EFFECTS OF TIME OUT ON SPACED RESPONDING IN PIGEONS

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Thomas J. Kramer

1968

THESIS

ABSTRACT

EFFECTS OF TIME OUT ON SPACED RESPONDING IN PIGEONS

by Thomas J. Kramer

This experiment was concerned with the temporal pattern and rate of responding of pigeons on a differential-reinforcement-of-low-rate-of-responding schedule (DRL), where the subjects received reinforcement for all responses terminating interresponse times (IRTs) greater than or equal to a certain time value. An IRT refers to the time which intervenes between any two consecutive responses. The purpose of this experiment was to see if pigeons could be trained to adjust their rate of responding to the delay requirements of a DRL schedule of reinforcement by use of special discrimination training involving time out from responding for all IRTs greater than or equal to that time value. In addition, the effects of this discrimination procedure in controlling responding on a DRL schedule were compared to the effects of the punishment procedure using shock in other studies.

Three White Carneaux pigeons were trained to peck a translucent disk in a standard Skinner box on a DRL 20-sec schedule for twenty daily sessions. During alternate sessions for the next thirty sessions, every response with an IRT of less than 20 sec was followed with a time out

of either 5, 10, or 20 sec during the entire session. A time out was accomplished by completely darkening the experimental chamber. At the end of this 30-session period, all birds were run on DRL 20-sec for 15 additional sessions, after which the delay requirement necessary for reinforcement was increased to 30 sec (DRL 30-sec) for ten sessions. Following this, all responses with IRTs of less than 30 sec were followed by a time out during alternate sessions for the next thirty sessions, using the same time-out values and procedure as with DRL 20-sec.

The results were analyzed using the IRTs/OP statistic which estimates the probability that the subject will respond within a certain time interval, given that he has reached the initial boundry of the interval and thus has an opportunity to respond within that interval. Inspection of the IRTs/OP curves showed little difference in responding among the three time-out values, both at DRL 20-sec and at DRL 30-sec. While temporal discriminations did not emerge during the initial 20-session exposure on DRL 20-sec, all birds formed a temporal discrimination while the time-out procedure was in effect at DRL 20-sec, and maintained this discrimination after the termination of the time-out procedure, although not to the same degree. When the delay requirement was increased to 30 sec, the rate of responding decreased and the temporal discrimination was preserved. Reinstatement of the time-out procedure further decreased the rate of responding while sharpening the discrimination.

In general, the effect of the time-out procedure was similar to effects achieved in other studies when all responses were punished with low intensities of shock, but superior to it in that responding did not revert back to the initial level prior to discrimination training, as is the case with punishment.

Date Feb 6, 1968 Chairman Mark Rilling

EFFECTS OF TIME OUT ON SPACED RESPONDING IN PIGEONS

By

Thomas James Kramer

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Psychology

1968

648575
3-15-68

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Mark Rilling, chairman of his committee, for his instruction, guidance, and the use of his equipment throughout all stages of this research. Thanks are also due to Drs. Ralph Levine and M. Ray Denney for their helpful criticism and advice.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

A schedule of reinforcement which has received increasing attention in the past few years is the differential reinforcement of low rates of responding (DRL), where the subject receives reinforcement for all responses terminating an interresponse time (IRT) greater than or equal to a certain time value. An IRT refers to the time which intervenes between two consecutive responses. For instance, if a subject is exposed to a DRL 20-sec schedule all IRTs of 20 sec or more are followed by reinforcement, whereas all IRTs of less than 20 sec are not. It is important to note that there is no external stimulus specified by the schedule which is correlated with time.

Little success has been achieved with pigeons in forming a temporal discrimination on DRL schedules. Reynolds (1964a,b) has noted that pigeons perform at a very inefficient rate on a DRL 20-sec schedule while maintained at 80% of their free-feeding weight. He reported that the performance after over 100 sessions on the schedule was basically unchanged from that after six sessions. The subjects emitted very few responses with long IRTs, and the data presented gave no indication that the subjects had formed a temporal discrimination. But Reynolds noted in a later article (1966) that pigeons performed poorly because they seemed to be unable to inhibit responding, but nevertheless do form some sort of temporal discrimination.

Staddon (1965), after exposing pigeons to a variety of schedules with varying delay requirements for 255 sessions, found that pigeons performed close to the maximum rate of efficiency up to about DRL 20-sec and apparently formed a temporal discrimination, but that the rate of responding at DRL 30-sec increased over that at DRL 20-sec for two of the three birds. He concluded that few pigeons, when exposed to DRL 30-sec, could adjust their rate of responding to the schedule requirements in a way comparable to their adjustment to shorter values. Staddon suggested that this may be accomplished by special training procedures.

Punishment has been used to reduce the rate of responding of pigeons on a DRL schedule (Holz and Azrin, 1963; Holz, Azrin, and Ulrich, 1963). Punishment of all responses with shock decreased the rate of responding as a direct function of the shock intensity, and in particular reduced the number of short IRTs, even at low intensities. But after punishment was discontinued, the rate of responding as well as the temporal pattern of responding returned to normal. Thus, the punishment had no lasting effect once it was removed, and the subjects did not form a temporal discrimination.

The purpose of the present experiment was to see if pigeons could be trained to adjust their rate of responding to the delay requirements of a DRL schedule of reinforcement by the use of special discrimination training involving time out from responding for all IRTs less than the minimum reinforced value, and reinforcement for all IRTs greater than or equal to this same value. In addition, the effects of this discrimination procedure in controlling responding on a DRL schedule were compared to the effects of the punishment procedure in other studies using shock.

METHOD

Subjects

The subjects were three experimentally naive male White Carneaux pigeons maintained at 80% of their free-feeding weight. They were purchased from the Palmetto Pigeon Plant and were approximately five years of age at the start of the experiment.

Apparatus

The experimental chamber in which the subjects were tested was 12 X 14 X 13 in. contained within a larger ice chest. A fan, mounted on the door of the chest, provided ventilation and masked any extraneous sound. The front panel of the experimental chamber contained three Lehigh Valley Electronics plastic pigeon keys which were mounted 8 1/2 in. above the floor with a horizontal separation of 3 in. Each key, mounted behind a 1-in. diameter hole, could be illuminated from behind with light. A force of approximately 15 gm was required to close the key. A rectangular opening located below the center key permitted access to the grain magazine which was raised to the feeding position and lighted during a 6-sec period for reinforcement. Two house lights were located above the response keys on the front panel. The programing equipment consisted of a system of electromechanical switches and timers, and IRTs were printed out on a Lehigh Valley

Electronics 9 channel serial-parallel entry printer, model 1660-9. The programing and recording equipment were located in a separate room.

Procedure

During session one the house lights were on and the center key was illuminated with white light. The food magazine was repeatedly presented to each bird until he ate promptly upon presentation. Immediately after a peck of at least 15 gm on the center key, the food magazine was presented. While the food magazine was presented, the center key light was always off. Every response on the center key was reinforced. The session was terminated with 25 reinforcements which occurred in rapid succession.

Starting with session two the house lights were on and the center key illuminated with white light. The subjects were placed on a DRL t-sec schedule, where t represents the IRT from either (1) the last response, (2) the last reinforcement termination, or (3) the start of the session, whichever occurred most recently. For session two t was 3 sec and was progressively increased by 1 sec each day until DRL 20-sec was reached. The criterion for termination of a daily session throughout the entire experiment was either (1) two hours of presentation of the illuminated center key, or (2) 25 reinforcements, whichever occurred first. The subjects were run on the average of six days out of seven.

All birds continued on DRL 20-sec for twenty sessions.

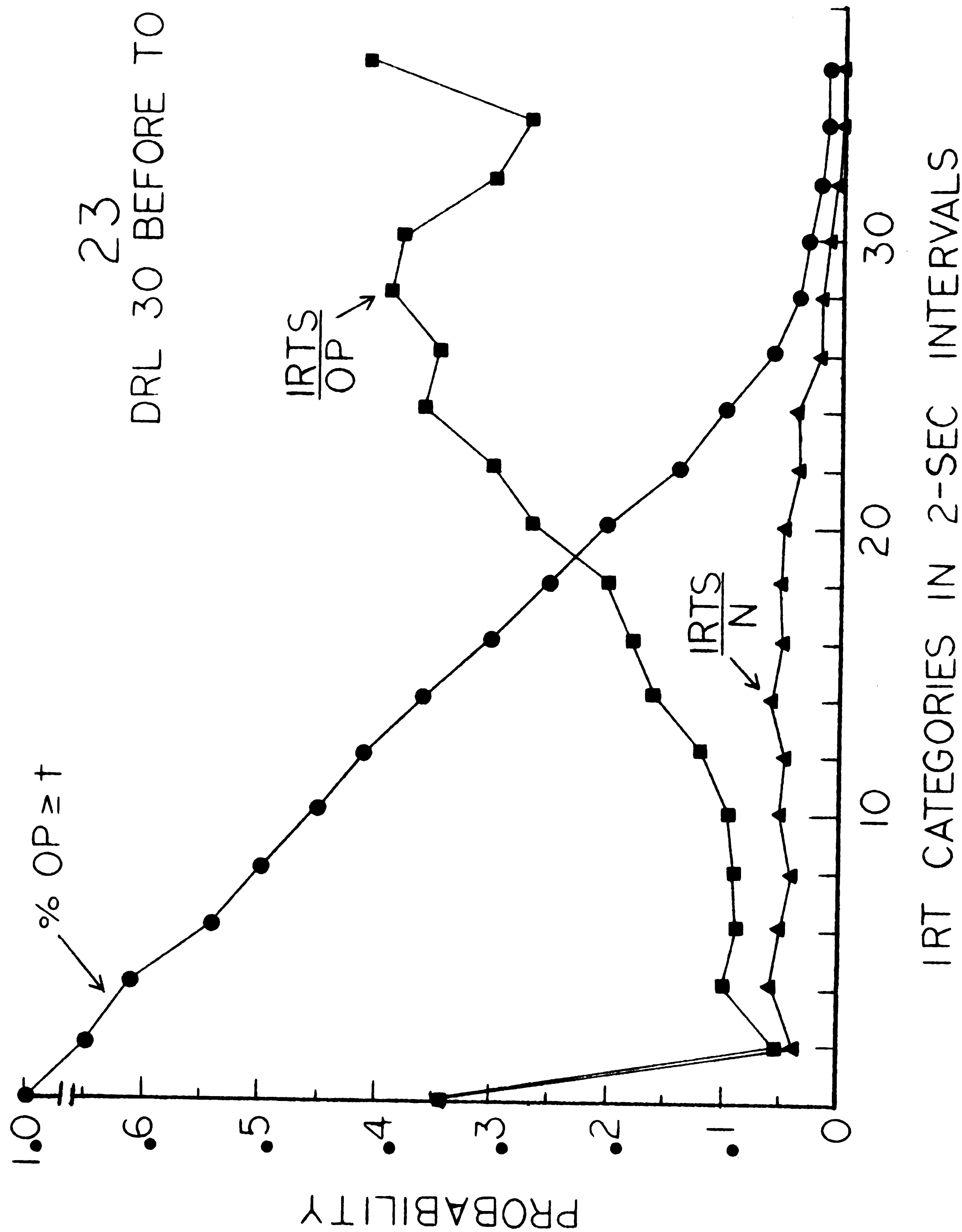
During alternate sessions for the next thirty sessions for all birds, every response to the center key with an IRT of less than 20 sec was followed with a time out of either 5, 10, or 20 sec during the entire session. A time out was accomplished by turning out the house and key lights which completely darkened the experimental chamber. All responses with IRTs of 20 sec or more did not produce a time out and were followed with reinforcement. The order of occurrence of the three time-out values was variable for each bird, five sessions being given at each of the three values. For those sessions in which time outs occurred, IRTs were measured from either (1) the start of the session, (2) the last reinforcement, or (3) the last time-out termination, whichever occurred most recently. For those sessions in which time outs did not occur, the procedure was as before at DRL 20-sec.

At the end of this 30-session period, all birds were run on DRL 20-sec with no time out for an additional 15 sessions, after which the delay requirement necessary for reinforcement was increased to 30 sec (DRL 30-sec) for ten sessions. Following this all responses with IRTs of less than 30 sec were followed by a time out during alternate sessions for the next thirty sessions, using the same time-out values and procedure as with DRL 20-sec.

RESULTS

The results of a study involving responding on a DRL schedule are usually presented in one or several graphs with the abscissa representing categories of IRTs in seconds (0-1, 2-3, 4-5, etc.) and the ordinate representing either IRTs/OP (interresponse times/opportunities) or IRTs/Total. IRTs/OP is a statistic which estimates the probability of a response occurring in a certain time interval on the condition that the subject reaches the initial boundry of the interval, and hence has the opportunity for a response in the interval. The IRTs/OP statistic is calculated by dividing the number of responses with IRTs which fall into a certain category by the number of responses with IRTs as long as or longer than the lower limit of the IRT category in question. Therefore, the IRTs/OP statistic is a conditional probability statistic while IRTs/Total is a relative frequency measure. These two statistics can often show quite different pictures of the results leading to opposite conclusions. Anger (1956, 1963) pointed out that there is good reason for believing that comparisons of relative frequency measures of IRTs between subjects or among different conditions for the same subject may be inappropriate for many purposes, particularly temporal discriminations. The opportunity for for responses to occur with short IRTs is much greater than for long since every response is followed with the opportunity to emit a response in the shortest IRT category. This can be easily seen from Fig. 1 which shows three curves drawn from actual data. The triangles represent the percent of the available opportunities for a response to occur in each 2-sec category. This curve shows the sharp decrease in the number of opportunities at first and then the steady decrease thereafter. The relative frequency curve (squares) and the IRTs/OP curve (circles) are quite different. The relative frequency curve shows little or no evidence of a temporal discrimination, while the IRTs/OP curve shows an increasing probability of responding as the length of the IRT increases. The points plotted on the IRTs/OP curve might be read as follows: given that the subject waited t sec or longer, what was the probability that he responded in the t - t+2 sec interval? Thus, the IRTs/OP statistic equates all IRT categories by using the opportunities for responses to occur in a category as the denominator. The desireability of this measure is further enhanced by the fact that, when no temporal discrimination exists in responding on a DRL schedule, rough equality can be expected in the various IRTs/OP values for the different IRT categories. Thus, a peak in the IRTs/OP values at or near the minimum reinforced IRT is evidence for a temporal discrimination. This discrimination is often obscured by the relative frequency graph due to the much greater

Fig. 1. Three methods of depicting the probability of interresponse times. The IRTs/OP curve shows the number of IRTs in each class divided by the total number of opportunities for IRTs in that class; the IRTs/N curve shows the number of IRTs in each class divided by the total number of IRTs during the session; the third curve shows the percentage of the total IRTs that were greater than the lower limit of each IRT category.


23
DRL 30 BEFORE TO
IRTS/OP
IRTS/N
% OP ≥ t
PROBABILITY
1.0
.6
.5
.4
.3
.2
.1
0
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

number of opportunities for short IRTs. Consequently, it seems that failure to find evidence for a temporal discrimination in the relative frequency distribution of IRTs is inconclusive; the IRTs/OP curve should be studied.

Visual inspection of the IRTs/OP curves plotted as a function of the IRT categories for each bird during the time-out procedure at DRL 20-sec and DRL 30-sec showed that there was very little difference in responding as a function of the time-out duration within any bird. Fig. 2 shows the IRTs/OP values as a function of the IRT category for each of the three time-out values during DRL 20-sec and DRL 30-sec for Pigeon # 45. The curves for the other two birds were quite similar in variability.

Figs. 3-5 show the IRTs/OP values plotted as a function of the IRT categories for days 16-20 combined on DRL 20-sec, the last three sessions of time out at each of the three time-out values combined at DRL 20-sec, and the last three sessions of time out at each of the three time-out values combined at DRL 30-sec for each bird. Although the curves show some dissimilarities across birds, distinctive trends stand out for all birds. The curves for DRL 20-sec prior to any manipulations for each bird show a high probability of responding in the shortest category, followed by a sharp drop for the 2-4 sec category, and then a steady rise. All reach an initial peak at about 8 sec and fluctuate about that value at longer IRTs, approximating equality. This is in marked contrast

Fig. 2. IRTs/OP values as a function of IRT categories for each of the last three sessions combined at each of the three time-out (TO) values during DRL 20-sec and DRL 30-sec for Pigeon # 45. No IRTs/OP values were computed where the opportunities were less than 20. The numbers on the abscissa represent the lower limit of each 2-sec IRT category.

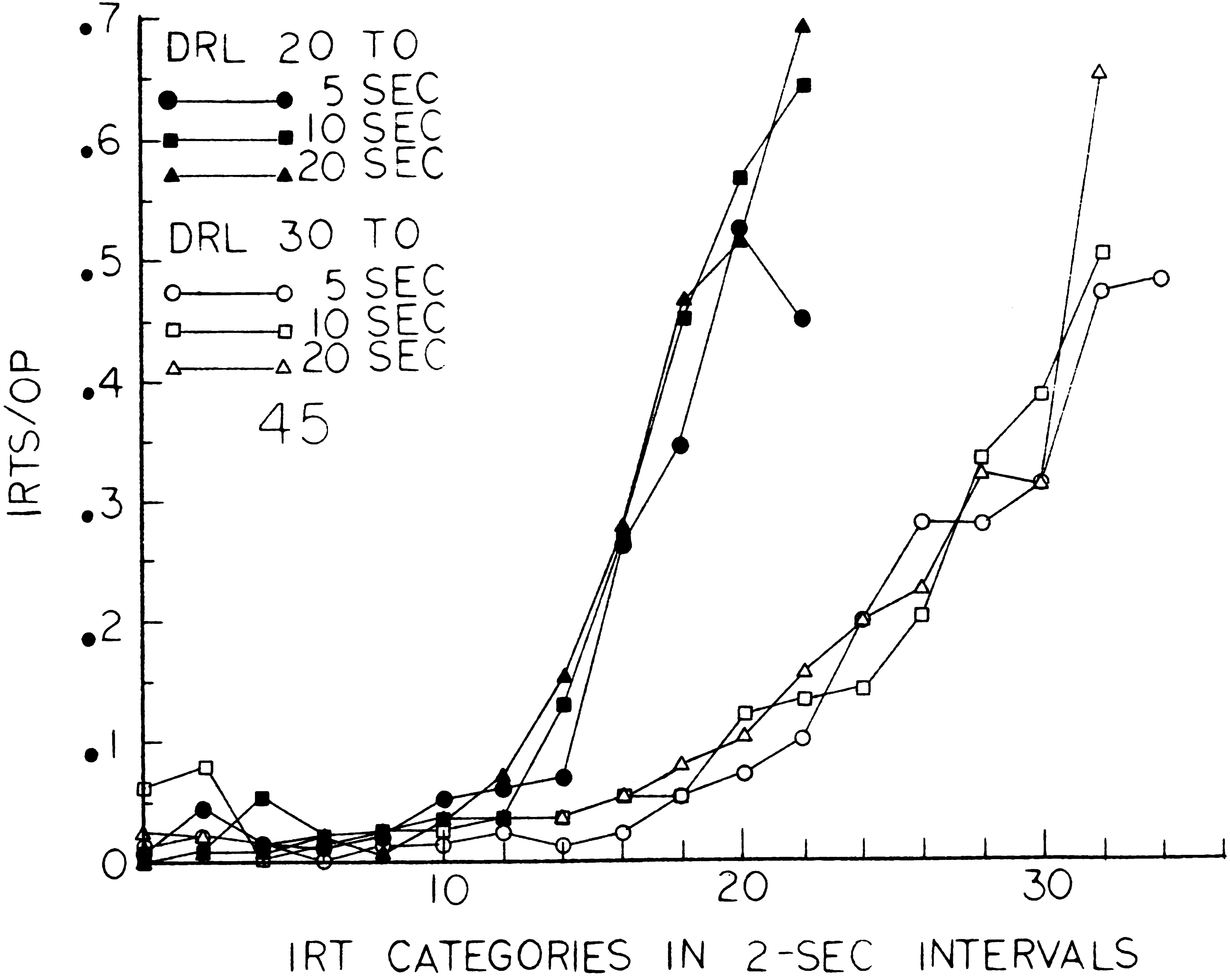
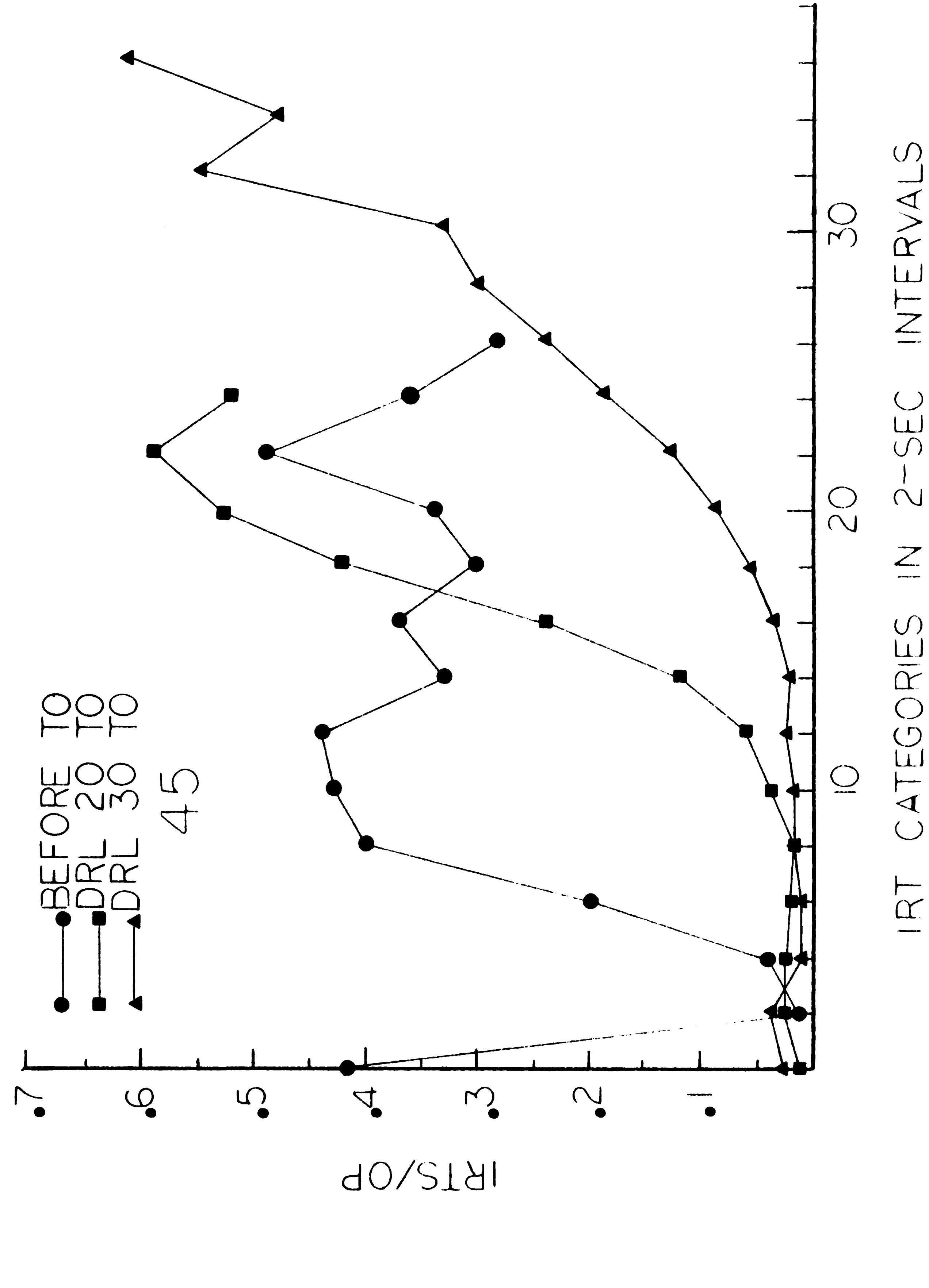

DRL 20 TO
5 SEC
10 SEC
20 SEC
DRL 30 TO
5 SEC
10 SEC
20 SEC
45
IRTS/OP
.7
.6
.5
.4
.3
.2
.1
0
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

Fig. 3. IRTs/OP values as a function of the IRT categories for Pigeon # 45 on DRL 20-sec before time out (BEFORE TO), DRL 20-sec during time out (DRL 20 TO), and DRL 30-sec during time out (DRL 30 TO). The numbers on the abscissa represent the lower limit of each 2-sec IRT category.



BEFORE TO
DRL 20 TO
DRL 30 TO
45
IRTS/OP
.1
.2
.3
.4
.5
.6
.7
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

Fig. 4. IRTs/OP values as a function of the IRT categories for Pigeon # 23 on DRL 20-sec before time out (BEFORE TO), DRL 20-se during time out (DRL 20 TO), and DRL 30-sec during time out (DRL 30 TO). The numbers on the abscissa represent the lower limit of each 2-sec IRT category.

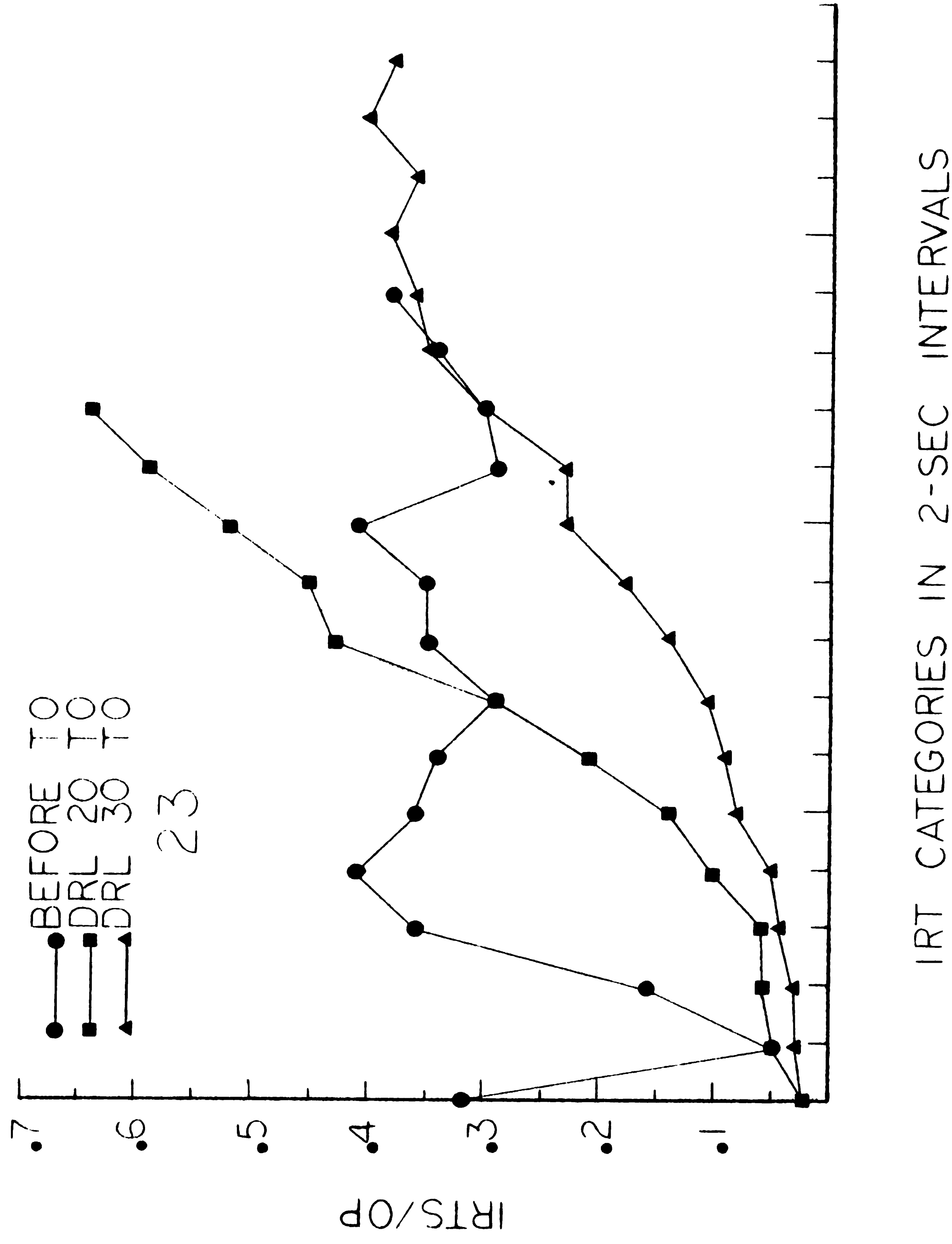
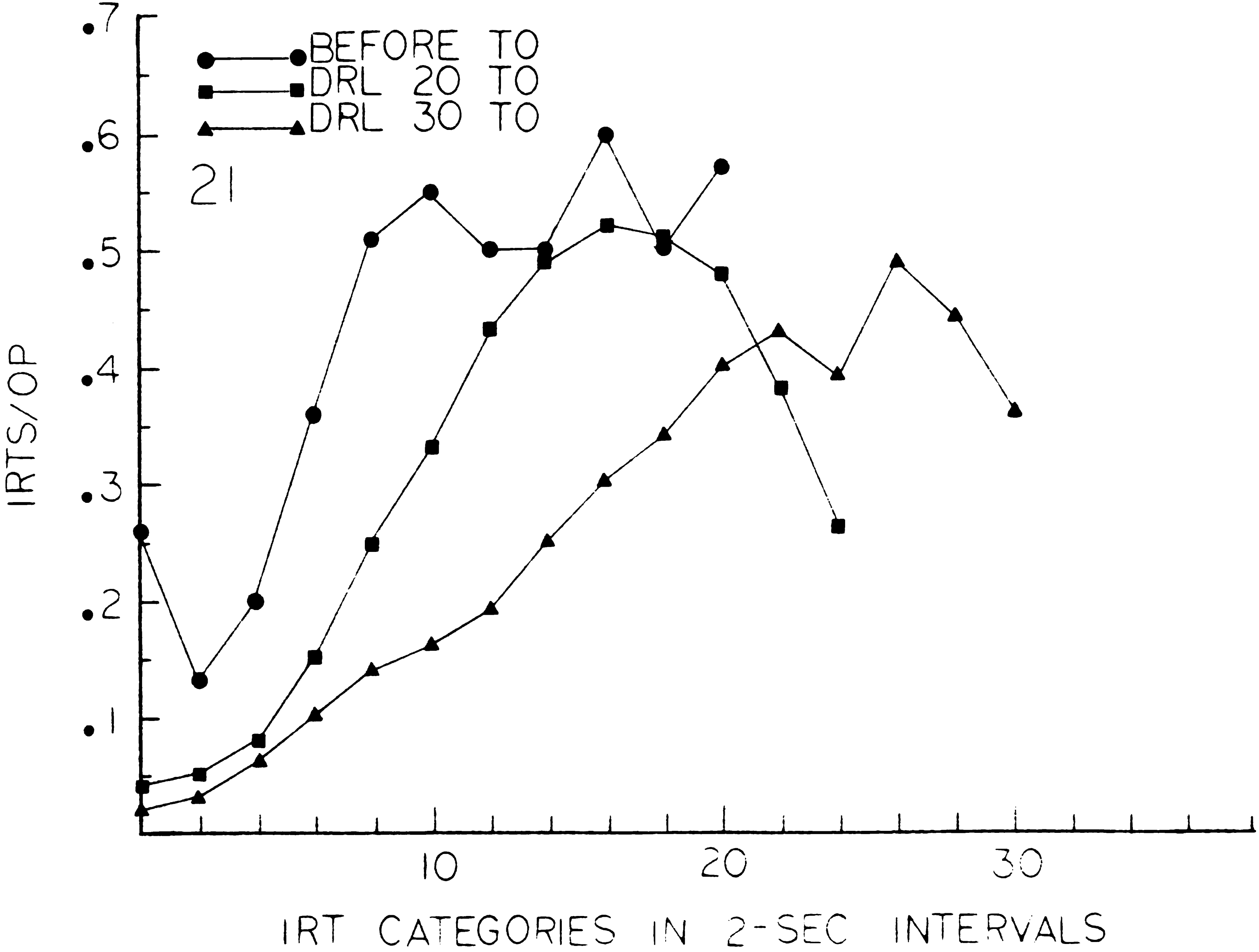

BEFORE TO
DRL 20 TO
DRL 30 TO
23
IRTS/OP
.1
.2
.3
.4
.5
.6
.7
IRT CATEGORIES IN 2-SEC INTERVALS

Fig. 5. IRTs/OP values as a function of the IRT categories for Pigeon # 21 on DRL 20-sec before time out (BEFORE TO), DRL 20-sec during time out (DRL 20 TO), and DRL 30-sec during time out (DRL 30 TO). The numbers on the abscissa represent the lower limit of each 2-sec IRT category.


BEFORE TO
DRL 20 TO
DRL 30 TO
21
IRTS/OP
.1
.2
.3
.4
.5
.6
.7
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

to the curves representing responding under the time-out condition at DRL 20-sec. The probability of a response in the shortest category is near zero for each bird, increasing monotonically to a peak probability just prior to the reinforced value for Pigeon # 21, and a peak for Pigeon # 45 and Pigeon # 23 near 24 sec. The curves for the time-out condition at DRL 30-sec follow the same general pattern as those for the time-out condition at DRL 20-sec. Each increases monotonically from a low initial value, but at a slower rate. Each curve peaks roughly at the same place relative to the minimum reinforced value for each bird as it did at DRL 20-sec.

Figs. 6-8 show the IRTs/OP values for each bird plotted as a function of the IRT categories combined for days 16-20 on DRL 20-sec (replotted as in Figs. 3-5), days 11-15 after the end of the time-out procedure at DRL 20-sec, and days 6-10 of DRL 30-sec, just prior to the start of the time-out procedure at that value. The curves for all three birds still show the presence of a temporal discrimination, although not to the same degree as when the time-out procedure was in effect. In addition, the discrimination is not as sharp as for the time-out condition, perticularly around the area of the reinforced values. The important fact is that responding did not revert back to the level which existed prior to the institution of the time out. It can also be seen that all three birds adjusted their rate of responding toward the

Fig. 6. IRTs/OP values as a function of the IRT categories for Pigeon # 45 on DRL 20-sec before time out (DRL 20 BEFORE TO), DRL 20-sec after time out (DRL 20 AFTER TO), and DRL 30-sec before time out (DRL 30 BEFORE TO). The numbers on the abscissa represent the lower limit of each 2-sec IRT category.

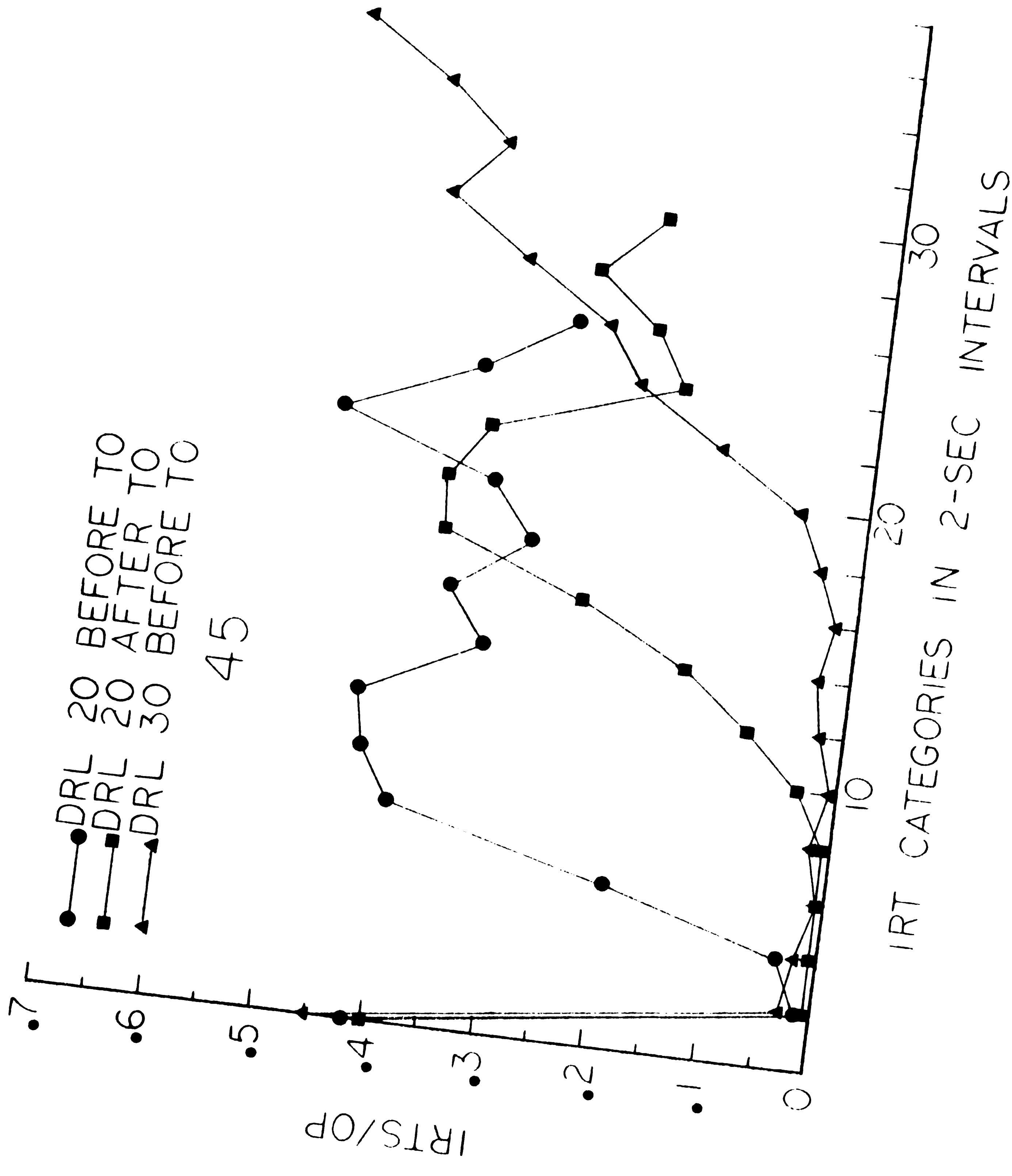

DRL 20 BEFORE TO
DRL 20 AFTER TO
DRL 30 BEFORE TO
45
IRTS/OP
.7
.6
.5
.4
.3
.2
.1
0
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

Fig. 7. IRTs/OP values as a function of the IRT categories for Pigeon # 23 on DRL 20-sec before time out (DRL 20 BEFORE TO), DRL 20-sec after time out (DRL 20 AFTER TO), and DRL 30-sec before time out (DRL 30 BEFORE TO). The numbers on the absccissa represent the lower limit of each 2-sec IRT category.

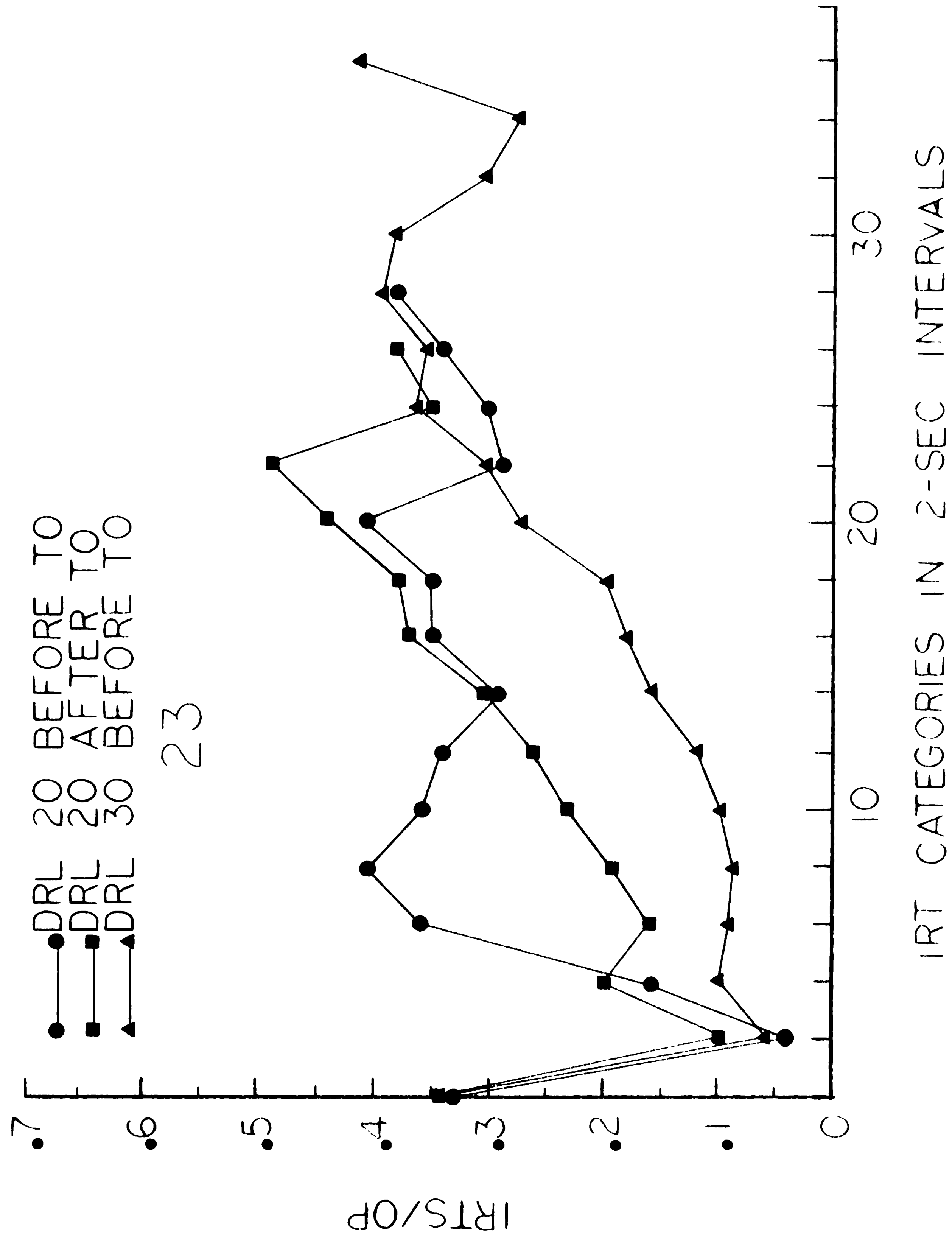
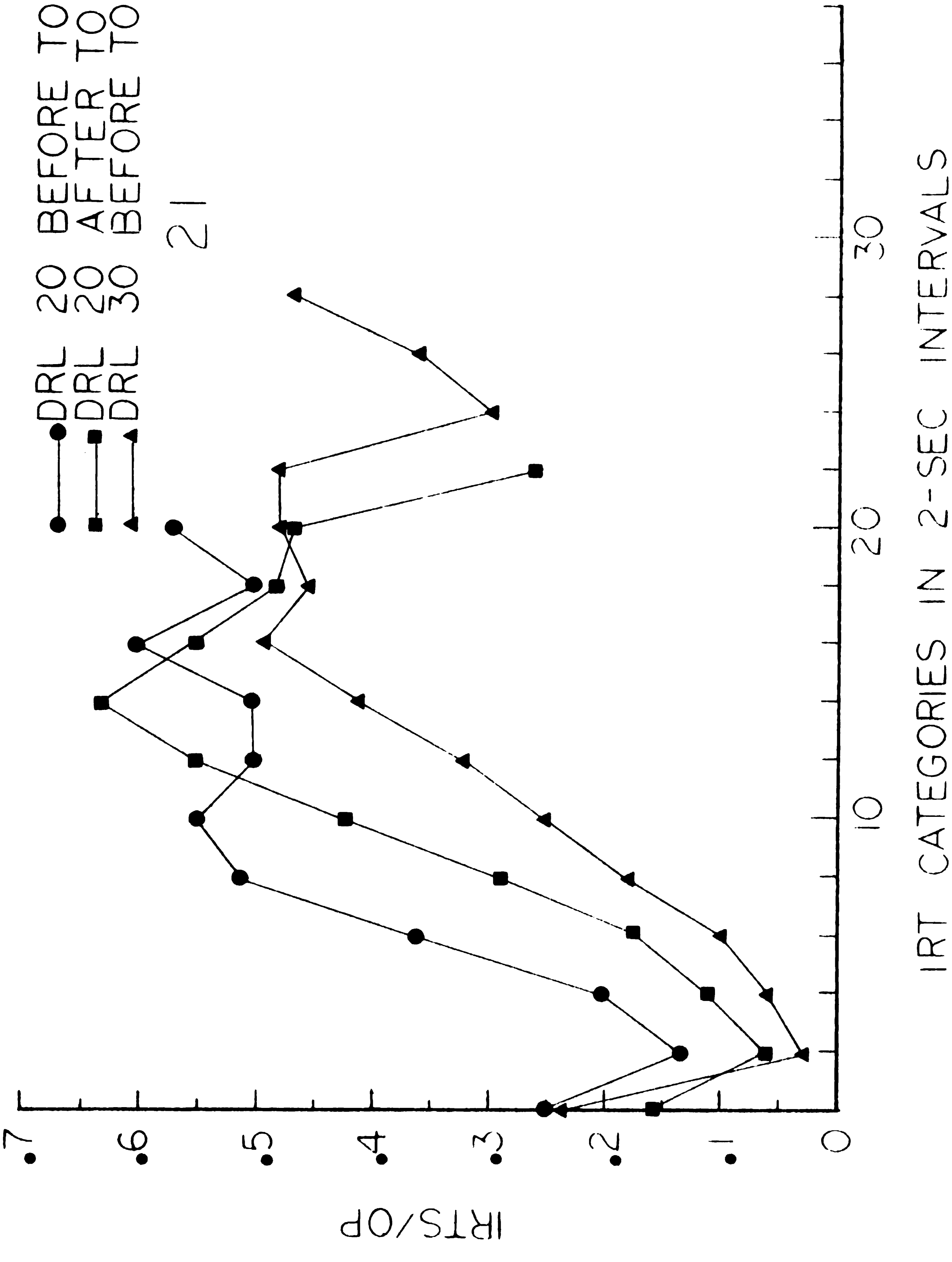

DRL 20 BEFORE TO
DRL 20 AFTER TO
DRL 30 BEFORE TO
23
IRTS/OP
.7
.6
.5
.4
.3
.2
.1
0
10
20
30
IRT CATEGORIES IN 2-SEC INTERVALS

Fig. 8. IRTs/OP values as a function of the IRT categories for Pigeon # 21 on DRL 20-sec before time out (DRL 20 BEFORE TO), DRL 20-sec after time out (DRL 20 AFTER TO), and DRL 30-sec before time out (DRL 30 BEFORE TO). The numbers on the abscissa represent the lower limit of each 2-sec IRT category.



DRL 20 BEFORE TO
DRL 20 AFTER TO
DRL 30 BEFORE TO
21
IRT CATEGORIES IN 2-SEC INTERVALS
IRTS/OP
0
.1
.2
.3
.4
.5
.6
.7
10
20
30

delay requirement at DRL 30-sec prior to the start of the time-out procedure at that value.

Table 1 presents the rate of responding during the conditions shown in the previous graphs as well as the rate of reinforcement for the same conditions. All birds decreased their rate of responding during the time-out sessions at DRL 30-sec over time-out sessions at DRL 20-sec. In addition, the percent decrease in the rate was quite comparable for all birds; 24.2% for Pigeon # 45, 23.8% for Pigeon # 23, and 21.4 for Pigeon # 21. The rate of responding after the time-out period at DRL 20-sec was lower than the rate prior to the time-out condition for all birds. The rate of responding on DRL 30-sec prior to the time-out procedure was lower than the rate at DRL 20-sec after the time out for all birds, further confirming the observation that all birds adjusted their rate of responding to the schedule requirements.

The reinforcement ratios included in Table 1 are in agreement with the data on respons rate. The reinforcement rate at DRL 20-sec during time-out sessions is higher than either before or after the time-out period for all birds, despite large individual differences. The reinforcement rates during time-out sessions at DRL 30-sec are again uniformily higher than before that procedure. Finally, the rate of reinforcement at DRL 30-sec during time-out sessions is equal to or greater than the rate at DRL 20-sec prior to exposure to time out.

Table 1. The response rate and reinforcement rate for each bird before, during, and after the time-out (TO) procedure at DRL 20-sec, and before and during the time-out procedure at DRL 30-sec.

	Responses/min			Reinforcements/min		
Condition	# 45	# 23	# 21	# 45	# 23	# 21
DRL 20 before TO	8.9	8.8	9.7	0.32	0.24	0.04
DRL 20 during TO	3.3	4.2	5.6	1.16	0.51	0.12
DRL 20 after TO	5.4	7.8	6.8	0.97	0.38	0.06
DRL 20 before TO	4.6	5.6	6.0	0.61	0.15	0.02
DRL 20 during TO	2.5	3.2	4.4	0.68	0.25	0.04

DISCUSSION

When time outs followed responses with IRTs which were less than the minimum reinforced value, all birds formed a temporal discrimination. It is unlikely that the birds would have formed this discrimination within 55 sessions since Reynolds (1964b) has shown that pigeons do not perform any better after over 100 sessions than they did after 6 sessions on DRL 20-sec.

The effect of time out in controlling responding on a DRL schedule is roughly similar to the effect achieved with low intensities of shock (Holz and Azrin, 1963; Holz, Azrin, and Ulrich, 1963). But the effect of time out and shock are not exactly the same. When responding was no longer punished with shock, responding reverted back to the pre-shock level, whereas with time out the birds continued to show a temporal discrimination, although there was some loss in discrimination. It should be pointed out that this difference in the rate of responding after removal of punishment as opposed to the removal of time out could be due to procedural differences, since in the studies cited above all responses were followed with shock, whereas in the present experiment only those responses which were not reinforced were followed with a time out.

The controlling effect of the time-out procedure is further stubstantiated by the decrease in the rate of responding and corresponding increase in reinforcement rate at DRL 30-sec from that at DRL 20-sec for all birds, both with and without the time-out procedure in effect. Staddon (1965) has presented IRTs/OP curves for three birds at DRL 20-sec after approximately 220 sessions of responding at various DRL values which are very similar to those presented here for DRL 20-sec with time out. But after apprximately 255 sessions, only one bird showed a temporal discrimination at DRL 30-sec while the rate of responding for the other two birds increased over the rate at DRL 20-sec. The present data show that all three birds formed a temporal discrimination at DRL 30-sec, even prior to the start of the time-out procedure at that value. Thus, pigeons do seem to be able to adjust their rate of responding to the delay requirements of a DRL 30-sec schedule, at least when special techniques are used.

The fact that there was little difference in responding under the three time-out values has important theoretical implications. It has been suggested (Kelleher, Fry, and Cook, 1959; Anger, 1963; Blough and Millward, 1965) that the important factor involved in temporal discriminations is the interoceptive stimulation produced from the last response and not any exteroceptive stimulation, such as a chain of behavior. If this were the case then it would be expected that the birds in this experiment would show a difference in responding under each of the three time-out conditions, since the actual delay necessary between an unreinforced response and the availability of reinforcement was either 25, 30, or 40 sec at DRL 20-sec and 35, 40, or 50 sec at DRL 30-sec. Since prior research indicates that it is unlikely that pigeons could adjust their rate of responding to the delay requirements of a DRL 50-sec schedule, the subjects in this experiment seemed to be estimating the interval by the length of time that the lights were on and not by the length of time from the last response. Therefore, the stimuli that seem to be controlling the discrimination in this experiment do not appear to be the response produced stimuli from the last key peck.

The high probability of responses in the shortest IRT category, which occurred during those conditions when the time-out procedure was not in effect, was quite similar during all three conditions for two of the three birds. Sidman (1956) referred to these short IRTs as bursts, defined as any sequence of two or more responses in which no consecutive responses are separated by more than 2 sec. Sidman showed with rats that the probability of a burst occurring increased as the length of the previous IRT increased, reaching a peak probability just prior to the minimum reinforced value. But there is little published data which has substantiated this same relationship with pigeons, although Holz and Azrin (1963) indicated that they obtained a partial relationship. In fact, those studies which have directly investigated the presence or abscence of this relationship in pigeons, showed that it was absent (Blough, 1963, 1966). Inspection of the present data for each bird did not reveal any consistent relationship between bursts and the length of the previous IRT. In addition, the probability of a burst was practically unchanged before and after time out at DRL 20-sec and before time out at DRL 30-sec while the shape of the IRTs/Op curves were quite different. This suggests that bursts of responding have a separate function, possibly that of providing additional stimulus feedback on a DRL schedule. Two additional facts support this idea; (1) bursts rarely occurred during time-out sessions, the time out providing immediate feedback, and (2) bursts never occurred if the response was reinforced, the response key light and magazine operation providing immediate feedback.

Collateral behavior. It was observed that Pigeon # 45 developed a well-defined chain of responses which effectively filled in the time between responses on both the DRL 20 and DRL 30-sec schedule. This bird would move to the back of the experimental chamber after a response and pace back and forth four to six times. He then approached the left front corner of the chamber, from where he would make a complete turn, and then peck the response key. This behavior is very similar to that reported for one bird by Holz, Azrin, and Ulrich (1963). The other two birds did not form any repeated chain, but both birds consistently turned away from the response key after pecking and moved toward the back of the chamber. The lack of a consistent pattern of behavior in all birds between responses, combined with the observation that all birds moved away from the response key after pecking, seems to indicate that at least some kind of competing behavior might be an important factor in the ability of pigeons to form a temporal discrimination on a DRL schedule. The recognition of this competing behavior, if it does exist in most birds, can only be achieved through direct observation over a long period of time. This could account for the lack of similar observations in the literature.

Concluding remarks. In general, the function of the time out as a special technique for bringing spaced responding under temporal control seems to be that of making the passage of time more salient to the animal. The assumption that animals do not normally attend to time as the relevant variable on a DRL schedule is supported by the findings of Bruner and Revusky (1961), who found that human subjects, exposed to DRL 8.2-sec Limited Hold 2.25-sec had no idea that reinforcement depended in any way upon the passage of time, as judged from post-experimental interviews. Staddon (1965) also suggested that exposing pigeons to various delay requirements over a long period of time makes the passage of time more salient to the animal.

REFERENCES

Anger, D. The dependence of IRTs upon the relative reinforcement of different interresponse times. J. comp. physiol. Psychol., 1956, 52, 146-161.

Anger, D. The role of temporal discrimination in the reinforcement of Sidman avoidance behavior. J. exp. Anal. Behav., 1963, 6, 477-506.

Blough, D. S. Interresponse times as a function of continuous variables: a new method and some data. J. exp. Anal. Behav., 1963, 6, 237-246.

Blough, D. S. The reinforcement of least-frequent interresponse times. J. exp. Anal. Behav., 1966, 9, 581-591.

Blough, D. S and Millward, R. B. Learning: operant conditioning and verbal learning. Annual Rev. Psychol., 1965, 16, 63-94.

Bruner, A. and Revusky, S. H. Collateral behavior in humans. J. exp. Anal. Behav., 1961, 4, 349-350.

Holz, W. C. and Azrin, N. H. A comparison of several procedures for eliminating behavior. J. exp. Anal. Behav., 1963, 6, 399-406.

Holz, W. C., Azrin, N. H., and Ulrich, R. E. Punishment of temporally spaced responding. J. exp. Anal. Behav., 1963, 6, 115-122.

Kellehar, R. T., Fry, W., and Cook, L. Interresponse times distribution as a function of differential reinforcement of temporally spaced responding. J. exp. Anal. Behav., 1959, 2, 91-106.

Reynolds, G. S. Accurate and rapid reconditioning of spaced responding. J. exp. Anal. Behav., 1964, 7, 273-276.

Reynolds, G. S. Temporally spaced responding by pigeons: development and effects of deprivation and extinction. J. exp. Anal. Behav., 1964, 7, 415-421.

Reynolds, G. S. Discrimination and emission of temporal intervals by pigeons. J. exp. Anal. Behav., 1966, 9, 65-68.

Sidman, M. Time discrimination and behavioral interaction in a free operant situation. J. comp. physiol. Psychol., 1956, 49, 469-473.

Staddon, J. E. R. Some properties of spaced responding in pigeons. J. exp. Anal. Behav., 1965, 8, 19-27.

APPENDIX A

Pigeon # 21

Response Frequency

IRT categories (2-sec)	DRL 20 before TO (5 days)	DRL 20 during TO (7 days)	DRL 20 after TO (5 days)	DRL 30 before TO (5 days)	DRL 30 during TO (9 days)
0-1	1513	199	687	889	110
2-3	572	246	188	73	150
4-5	756	373	340	169	269
6-7	1053	631	470	263	418
8-9	950	874	665	404	518
10-11	508	865	674	468	518
12-13	209	760	518	443	507
14-15	107	486	263	390	525
16-17	63	211	85	268	483
18-19	21	99	33	128	380
20-21	12	47	17	75	295
22-23	2	19	5	39	189
24-25	5	11	5	12	99
26-27	2	5	4	11	75
28-29	0	6	4	9	34
30-31	0	1	0	5	16
32-33	0	0	0	3	12
34-35	0	2	0	1	7
36-37	0	3	0	0	1
38 +	0	3	1	1	8

Pigeon # 23

Response Frequency

IRT categories (2-sec)	DRL 20 before TO (5 days)	DRL 20 during TO (9 days)	DRL 20 after TO (5 days)	DRL 30 before TO (5 days)	DRL 30 during TO (9 days)
0-1	1371	41	849	1176	79
2-3	127	55	169	134	78
4-5	433	100	299	212	88
6-7	816	96	191	159	127
8-9	590	148	190	141	128
10-11	308	190	191	158	199
12-13	187	257	167	162	203
14-15	107	276	141	191	215
16-17	92	294	122	178	236
18-19	59	173	81	166	276
20-21	46	110	58	180	277
22-23	19	60	36	144	214
24-25	14	27	13	123	217
26-27	11	7	9	75	177
28-29	8	2	7	55	120
30-31	4	1	3	32	81
32-33	2	2	2	16	47
34-35	4	0	1	10	33
36-37	0	0	1	11	14
38 +	3	3	1	16	36

Pigeon # 45

Response Frequency

IRT categories (2-sec)	DRL 20 before TO (5 days)	DRL 20 during TO (9 days)	DRL 20 after TO (5 days)	DRL 30 before TO (5 days)	DRL 30 during TO (9 days)
0-1	2019	3	311	503	22
2-3	27	11	4	15	28
4-5	101	18	4	9	6
6-7	515	10	3	4	10
8-9	825	11	3	12	11
10-11	538	21	15	4	13
12-13	307	33	32	9	17
14-15	130	62	49	14	16
16-17	97	125	67	12	26
18-19	50	140	78	21	39
20-21	39	104	48	32	54
22-23	37	55	27	65	67
24-25	14	18	9	88	85
26-27	7	12	9	76	88
28-29	5	4	9	77	88
30-31	3	1	5	65	65
32-33	6	2	3	33	72
34-35	1	0	3	25	29
36-37	1	0	2	17	19
38 +	2	1	11	17	12