment, but both were as efficient as extinction. Because the omission trained groups with the same or different reinforcers between pretraining and treatment phases both had an equivalent response reduction efficiency relative to extinction, it appears that the use of a gradual omission training schedule is sufficient to produce comparable results between the use of omission and extinction training. Past research using a between-groups design found that a gradual omission schedule was more efficient than extinction in reducing responding in mentally deficient individuals (Cross et al., 1978). One procedural difference that may have caused different findings between the present and past research was the use of different subject populations. Another possible reason why the gradual omisson schedule was not more efficient than extinction was the initiation of the omission training schedule. If a subject had a prior, relatively low rate of responding during pretraining, often that subject would be reinforced before any responding occurred when initially placed on the omission training schedule. In some cases, the subject did not eat or drink from the hopper when these reinforcers were presented. When a subject did not respond, the omission schedule was advanced because the requirement for advancement had been met. When a gradual omission training schedule is initiated, response reduction may occur from the effects of extinction and from reinforcement for short periods of non-responding (Topping et al., 1972). Although in the present study subjects were reinforced for not responding, the added response reduction effects of extinction did not occur if a subject was not initially responding. Some subjects did not begin to respond on an omission training schedule until the response-reinforcer interval was much longer than the initial interval. For these birds, the initial advantage of a gradually introduced omission schedule was bypassed. This may account for the omission training groups not being more efficient than the extinction groups. In future studies, this problem may be avoided by requiring that the subject first make a response before the omission schedule begins.

Zeiler (1971) suggested that competing responses are learned in an omission procedure. These competing behaviors, which are a particular form of not emitting the target response, occur because the behavior prior to the delivery of reinforcement becomes stereotyped (Zeiler, 1971). In the present study, 6 out of 8 birds observed in the omission training treatment phase remained near the reinforcer hopper (often placing their head inside it) throughout the session. The other 2 birds made circular movements around the operant chamber, and rocking motions from side to side in front of the observation window. It appears, for the most part, that the learning of competing responses to key-pecking was not the primary impetus for the effectiveness of omission training. This finding concurs with previous research by Uhl (1974) in which rats on an omission training schedule were found to remain near the dipper housing, and often showed responses that more likely indicated anticipatory consummatory responses (licking and gnawing), rather than a specific stereotyped behavior (i.e., competing responses). An interesting observation in the present study was that omission trained birds who received the same reinforcer in pretraining and the treatment phases often continued to show the same behavior in the recovery phase as in the treatment phase. The omission trained birds who switched reinforcers from Phase 1 to Phase 2, and the birds who had received extinction showed behavior similar to that in pretraining (going directly from the hopper back to the key after reinforcement) or, specific individual behavior (pecks the panel to the right of the key; moves from left to right in front of key) during the recovery phase.

The omission trained birds with the same reinforcer in pretraining and the treatment phase responded significantly less than the omission trained birds with different reinforcers, and the extinction birds, when placed on the recovery VT 30-s schedule. The durability of the response reduction effects from omission training has been unanimously found to exceed the durability of response reduction found from other procedures (Parker et al., 1980; Uhl, 1973; Uhl & Garcia, 1969; Uhl & Homer, 1974; Uhl & Sherman, 1971; Zeiler, 1971), except when a contingent VI schedule is used to test durability (Mulick et al., 1976; Uhl & Garcia, 1969; Uhl and Sherman, 1971). In previous research, the same reinforcer was used in the treatment and the recovery (durability) phases. In the present experiment, it was expected that the omission trained birds with different reinforcers from the pretraining and the treatment phases would show response rates similar to the extinction trained birds during the recovery phase because both groups had not learned to reduce responding in the presence of the reinforcer given during the recovery phase. This hypothesis was supported, suggesting that the reinforcer given during pretraining acts as a stimulus to resume responding when presented in the recovery phase. One can also interpret the low response rates by the omission trained birds who experienced the same reinforcer throughout the experiment in terms of transfer of training. Response rates that are similar at the end of Phase 2 and at the beginning of Phase 3 may indicate increased transfer of training than less similar rates. On the first day of Phase 3, the omission trained birds who kept the same reinforcer throughout the experiment showed the greatest transfer of training as indicated by the similar response rates to the last day of Phase 2 (see Figure 4).

Birds who received either omission or extinction training showed more response reduction (total amount of responding during the treatment phase relative to the pretraining phase) than did the omission yoked controls. This finding differs from an earlier report by Uhl (1974) in which yoked groups of rats showed as much response reduction as the omission groups. Procedural differences may account for this discrepancy. In his study, Uhl (1974) compared a combination of scores from a constant and an adjusting omission training schedule to the yoked subjects. The present experiment obtained omission training scores solely from an adjusting, gradual omission training schedule, which omitted any possible effects caused by a less efficient constant omission schedule. Results obtained showing the significant response reduction capacity of the omission procedures equivalent to extinction, and over that of the yoked treatments, attests to the viability of omission training as an effective response reduction technique. However, it should be pointed out that Church (1964) addressed problems in assessing the effectiveness of an event (such as receiving a reinforcer) by comparing responses made from a contingently reinforced subject and its yoked control partner.

An interesting result from the present study, when comparing the logarithm of the total time spent in the treatment phase, was the significant interaction of the type of reinforcer given in pretraining and treatment group. There was a significant simple main effect of the use of water vs. food in pretraining for the omission training groups with different reinforcers in the pretraining and treatment phases. The omission group switched to food as a reinforcer in the treatment phase reached the response elimination criterion for this phase faster than the omission group switched to water. A finding that may be related to the difference of efficiency in response reduction between these two groups was the number of days that occurred for magazine training to the different reinforcer. Because birds do not readily eat or drink from the hopper when the reinforcer is changed, omission trained birds and their yoked controls who switched reinforcers were individually magazine trained to the different reinforcer before the omission subject and its yoked control were placed in the treatment phase. The subjects who were required to magazine train to water took an average of 1.50 days to train, while the birds required to magazine train to food took an average of 5.50 days. There was a significant negative correlation between the number of days that elapsed between the pretraining and treatment phases and the total log time required for successful completion of the response elimination criterion in the treatment phase. The added number of days for the birds training to a food reinforcer may have led to an increase in discrimination between the pretraining and the treatment phases which would allow for faster response reduction. It appears that the elapsed days did not cause simply a general reduction in response rates because yoked birds with the same amount of time between Phase 1 and 2 as their omission trained partner had a mean relative response rate of .51 for those switching from food to water, and 1.17 for the birds switching to food during the treatment phase.

The difficulty in switching birds from a water to a food reinforcer relative to birds switching from food to water, may be due to differences in the degree of food or water deprivation. Birds who received food as a reinforcer during pretraining and who were to be trained with a water reinforcer for the treatment phase would drink from the water hopper in the operant chamber given one or two days of total water deprivation. Birds switching from a water to a food reinforcer often would not eat from the food hopper in the operant chamber during their initial days of magazine training, even though little consumption of food had occurred in their home cage. Many times these birds stopped eating from the hopper for the entire session when a slight change, such as a brief lowering of the hopper, occurred in the operant chamber. Even though the present water deprivation schedule for these birds was mild, when given water in the home cages, they appeared to drink more, i. e., they would emerse their heads' in the water tray longer, than the birds who had been exclusively deprived of water. Zeigler et al. (1972) found that when pigeons are water deprived, there is a significant reduction in food consumption. It is possible that the birds switched from a water reinforcer in pretraining to a food reinforcer during the treatment phase took longer to magazine train because the reinforcer presented (food) was not adequate in influencing behavior due to the extent of water deprivation. An observation that supported the finding of Zeigler et al. (1972) was that birds deprived of water during pretraining often had food remaining in their food tray at their home cage even though their weight was at or below 80% of their free-feeding weight. The birds who were deprived of food during pretraining (who were also partially deprived of water) always drank from the water tray when given the opportunity, and never had food remaining in their food trays. Thus, the extent and durability of the effects of water deprivation may have prolonged magazine training for the birds switching from a water to a food reinforcer which, with the passing of days, may have caused greater discriminability between the pretraining and the treatment phase.

The present findings indicate that omission training is a viable alternative to other response reduction techniques. Changing the reinforcer between the pretraining and the treatment phase did not increase the efficiency of omission training. However, the ability of the reinforcer to act as a stimulus to respond was demonstrated in that the omission trained birds who kept the same reinforcer throughout the experiment showed significantly less responding in the recovery phase than the omission trained birds that switched reinforcers, and the birds who received extinction. Thus, if the efficiency of response reduction is of interest, the use of a gradually introduced omission training schedule has been shown to equal the efficiency of extinction training. If the durability of response reduction is of interest, omission training in which the conditions throughout the experiment are kept similar (i.e., using the same reinforcer) has been shown to be more durable than extinction training, or omission training with less similarity (i.e., using different reinforcers) between the treatment phase and the other phases. If omission training is to be employed as a durable response reduction technique in behavior modification, the reinforcer that is maintaining the response to be eliminated should first be determined. The use of this reinforcer in a gradually introduced omission schedule should reduce responding as rapidly as extinction, and should provide longer lasting response reduction than the use of extinction training or omission training using a different reinforcer.

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Footnotes

[1]In a within-groups design, typically a multiple schedule is used in which some external stimulus signals which condition (either extinction or omission) is occurring at that particular time.

[2]The reinforcer-reinforcer interval refers to the time that must pass between delivery of reinforcers in the absence of a response.

Terminal 10 Days Baseline Rates (per min) for Subjects in Groups A and A-Y

Ss#	1	2	3	4	5	6	7	8	9	10
					Days					
1	34.50	33.71	41.57	37.71	36.22	40.54	38.95	38.48	33.15	25.55
2	51.98	18.93	34.11	46.16	31.33	47.26	39.20	39.40	36.88	37.96
3	58.45	79.69	70.19	79.93	80.48	67.02	63.83	77.06	70.99	71.07
4	54.97	53.09	53.62	35.09	44.95	49.13	59.58	44.34	54.72	57.07

Group A

Ss#	1	2	3	4	5	6	7	8	9	10
					Days					
1-Y	43.63	43.28	36.33	39.10	37.77	47.10	42.46	34.51	41.75	47.32
2-Y	40.64	28.64	34.66	35.09	40.33	43.00	45.13	42.72	38.27	41.88
3-Y	46.26	46.47	40.88	40.87	54.40	56.09	59.71	52.54	51.04	46.91
4-Y	19.23	22.40	23.68	17.95	14.33	12.79	11.42	17.11	19.34	22.40

Group A-Y

Terminal 10 Days Baseline Rates (per min) for Subjects in Groups B and B-Y

Ss#	1	2	3	4	5	6	7	8	9	10
5	19.60	14.13	13.94	11.44	16.27	14.43	19.83	14.49	15.89	9.88
6	44.27	42.66	31.54	36.15	23.71	33.24	37.31	33.64	45.20	36.59
7	31.83	40.36	35.36	33.74	32.51	29.37	34.06	34.03	43.46	32.66
8	62.47	58.49	68.57	60.16	63.13	56.80	59.42	69.09	52.19	60.01

Days (column heads 1–10)

Group B

Ss#	1	2	3	4	5	6	7	8	9	10
5-Y	53.43	38.86	37.02	40.56	43.45	41.29	37.86	51.14	46.33	42.33
6-Y	68.62	69.16	72.35	68.22	74.54	67.95	72.56	64.20	67.48	72.78
7-Y	30.34	40.72	33.33	47.99	40.45	35.60	42.92	34.33	33.77	36.50
8-Y	44.46	34.55	35.66	46.39	48.15	43.96	46.73	42.49	44.22	39.83

Days (column heads 1–10)

Group B-Y

Terminal 10 Days Baseline Rates (per min) for Subjects in Groups C and C-Y

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
9	41.37	43.33	36.31	43.32	38.94	35.48	32.06	41.57	43.55	38.12
10	47.39	40.25	49.09	44.82	39.72	45.82	54.78	38.33	40.34	45.02
11	44.68	39.67	44.54	54.37	49.63	49.27	45.11	49.15	45.62	50.44
12	46.91	47.90	50.10	48.57	42.60	57.06	47.26	46.50	45.10	43.04

Group C

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
9-Y	42.20	44.73	43.13	42.41	43.39	45.19	41.90	45.68	40.21	48.19
10-Y	29.86	28.43	32.35	33.71	32.23	31.86	31.12	34.99	26.67	31.01
11-Y	44.08	36.68	32.61	28.36	36.67	36.75	47.86	48.28	53.89	44.14
12-Y	48.73	59.58	43.60	43.63	43.25	55.82	49.30	47.40	54.35	55.73

Group C-Y

Terminal 10 Days Baseline Rates (per min) for Subjects in Groups D and D-Y

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
13	29.97	37.27	29.35	40.94	38.55	29.68	40.28	33.09	34.85	34.07
14	41.15	43.38	31.35	38.49	17.50	47.80	36.65	41.00	36.19	34.96
15	35.30	39.18	39.19	41.40	38.34	37.65	39.74	41.47	46.44	36.10
16	120.9	96.85	112.3	103.7	99.87	102.1	117.9	116.8	117.3	107.0

Group D

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
13-Y	28.81	24.80	33.78	32.06	28.89	34.85	31.26	30.00	36.91	32.55
14-Y	37.34	35.25	27.93	31.61	24.89	37.06	30.67	38.35	34.32	28.43
15-Y	38.15	36.72	32.76	29.93	38.32	32.68	29.29	31.49	32.04	34.86
16-Y	74.15	62.29	73.80	67.51	69.49	57.80	68.04	70.95	69.84	65.25

Group D-Y

Terminal 10 Days Baseline Rates (per min) for Subjects in Groups E and F

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
17	52.89	46.86	32.58	55.88	57.64	50.63	38.60	52.57	39.60	35.49
18	39.10	44.86	46.97	42.33	50.17	43.21	44.14	46.21	44.70	38.29
19	45.50	42.59	46.73	37.33	42.95	43.45	46.53	44.61	36.94	46.68
20	60.40	68.05	56.29	69.58	60.92	63.16	49.12	58.54	61.71	61.88

Group E

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
21	35.38	23.71	29.73	35.31	26.96	33.51	33.36	36.91	31.00	32.27
22	38.29	28.11	39.34	36.78	34.85	33.24	32.77	32.45	33.01	28.29
23	44.01	41.33	38.54	41.46	50.31	46.96	47.28	53.22	45.07	45.97
24	43.14	44.48	45.43	35.51	39.71	36.97	40.08	44.77	36.79	42.33

Group F

<u>Individual Treatment (Phase 2) Rates (per min)</u>

<u>for Groups A and A-Y</u>

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
1	5.16	3.65	.80	.18	0	*	*
	*	*	*	*	*	*	*
2	21.99	1.03	4.55	12.61	6.60	4.39	2.74
	5.68	1.26	.70	1.27	*	*	*
3	55.34	5.94	.95	.49	*	*	*
	*	*	*	*	*	*	*
4	24.52	14.83	.91	.57	.90	*	*
	*	*	*	*	*	*	*

Group A

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
1-Y	0	38.90	60.37	43.72	60.62	*	*
	*	*	*	*	*	*	*
2-Y	49.83	30.58	43.30	36.42	28.46	41.89	35.70
	39.16	37.59	29.85	41.86	*	*	*
3-Y	34.67	75.91	76.68	66.79	*	*	*
	*	*	*	*	*	*	*
4-Y	27.85	22.69	26.49	18.68	15.53	*	*
	*	*	*	*	*	*	*

Group A-Y

<u>Individual Treatment (Phase 2) Rates (per min)</u>

<u>for Groups B and B-Y</u>

	Days						
	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
5	.51	19.87	7.99	1.85	.36	.31	.06
	*	*	*	*	*	*	*
6	34.59	15.36	5.55	.23	.18	.36	*
	*	*	*	*	*	*	*
7	31.55	11.92	8.22	5.20	1.52	.61	.49
	*	*	*	*	*	*	*
8	53.46	10.84	15.82	3.60	7.60	.30	.24
	.06	*	*	*	*	*	*

Group B

	Days						
	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
5-Y	57.70	74.48	68.86	77.47	92.81	90.03	96.37
	*	*	*	*	*	*	*
6-Y	80.41	72.40	78.92	79.73	58.97	43.85	*
	*	*	*	*	*	*	*
7-Y	28.94	5.36	12.98	23.20	8.19	3.23	9.01
	*	*	*	*	*	*	*
8-Y	40.53	38.46	37.20	32.65	39.44	27.91	27.64
	19.51	*	*	*	*	*	*

Group B-Y

Individual Treatment (Phase 2) Rates (per min) for Groups C and C-Y

	Days						
	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
9	15.32	32.91	31.18	16.81	4.22	1.61	.40
	1.29	*	*	*	*	*	*
10	51.57	7.66	9.46	2.13	4.57	2.17	1.22
	5.23	4.30	2.73	4.95	.34	.52	1.59
11	17.29	16.01	17.79	12.57	2.52	1.49	.70
	*	*	*	*	*	*	*
12	31.67	.28	.19	11.68	.19	1.40	14.66
	1.91	.78	5.27	1.40	.46	.47	*

Group C

	Days						
	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
9-Y	33.08	26.10	17.86	26.79	23.92	19.28	19.11
	12.16	*	*	*	*	*	*
10-Y	32.47	19.87	19.57	11.39	9.47	3.58	8.94
	1.22	2.52	2.83	5.74	3.61	5.84	3.13
11-Y	29.07	13.91	16.73	5.13	7.08	4.23	.70
	*	*	*	*	*	*	*
12-Y	32.63	32.54	47.88	29.13	33.83	51.42	51.78
	56.61	42.62	54.33	60.68	61.71	61.78	*

Group C-Y

<u>Individual Treatment (Phase 2) Rates (per min)</u>

<u>for Subjects in Groups D and D-Y</u>

Days

	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
13	43.07	16.68	2.67	1.34	1.03	*	*
	*	*	*	*	*	*	*
14	24.81	6.48	8.38	.88	3.86	.06	0
	.12	*	*	*	*	*	*
15	29.36	6.25	1.15	14.71	2.25	.97	4.74
	1.41	.28	1.75	*	*	*	*
16	68.64	57.58	3.12	2.07	.12	*	*
	*	*	*	*	*	*	*

Group D

Days

	1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
13-Y	22.04	12.57	.96	.34	18.83	*	*
	*	*	*	*	*	*	*
14-Y	44.78	55.86	34.07	17.65	17.90	1.13	1.33
	5.62	*	*	*	*	*	*
15-Y	39.19	54.47	52.51	61.80	42.72	36.82	35.32
	39.52	32.05	38.87	*	*	*	*
16-Y	62.11	47.44	32.27	25.69	49.23	*	*
	*	*	*	*	*	*	*

Group D-Y

Individual Treatment (Phase 2) Rates (per min) for Groups E and F

	Days 1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
17	67.24	17.17	4.14	.51	1.38	*	*
	*	*	*	*	*	*	*
18	25.73	5.62	2.84	1.68	.10	*	*
	*	*	*	*	*	*	*
19	49.33	11.27	.61	3.19	.34	*	*
	*	*	*	*	*	*	*
20	60.61	18.87	13.55	1.38	6.75	.37	0
	*	*	*	*	*	*	*

Group E

	Days 1	2	3	4	5	6	7
Ss#	8	9	10	11	12	13	14
21	26.64	6.85	5.34	.44	.13	0	*
	*	*	*	*	*	*	*
22	18.41	3.13	.36	.69	*	*	*
	*	*	*	*	*	*	*
23	26.16	4.26	1.47	5.55	.85	.17	1.45
	*	*	*	*	*	*	*
24	30.91	15.95	3.19	2.31	2.01	*	*
	*	*	*	*	*	*	*

Group F

Individual Treatment (Phase 2) Transformed Scores for Groups A and A-Y

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
1	.14	.10	.02	.00	.00	*	*
	*	*	*	*	*	*	*
2	.57	.03	.12	.33	.17	.11	.07
	.15	.03	.02	.03	*	*	*
3	.77	.08	.01	.01	*	*	*
	*	*	*	*	*	*	*
4	.48	.29	.02	.01	.02	*	*
	*	*	*	*	*	*	*

Group A

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
1-Y	.00	.94	1.46	1.06	1.47	*	*
	*	*	*	*	*	*	*
2-Y	1.28	.78	1.11	.93	.73	1.07	.91
	1.00	.96	.76	1.07	*	*	*
3-Y	.70	1.53	1.55	1.35	*	*	*
	*	*	*	*	*	*	*
4-Y	1.54	1.26	1.47	1.03	.86	*	*
	*	*	*	*	*	*	*

Group A-Y

Individual Treatment (Phase 2) Transformed Scores for Groups B and B-Y

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
5	.03	1.33	.53	.12	.02	.02	.00
	*	*	*	*	*	*	*
6	.95	.42	.15	.01	.00	.01	*
	*	*	*	*	*	*	*
7	.91	.34	.24	.15	.04	.02	.01
	*	*	*	*	*	*	*
8	.88	.18	.26	.06	.12	.00	.00
	.00	*	*	*	*	*	*

Group B

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
5-Y	1.33	1.72	1.59	1.79	2.15	2.08	2.23
	*	*	*	*	*	*	*
6-Y	1.15	1.04	1.13	1.14	.84	.63	*
	*	*	*	*	*	*	*
7-Y	.77	.14	.35	.62	.22	.09	.24
	*	*	*	*	*	*	*
8-Y	.95	.90	.87	.77	.92	.65	.65
	.46	*	*	*	*	*	*

Group B-Y

Individual Treatment (Phase 2) Transformed Scores for Groups C and C-Y

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
9	.39	.84	.79	.43	.11	.04	.01
	.03	*	*	*	*	*	*
10	1.16	.17	.21	.05	.10	.05	.03
	.12	.10	.06	.11	.01	.01	.04
11	.37	.34	.38	.27	.05	.03	.01
	*	*	*	*	*	*	*
12	.07	.01	.00	.25	.00	.03	.31
	.04	.02	.11	.03	.01	.01	*

Group C

Days

Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
9-Y	.76	.60	.41	.61	.55	.44	.44
	.28	*	*	*	*	*	*
10-Y	1.04	.64	.63	.36	.30	.11	.29
	.04	.08	.09	.18	.12	.19	.10
11-Y	.71	.34	.41	.13	.17	.10	.02
	*	*	*	*	*	*	*
12-Y	.65	.65	.95	.58	.67	1.03	1.03
	1.13	.85	1.08	1.21	1.23	1.23	*

Group C-Y

Individual Treatment (Phase 2) Transformed

Scores for Groups D and D-Y

	Days						
Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
13	1.24	.48	.08	.04	.03	*	*
	*	*	*	*	*	*	*
14	.67	.18	.23	.02	.10	.00	.00
	.00	*	*	*	*	*	*
15	.74	.16	.03	.37	.06	.02	.12
	.04	.01	.04	*	*	*	*
16	.63	.53	.03	.02	.00	*	*
	*	*	*	*	*	*	*

Group D

	Days						
Ss#	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
13-Y	.70	.40	.03	.01	.60	*	*
	*	*	*	*	*	*	*
14-Y	1.37	1.71	1.05	.54	.55	.03	.04
	.17	*	*	*	*	*	*
15-Y	1.17	1.62	1.56	1.84	1.27	1.10	1.05
	1.18	.99	1.16	*	*	*	*
16-Y	.91	.70	.48	.38	.72	*	*
	*	*	*	*	*	*	*

Group D-Y

Individual Treatment (Phase 2) Transformed Scores for Groups E and F

Group E

Ss#	Days 1 / 8	2 / 9	3 / 10	4 / 11	5 / 12	6 / 13	7 / 14
17	1.45	.37	.09	.01	.03	*	*
	*	*	*	*	*	*	*
18	.58	.13	.06	.04	.00	*	*
	*	*	*	*	*	*	*
19	1.14	.26	.01	.07	.01	*	*
	*	*	*	*	*	*	*
20	.99	.31	.22	.02	.11	.01	.00
	*	*	*	*	*	*	*

Group F

Ss#	Days 1 / 8	2 / 9	3 / 10	4 / 11	5 / 12	6 / 13	7 / 14
21	.84	.22	.17	.01	.00	.00	*
	*	*	*	*	*	*	*
22	.55	.09	.01	.02	*	*	*
	*	*	*	*	*	*	*
23	.58	.09	.03	.12	.02	.00	.03
	*	*	*	*	*	*	*
24	.76	.39	.08	.06	.05	*	*
	*	*	*	*	*	*	*

Daily Recovery (Phase 3) Rates (per min) for Groups A and A-Y

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
1	6.12	11.95	27.36	32.91	41.63	39.28	35.61	33.18	31.92	32.29
2	12.27	28.66	8.75	29.16	22.06	23.62	7.65	5.21	3.51	.74
3	38.73	41.39	20.58	10.96	5.09	13.11	20.48	13.26	8.99	2.79
4	3.27	57.99	51.46	49.80	56.55	59.13	53.29	39.35	36.16	50.79

Group A

	Days									
Ss#	1	2	3	4	5	6	7	8	9	10
1-Y	70.86	67.62	68.09	64.06	75.70	38.54	2.54	67.49	49.56	9.88
2-Y	42.09	49.60	55.90	48.64	51.45	49.53	33.18	36.24	40.66	38.60
3-Y	38.46	59.44	51.24	37.10	49.56	46.83	42.14	49.06	37.32	40.88
4-Y	10.40	24.61	28.21	21.09	20.55	22.88	14.73	10.54	5.94	7.53

Group A-Y

Daily Recovery (Phase 3) Rates (per min) for Groups B and B-Y

Ss#	Days 1	2	3	4	5	6	7	8	9	10
5	.07	.27	.13	.00	.00	.00	.00	1.46	2.46	3.56
6	.27	1.84	15.84	9.47	3.62	16.53	20.92	23.03	28.34	37.28
7	.07	.00	.07	.07	.00	.00	.00	.00	.00	.28
8	.13	.48	1.33	.07	.13	8.67	4.91	.00	3.19	1.38

Group B

Ss#	Days 1	2	3	4	5	6	7	8	9	10
5-Y	83.73	74.66	75.18	70.39	74.35	80.53	78.15	62.45	68.35	72.51
6-Y	43.33	30.93	24.44	33.73	65.10	62.53	62.54	85.20	69.81	59.86
7-Y	11.61	14.92	11.51	11.12	9.72	8.55	17.56	10.38	9.43	7.51
8-Y	20.17	18.41	8.46	10.38	12.54	9.95	10.10	7.67	5.49	5.87

Group B-Y

Daily Recovery (Phase 3) Rates (per min) for Groups C and C-Y

Ss#	1	2	3	4	5	6	7	8	9	10
9	27.46	36.38	33.90	26.99	25.17	17.60	10.85	13.06	10.32	13.37
10	5.16	4.31	1.74	1.86	3.20	4.72	2.26	.67	2.10	1.22
11	2.42	22.50	31.16	37.01	21.08	22.58	15.18	10.46	14.01	18.04
12	1.30	4.80	24.91	24.85	20.07	8.89	12.84	12.54	30.01	23.93

Days (column heads 1–10)

Group C

Ss#	1	2	3	4	5	6	7	8	9	10
9-Y	23.62	43.99	46.64	29.87	36.58	39.67	32.49	26.73	23.72	27.50
10-Y	1.41	26.54	28.64	24.65	23.44	30.75	21.39	28.72	27.15	28.89
11-Y	.20	4.53	15.96	17.48	13.49	18.02	17.98	15.25	17.90	17.57
12-Y	58.49	57.09	66.87	60.61	43.55	33.05	52.69	42.89	50.72	54.99

Days (column heads 1–10)

Group C-Y

Daily Recovery (Phase 3) Rates (per min) for Groups D and D-Y

Ss#	Days 1	2	3	4	5	6	7	8	9	10
13	2.35	.41	.62	4.24	1.56	1.60	1.90	3.99	6.92	6.21
14	.14	.13	.07	.07	.07	.13	.13	.07	.07	.07
15	.14	.13	.53	2.45	.07	.20	.07	.27	.60	.13
16	.33	.07	.07	.07	.20	.07	.14	.07	.07	.07

Group D

Ss#	Days 1	2	3	4	5	6	7	8	9	10
13-Y	8.61	14.72	13.17	15.67	15.05	13.48	14.81	12.33	17.33	13.89
14-Y	20.18	15.27	9.16	4.76	3.67	1.97	.27	1.05	.68	1.53
15-Y	35.07	32.98	29.29	31.09	29.35	30.03	30.37	37.68	28.15	35.26
16-Y	52.06	50.98	38.74	49.69	47.92	55.53	61.21	46.92	46.55	64.57

Group D-Y

Daily Recovery (Phase 3) Rates (per min) for Groups E and F

Days

Ss#	1	2	3	4	5	6	7	8	9	10
17	9.21	32.98	33.29	37.47	31.09	22.83	4.68	4.06	12.52	10.80
18	22.19	30.34	29.60	33.56	28.22	18.98	32.09	37.49	45.25	44.72
19	.48	31.43	42.61	46.54	33.63	36.33	17.23	24.21	20.51	18.38
20	35.44	43.07	41.84	49.38	21.33	30.78	41.83	40.05	48.80	54.83

Group E

Days

Ss#	1	2	3	4	5	6	7	8	9	10
21	10.28	26.78	14.07	17.74	14.98	22.98	21.30	23.14	26.79	21.82
22	9.76	15.32	15.61	19.44	21.51	13.80	11.81	18.07	19.97	10.67
23	21.98	24.70	25.33	24 81	20.34	21.38	16.13	17.20	12.63	7.91
24	31.38	37.37	39.27	25.67	21.66	16.96	9.78	10.52	12.41	10.10

Group F

A COMPARISON OF OMISSION TRAINING WITH CONSTANT OR CHANGING REINFORCERS VS. EXTINCTION: RESPONSE REDUCTION AND RECOVERY

by

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Abstract

Pigeons given a gradually introduced omission training schedule in which the reinforcers switched between pretraining and omission training were compared to birds receiving omission training with unchanging reinforcers and extinction, and yoked controls, with respect to the efficiency and durability of response reduction. 40 experimentally naive, water and food deprived pigeons were used. Pretraining (Phase 1) consisted of a VI 30-s schedule with either food or water as a reinforcer. Subjects were then placed into groups in Phase 2, given either omission training with the same or different reinforcer from pretraining, extinction, or were placed in a yoked control group. After birds in the omission or the extinction trained groups reduced responding to 10% of their pretraining response rate for three consecutive days, they were placed on a VT 30-s schedule for the 10 day recovery phase (Phase 3). While the yoked birds had a higher relative response rate in Phase 2 than the omission trained or extinction birds, no difference in efficiency of response reduction was found between the omission and extinction groups. Omission trained birds with the same reinforcer throughout the experiment responded less in the recovery phase than all the other groups. The use of a gradually introduced omission schedule produced response

reduction comparable to extinction. Durability of response reduction was greatest when an omission training schedule with unchanging reinforcers throughout the phases was employed.