CONDITIONED AVERSIONS TO VISUAL CUES IN THE PIGEON

PAUL SINCLAIR JARVIS


CENTRE FOR NFLD. STUDIES
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MEMORIAL UNIVERSITY
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Conditioned Aversions To Visual Cues In The Pigeon

by

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of the requirements for the degree of
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Department of Psychology
Memorial University of Newfoundland

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Abstract

The purpose of this thesis was to determine whether or not pigeons could form a conditioned food aversion to the visual properties of food. Prior research has shown that other species will learn to avoid a food the ingestion of which has been paired with sickness. This thesis attempted to expand these results, first by demonstrating the phenomenon in the pigeon, and then by utilizing visual cues present at ingestion but not physically part of the food, and by testing to see if the aversion formed to these visual cues would generalize to other food-related behaviours.

In the first study, pigeons consumed pigeon checkers coloured either red or green. Ingestion of one colour of checker was paired with sickness, produced by LiCl injection, while ingestion of the other checkers produced no negative consequences. In a choice test between the two types of checkers, the pigeons strongly preferred the previously safe checkers.

In each of the second, third and fourth experiments, pigeons were trained to eat uncoloured pigeon checkers from a white-illuminated food magazine in an operant chamber. On the conditioning day the magazine was illuminated with red light and following consumption, half the birds were injected with LiCl and half were injected with physiological saline, an inert substance. After one such red-illuminated conditioning session, a significant proportion of the LiCl injected birds subsequently decreased consumption of red-

illuminated checkers while the saline injected birds maintained or increased their consumption of red-illuminated checkers. The aversion to red-illuminated checkers grew stronger as a function of red-illuminated consumption-sickness pairings in the LiCl injected birds, reaching almost total suppression of red-illuminated consumption after two such pairings.

Conditioning of the red-illumination consumption aversion was followed in Experiments 3 and 4 by an autoshaping procedure. In Experiment 3, the key-light to which autoshaping occurred was either red or green and the prediction was that the birds which were averse to red-illumination in the magazine would be slower to autoshape to the red key than those presented with a green key. The autoshaped responding which resulted was so erratic that it was impossible to verify this prediction. In Experiment 4, autoshaping to a yellow key-light was followed by conditioned suppression testing using either red or green key-lights on discrete trials. Again, the level of autoshaped responding made meaningful interpretation of the data impossible.

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I wish to express my gratitude to Dr. Barry Mackay who, as my supervisor, provided generous guidance and encouragement throughout all phases of the project.

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The purpose of this thesis was to study conditioned food aversions in pigeons. A conditioned food aversion occurs when ingestion of a substance, liquid or solid, is followed by sickness. The resultant learned behaviour is avoidance of the substance on subsequent presentations. In this study two specific questions were asked. First, could the pigeon employ visual cues in conditioned food aversion learning? Second, could a visual cue associated with sickness affect other food-related behaviours?

Interest in the effectiveness of different stimulus modalities in mediating conditioned aversion learning was sparked by the work of Garcia and Koelling (1966). They gave rats saccharin water under conditions such that each lick produced visual and auditory stimuli (bright-noisy water); ingestion was paired with one of two consequences, foot shock or sickness. When tested the animals which had been sick avoided only the flavoured water and the animals which had been shocked avoided only the bright-noisy water. The flavour of the water became aversive only when associated with illness and was not aversive when paired with shock.

These results led to the postulation, often termed stimulus relevance (Capretta, 1961), that the associative strength of a cue may depend on the nature of the consequence. That is, taste (an internal stimulus) and sickness (an internal consequence) are readily associated with one another as are light (an external stimulus) and foot shock (an

external consequence). External-internal associations, however, would be difficult to form (Garcia & Ervin, 1968; c.f. Revusky, 1971). Capretta (1961) has stated the postulation more broadly, suggesting that certain associations are formed more easily if the stimuli are perceived as belonging together.

The conclusion that only tastes are readily associated with illness proved to be too simplistic. Wilcoxon, Dragoin and Kral (1971) showed that bobwhite quail, but not rats, could form aversions to the colour of water, an external cue. They gave rats and quail a blue, sour (HCl) water solution paired with injection of cyclophosphamide. They found that the rats showed aversions to the sour component but not to the colour component of the solution. In contrast, the quail demonstrated aversions to the colour but not to the sour component, although they could form taste aversions when no colour was present. Thus, the visual cue appeared to overshadow the taste cue for quail.

Other studies have demonstrated the effective use of visual cues in aversion learning by guinea pigs (Braveman, 1974) monkeys (Gorry & Ober, 1971), garter snakes (Burghardt, Wilcoxon & Czaplicki, 1973), codfish (Mackay, 1974 and 1977), and rats (Revusky & Parker, 1976: Riley, Note 1). Further, Taukulis (1974) has demonstrated the use of olfactory cues in the formation of conditioned aversions in rats.

In the interest of extending the generality of aversions to the visual properties of food substances, or

'visually-based' aversions, the initial issue addressed in this thesis was whether or not pigeons could form visually-based aversions. The use of visual cues by pigeons in discrimination learning (Jenkins & Sainsbury, 1969) for example, suggested the possibility that visual cues might effectively mediate food aversion learning. Accordingly, Experiments 1 and 2 were conducted to determine the efficacy of visual cues in the conditioned food aversion learning paradigm with pigeons.

Visual cues arising from something other than the ingested substance itself were conditioned to sickness in three of the studies mentioned above. That is, the visual cues were external to the food itself. Revusky and Parker (1976), using rats, demonstrated an aversion to the drinking container when drinking from that container had been paired several times with toxicosis. Mackay (1977) showed that codfish given experience with two visually distinctive manipulanda, formed an aversion to the manipulandum which delivered toxicosis related food. Finally, Riley (Note 1) demonstrated that certain areas of an open field were avoided (or more specifically, eating in those areas was avoided) when eating in that area had been followed by toxicosis.

The above studies demonstrate that stimuli correlated with consumption, but not part of the food itself, may themselves become aversive if followed by illness. It seems likely these results were due to higher-order conditioning.

If so, it seems likely also, that generalization should occur to stimuli similar to those intrinsic in the food itself, such as the colour of the food. That is, an aversion to coloured food might generalize to colours not present in the food itself. Experiments 3 and 4 were performed to explore this hypothesis.

EXPERIMENT 1

Method

Subjects. Ten experimentally naive homing pigeons, locally obtained, were individually housed with free access to water throughout the experiment.

Apparatus. The home cage, constructed of wire fencing, had approximate dimensions of 50 cm by 50 cm by 40 cm. White plastic food cups were attached to the front of the cage approximately 10 cm on either side of the clear plastic water cup. Food was coloured by a brief soaking (30 seconds) in coloured water (ratio 1:1, water to Schwartz's food dye).

Procedure. In Stage 1, untreated Purina pigeon checkers were presented in both food cups on a 15 min/24 hr schedule for 10 days. Daily consumption from each food cup was recorded. Stage 2 differed only in that the checkers were coloured as follows. For Group Green (n = 6) the food cups contained lime-green checkers on Day 11, blue checkers on Day 12, red checkers on Day 13 and dark-green checkers on Day 14, the conditioning day. For Group Red (n = 4) the

checkers on Days 11-14 were coloured blue, lime-green, dark-green, and red on the conditioning day. While Group Red initially contained 6 pigeons, 2 birds died prior to performance testing. This procedure allowed the birds to adapt to eating coloured food.

A daily change of food colour was given to habituate the strong neophobia displayed on the initial coloured-food day. It was desirable that consumption on the final two coloured-food days (Days 13 and 14) be equivalent to one another (demonstrating no natural colour preference) and that the colours be novel.

Immediately following food presentation on Day 14 all birds were injected intraperitoneally with 0.3 M LiCl, 1.5 percent of body weight.

On Day 15 the birds were given a 15 min presentation of untreated pigeon checkers in both food cups and consumption data was collected. They were then given free access to untreated checkers for 24 hrs. The birds were then returned to the 15 min/24 hr schedule for the remainder of the experiment. The food presented on Day 17 was untreated.

On Day 18 preference testing was begun. Of the two food cups presented to the birds, one contained the previously safe food (that consumed on Day 13) and the other the toxicosis related food (that consumed on Day 14). Amount of each food consumed was recorded. Preference testing was continued for a total of 10 days. The safe and toxicosis related foods were alternated from side to side between days.

Results

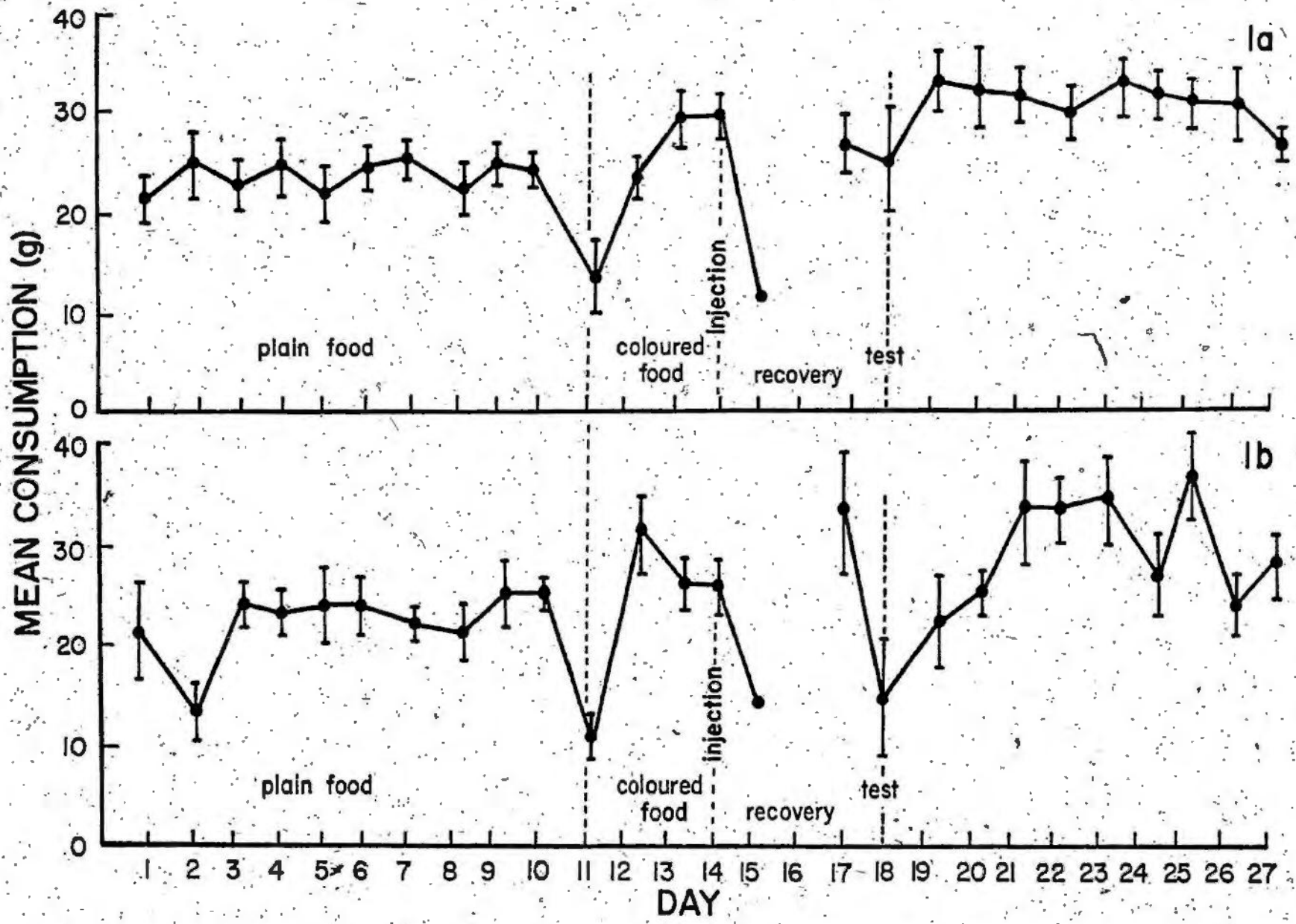
Displayed in Figures 1a and 1b are the mean amounts consumed and the standard deviations on each day for Groups Green and Red respectively. It can be seen that during Stage 1 both groups consumed approximately the same amount of untreated checkers each day. On Day 11 when coloured food was presented for the first time consumption dropped to less than half the normal amount in each group. A t-test comparing consumption on Days 10 and 11 gave $t(5) = 2.83$, $p < .05$ for Group Green and $t(3) = 4.52$, $p < .05$ for Group Red. Consumption returned on the following day to baseline levels or above and remained there for subsequent coloured food days. A comparison of consumption data for Days 10 and 12 showed no significant difference for each group.

Presumably the sharp decline in consumption shown in Figures 1a and 1b on Day 11 reflects neophobia or a novelty effect to the presence of coloured food. The rapid recovery on Day 12 could reflect the weakening of this effect but more likely is the result of increased hunger. Consumption levels on each of Days 13 and 14, however, reflect weakened neophobia.

The decreased consumption on Day 15 reflects the effects of sickness. There was no measure for Day 16. By Day 17 consumption had returned to or was above pre-injection levels.

On Day 18, the first preference test, both groups decreased their total consumption (red and green food) but

Figure 1. Mean amount of Food consumed by Groups Green (1a) and Red (1b) over each day of Experiment 1. Beginning on Day 18 both red and green food was offered and the data reflects total consumption.


1a
1b
MEAN CONSUMPTION (g)
0
10
20
30
40
plain food
coloured food
injection
recovery
test
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
DAY

the decrease from Day 14 consumption levels was not statistically significant. This decrease could be the result of a generalized aversion to coloured food or alternatively, sight of the aversive food might have depressed overall consumption. Clearly, any such effects dropped out rapidly over subsequent days. An equally valid interpretation of this effect as seen in Figure 1b would be a decreased deprivation level as a result of the high consumption level on Day 17.

Figure 2 shows the mean preference ratio for each group during Days 18 through 27. Individual preference ratios were calculated for each day by dividing toxicosis-related food consumption by the total of toxicosis-related food plus safe food consumption for each bird. The low ratios in each group reflect a strong preference for the safe food; a ratio of 0.50 would reflect no preference. A Wilcoxon matched-pairs signed-ranks test comparing amount consumed of each type of food for each bird yielded $\underline{W}obs\ (10) = 0$, $p < .005$ for all but Day 9, when $\underline{W}obs\ (10) = 1$; $p < .005$. Thus, it is clear that the pigeons formed strong aversions to the food paired with LiCl injection and that the effect persisted throughout the entire test period. That is, there is little evidence of extinction in Figure 2.

While parametric work with the dyes used has shown them to be tasteless in guinea pigs (Braveman, 1974), similar work has not been conducted with the pigeon. The suggestion that the aversion was visually guided and not mediated by

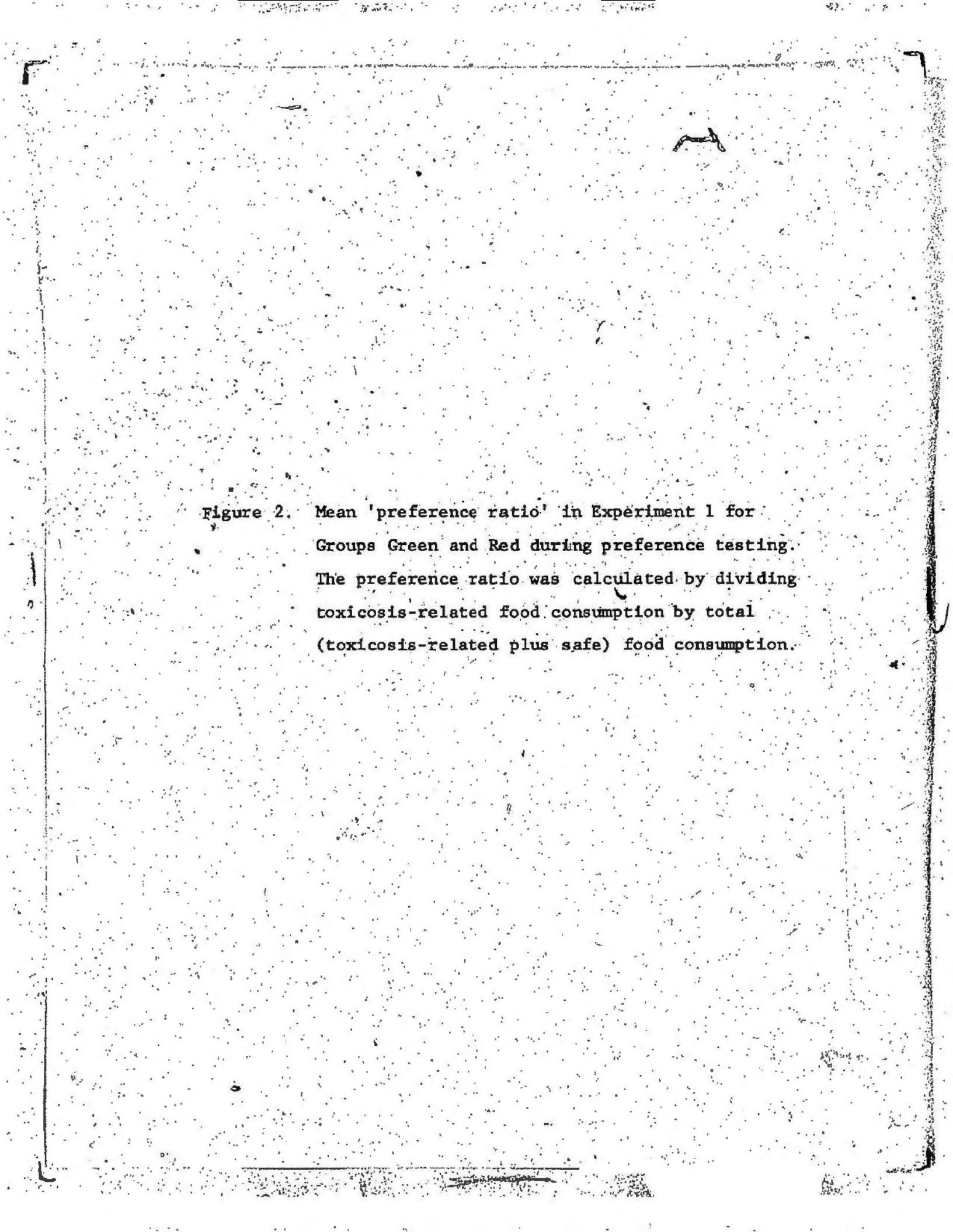
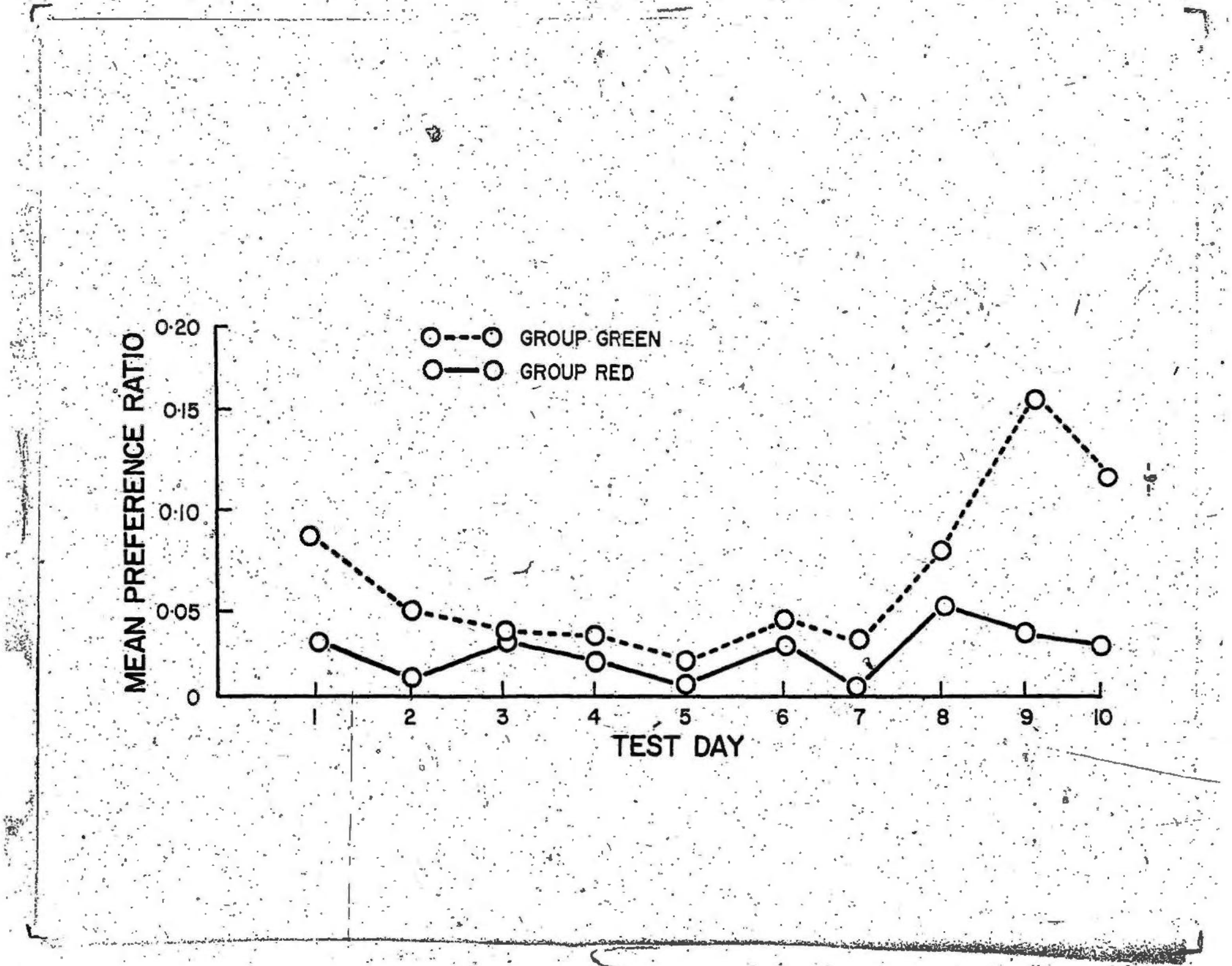


Figure 2. Mean 'preference ratio' in Experiment 1 for Groups Green and Red during preference testing. The preference ratio was calculated by dividing toxicosis-related food consumption by total (toxicosis-related plus safe) food consumption.


GROUP GREEN
GROUP RED
MEAN PREFERENCE RATIO
0·20
0·15
0·10
0·05
0
1
2
3
4
5
6
7
8
9
10
TEST DAY

taste can be supported by some behavioural observations. In both groups, during the initial presentation of both safe and toxicosis-related foods, the birds approached both food cups but would eat only from the cup which contained the safe food. The toxicosis-related food was left untouched (although approached) by 3 of the 10 birds, and a further 4 birds pecked at but did not consume the toxicosis-related food. For the 4 birds which pecked but did not consume, as with the remaining 3 birds which consumed minimal amounts, it was not possible to quantify the spillage which occured. It should be clear that the preference ratios would have been even lower had such quanitification been possible.

EXPERIMENT 2

Several questions were left unanswered by Experiment 1. While there was evidence that the observed aversion was not mediated by taste cues, one could not exclude the possibility that odour cues had been employed by the birds to discriminate the safe and toxicosis-related foods. Food dyes, while very low in volatility and thus odourless to humans (Stein, Note 2), might well offer the pigeon olfactory cues which could be confounded with the visual cues present. Thus, it was desirable to employ a technique that eliminated the use of any cues other than visual cues.

A second desirable refinement was the addition of a group of birds which received physiological saline solution injections in place of the LiCl injections. Work with other

species has made it clear that the LiCl drug effect, and not artifacts of the injection procedure itself, leads to aversion formation (Revusky & Garcia, 1970). It seemed desirable nevertheless to replicate these findings with the pigeon.

Finally, in eating from the foodcups in Experiment 1 the birds spilled some of the food. It seemed desirable to attempt to minimize this occurrence so that consumption data could be unequivocally interpreted.

The operant chamber seemed to offer a practical means of approaching these problems. The food magazine offers little opportunity for food spillage and visual cues could be varied by changing the illumination of the food. Thus, the magazine light could be coloured which in turn would colour the food present in the magazine. Any odour or taste cues afforded by the food would be rendered irrelevant in that they would be common to all magazine-light colour combinations.

Successful conditioned aversions to colour-illuminated food would be of interest for two reasons. First, the control of olfactory stimuli has been mentioned. Colour, however, is a widely used stimulus in many operant procedures. Studies of transfer of control by colour stimuli associated with conditioned aversions could be most useful, both in exploring the conditioned aversion phenomenon (for example, generalization) but perhaps also in studying stimulus-stimulus, stimulus-reinforcer relationships (for example, autoshaping).

Experiment 2 then, was similar to Experiment 1 but was conducted in an operant chamber with illuminated as opposed to dyed food. In addition, a saline control group was employed.

Method

Subjects. Seventeen naive, locally-obtained homing pigeons were individually housed with free access to water throughout the experiment.

Apparatus. Three Colbourne small animal operant chambers were employed. Each chamber contained a single response key immediately above the food magazine. Light in the magazine could be changed from white to red by the insertion of a sheet of red theatrical gel plastic (i.e., as used in spotlights) between the magazine light and the top of the magazine opening. Throughout all phases of the experiment Purina pigeon checkers were employed.

Procedure. After all birds reached the food deprivation level of between 80 percent and 85 percent of their free-feeding weights, magazine training was begun. Each bird was placed in the chamber with the magazine raised and illuminated with white light. After 20 seconds of eating, the magazine was lowered and presented 15 times at 30-second intervals. The first three of these presentations lasted until the bird had eaten for 10 seconds. The subsequent 12 presentations lasted 5 seconds.

The following day baseline recording was begun. During this phase a daily session consisted of 30, 5-second magazine

presentations on a fixed-time 20-second schedule. Thus, each bird was allowed a total of 2.5 minutes access to food in a 10 minute session. Magainze illumination was with white light. Amount consumed (in grams) was recorded for each bird at the end of each session. Auditory masking was accomplished through presentation of white noise throughout the session and the chamber was illuminated by a white house-light.

The number of sessions of baseline recording was varied between birds to examine the possible effects of length of pre-conditioning experience. As no difference resulted from this experience the data for all birds have been displayed together. Nine birds received eight sessions. Seven birds received six sessions in the chamber and one 2.5 minute food presentation in the home cage (what would have been session five was missed because of experimenter illness). One bird received four baseline sessions.

Aversion training was begun the day following the final baseline recording session. The session was conducted as in baseline recording but the magazine was illuminated with red light. As for baseline sessions, amount consumed was recorded. Immediately following the session birds were assigned to one of two groups and treated as follows: Group LiCl (n = 10) was injected intraperitoneally with 0.3 M LiCl, 1.5 percent of body weight. Group Sal (n = 7) was injected intraperitoneally with physiological saline, 1.5 percent of body weight. Assignment to these groups was based on the criterion,

visually observed, that the birds in Group LiCl consume at least some food on a minimum of five of the final 10 magazine presentations.

On the following day birds were given 2.5 minutes access to food in the home cage. The next day the recovery session was conducted in the test chamber with food illuminated by white light. This session was identical in all respects to those conducted during baseline recording. For those birds which evidenced recovery (i.e., consumed an amount equal to or in excess of that consumed during baseline recording), the next day consisted of a second red-illuminated aversion training session. Injections were as before. However, only those birds which ate from the magazine were injected. For those birds which did not eat from the magazine no injection was given. Those birds which did not evidence recovery during the first recovery session were given subsequent recovery sessions until consumption returned to normal. At that time the second aversion training session was conducted.

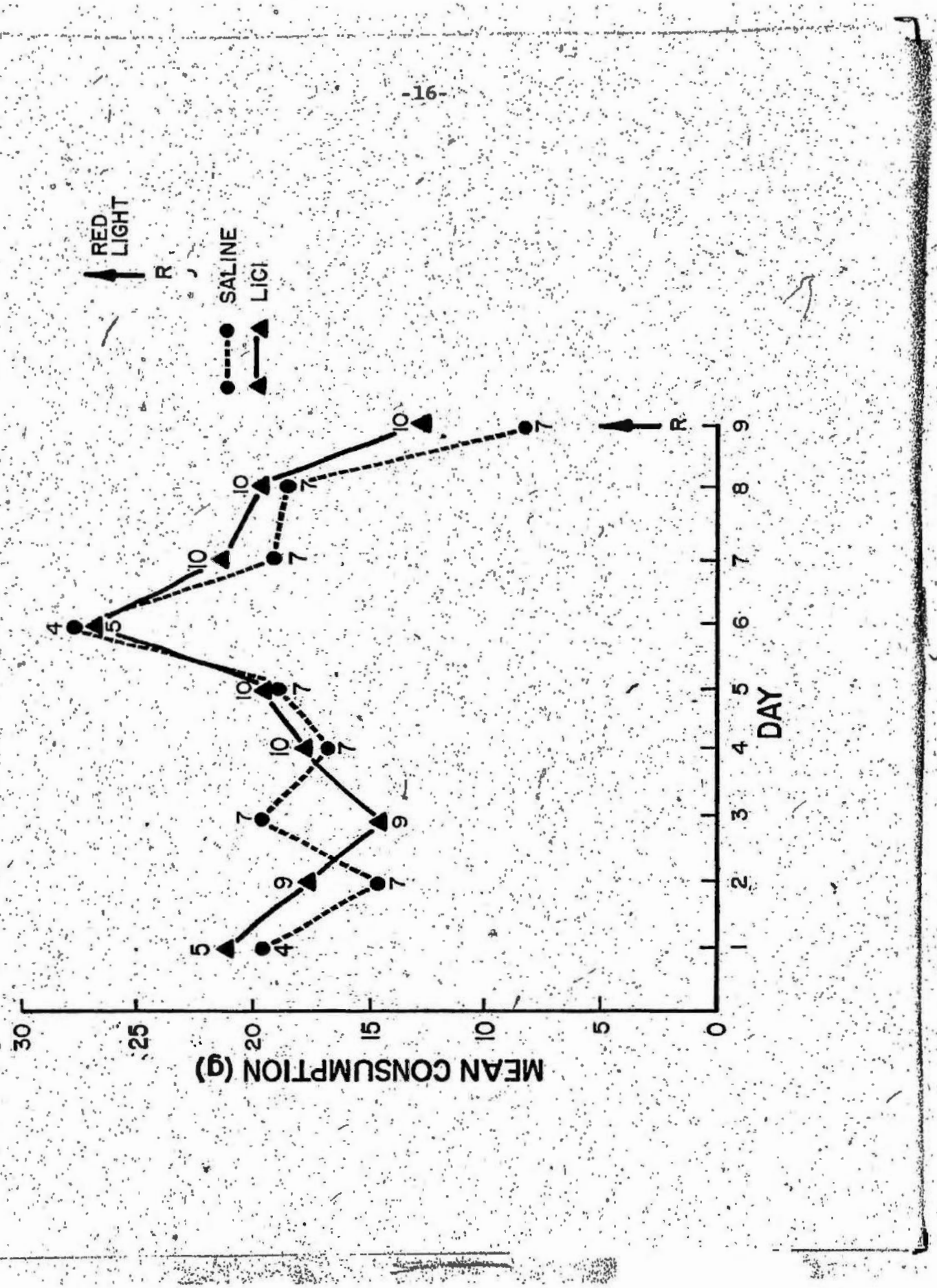
The second aversion training session was followed by the same recovery procedure as the first with the exception that both the first and second post-injection sessions were conducted in the operant chamber. The procedure was continued for a total of four aversion training sessions. Aversion training was identical in each session and the recovery procedures for the last three sessions were identical.

Results

All birds began eating reliably from the food magazine by the end of the 15-trial magazine session. As noted above, the number of baseline sessions varied between birds. Thus, while Figure 3 displays the mean amount consumed for each group over each day of baseline recording, the number of birds contributing to each point is variable and noted above each point. It can be seen that comparable amounts were consumed in each session. For Group LiCl the mean over the final four baseline sessions was 20.3 g and the range was 11 to 33 g. For Group Sal the mean over the final four sessions was 18.9 g and the range was 10 to 33 g. Thus, the groups did not differ during the baseline phase of the experiment.

Also apparent in Figure 3 is a substantial drop in consumption on Day 9 when the food in the magazine was illuminated by red light for the first time. After combining the two groups, a t-test comparing the final white-illuminated session consumption with consumption on Day 9 gave $t(16) = 4.72$, $p < .001$. This depression in consumption of red-illuminated food replicates the finding of a neophobia or novelty effect seen in Experiment 1. That is, the presence of red illumination in the magazine was sufficient on its initial presentation to depress consumption for both groups.

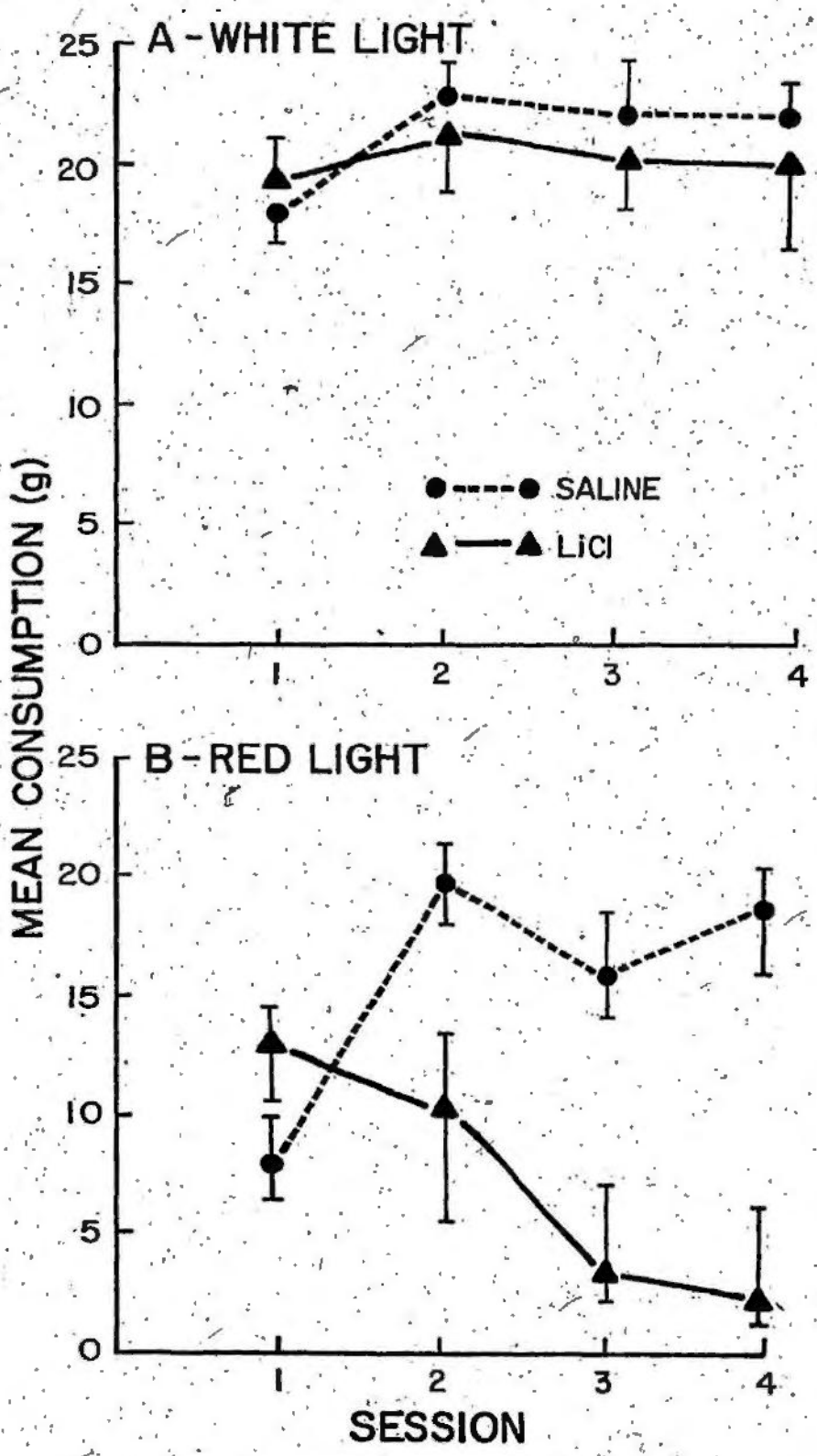
Figure 3. Mean amounts of food consumed by Groups LiCl and Sal during baseline recording (white-illuminated food) and the initial red-illuminated session (Day 9) of Experiment 2. The n is indicated at each point.


RED LIGHT
R
SALINE
LiCl
MEAN CONSUMPTION (g)
DAY
0
5
10
15
20
25
30
1
2
3
4
5
6
7
8
9
R

During the aversion training-recovery sessions phase of the procedure only two birds did not evidence recovery within the two-day post-injection period. That is, on the second day post-injection, consumption levels in the recovery session had not returned to baseline levels for these birds. One bird required one additional recovery session after the first injection. The other required two additional recovery sessions after each of the first and second injections. Both birds were from Group LiCl.

The data displayed in Figure 4a (the top half of Figure 4) represent the mean amounts of food consumed and standard deviations for each of Groups LiCl and Sal over the final baseline session and the white-illuminated recovery sessions which preceded the second, third and fourth red-illuminated aversion training sessions. In Figure 4b (the lower half of Figure 4) are the mean amounts of food consumed and the standard deviations over the four red-illuminated aversion training sessions. It can be seen that consumption for all sessions except the red-illuminated sessions of Group LiCl (Figure 4b) was maintained at levels approximating baseline consumption levels. That is, with successive red-illumination-LiCl pairings, consumption in the presence of red illumination dropped for Group LiCl although consumption in the presence of white illumination remained unchanged. For Group Sal neither red nor white illumination had any effect on consumption levels.

Figure 4. Mean consumption and standard deviations in Experiment 2 for Groups LiCl and Sal during white-illuminated recovery sessions (4a) and red-illuminated aversion training sessions (4b). Session I in 4a reflects final baseline session consumption.


A - WHITE LIGHT
B - RED LIGHT
SALINE
LiCl
MEAN CONSUMPTION (g)
SESSION
0
5
10
15
20
25
1
2
3
4

An analysis of variance (2x2x4 repeated measures with subjects nested within groups; levels proportional) was conducted on these data, the results of which are displayed in Table 1. The factors in the design were groups (LiCl vs Sal), illumination conditions (red vs white), and session (1 through 4). The significant main effects and two-factor interactions shown in Table 1 can best be understood in the light of the significant three-way interaction between groups, illumination and session. As consumption decreases for Group LiCl in the presence of red illumination over sessions, in all other conditions the consumption levels are maintained or increase slightly. Thus, it is clear that the three-way interaction demonstrates a visually mediated conditioned aversion.

If an aversion is defined as eating less than one-third the amount eaten during the original red-illuminated aversion training session, 4 birds in Group LiCl displayed aversions during the second red-illuminated session, while 8 birds of the possible 10 in Group LiCl displayed an aversion in the third and fourth aversion training sessions. As can be inferred from Figure 4b, all birds in Group Sal increased consumption over the second, third and fourth red-illuminated sessions.

These results, together with those of Experiment 1, would seem to offer strong evidence of the formation of a visually mediated aversion in pigeons. The similarity of

TABLE 1

Analysis of Variance: Experiment 2

Source	df	MS	F
Group (A)	1	501.5	10.2837**
Subjects (S)	15	48.8	
Illumination (B)	1	2909.1	38.9489***
A x B	1	429.9	5.7556*
B x S	15	74.7	
Session (C)	3	90.3	3.4124*
A x C	3	237.0	8.9553***
C x S	45	26.5	
B x C	3	50.6	2.1385
A x B x C	3	109.6	4.6313**
B x C x S	45	23.7	

Note - Analysis of Variance on consumption data for Groups LiCl and Sal during white-illuminated final baseline and recovery sessions and red-illuminated aversion training sessions.

* $p < .05$

** $p < .01$

*** $p < .001$

consumption levels for Groups Sal and LiCl in the presence of white illuminated food indicates no general aversion as a result of LiCl injection. Birds in Group LiCl decreased consumption only when the food was illuminated with red light. Further, the initial depression in consumption of food illuminated with red light in Group Sal immediately dropped out in the absence of LiCl injection. Thus, the depression in consumption noted over the second, third and fourth red-illuminated sessions for Group LiCl clearly results from association of toxicosis with the red illumination and not from a general depression related to the apparatus or simple coloured illumination of the food. The restriction of the aversion to the conditioned colour in Experiment 1 also supports this conclusion.

The two birds from Group LiCl which did not display an aversion to the red-illuminated magazine were physically different from those pigeons which did show the effect (i.e., they had long, stork-like necks and 20 percent greater body weights than the next largest birds). It is possible that a species difference or perhaps a less effective drug effect because of the increased body weight led to their poor performance. The LiCl dosage given these birds was of course greater because of their greater body weights but perhaps the dosage ratio becomes less effective as weight increases. An analysis conducted with these birds removed provided even stronger statistical support for a visual aversion in Group LiCl.

Finally, it was apparent from observation of some of the birds in Groups LiCl and Sal during aversion training sessions that the aversion was to aspects of the food magazine. That is, many birds in Group LiCl, after the initial aversion training session, did not approach the magazine in the presence of red illumination sufficiently to see the actual food being presented. This would seem to imply that cues present at ingestion but not necessarily components of the food itself could be associated with toxicosis by pigeons although it also seems clear that such cues are not as readily associated with toxicosis as are food related cues. This result concurs with the findings of Revusky and Parker (1976) noted above.

EXPERIMENT 3

Experiment 2 demonstrates that pigeons form aversions to a colour stimulus associated with toxicosis. A question which arises from this result is whether or not a colour associated with toxicosis will have aversive properties in situations other than that in which the aversion was originally formed. If the effect of an aversion to a visual cue is to inhibit consumption in the presence of that cue, the question is whether other food-related behaviours will also be inhibited by this cue. In other words, do the aversive properties established to a particular colour cue generalize or is the aversion specific to the consumption process in which it was learned? One method of approaching

this problem is the autoshaping paradigm.

The basic autoshaping paradigm pairs a lighted response key with food magazine presentation in close temporal association. With repeated response key-food presentation pairings, the bird begins responding on the response key despite the absence of any scheduled consequence. That is, the response has no effect on the delivery of reinforcement. In some autoshaping procedures a response does result in immediate reinforcement but the response is not necessary for its delivery. That the phenomenon is a form of associative learning has been demonstrated by several control procedures and the replication of the effect in several species.

Brown and Jenkins (1968) found forward pairings (key-light preceding reinforcement) were effective in establishing responding but the reverse procedure, backward conditioning, was not. Unpaired control and truly random control procedures both failed to yield conditional responding (Bilbrey & Winokur, 1973). Key-light presentations in the absence of reinforcement and a constantly illuminated key-light with intermittent reinforcement were also ineffective (Brown & Jenkins, 1968). Thus, temporal association between the key-light stimulus and reinforcement in a forward pairing presentation is essential for the occurrence of autoshaping.

The autoshaping procedure closely matches the operational definition of the classical conditioning paradigm. The key-light acts as CS, grain as the UCS, with the key-

peck as CR and a peck to the grain as the UCR. As in classical conditioning, the CR has no effect on the occurrence or nonoccurrence of the UCS. That is, no instrumental contingency links the response to the reinforcement.

Jenkins and Moore (1973) investigated the form of the autoshaped key-peck response. An autoshaping procedure was conducted using food or water deprived birds and food or water reinforcement. They found that the topography of the key-peck was related to the type of reinforcement: "...each stimulus evoked features of the consummatory pattern appropriate to the specific reinforcer that it signaled" (p. 169).

The relevant aspect of these data is that the response elicited by the key-light in autoshaping is similar to the response elicited by the reinforcer. If a particular stimulus or cue associated with the UCS or magazine presentation was aversive (i.e., red illumination), one could predict that autoshaping to a key-light displaying the aversive stimulus (or at least one component of the aversive stimulus, the colour red) would be retarded or non-existent.

Fisher and Catania (1977) have demonstrated that the magazine light plays an important role in autoshaped responding. They found that in a two-key autoshaping procedure when two key-light colours were simultaneously presented, responding occurred to the key-light which matched the magazine light colour. This would suggest at least some generalization from magazine light to key-light. As the aversion in Experiment 2 was demonstrated to the red

colour present in the magazine it seemed reasonable that an aversion would also be demonstrated to a red key in an autoshaping procedure. That is, as the pecking response generalizes from magazine-light to key colour, an aversion should also generalize along this dimension.

In Experiment 3 pigeons were made averse to red illumination in the magazine. Autoshaping was then conducted. Birds received single key autoshaping to either a green or a red key-light. The magazine was left white during the autoshaping phase. Thus, the birds were tested to see if a prior aversion to the colour red generalized to the response key. The prediction was that an aversion to red magazine illumination would disrupt autoshaping in the single red key condition but not in the single green key condition.

Method

Subjects. Twelve naive wild pigeons and four naive homing pigeons, each locally obtained, were individually housed with free access to water throughout the experiment. The wild pigeons, each grey in colour, had body weights similar to those of the homing pigeons.

Apparatus. The apparatus was that employed in Experiment 2.

Procedure. Magazine training, conducted as it was in Experiment 2, was begun when the birds reached between 80 percent and 85 percent of their free-feeding weights. Baseline recording consisted of seven white-illuminated sessions identical to those conducted in Experiment 2.

Further, the first two aversion training sessions differed from those of Experiment 2 only in that all birds in each of the two groups (Group LiCl, n = 8; Group Sal, n = 8) were injected (with LiCl and physiological saline respectively) after each of the two red-illuminated aversion training sessions regardless of consumption levels during the session. Each aversion training session was followed one day later by 2.5 minutes access to food in the home cage. The second day post-injection was a white-illuminated recovery session conducted as in Experiment 1. Following the second recovery session a third red-illuminated session was conducted.

After this third red-illuminated session none of the birds in either group was injected because a choice had to be made between a) delay to the autoshaping phase because of recovery time from a third injection, and b) the possibility of extinction of the aversion or insufficient conditioning if the third injection was not given. The performance of several of the birds in Experiment 2 suggested that extinction of the aversion was unlikely to occur after only one non-reinforced red-illuminated session. Amount consumed for each baseline, aversion training and recovery session was recorded.

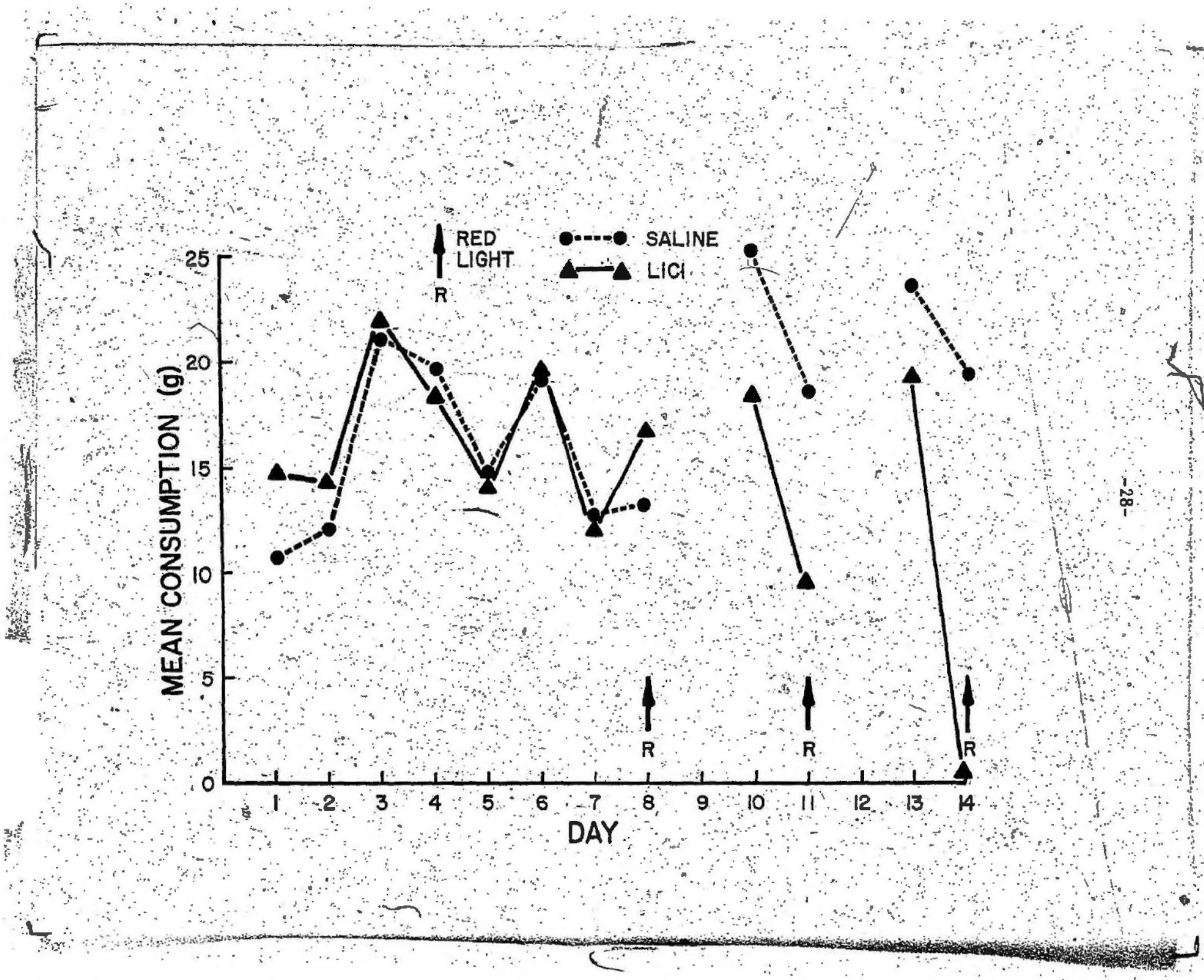
All birds were then reduced to between 80 percent and 85 percent of their free-feeding weights, a process which took 4 days. When this criterion was reached, autoshaping was begun.

A session consisted of repeated 8-second single-key illuminations, each followed immediately by a 4-second magazine presentation. The presentation schedule was a variable-time 60-second schedule. The first session was 60 minutes in length. The second session, conducted the following day, was 30 minutes long. The birds from Groups LiCl and Sal were divided into four groups; Groups LiCl-red (n = 4), LiCl-green (n = 4), Sal-red (n = 4), and Sal-green (n = 4). For birds in Group LiCl-red and Group Sal-red, key illumination was red. For birds in Group LiCl-green and Sal-green, key illumination was with green light. For all groups the magazine was illuminated with white light during autoshaping. Total number of key-pecks and pecks per trial were recorded for each bird during each session.

Results

All birds began eating reliably from the food magazine by the end of the 15-trial magazine training session, as was the case in Experiment 2. In Figure 5 are displayed the mean amounts of food consumed by Groups LiCl and Sal over sessions of baseline, aversion training, and recovery. During the baseline phase it is apparent that the groups ate comparable amounts. Over the final four baseline sessions the mean and range for Group LiCl were 16 g and 8 to 27 g respectively. For Group Sal the mean over the final four baseline sessions was 16.7 g and the range was 0 to 32 g.

Figure 5. Mean consumption by Groups LiCl and Sal during in-chamber sessions of Experiment 3. Food was illuminated by white light except on indicated days (Days 8, 11 and 14), during which red light was used.


RED LIGHT
R
SALINE
LICI
MEAN CONSUMPTION (g)
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DAY
R
R
R

Comparisons of Figures 5 and 3 show the birds of Experiment 3 to be more phasic in their consumption during baseline recording than the birds used in Experiment 2. This wide variation in consumption over days was not restricted to the wild pigeons or the homing pigeons. Although it seems unlikely that this variability was due to any systematic difference between the procedures in the two experiments, it could account for the slight increase in consumption observed on the initial red-illuminated aversion training session. That is, whereas red consumption in Experiment 2 was decreased for both groups as a result of neophobia, the low consumption of the birds in Experiment 3 on the day preceding red illumination (i.e., Day 7) may have masked this effect by increasing the deprivation levels of the birds for the initial red illumination session.

The data displayed in Figure 6a represent the mean amounts consumed and standard deviations for each of Groups LiCl and Sal over the white-illuminated final baseline session and the recovery sessions which preceded the second and third red-illuminated sessions. In Figure 6b are the mean amounts consumed and standard deviations over the three red-illuminated sessions. It is clear from this figure that consumption under red- and white-illuminated conditions was equal to, or increased over, the baseline consumption means for Group Sal. For Group LiCl, consumption in the presence of the red-illuminated magazine decreased across sessions, while white-illuminated consumption increased to levels approaching those of Group Sal. This

Figure 6. Mean consumption and standard deviations in Experiment 3 for Groups LiCl and Sal during white-illuminated recovery sessions (6a) and red-illuminated aversion training sessions (6b). Session 1 in 6a reflects final baseline session consumption.

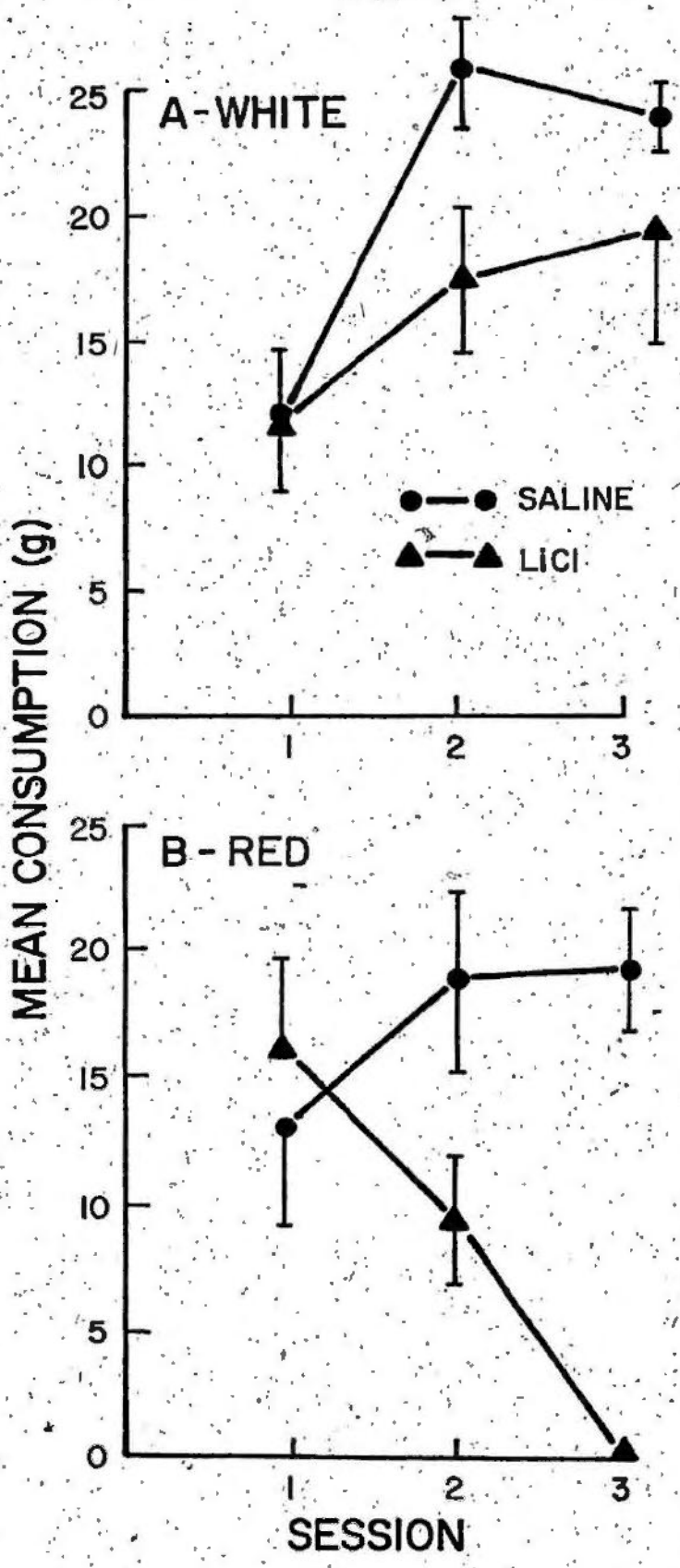

A-WHITE
B-RED
SALINE
LICI
MEAN CONSUMPTION (g)
SESSION
0
5
10
15
20
25
1
2
3

figure clearly replicates the visual aversion found in Experiment 2.

An analysis of variance similar to that of Experiment 2 was conducted on these data, the results of which are summarized in Table 2. As in Experiment 2, the significant main and two-factor interactions can best be understood in the light of the significant three-way interaction between groups, illumination and session. That is, the effects would seem to be the result of decreasing consumption levels in the presence of red illumination for Group LiCl and maintained or increased consumption levels in all other conditions.

Aversions, defined as eating less than one-third the amount eaten during the original red-illumination aversion training session, were observed after one injection in 3 birds from Group LiCl and 1 bird from Group Sal. After the second injection all of the birds in Group LiCl evidenced aversions while consumption of all birds in Group Sal increased relative to the baseline. It would seem the aversion displayed by the bird from Group Sal was likely the result of non-associated factors inasmuch as the effect was displayed only once.

Table 3 lists the acquisition data for each bird during the single-key autoshaping procedure. Represented are the first trial with a key-peck response, total number of trials with a response, total on-key responses and group means of these data for each session. It can be seen that all the

TABLE 2

Analysis of Variance: Experiment 3

Source	df	MS	F
Group (A)	1	1320.0	10.1790**
Subjects (S)	18	129.7	
Illumination (B)	1	896.5	40.4688***
A x B	1	158.7	7.1636*
B x S	18	22.2	
Session (C)	2	214.2	16.6814***
A x C	2	501.2	39.0445***
C x S	36	12.8	
B x C	2	487.6	14.7543***
A x B x C	2	193.9	5.8693**
B x C x S	36	33.0	

Note - Analysis of Variance on consumption data for Groups LiCl and Sal during white-illuminated final baseline and recovery sessions and red-illuminated aversion training sessions.

* $p < .05$

** $p < .01$

*** $p < .001$

TABLE 3

Autoshaping Response Data: Experiment 3

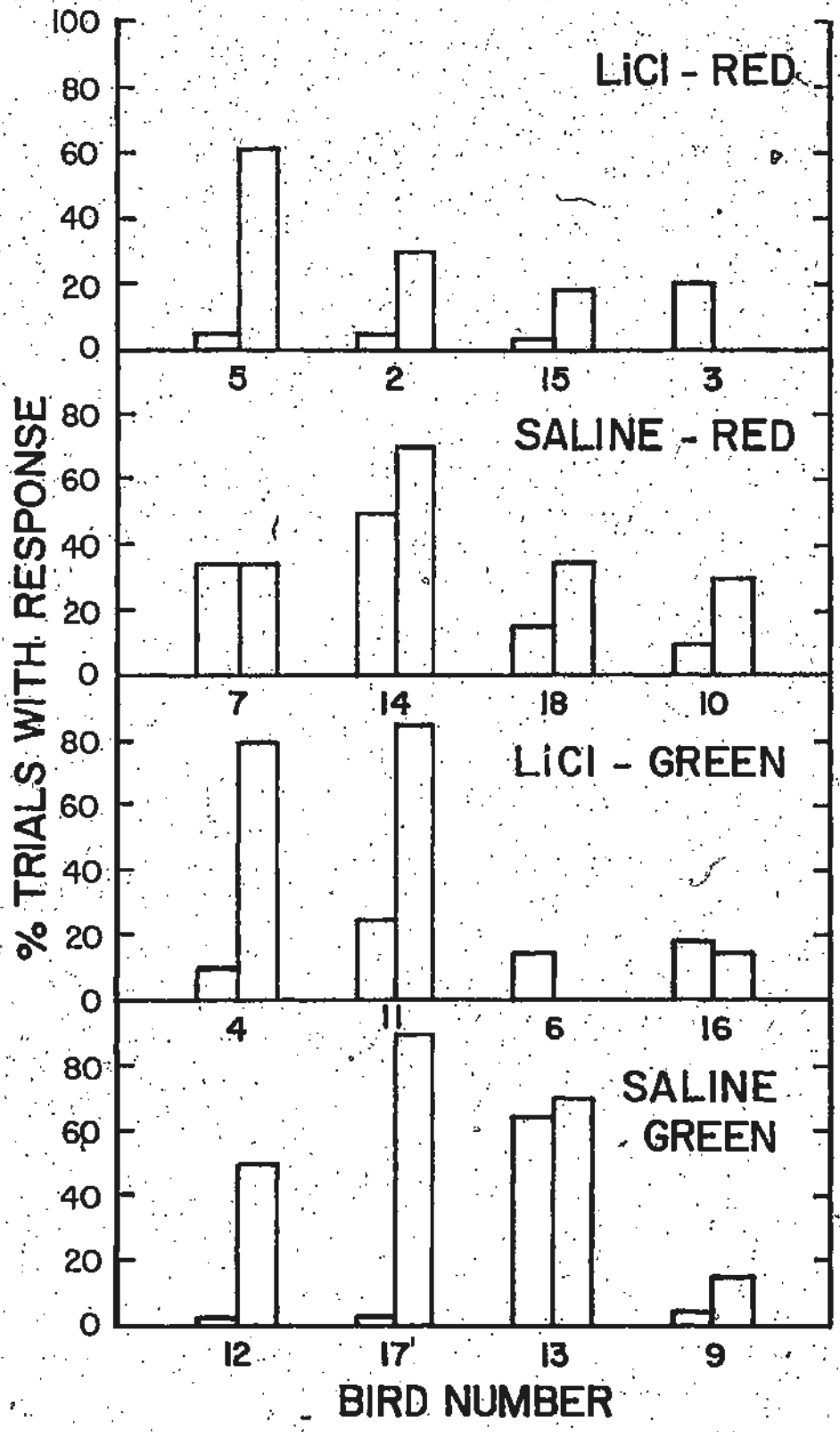
Key Colour	Dependent Measure	Group LiCl	$\bar{X}$	Group Sal	$\bar{X}$
Red	First trial with peck	21 19 16 42 (8) (4) (8) (0)	18.7 (5)	13 9 20 18 (2) (1) (13) (3)	15 (4.8)
	Total trials with peck	4 4 1 14 (20) (10) (6) (0)	5.8 (9)	22 19 10 5 (11) (21) (11) (9)	16.5 (13)
	Total on-key pecks	12 6 1 23 (133) (18) (9) (0)	10.5 (40)	57 183 14 6 (32) (306) (21) (10)	65 (92.3)
Green	First trial with peck	13 6 28 13 (2) (2) (0) (11)	15 (3.8)	20 18 5 36 (1) (2) (2) (5)	19.8 (2.5)
	Total trials with peck	5 15 7 9 (24) (26) (0) (3)	9 (13.3)	1 1 40 4 (16) (27) (23) (5)	11.5 (17.8)
	Total on-key pecks	5 68 11 22 (90) (175) (0) (4)	26.5 (67.3)	2 1 275 11 (19) (161) (100) (5)	72.3 (71.3)

Note - Session 2 data in parentheses.

birds responded within the first session, initial responses ranging from trial 5 to 42. These values fell well within the range reported by Brown and Jenkins (1968). However, the percentage of trials with a response displays considerably more variability than is usually associated with this autoshaping procedure. Figure 7 displays the percentage of trials with a response for each bird in each session. Only 6 of the 12 birds demonstrated what could be called good autoshaping (i.e., percentages at or above the 60 percent level). Brown and Jenkins (1968) reported this fixed key-light illumination autoshaping to be less reliable in maintaining responding than a contingent autoshaping procedure (where a peck to the lighted response key terminates the trial and delivers reinforcement). However, in previous studies by the experimenter this fixed illumination procedure produced reliable and high rates of responding. It is difficult to account for the lack of consistency in responding by these birds.

Downing and Neuringer (1976) reported normal autoshaping in pigeons after the birds had been pre-exposed to 250 magazine-only presentations. However, in a second study using chickens they found that the amount of pre-exposure to food magazine can affect subsequent autoshaping. The authors found that chickens pre-exposed to 100 magazine-only presentations autoshaped more quickly and more reliably than chickens recieving 1, 10 or 1000 magazine-only presentations. This led the authors to postulate a U-shaped function where-

Figure 7. Percentage of trials in Experiment 3 with a response for each bird during sessions 1 (60 trials) (left bar) and session 2 (30 trials) (right bar) of autoshaping.


LiCl - RED
SALINE - RED
LiCl - GREEN
SALINE GREEN
% TRIALS WITH RESPONSE
BIRD NUMBER
100
80
60
40
20
0
5
2
15
3
7
14
18
10
4
11
6
16
12
17
13
9

in a degree of pre-exposure to the magazine facilitates autoshaping but increasing or decreasing amounts of pre-exposure from this point fail to do so. Indeed, at great amounts of pre-exposure, autoshaping may actually be inhibited to some degree.

The magazine experience of the birds in the present study was equivalent to that of the pigeons in Downing and Neuringer's study and indeed, half of the present birds did display normal autoshaping. However, it is possible that the pre-exposure received by the birds in the present study to the food magazine placed them at the fulcrum of the pre-exposure gradient as postulated by Downing and Neuringer (1976). It would seem much more likely, however, that the U-shaped function developed by the authors would provide for a gradual decline in autoshaped responding rather than a precipitous decline or all-or none phenomenon as was observed in this experiment.

Analysis, both parametric (t-test) and non-parametric (Mann-Whitney U), of the three dependent measures noted in Table 3, both between groups and group combinations, gave no significant differences, possibly as a result of the extreme variability. The trend of the group means was in the expected direction. That is, Group LiCl-red displayed the lowest total number of pecks and fewest trials with a peck and made the first peck response later than Group Sal-red and Group LiCl-green. However, it is impossible to conclude that any aversion conditioned to the red

magazine illumination generalized to the red key-light presented during autoshaping.

EXPERIMENT 4

The autoshaping procedure of Experiment 3 failed to support the idea that the aversive properties of a colour established in the conditioned aversion procedure generalize to autoshaping. As was noted, however, this failure could have been the result of the small effective sample size in each group and the high variability in autoshaping which occurred. The appetitive nature of the autoshaping procedure also could have accounted for the failure of the red aversion to generalize. That is, appetitive conditioning in the autoshaping procedure could conceivably have overridden any aversive properties of the colour cue. Thus, a second test procedure was conducted using a form of conditioned suppression.

Typically in conditioned suppression studies an aversive CS is superimposed upon some on-going excitatory baseline schedule of responding (eg., Kamin, 1963; Estes & Skinner, 1941). A decrease from the baseline response rate during CS presentation is considered to be evidence of conditioned suppression.

It was felt an adaptation of the conditioned suppression method might well be more sensitive as a test for the aversive properties of the red colour associated with toxicosis

than the autoshaping procedure used in Experiment 3. The suppression measure should be more sensitive, in that baseline rates would be available for each bird and deviations from baseline could be noted. As well, these test trials might be more discriminable for the birds. That is, a change from yellow to red on the response key might be more attended to than the unchanged red response key of Experiment 3. Further, the red stimulus would be present on only 20 percent of the available trials as opposed to 100 percent in the autoshaping procedure of Experiment 3. If the failure in Experiment 3 was in some way the result of extinction of the aversion, the proposed partial exposure to the red stimulus might lead to less rapid extinction.

In Experiment 4 an aversion to red illumination in the magazine was initially established by the method noted in Experiments 2 and 3 above. Once established, autoshaping to a yellow, presumably neutral, key was conducted. At intervals during the yellow-key autoshaping session either red or green key-lights were substituted for the yellow key-light on two consecutive trials. The prediction was that a yellow-to red-key colour shift should be disruptive if red is indeed an aversive stimulus, and a yellow-to green-key colour shift should lead to minimal or no suppression in autoshaped responding.

Method

Subjects. Sixteen naive wild pigeons and eight naive homing

pigeons, locally obtained, were individually housed with free access to water throughout the experiment. There were two homing pigeons in each of Groups LiCl-red and Sal-red, three in Group Sal-green, and one in Group LiCl-green.

Apparatus. The apparatus was that used in Experiment 3.

Procedure. Magazine training, baseline recording and aversion training procedures were identical to those of Experiment 3. However, one home-cage and two white-illuminated recovery sessions followed the first aversion training session and one home-cage and three white-illuminated recovery sessions followed the second aversion training session.

No injections were given following the third red-illuminated training session and subsequently birds were deprived to between 80 percent and 85 percent of their free-feeding weights, a process which took 5 days. When this criterion was met, single-key autoshaping conducted as in Experiment 3 was begun. Key illumination for all birds was with a yellow key-light and magazine illumination was with white light.

As soon as a bird reached a stable responding level (defined as responding on 5 of the previous 6 trials) suppression testing was begun. For six birds from each of Groups LiCl and Sal the key colour changed, prior to trial onset, from yellow to red for 2 consecutive trials (Groups LiCl-red and Sal-red respectively). For the other six birds from each of Groups LiCl and Sal the key colour was green

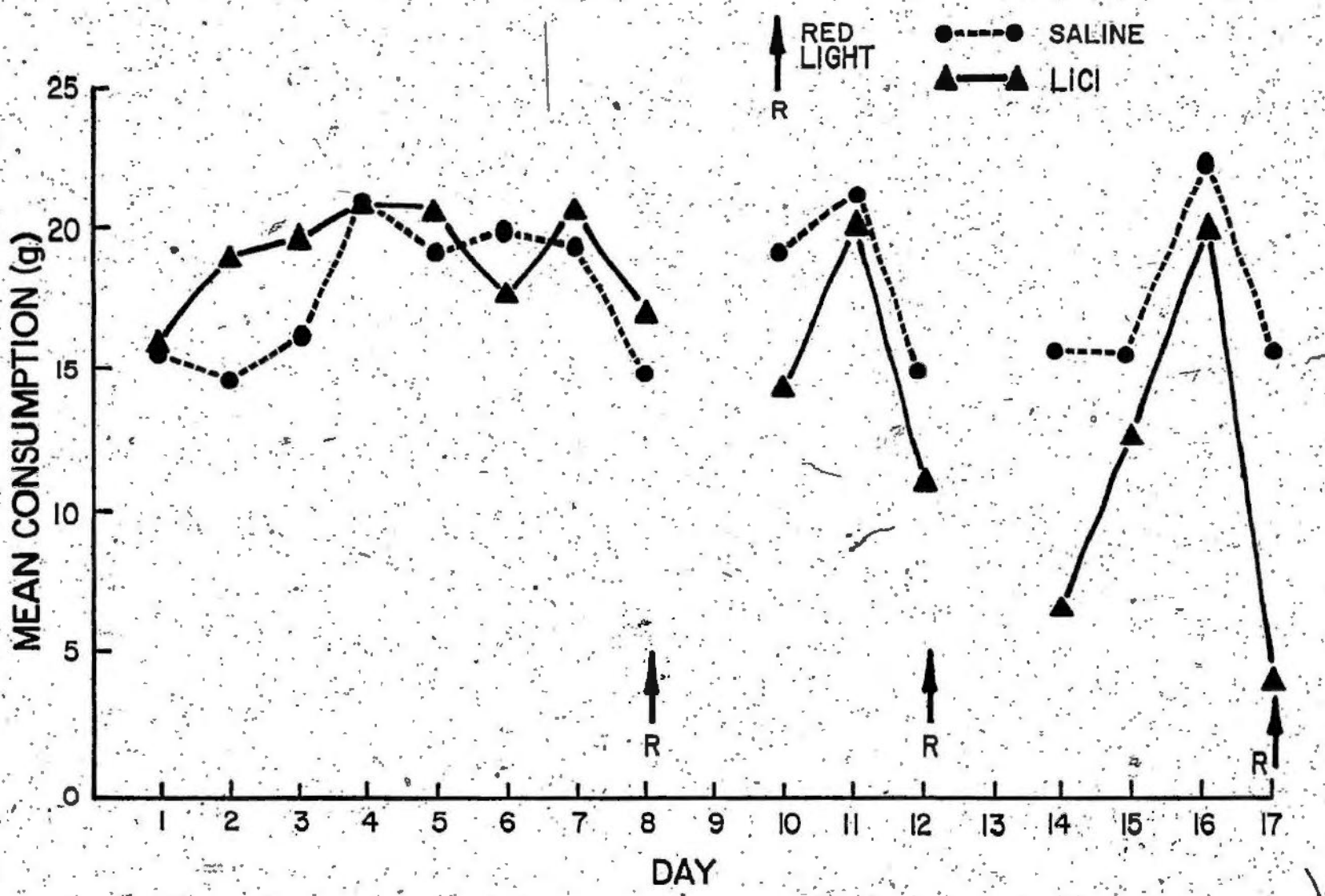
instead of yellow for 2 consecutive trials (Groups LiCl-green and Sal-green respectively). A maximum of 3 suppression tests were conducted per session. Thus, the potential maximum number of suppression tests for each bird was 9 but to reach this number the bird would have to begin autoshaped responding on virtually the first trial. Six birds received a fourth session because their autoshaping performance was so poor. Total key-pecks and pecks per trial were recorded for each bird.

Results

All birds began reliably eating from the food magazine within the 15-trial magazine training session. In Figure 8 are displayed the mean amounts of food consumed for each group over sessions of baseline, aversion training and recovery. As in Experiments 2 and 3 Groups LiCl and Sal consumed similar amounts during baseline observations. Over the final four baseline sessions the mean and range for Group LiCl were 20.2 g and 6 to 28 g respectively. For Group Sal the mean over the final four baseline sessions was 19.3 g and the range was from 11 to 28 g.

As in Experiment 2 the birds in this study showed an initial depression of consumption during the first red-illuminated aversion training session. A t-test comparing consumption on this and the previous day gave $t(23) = 45$, $p < .001$.

Figure 8. Mean consumption by Groups LiCl- and Sal during in-chamber sessions of Experiment 4. Illumination of food was white except on the days indicated (Days 8, 12 and 17) during which red light was used.


RED LIGHT
R
SALINE
LICI
MEAN CONSUMPTION (g)
25
20
15
10
5
0
R
R
R
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
DAY

The data displayed in Figure 9 represent the mean amounts consumed and standard deviations for each group over the final baseline session and the recovery sessions which preceded the second and third red-illuminated training sessions. In Figure 9b are the mean amounts consumed and standard deviations over the three red-illuminated sessions. These results replicate those of Experiments 2 and 3 in that consumption for all but the red-illuminated sessions of Group LiCl and was maintained at levels approximating baseline consumption levels. Red-illuminated consumption by Group LiCl dropped over sessions.

An analysis of variance similar to that conducted in Experiments 2 and 3 was conducted on these data, the results of which are summarized in Table 4. As was the case in Experiments 2 and 3, the significant main effects and two-factor interactions can best be understood in light of the significant three-way interaction between groups, illumination conditions and session. That is, the effects would seem to be the result of decreasing consumption levels in the presence of red illumination for Group LiCl and maintained or increased consumption levels in all other conditions.

There is one finding shown in Figure 9a and 9b which is at variance with the results of Experiments 2 and 3. Although an aversion definitely was formed to red illumination in the magazine by the birds in Group LiCl, this aversion was not as strong as that found in the previous

Figure 9. Mean consumption and standard deviations in Experiment 4 for Groups LiCl and Sal during white-illuminated recovery sessions (9a) and red-illuminated aversion training sessions (9b). Session 1 in 9a reflects final baseline session consumption.

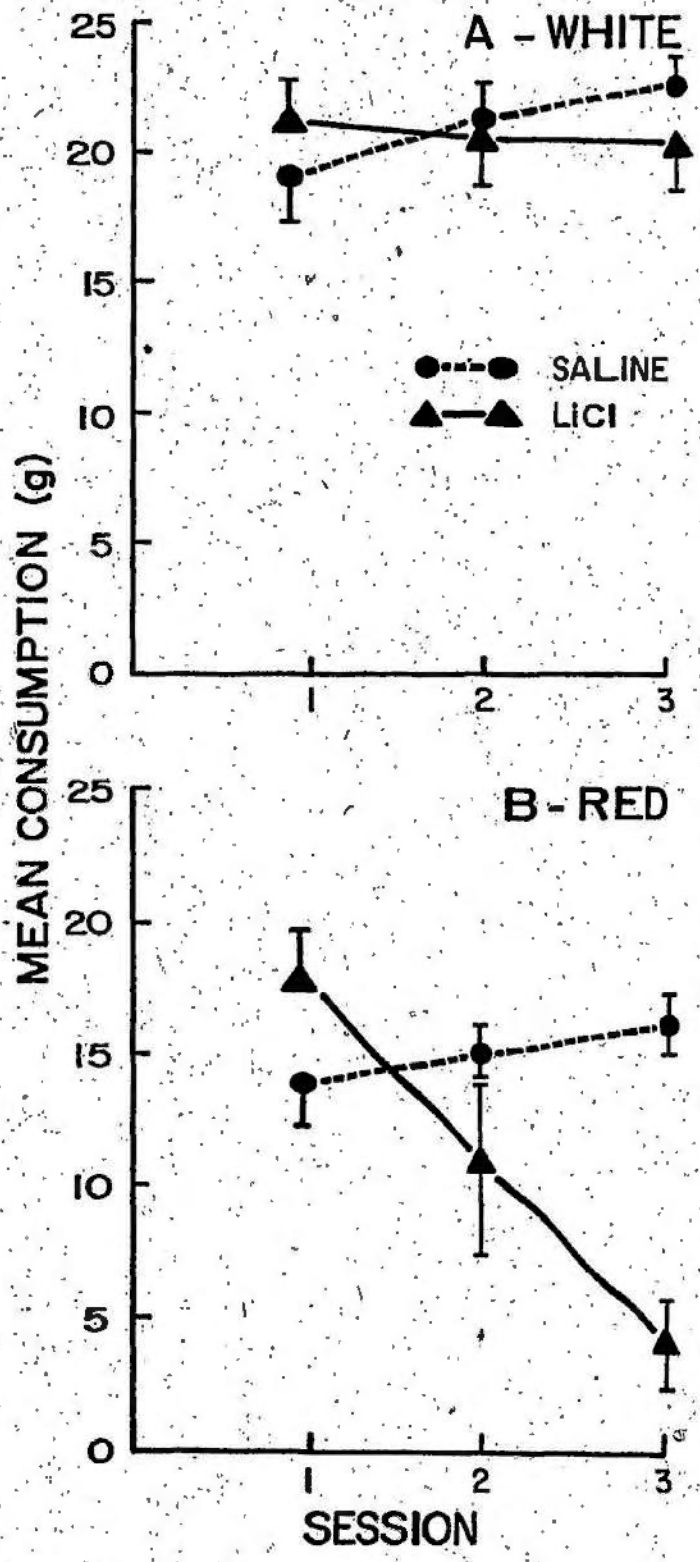

A - WHITE
B - RED
SALINE
LiCl
MEAN CONSUMPTION (g)
SESSION
0
5
10
15
20
25
1
2
3

TABLE 4

Analysis of Variance: Experiment 4

Source	df	MS	F
Group (A)	1	184.5	3.3160
Subjects (S)	22	55.6	
Illumination (B)	1	2023.5	66.6913***
A x B	1	134.2	4.4025*
B x S	22	30.5	
Session (C)	2	51.0	4.8030*
A x C	2	247.7	28.0035***
C x S	44	10.6	
B x C	2	116.1	8.3122***
A x B x C	2	68.2	4.8794*
B x C x S	44	13.9	

Note - Analysis at Variance on consumption data for Groups LiCl and Sal during white-illuminated final baseline and recovery sessions and red-illuminated aversion training sessions.

* $p < .05$

** $p < .01$

*** $p < .001$

two experiments. That is, consumption in the presence of red illumination by Group LiCl was slightly less depressed than it was in the previous studies as seen in Figures 4b and 6b. The absence of a main effect for groups in the analysis of variance on the data for this study could be accounted for by this somewhat weaker aversion displayed by Group LiCl or it could be due to reduced consumption of the control group.

The procedure for the current study was modified from that originally planned by the inclusion of extra in-chamber recovery sessions. As Figure 8 displays, the Group LiCl birds seemed slow to recover from the injection effects. Since these birds were obtained at the same time and from the same source as those used in Experiment 3, and as the drug employed was identical to that employed in the earlier studies, the likeliest explanation for the slow recovery is that this phase of the experiment coincided with a week of very hot and humid weather. It should also be noted that both the homing and wild pigeons in Group LiCl showed this slow recovery effect. It seems possible that these weather factors might have led to the weaker aversion demonstrated by Group LiCl although it could also be argued that longer recovery time reflects greater sickness which should result in a stronger aversion.

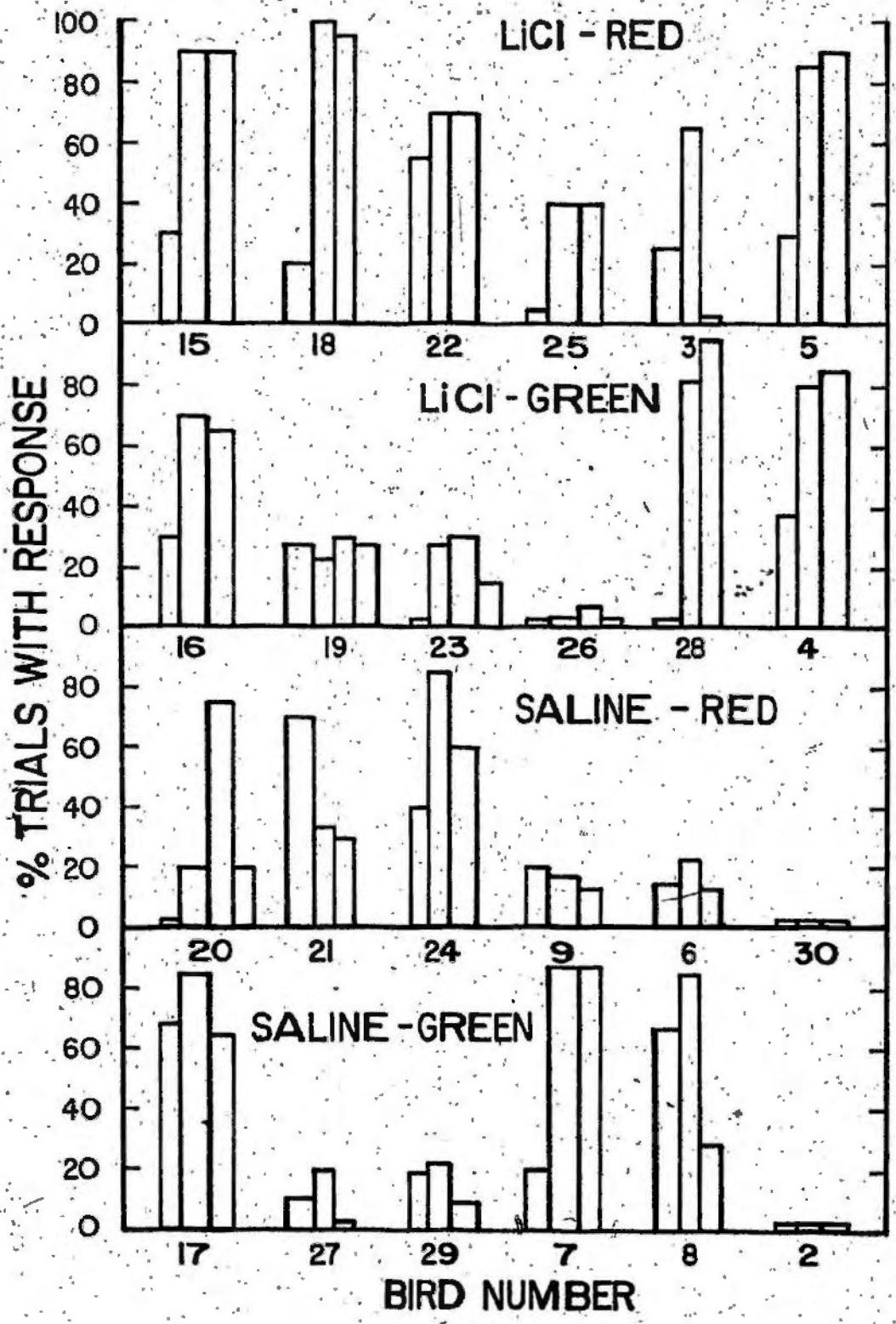
Aversions, defined as in Experiments 2 and 3 as a two-thirds drop in consumption in the presence of red illumination, were observed after one injection in 4 birds from

Group LiCl. After two injections a total of 8 birds from Group LiCl demonstrated aversions. An additional 2 birds from Group LiCl evidenced a 50 percent decrease in consumption. All birds in Group Sal increased or maintained their red-illuminated consumption levels.

Initial responses to the yellow key-light in autoshaping ranged from trial 2 to trial 45 (mean of 16.1) for the 22 birds which did autoshape. This result is in keeping with the initial autoshaped response data reported by Brown and Jenkins (1968). One bird from each of Groups Sal-red and Sal-green did not respond during 4 sessions. Figure 10 displays the percentage of trials with a response for each bird in each session. It can be seen that responding was variable both between and within birds but perhaps less variable than that observed in Experiment 3.

Suppression ratios were calculated for all members of Group LiCl-red, 5 members of Group LiCl-green and 3 members of each of Groups Sal-red and Sal-green. Only these 17 birds could be tested because the other 5 birds which did respond at all on the key did so erratically. That is, they did not reach the criterion of responding on five of six consecutive trials and accordingly no meaningful data could be derived from these birds. Further, for those birds which did respond at rates that allowed for testing of suppression, the number of tests varies because of changes in response rates. That is, several birds which responded well overm

Figure 10. Percentage of trials with a response for each bird in Experiment 4 over each of 3 sessions of autoshaping.


LiCl - RED
LiCl - GREEN
SALINE - RED
SALINE - GREEN
% TRIALS WITH RESPONSE
BIRD NUMBER
100
80
60
40
20
0
15
18
22
25
3
5
16
19
23
26
28
4
20
21
24
9
6
30
17
27
29
7
8
2

the first 30 trials, ceased responding while others did not begin to reliably respond until the last session. The suppression ratio itself was derived by dividing responses made during the 2-trial suppression tests by responses made during the previous 2 yellow trials. These ratios are displayed in Figure 11.

While it might appear that Groups LiCl-red and LiCl-green showed greater suppression than Groups Sal-red and Sal-green over the 6 possible suppression trials, this was only the case at three points. Group LiCl-red suppressed significantly more than the combined Sal groups on trial 2 ($U = 35$, $p < .01$). However, the combined ratios of Groups LiCl-red and LiCl-green were also significantly less than the combined Sal groups on trial ($U = 54$, $p < .01$). On trial 3, the responses of Group LiCl-red were suppressed significantly more than the combined control Groups Sal-red, Sal-green and LiCl-green. The high variability of these data conceals any further possible differences and indeed, it is very doubtful that the differences noted can be interpreted in any meaningful manner. Thus, it seems very clear that this procedure failed, as did the procedure in Experiment 3, to provide any evidence for the transfer of an aversion conditioned to the red-illuminated magazine. As was true in Experiment 3, however, it is not possible to conclusively rule out the possibility of such a transfer, at least on the basis of the failure to demonstrate it in these studies. A more reliable procedure for generating

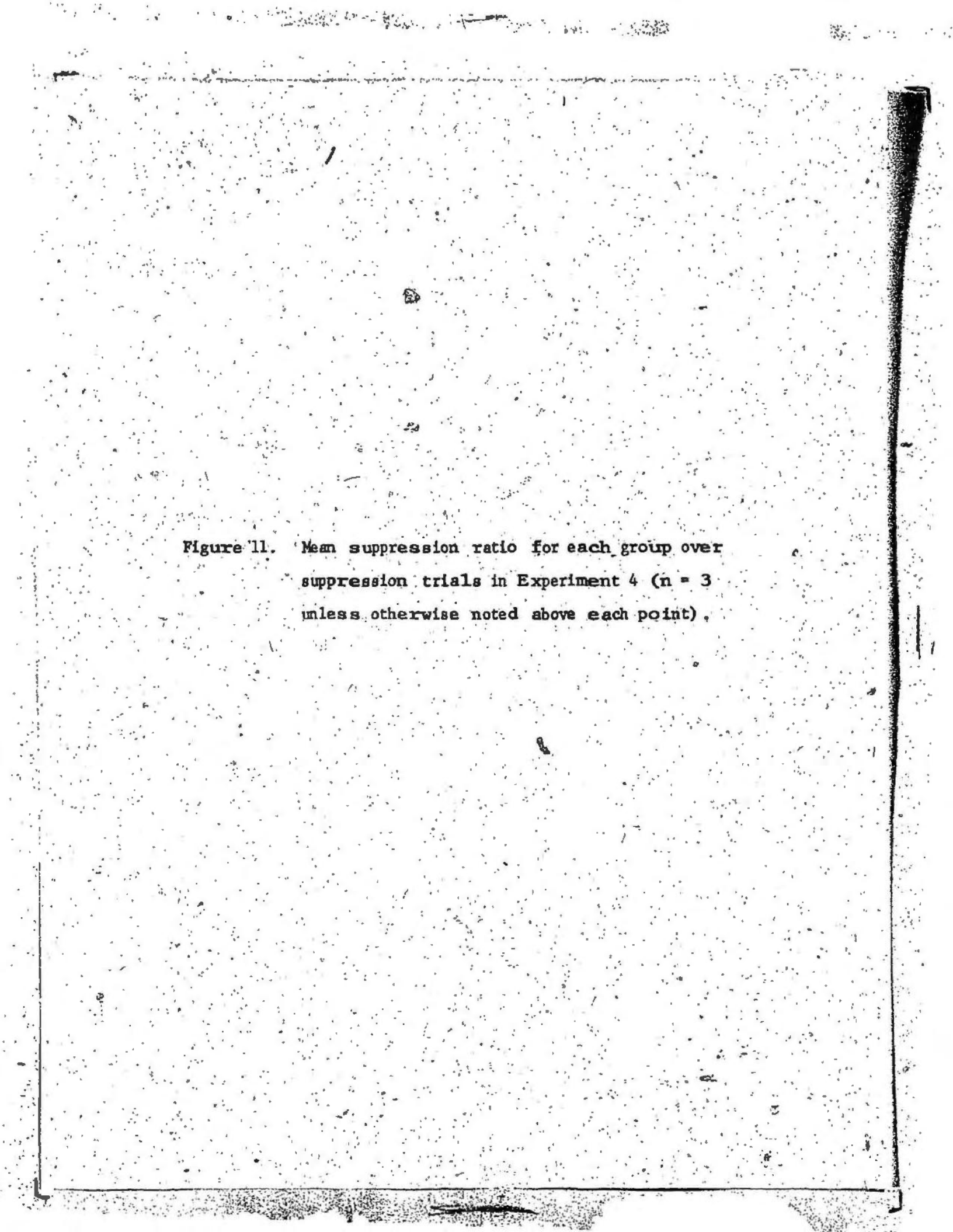
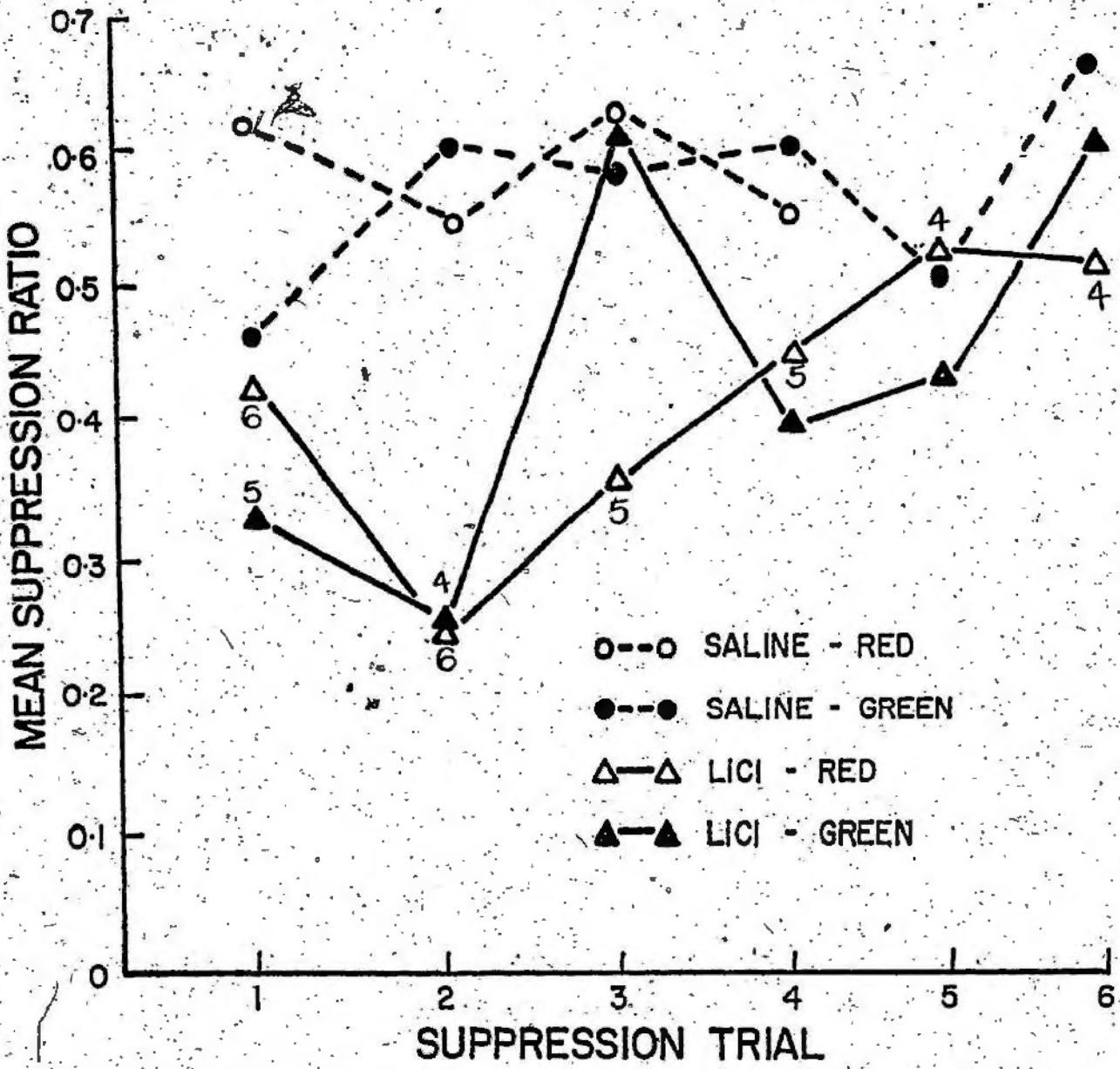


Figure 11. Mean suppression ratio for each group over suppression trials in Experiment 4 (n = 3 unless otherwise noted above each point).


MEAN SUPPRESSION RATIO
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
1
2
3
4
5
6
SUPPRESSION TRIAL
o--o SALINE - RED
●--● SALINE - GREEN
△—△ LICI - RED
▲—▲ LICI - GREEN

key-peck responding than the autoshaping used in this study might enable a more authoritative treatment of this problem.

GENERAL DISCUSSION

The significant result of this series of experiments was that pigeons form conditioned aversions to a visual stimulus present during ingestion if ingestion is paired with toxicosis. The initial demonstration of this phenomenon in Experiment 1 was equivocal in that the remote possibility existed that odour cues could have been utilized by the birds. However, the procedure employed in Experiments 2, 3 and 4 assured that only the colour cue present during ingestion was relevant. Identical odour cues were present during both white-illuminated (safe) and red-illuminated (toxicosis-related for Group LiCl) conditions.

It is difficult to see how these colour aversions could be due simply to sensitization. In Experiment 1, the aversion was unique to the coloured food paired with LiCl; the birds did not avoid other coloured foods. Similarly, the birds that received red-illuminated food paired with sickness in Experiments 2, 3 and 4 avoided the red-illuminated but not the white-illuminated food.

In Experiment 1 a single colour-toxicosis pairing was sufficient to produce a strong aversion. The procedure employed in Experiments 2, 3 and 4, while effective in producing a one-trial aversion in 11 of the 30 birds employed, produced optimal results after a minimum of at least 2

colour-sickness pairings. Given the differences in procedures between Experiment 1 and Experiments 2, 3 and 4 it is not clear whether this difference reflects a more effective aversion producing procedure in Experiment 1 or, more probably, whether this reflects the difference in test methods between Experiments 2, 3 and 4 and Experiment 1. That is, the choice situation in Experiment 1 where both safe and toxicosis-related foods were available (a two-bottle test) is probably much less conservative than the test employed in Experiments 2, 3 and 4 (a one-bottle test) where the birds faced an all or none proposition as the choice was to consume toxicosis-related food or none at all. It should be noted that no significant differences in deprivation level as measured by weight decrease from free-feeding weight were present between those birds in Experiments 2, 3 and 4 which did and did not show one-trial aversions, indicating that deprivation level did not interfere with demonstration of the aversion on the first trial.

The results of Experiments 3 and 4 provide only a tentative answer to the question of whether an aversion to red-illuminated food will generalize to a red-illuminated key-light. That is, the colour red when displayed in the food magazine was effective in suppressing consumption, but when displayed on the response key the red colour was not effective in suppressing autoshaped responding. If any conclusion can be drawn it would be that the visual

stimulus is effective only in the situation where toxicosis previously followed its presentation. There are, however, several elements of these two experiments which make this conclusion tentative.

In both Experiment 3 and Experiment 4, the final red-illuminated session was not followed by toxicosis. It is possible, therefore, that the red aversion did not affect autoshaping due to extinction of the aversion. These injections were omitted because it was felt that the delay between aversion formation and the autoshaped tests should be as short as possible. It seems unlikely that the failure to inject after this presentation of the visual stimulus led to substantial extinction of the aversion. The birds in Experiment 2 that manifested an aversion after only one injection still had aversions after the three subsequent unreinforced red presentations. Further, the birds in Experiment 1 showed little extinction after 10 days of testing. However, as noted above, extinction in Experiment 1 could have been retarded by the use of the two-bottle test and it would seem desirable, if an authoritative answer is to be reached on this point, that the possibility of extinction in this manner be removed. It is possible that the aversion would be less sensitive to the greater delay necessitated by an additional injection than it was to this extinction session.

A related point of procedure arises in Experiment 4. The choice of order between key-peck response phase and

the aversion formation phase in this experiment was arbitrary. In Experiment 3 the aversion formation phase of necessity preceded the autoshaping phase as autoshaping was the test in Experiment 3, rather than the means of generating key-peck responding as it was in Experiment 4. Neither Experiment 3 nor Experiment 4 yielded a satisfactory level of stable autoshaped responding, perhaps because the pre-exposure to the aversion training procedure interfered with autoshaping. While it is difficult to see why the training received during the aversion formation phase should have been so disruptive to the autoshaping phase, and indeed, it is possible that a more general factor such as weather could have accounted for the disruption, the fact that autoshaping was disrupted removed the opportunity to observe any possible aversive properties of the colour stimulus.

Since both Groups Sal and LiCl displayed poor autoshaping, it seems unlikely that the sickness aspect of the aversion training procedure could have accounted for this disruption. Perhaps the experience in the chamber coupled with the handling involved in injection of both LiCl and saline rendered the light cue less salient for these birds when in the chamber.

Finally, the key-colour and magazine-light colour correspondence was identical to the human eye. It is possible, however, that to the pigeon these colours did not bear the same resemblance and that autoshaping and/or

suppression testing suffered due to generalization decrement. In a subsequent study it might be best to equate these two colours more precisely.

Given these factors, a more appropriate design might involve first training the birds to reliably respond on a variable or fixed interval schedule to a yellow key-light and then to conduct the aversion formation phase of the experiment. A subsequent suppression test (if the aversion formation phase does not also disrupt responding while under a traditional instrumental contingency) would at least offer a substantial baseline against which to measure the effects of the conditioned colour stimulus on responding.

Finally, the visual stimulus effective in mediating a conditioned aversion may well be effective only if present at ingestion. This does not, however, preclude the possibility of stimulus control transferring across situations. That is, is the colour red which suppresses food consumption because of a completed conditioning procedure also capable of suppressing water consumption? The design would involve conditioning an aversion to red-illuminated or coloured food and testing with red-illuminated or coloured water. The test would presumably be for generalization of stimulus control specific to the consumption or ingestion procedure.

In summary, Experiments 3 and 4 did not show transfer of control, but neither has it been shown to be an invalid hypothesis. The alternatives suggested might prove useful in further examining the possibility of such an effect.

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