EFFECTS OF 60 Hz ELECTRIC FIELDS ON OPERANT AND SOCIAL STRESS BEHAVIORS OF NONHUMAN PRIMATES: PROJECTS 3 AND 4

FINAL REPORT: APPENDICES

Department of Energy Contract No. DE-AC01-80RA50219
SwRI Project No. 14-6253

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XI. APPENDIX A - ELECTRIC FIELD RESEARCH PRESENTATIONS, REPORTS, AND PUBLICATIONS MADE BY THE SwRI RESEARCH GROUP DURING THE PERIOD OF DOE CONTRACT DE-AC02-80RA5029

1. Coelho AM Jr. Effects of 60-Hz electric fields of 30 kV/m and 60 kV/m on social stress behaviors of nonhuman primates. Presented at CREIPI; Tokyo, Japan; August, 1987.

2. Coelho AM Jr, Easley SP, Taylor LL and Rogers WR. Effects of electric field on social stress behavior. Presented at Department of Energy Contractors Review; Kansas City, Missouri; November, 1987.

3. Cory WE, Polonis JJ and Rogers WR. High intensity, 60-Hz electric field exposure facility for nonhuman primates. Presented at 5th Annual Meeting, Bioelectromagnetics Society; Boulder, Colorado; June, 1983.

4. Cory WE, Barsun HF, Lucas JH, Polonis JJ and Rogers WR. High intensity 60-Hz electric field exposure facility for nonhuman primates. In: Interaction of Biological Systems with Static and ELF Electric and Magnetic Fields. Anderson LE, Kenman BJ and Wiegel RJ. (eds). Proceedings of the 23rd Hanford Life Sciences Symposium, October 2-4, 1984. Pacific Northwest Laboratory; Richland, Washington; 1987; pp. 101-110.

5. Easley SP, Taylor LL, Coehlo AM Jr and Rogers WR. Effects of exposure to a 30 kV/m electric field on social stress behavior in baboons. Presented at 9th Annual Meeting, Bioelectromagnetics Society; Portland, Oregon; June, 1987.

6. Orr, JL. Effects of 60-Hz electric fields of 30 kV/m and 60 kV/m on operant behaviors of nonhuman primates. Presented at CREIPI; Tokyo, Japan; August, 1987.

7. Orr JL and Rogers WR. Determination of threshold intensity for detection of 60-Hz electric fields. Presented at 7th Annual Meeting of Bioelectromagnetics Society; San Francisco, California; June, 1985.

8. Orr JL, Smith HD and Rogers WR. Effects of 30 kV/m electric fields on the operant behavior of the nonhuman primate. Presented at 9th Annual Meeting, Bioelectromagnetics Society; Portland, Oregon; June, 1987.

9. Orr JL, Rogers WR and Smith HD. Joint CRIEPI/DOE Bioeffects Research Program. Determination of threshold intensity for detection of 60-Hz electric fields by baboons. Project Report for Department of Energy Contract No. DE-AC02-80RA50219; May, 1986.

10. Orr JL, Smith HD, Lucas JH, Moore GT and Rogers WR. Effects of 60-Hz electric fields on operant behavior. Presented at Department of Energy Contractors Review; Kansas City, Missouri; November, 1987.

11. Orr JL, Lucas JH, Moore GT, Smith HD and Rogers WR. Determination of threshold intensity for detection of 60-Hz electric fields. Presented at 8th Annual Meeting, Bioelectromagnetics Society; Madison, Wisconsin; June, 1986.

12. Rogers WR. Overview of CREIPI/DOE 60-Hz electric field bioeffects research program. Presented at CREIPI; Tokyo, Japan; August, 1987.

13. Rogers WR. Status report on joint CRIEPI/DOE 60-Hz Bioeffects Research Program conducted at SwRI; Tokyo, Japan; June, 1986.

14. Rogers WR. Nonhuman primates' thresholds for detection of and escape from 60-Hz electric fields. Presented at Department of Energy Contractors Conference; Alexandria, Virginia; November, 1985. Transmission/ Distribution Health and Safety Report 4:8-9, 1986 (Abstract).

15. Rogers WR. Joint CRIEPI/DOE 60-Hz Bioeffects Research Program. Program review; Project Report for Department of Energy Contract No. DE-AC02-80-RA50219; March, 1986.

16. Rogers WR. Effects of 60-Hz electric fields on the behavior of groups of nonhuman primates. Presented at Department of Energy Contractors Conference; St. Louis, Missouri; November, 1984. Transmission/ Distribution Health and Safety Report 3:9, 1985 (Abstract).

17. Rogers WR. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates. Annual Report submitted to the Department of Energy; October, 1985; SwRI Project 14-6253.

18. Rogers WR. Effects of 60-Hz electric fields on the behavior of groups of baboons. Presented at Department of Energy Contractors Conference. Kansas City, Missouri; November, 1983. Transmission/ Distribution Health and Safety Report 2:2, 1984 (Abstract).

19. Rogers WR. A study of the effects of high intensity, 60-Hz electric fields on baboon behavior: project status report. Presented at 21st Annual Meeting of International Right of Way Association; College Station, Texas; August, 1983.

20. Rogers WR. Effects of 60-Hz electric fields on the behavior of groups of baboons. Presented at Department of Energy Contractors Conference; Denver, Colorado; November, 1982.

21. Rogers WR and Smith HD. Effects of electric fields on posture and position of nonhuman primates. Presented at Department of Energy Contractors Review; Kansas City, Missouri; November, 1987.

22. Rogers WR and Smith HD. Effects of 30 kV/m electric field upon the baboon's postures and positions. Presented at 9th Annual Meeting, Bioelectromagnetics Society; Portland, Oregon; June, 1987.

23. Rogers WR and Orr JL. Determination of threshold intensity for avoidance of 60-Hz electric fields by baboons. Presented at 7th Annual Meeting of Bioelectromagnetics Society; San Francisco, California; June, 1985.

24. Rogers WR, Coelho AM Jr and Orr JL. Effects of 30 and 60 kV/m electric fields on operant and social stress behaviors. Annual Report submitted to the Department of Energy; October, 1987.

25. Rogers WR, Orr JL and Coelho AM Jr. Effects of 60 kV/m electric fields on the behavior of nonhuman primates. Presented at Department of Energy Contractors Conference; Denver, Colorado; November, 1986.

26. Rogers WR, Orr JL and Smith HD. Joint CRIEPI/DOE Bioeffects Research Program. Determination of threshold intensity for avoidance of 60-Hz electric fields by baboons. Project Report for Department of Energy Contract No. DE-AC02-80RA50219; May, 1986.

27. Rogers WR, Lucas JH and Moore GT. Joint CRIEPI/DOE Bioeffects Research Program. Facility Operation and Animal Care. Core Laboratory Reports. Project Report for Department of Energy Contract No. DE-AC02-80RA50219; May, 1986.

28. Rogers WR, Feldstone CS, Gibson EG, Polonis JJ, Smith HD and Cory WE. Effects of high-intensity 60-Hz electric fields on operant and social behavior of nonhuman primates. In: Interaction of Biological Systems with Static and ELF Electric and Magnetic Fields. Anderson LE, Kelman BJ and Wiegel RJ. (eds), Proceedings of the 23rd Hanford Life Sciences Symposium, October 2-4, 1984. Pacific Northwest Laboratory; Richland, Washington; 1987; pp. 365-378.

29. Rogers WR, Orr JL, Easley SP and Coelho AM Jr. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates: Volume I, Summary. Final Report submitted to the Department of Energy; December, 1987; SwRI Project 14-6253.

30. Rogers WR, Coelho AM Jr, Easley SP, Lucas JH, Moore GT, Orr JL, Smith HD, Taylor LL and Tuttle ML. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates: Volume II, Projects 3 and 4. Final Report submitted to the Department of Energy; December, 1987; SwRI Project 14-6253.

31. Rogers WR, Coelho AM Jr, Lucas JH, Moore GT and Orr JL. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates. Annual Report submitted to the Department of Energy; October, 1987; SwRI Project 14-6253.

32. Rogers WR, Coelho AM Jr, Lucas JH, Moore GT and Orr JL. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates. Annual Report submitted to the Department of Energy; October, 1986; SwRI Project 14-6253.

33. Rogers WR, Lucas JH, Moore GT, Smith HD and Tuttle ML. Effects of 60-Hz electric fields on operant and social stress behaviors of nonhuman primates: Volume III, Facility operation and animal health during projects 3 and 4. Final Report submitted to the Department of Energy; December, 1987; SwRI Project 14-6253.

34. Rogers WR, Lucas JH, Moore GT, Smith HD and Orr JL. 60-Hz electric fields do not serve as a negative reinforcer in nonhuman primates. Presented at 8th Annual Meeting, Bioelectromagnetics Society; Madison, Wisconsin; June, 1986.

XII. APPENDIX B - ADDITIONAL DETAILS ON PROJECT 3 RESULTS

A. Results of Experiment I (30 kV/m)

1. Analyses of Data by Weeks

Data array.-- The data array for these eight ANOVAs included 12 rows (six for Experimental group subjects and six for Control group subjects) and 18 columns (six means from the Weeks of each of the three Periods (Pre-Exposure, Exposure, and Post-Exposure). Thus, each array consisted of 216 entries. To produce each data point in the array, the Crosstab routine of the Reflex software package was used to examine the complete database and to average each subject's performance data across the six sessions of each day and the seven days of the week. Thus, each data point is the mean of approximately 42 or 30 points. (In weeks One, Three, Four, and Six, the animals worked seven days a week; in weeks Two and Five, the animals worked on only five days due to the regularly scheduled cage cleaning and mapping.) Overall, we conducted 97.5 percent of the scheduled sessions, so missing data are not a problem in this program. (Missed sessions almost always occurred because of equipment malfunction.)

ANOVA design.-- The form of the ANOVA summary table is given in Table XII.1. It is a three-factor, mixed design with one between-subjects factor and two within-subjects factors. B.J. Winer (Statistical Principles in Experimental Design, New York, McGraw-Hill, 2nd edition, 1971, pp. 539 ff) calls the p × q × r factoral experiment with repeated observations on the last two factors "Case I"; his text provides a full explanation, accompanied by several examples, of the use of this design. E.F. Lindquist (Design and Analysis of Experiments in Psychology and Education, Boston, Houghton Mifflin, 1953, pp. 267 ff) calls this a "Type I" design.

Not all of the F ratios are of equal interest. For example, a Groups effect by itself is not of interest if the Groups differ equally in the Pre-Exposure, Exposure, and Post-Exposure periods, meaning electric field exposure has had no effect. Likewise, a Week effect is not of interest if the pattern of weekly means is the same for Groups and Periods. Even a Period effect by itself is of no interest unless the pattern of means among Pre-Exposure, Exposure, and Post-Exposure periods differ by Group in a manner which is related to electric field exposure of the Experimental group.

We are more interested in the "interactions" of the variables than in their "main effects." A Group × Period interaction or a Period × Weeks interaction introduces the possibility that electric field exposure has made a difference with respect to the dependent variable being analyzed. The "triple" interaction of Group × Period × Weeks also is of interest, but the Group × Weeks interaction by itself is not.

As an example, the complete summary table produced by the ANOVA for weekly mean number of DRL responses per session is indicated in Table XII.2. The analysis indicated that the mean number of DRL responses made per session did not vary with Group, Period, or Weeks. This specific example is given to illustrate in detail the form of the ANOVA.

Table XII.1

General Summary of the ANOVAs Resulting when Experiment I (30 kV/m) Data were Analyzed by Weeks

Source	SS	df	MS	F	P<
Between Groups					
GROUP	XX	1	YY	X.X	.xx
Error	XX	10	YY		
Within Groups					
PERIOD	XX	2	YY	X.X	.xx
GROUP × PERIOD	XX	2	YY	X.X	.xx
Error	XX	20	YY		
WEEK	XX	5	YY	X.X	.xx
GROUP × WEEK	XX	5	YY	X.X	.xx
Error	XX	50	YY		
PERIOD × WEEK	XX	10	YY	X.X	.xx
GROUP × PERIOD × WEEK	XX	10	YY	X.X	.xx
Error	XX	100	YY		
Total	XXX	215			

Table XII.2

ANOVA Summary Table for Weekly Mean Number of Responses Made per DRL Session

Source	df	MS	F	P<
GROUPS	1	67,734	2.160	.17
Error	10	31,356		
PERIOD	2	1,307	0.902	
G×P	2	1,645	1.135	.34
Error	20	1,449		
WEEKS	5	370	0.703	
G×W	5	396	0.752	
Error	50	527		
P×W	10	625	1.411	.19
G×P×W	10	319	0.719	
Error	100	443		

Overall, the Experimental group made 83.8 responses per session and the Control group made 48.4. The mean number of responses made during Pre-Exposure, Exposure, and Post-Exposure were 69.9, 61.5, and 66.9, respectively. During Weeks One through Six, respectively, the mean responses were 71.9, 65.7, 63.5, 63.8, 64.3, and 67.4. Figure XII.1 provides the means and standard deviations (SD) for the Control and Experimental groups.

Homogeneity of variance.-- ANOVA makes several assumptions, including normality of distributions and homogeneity of the variances, about the nature of the data being examined, and failure to uphold these assumptions can produce misleading ANOVA results. Although statisticians have differing opinions on the issue (cf. B.J. Winer, Statistical Principles in Experimental Design, 2nd Edition, New York, McGraw-Hill, 1971, pp. 205-210; and W.L. Hays, Statistics for Psychologists, New York, Holt, Rinehart & Winston, 1963, 380-381), it is common practice to examine the data following completion of an ANOVA to determine, conducting Hartley's F max test, whether the assumption of homogeneity of variance is tenable.

Winer (p. 206 ff) discusses the use of Hartley's F max test to evaluate this assumption. The largest treatment variance is divided by the smallest, and the resulting number is evaluated relative to the distribution of the F max statistic with degrees of freedom equal to k, n - 1: k is the number of treatment variances, and n is the sample size. In our case, k = 35 and n = 6. The largest k given in Table C.7 of Winer is 10; the critical value of the ratio is 26.5 for $P<.05$.

In the case of mean number of DRL responses per session, the largest variance is 7,257 and the smallest is 45. Thus, the F max statistic is 163, indicating that the variances are not all approximately the same size. To deal with this problem, the data should be subjected to a transformation, such as log or square root, to produce a scale of measurement where the variances are homogeneous. Thus, stictly speaking, the ANOVA presented above is not valid; it must be repeated after the data have been subjected to a transformation which produces homogeneity of variance. The ANOVA and the F max tests can then be repeated. We have followed this practice.

The results of the F max tests on all of the data from Experiment I analyzed by Weeks are given in Table XII.3. In the table, for small n, the critical value increases noticeably as k increases. Thus, we made very conservative tests using 26.5 as the criterion value.

"Raw" (untransformed) scores were used for three variables where the F max test failed to reject the hypothesis of no differences among variances. The common log (base 10) transformation achieved homogeneity in two cases, and the square root transformation was used in another instance. Neither of the two most commonly used transformations achieved homogeneity for two variables, so the data set with the smallest F max value was used. Fortunately, ANOVA is regarded widely to be "robust," i.e., it functions well even if homogeneity is not present in a data set, so these two ANOVAs probably produced meaningful results.

Major means.-- For each of the eight variables in this set of analyses, the means for the two Groups and three Periods are given in Table XII.4. The differences between Groups for mean number of FR responses, DRL responses,

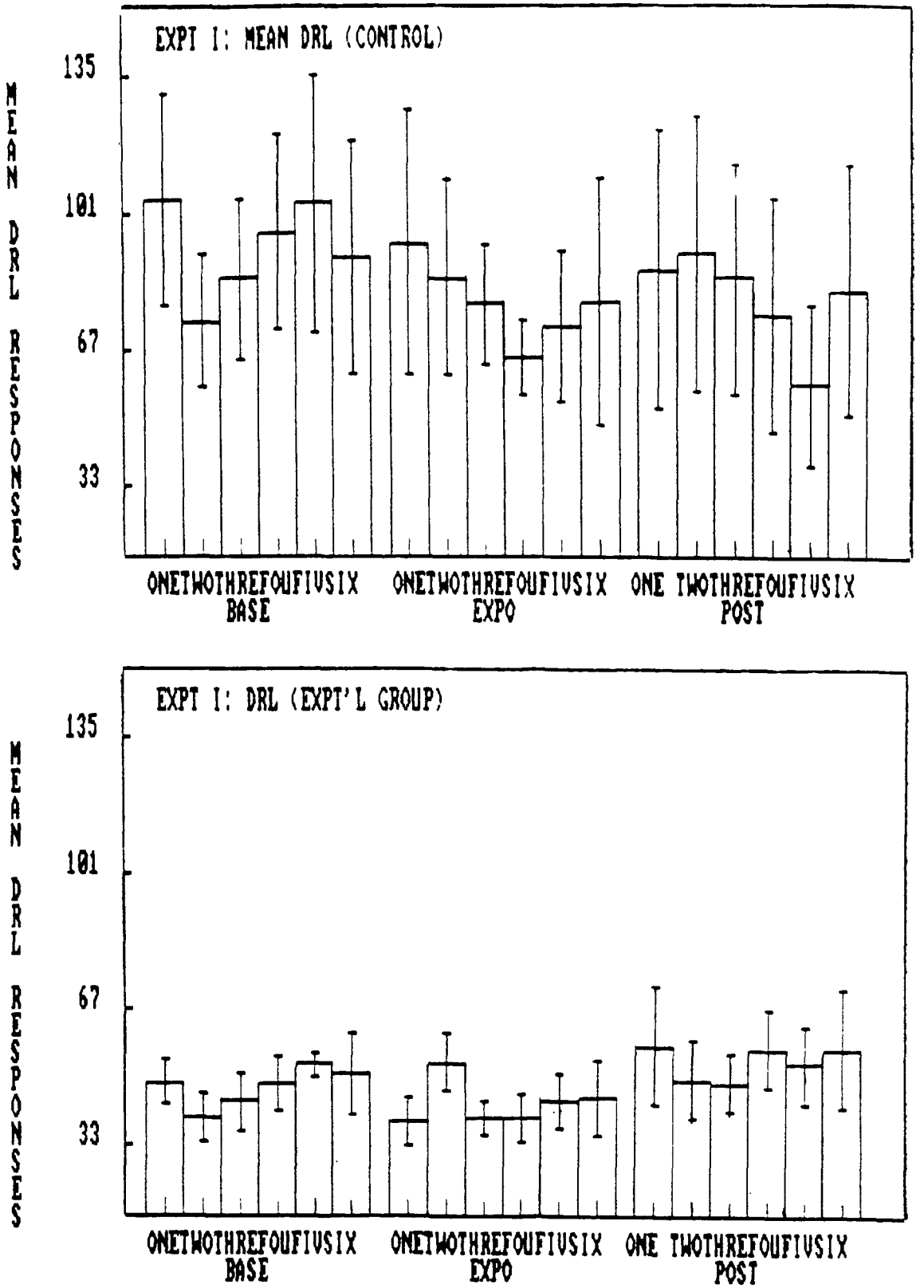


Figure XII.1. The upper panel shows the weekly mean number of DRL responses per session for the Control group, and the lower panel provides the same information for the Experimental group. The bars indicate the standard errors for the means. The data are from Experiment I (30 kV/m).

Table XII.3

Summary of Results of F Max Tests of 36 Treatment Variances for Experiment I (30 kV/m) Data by Weeks

Variable	Raw Score	Log	Square Root
Mean FR Resp.	4.9#	NA	NA
SD FR Resp.	13.5#	NA	NA
Mean DRL Resp.	163	8.6#	NA
SD DRL Resp.	37	8.5#	NA
Mean DRL Rew.	73.5#	231	115
SD DRL Rew.	21.1#	NA	NA
Mean DRL Eff.	65.7#	NA	25.5#
SD DRL Eff.	2485	28.2#	212

Used in ANOVA.

Table XII.4

Summary of Principal Means from ANOVAs of Experiment I (30 kV/m) Data by Weeks

	Group		Period		
Variable	Contr.	Exper.	Pre.	Expo.	Post.
Mean FR Resp.	1287	776	965	1015	1115
SD FR Resp.	554	524	446	567	604
Mean DRL Resp.	84	48	70	61	67
SD DRL Resp.	54	43	48	50	48
Mean DRL Rew.	25	20	24	22	22
SD DRL Resp.	6.1	9.9	7.4	8.3	8.5
Mean DRL Eff.	3.9	2.7	3.3	3.3	3.4
SD DRL Eff.	2.7	2.2	2.3	2.5	2.6

and DRL rewards appear relatively large. Inspection of the means for Periods does not detect impressive orderly differences which might be attributed to an effect occurring during the Exposure period.

ANOVA summary.-- For each of the seven F ratios on all eight variables, Table XII.5 presents all probability values less than 0.10. The conventional practice is to use the probability of a Type I error at $P<.05$ as the decision rule for rejecting the null hypothesis (of no difference) and accepting the alternative hypothesis that the experimental variable has had a statistically significant effect on the measure of interest.

Table XII.5

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment I (30 kV/m) Data by Weeks

Variable	Group	Period	G×P	Week	G×W	P×W	G×P×W
FR Resp.	.04	NS@	NS	.03	NS	NS	.07
SD Resp.	.08	.001	NS	.05	NS	.10	NS
DRL Resp.	NS	NS	NS	NS	NS	NS	NS
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	.10	NS	NS	NS	NS	.02	NS
SD Rew.	NS	.10	NS	NS	NS	NS	.07
DRL Eff.	NS	NS	NS	NS	NS	NS	NS
SD Eff.	NS	NS	NS	NS	NS	NS	NS

@ Not significant.

FR responses.-- Overall, the Control group made an average of 1287 responses per 15 minute component, while the Experimental group made 776. This difference is statistically significant ($P<.04$). On the FR30 task, the number of rewards earned is estimated accurately by the integer number resulting when the number of responses is divided by 30. Thus, we did not analyze FR rewards as a separate variable. The Control animals earned an average of 42 rewards, and the Experimental group received an average of 26 rewards per component. However, the group difference occurred across all three experimental Periods, so this observation is unrelated to field exposure. With only six animals per group, relatively poor performance by only one animal strongly affects the mean for the group. The mean performance of the West end animals happened to be less than that of the East end animals from the first week of Pre-Exposure.

The average scores by Week also differed significantly ($P<.03$): the means for weeks One through Six, respectively, were 1,019, 963, 990, 1,062, 1,012, and 1,144. This represents variation of 7 percent to 11 percent from the grand mean. By itself, this finding is of little interest in an electric field bioeffects experiment because the means for Weeks are computed across both the three experimental Periods (Pre-Exposure, Exposure, and Post-Exposure) and the two Groups (Control and Experimental).

Analyses of the variability in FR responding detected two statistically significant F ratios, neither of which is indicative of an electric field effect. The means for the Pre-Exposure (446), Exposure (567), and Post-Exposure (604) periods differed significantly ($P<.001$). The means for Weeks also differed significantly ($P<.05$). This represents variation from 8 percent to 9 percent from the overall mean. The cell means for weeks One through Six were 533, 497, 527, 536, 556, and 585. A Period × Group interaction would have been much more interesting.

DRL responses.-- No statistically significant F ratios were found when the data on either mean or SD of DRL responses were tested by ANOVA. The mean number of DRL responses per 15 minute component for the Control group was 84, and the mean for the Experimental group was 48.

DRL rewards.-- Although the Control group always received more DRL rewards (Figure XII.2), the Group's effect was not statistically significant ($P<.10$). The means were 25 for the Control group and 20 for the Experimental group. The ANOVA also indicated the existence of a significant ($P<.02$) Period × Week interaction. Although the F ratios for Period ($P<.10$) and Period × Weeks ($P<.07$) had relatively small probability values, neither meet the conventional level of $P<.05$ for a Type I error.

DRL efficiency.-- No statistically significant effects were detected by the ANOVAs conducted on the data for either the mean or the SD of DRL efficiency. DRL efficiency is defined as the number of DRL responses per component divided by the number of DRL rewards received/component. Perfect performance would result in an efficency index of 1.0. The means for Control and Experimental groups were 3.9 and 2.7, respectively, meaning the Experimental group performed the DRL task slightly more efficiently.

Efficiency, the key measure of DRL performance, is described as the number of responses made divided by the number of rewards. Ideal performance would be 1.0. However, the efficiency index can be larger than 1.0 for several reasons. One, an animal can be performing poorly and emitting responses after incorrect, either systematically or randomly, inter-response variables. Two, an animal can make responses with correct inter-response times, but then make several responses in rapid succession as it impatiently works to earn its reward. We believe our animals followed the latter pattern.

2. Analyses by Sessions

Data array.-- For this approach, the data were averaged across the six weeks of each Period, meaning each data point is based on approximately 38 operant sessions. (Four weeks with seven days and two weeks with five days.) The array includes 12 rows from two Groups of six subjects; each subject has 18 scores, one for each of the six daily Sessions from each of the three experimental Periods.

ANOVA design.-- The ANOVA summary table (Table XII.6) for this set of analyses is the same as that summarized in Table XII.2 except Session replaces Week.

Homogeneity.-- For this set of F max tests (Table XII.7), the critical value selected from Table C.7 in Winer (1971) again was 26.5 for $n = 6$, $k = 10$, and $P<.05$.

Major means.-- The primary treatment means for the two Groups and the three Periods are given in Table XII.4. Because the analyses by Weeks and Sessions use the same data, the means are essentially the same and thus are not presented and discussed again.

ANOVA summary.-- Table XII.8 summarizes the results of this set of ANOVAs. Session effects occur in all cases, and several main effects and interactions also were detected.

FR responses.-- Overall, the Control group made an average of 1298 FR responses per component while the Experimental group made only 779; this difference is statistically significant ($P<.04$). As with all eight variables in this set, the Session effect was highly significant ($P<.0001$). The Period

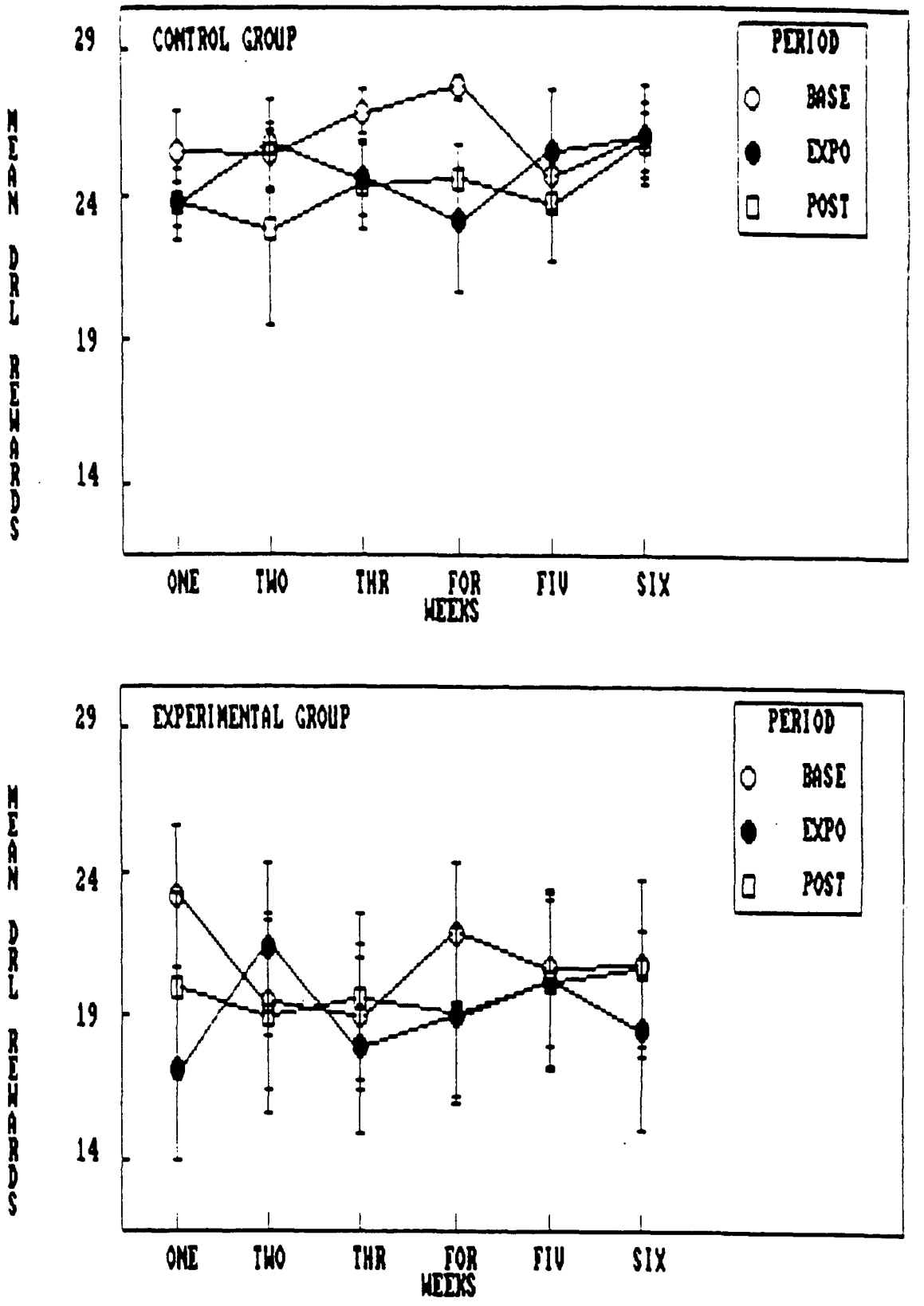


Figure XII.2. Mean DRL rewards per component for Experimental and Control groups of Experiment I (30 kV/m). The vertical bars indicate the standard errors (SEM) of the means.

Table XII.6

General Summary of the ANOVAs Resulting when Experiment I (30 kV/m) Data were Analyzed by Sessions

Source	SS	df	MS	F	P
Between Groups					
GROUP	XX	1	YY	X.X	<.XX
Error	XX	10	YY		
Within Groups					
PERIOD	XX	2	YY	X.X	<.XX
GROUP × PERIOD	XX	2	YY	X.X	<.XX
Error	XX	20	YY		
SESSION	XX	5	YY	X.X	<.XX
GROUP × SESSION	XX	5	YY	X.X	<.XX
Error	XX	50	YY		
PERIOD × SESSION	XX	10	YY	X.X	<.XX
GROUP × PERIOD x SESSION	XX	10	YY	X.X	<.XX
Error		100			
Total	XXX	215			

Table XII.7

Summary of Results of F Max Tests of 36 Treatment Variances for Experiment I (30 kV/m) Data by Sessions

Variable	Raw Score	Log	Square Root
Mean FR Resp.	6.6#	NA	NA
SD FR Resp.	16.4#	NA	NA
Mean DRL Resp.	52.3	74.4	18.8#
SD DRL Resp.	52.5	14.6#	NA
Mean DRL Rew.	69.1#	900	186
SD DRL Rew.	11.3#	NA	NA
Mean DRL Eff.	56.3	13.8#	NA
SD DRL Eff.	744	13.7#	NA

Used in ANOVA.

Table XII.8

Summary of Lowest Probablities for F Ratios
in Analyses of Experiment I (30 kV/m) Data by Sessions

Variable	Group	Period	G×P	Session	G×S	P×S	G×P×S
FR Resp.	.04	NS@	NS	.001	NS	.001	NS
SD Resp.	NS	.05	NS	.002	.02	NS	NS
DRL Resp.	NS	NS	NS	.001	NS	NS	NS
SD Resp.	NS	NS	.10	.001	NS	NS	NS
DRL Rew.	NS	.07	NS	.001	NS	.005	.07
SD Rew.	NS	NS	NS	NS	NS	NS	NS
DRL Eff.	NS	NS	NS	.001	NS	NS	NS
SD Eff.	NS	NS	NS	.001	NS	NS	NS

@ Not significant.

× Session interaction also was significant (P<.0001). The means for the interaction are given below:

Period	One	Two	Three	Four	Five	Six	Mean
Pre.	657	934	905	1,234	1,140	968	973
Expo.	520	916	1,003	1,387	1,259	1,002	1,014
Post.	602	1,092	1,208	1,473	1,472	927	1,129
Mean	593	980	1,039	1,365	1,290	966	

Figure XII.3 shows the data from the two groups. The "inverted U" shape is clear for both groups, and the higher mean level for the Control group also is apparent. For the Control group, the Session means for the Exposure period fall between the means for the Pre-Exposure and Post-Exposure periods, and all seem to overlap. The same is true for the Experimental group, but the variation for the means among Periods seems to be even less than for the Control group.

Variability in FR responding exhibited three statistically significant F ratios. The mean SD values for the difference is at the P<.05 level. The Session (P<.002) and the Group × Session effects (P<.02) also were significant. The means for the Group × Session effect are indicated below:

Group	One	Two	Three	Four	Five	Six	Mean
Contr.	444	444	515	410	469	684	494
Exper.	304	459	501	445	516	458	447
	374	452	508	427	492	571	

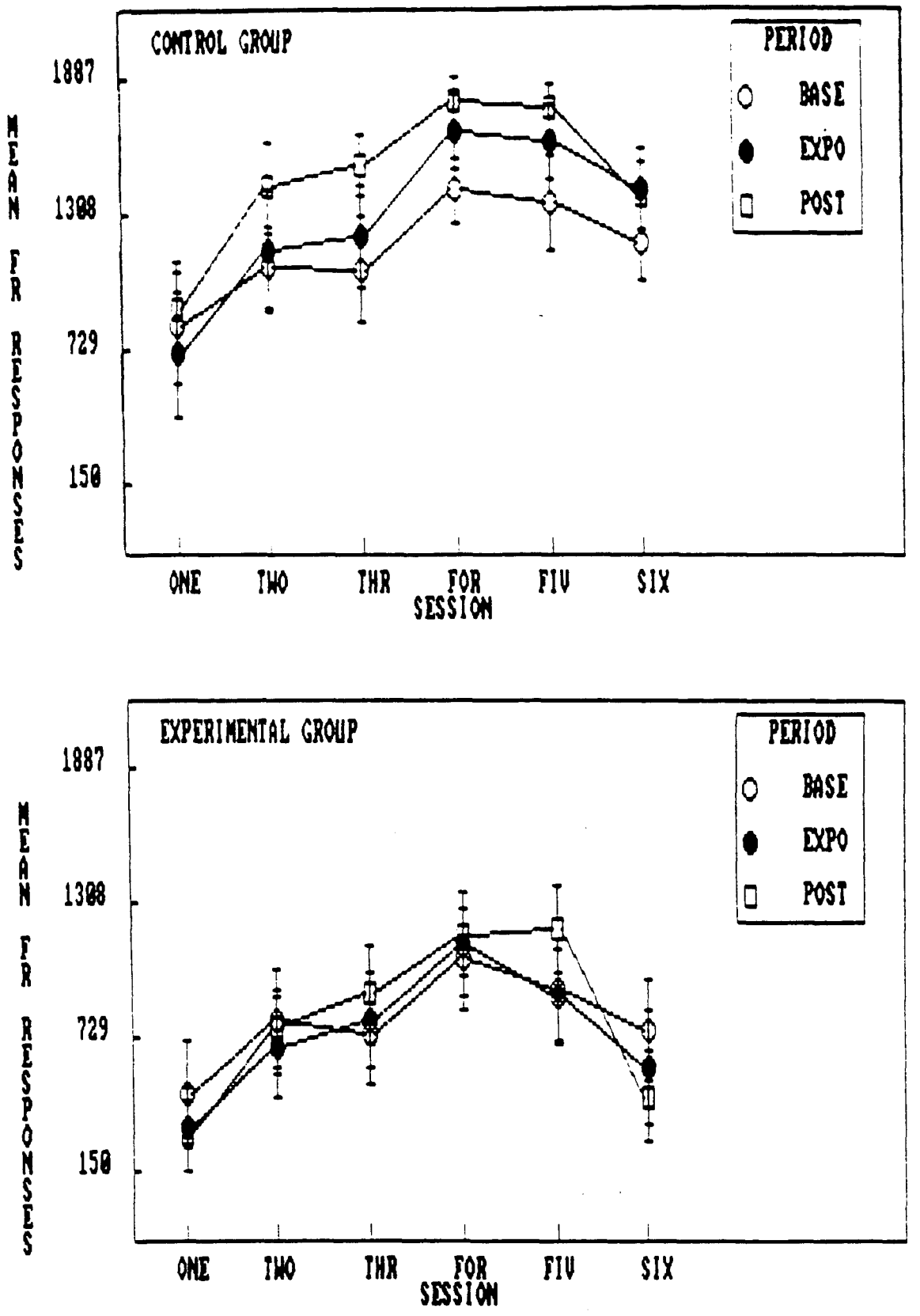


Figure XII.3. For Experiment I (30 kV/m), Mean FR responses per component for the Control and Experimental groups during three Periods (Pre-Exposure, Exposure, and Post-Exposure) for six Sessions distributed over a 12-hour period each day. The vertical bars indicate the standard error (SEM) of the mean.

As indicated in Figure XII.4, the Control group's means for the three Periods differ by little. Interestingly, their Session means lack the "inverted U" shape usually seen in data from this experiment when Sessions are a factor. The Experimental group also shows little difference among the three Period means, and the pattern of Session means is more like the "inverted U".

DRL responses.-- The only statistically significant effect was the Session effect ($P<.0001$). The arithmetic means of the raw data, by Session, were 36, 65, 62, 91, 80, and 64. When the variability in DRL responses was examined, the Session effect for the SD data also was significant ($P<.0001$). The means for Sessions One through Six were 28, 46, 38, 57, 54, and 55, respectively.

DRL rewards.-- For mean DRL rewards/component, the Session ($P<.0001$) and Condition × Session ($P<.005$) effects were statistically significant. The means for the Condition × Session effect are given below:

Period	One	Two	Three	Four	Five	Six	Mean
Pre.	18	23	22	26	25	22	23
Expo.	12	20	20	26	23	20	20
Post.	13	22	22	26	24	17	21
Mean	15	22	21	26	24	20	

The plot of all of the principal means (Figure XII.5) appears typical of the others presented previously. The SDs of these means displayed only a significant Session effect. The mean SDs were ($P<.04$) 7.6, 8.2, 8.4, 6.1, 7.3, and 8.1 for Sessions One through Six.

DRL efficiency.-- Mean DRL efficiency differed only with respect to Session. The six (untransformed) means were 2.4, 3.8, 3.9, 2.4, 2.6, and 2.9. The data show no sign of an electric field effect on DRL performance of non-human primates. The same result occured with respect to the SD of mean DRL efficiency: the Session effect was highly significant ($P<.0001$), and it was the only statistical effect detected. The six Session means were 1.2, 2.3, 2.2, 2.9, 2.6, and 4.2. The animals were less efficient during the last session (9:00-9:30 p.m.) of the day.

3. Analyses by Days

Introduction.-- In general, the a priori analyses were planned to search for "chronic" field effects in a design including Pre-Exposure, Exposure, and Post-Exposure periods. The analysis of variance (ANOVA) model described in the proposal and protocol was completed, and we found relatively few statistically significant effects relating to electric field exposure. However, the data suggested that the effect of electric field exposure was a transient effect occurring on the first few days of electric field exposure. The statisticians urged us to complete some post hoc data analyses designed to describe these "acute" field effects. We completed these additional data analyses, and the results now available support our observation that electric field exposure has a transient effect on operant behavior.

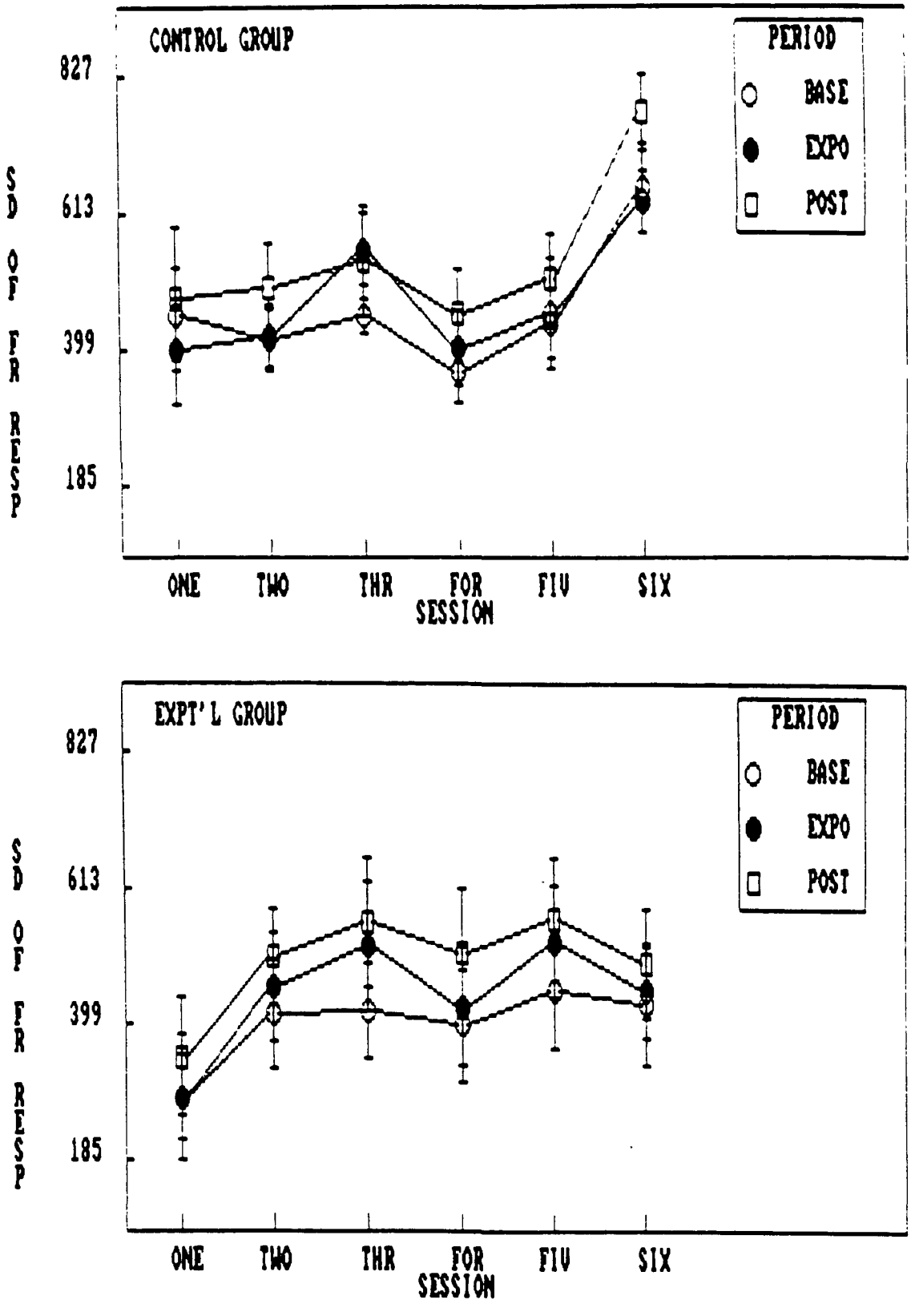
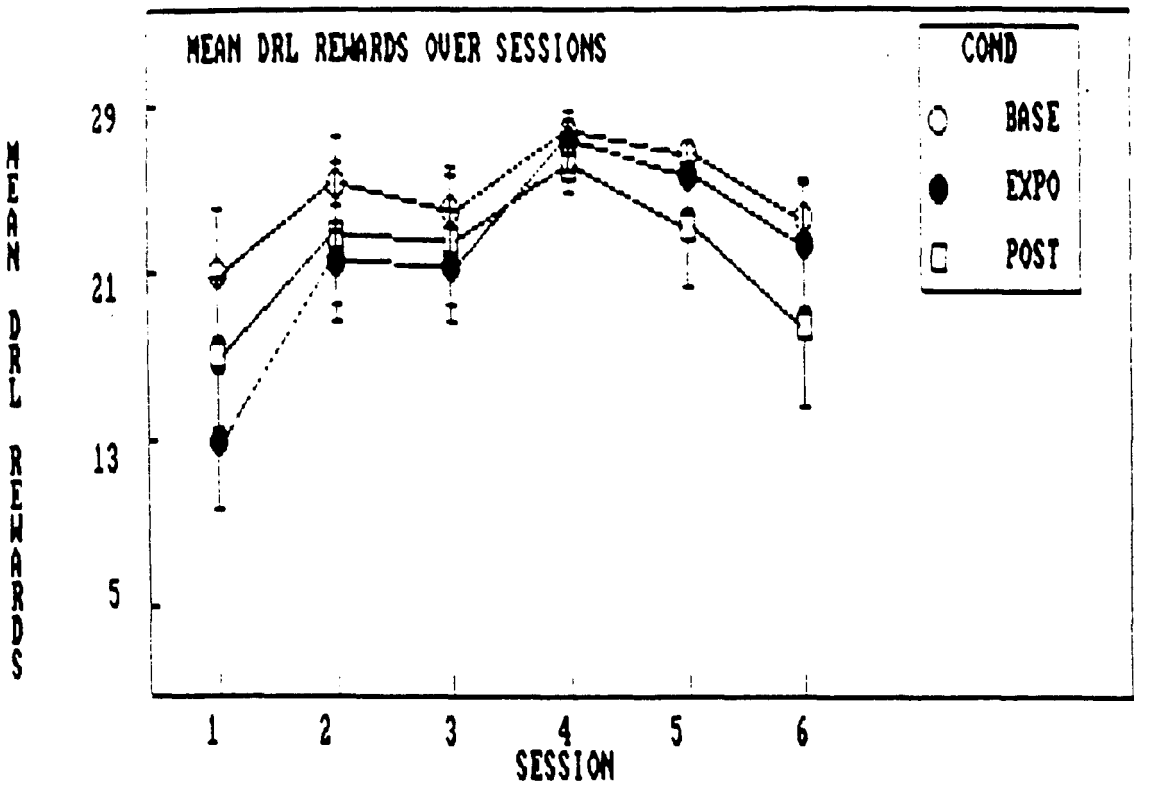


Figure XII.4. Plots of mean SD for the Control and Experimental groups of Experiment I (30 kV/m) over the six daily Sessions for the three Experimental Periods. Standard errors also are shown.



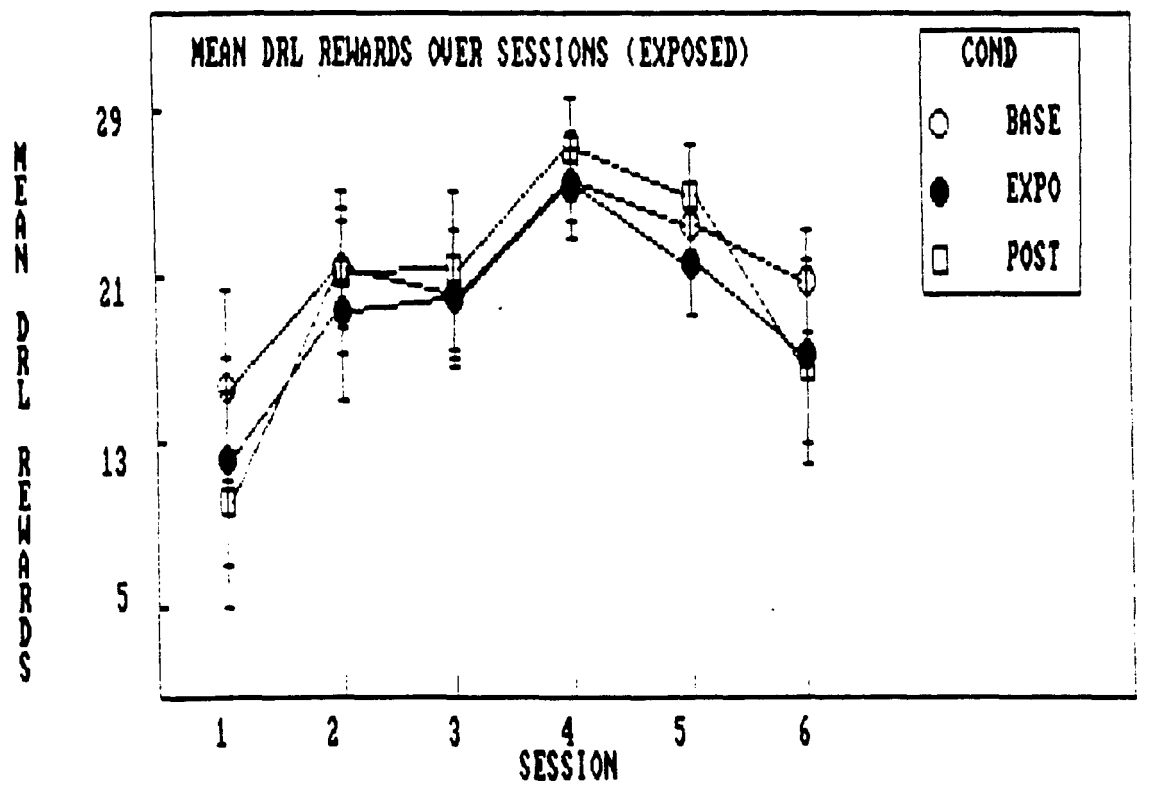


Figure XII.5. Mean DRL rewards, with SEMs, earned by Control and Experimental groups for the six daily Sessions by three Experimental Periods of Experiment I (30 kV/m).

Results.-- Analysis of the data from the last week of Pre-Exposure and the first week of Exposure presents a different picture. As indicated in Figure XII.6 for mean FR responses, the animals clearly made a reduced number of responses on the first day of electric field exposure. However, on subsequent days, the FR responding of the exposed animals during Exposure did not differ from their behavior during the preceding week. Analysis of the data for mean DRL responses per component (Figure XII.7) and mean DRL rewards per component (Figure XII.8) indicates the same result occurred. .

For this data set (including both Pre-Exposure and Exposure periods), the Experimental group received an average of 14 percent fewer rewards on the DRL task than did the Control group (Table XII.9). With the Experimental and Control groups combined, mean DRL rewards received per component during Exposure was 12 percent less than mean DRL rewards during Pre-Exposure. The four means for the Period by Group interaction effect indicate that the Control group earned DRL rewards at (about) the same rate during Pre-Exposure and Exposure, but the Experimental group received 17 percent few rewards during seven days of Exposure than they had during seven days of Pre-Exposure. Examination of the daily means (averaged across groups and periods) shows that performance on day one, and perhaps on day two, was less than on the other days.

Table XII.9

Summary of Major Means for DRL Rewards in Experiment I (30 kV/m) Data by Days

Factor	Mean	Factor	Mean
Control	22.2	Day 1	18.9
Experimental	19.1	Day 2	22.1
Pre-Exposure	21.9	Day 3	21.4
Exposure	19.4	Day 4	21.8
Control (Pre.)	22.9	Day 5	21.2
Control (Expo.)	21.4	Day 6	19.3
Expt'l (Pre.)	20.9	Day 7	19.9
Expt'l (Expo.)	17.4		

The ANOVA of the DRL reward data (Table XII.10) is particularly interesting because many statistically significant effects were detected. Further analysis and interpretation is required, but these results appear to support the original hypothesis that DRL performance might be particularly sensitive to ELF electromagnetic field exposure.

4. First Few Sessions

Sessions.-- We also have begun to examine the data Session by Session during the first few days of exposure. For example, Figure XII.0 presents data on mean FR responses per 15-minute component for Control and Experimental animals. The mean performance on the last seven days of Pre-Exposure is shown

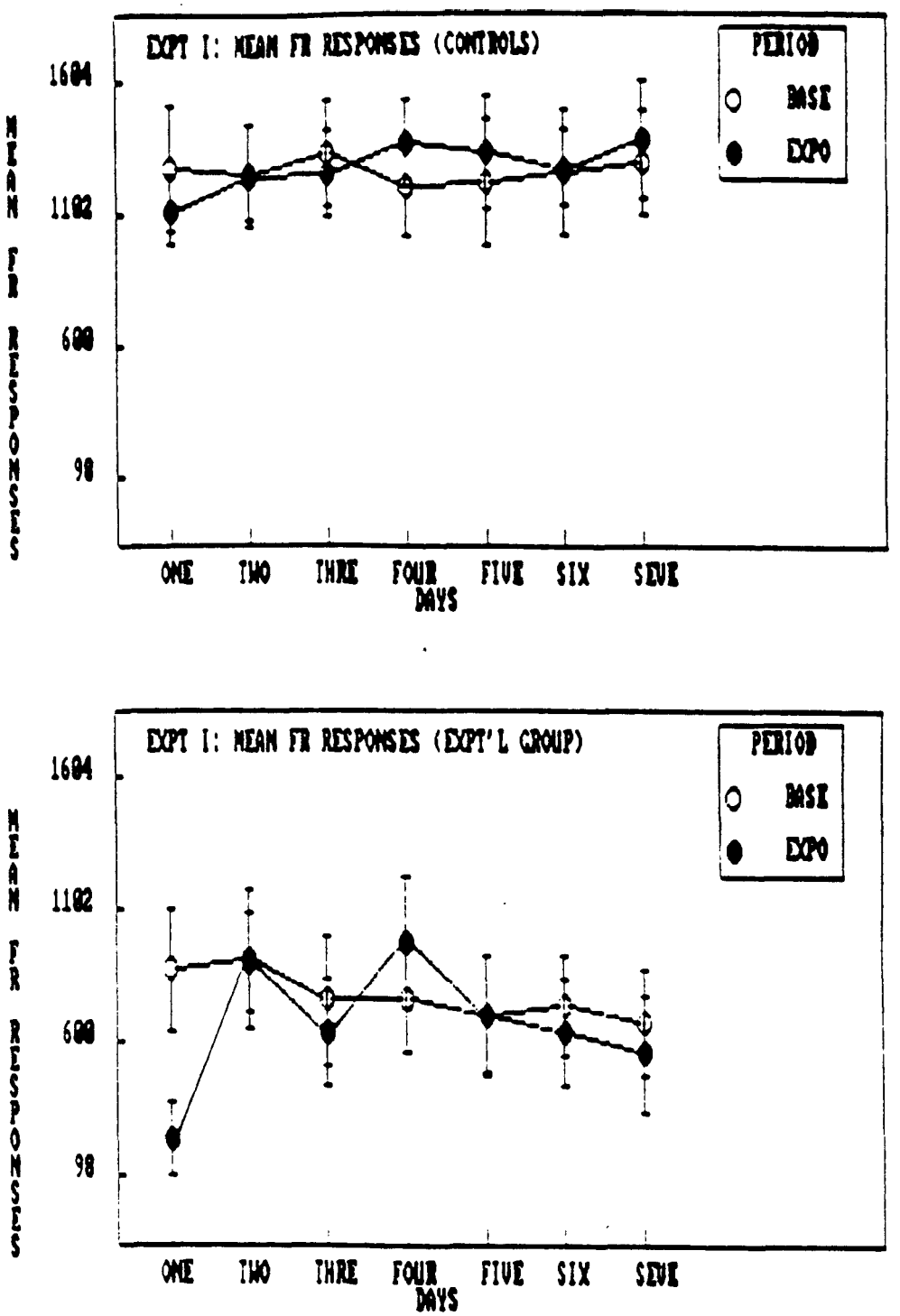


Figure XII.6. Mean FR responses per day for Control (top) and Experimental (bottom) animals of Experiment I (30 kV/m) during the last week of the Pre-Exposure period and the first week of the Exposure period.

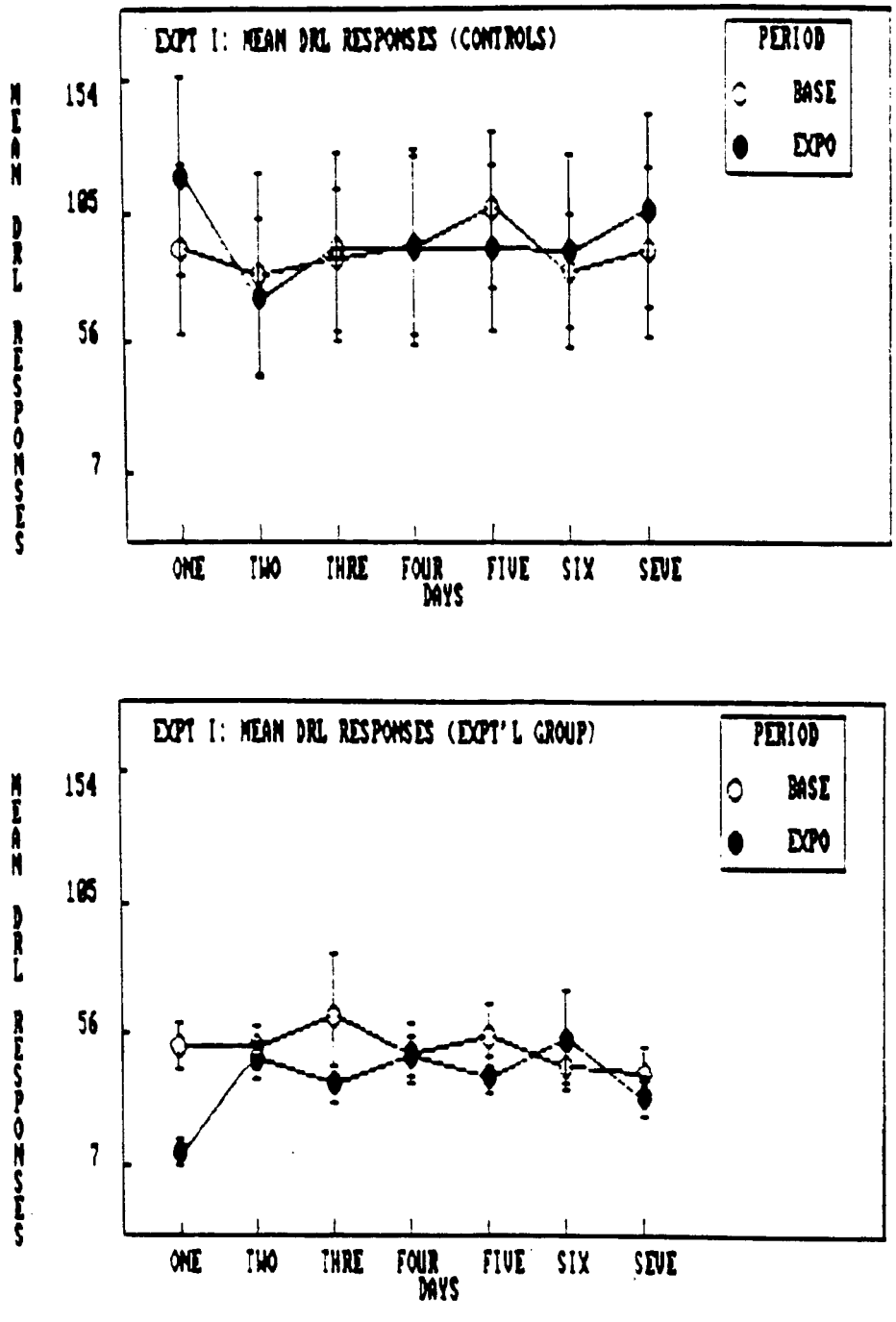


Figure XII.7. Mean DRL responses per component for the Control (upper panel) and Experimental groups of Experiment I (30 kV/m) on the last seven days of the Pre-Exposure period and the first seven days of the Exposure period. The error bars indicate the SEM.

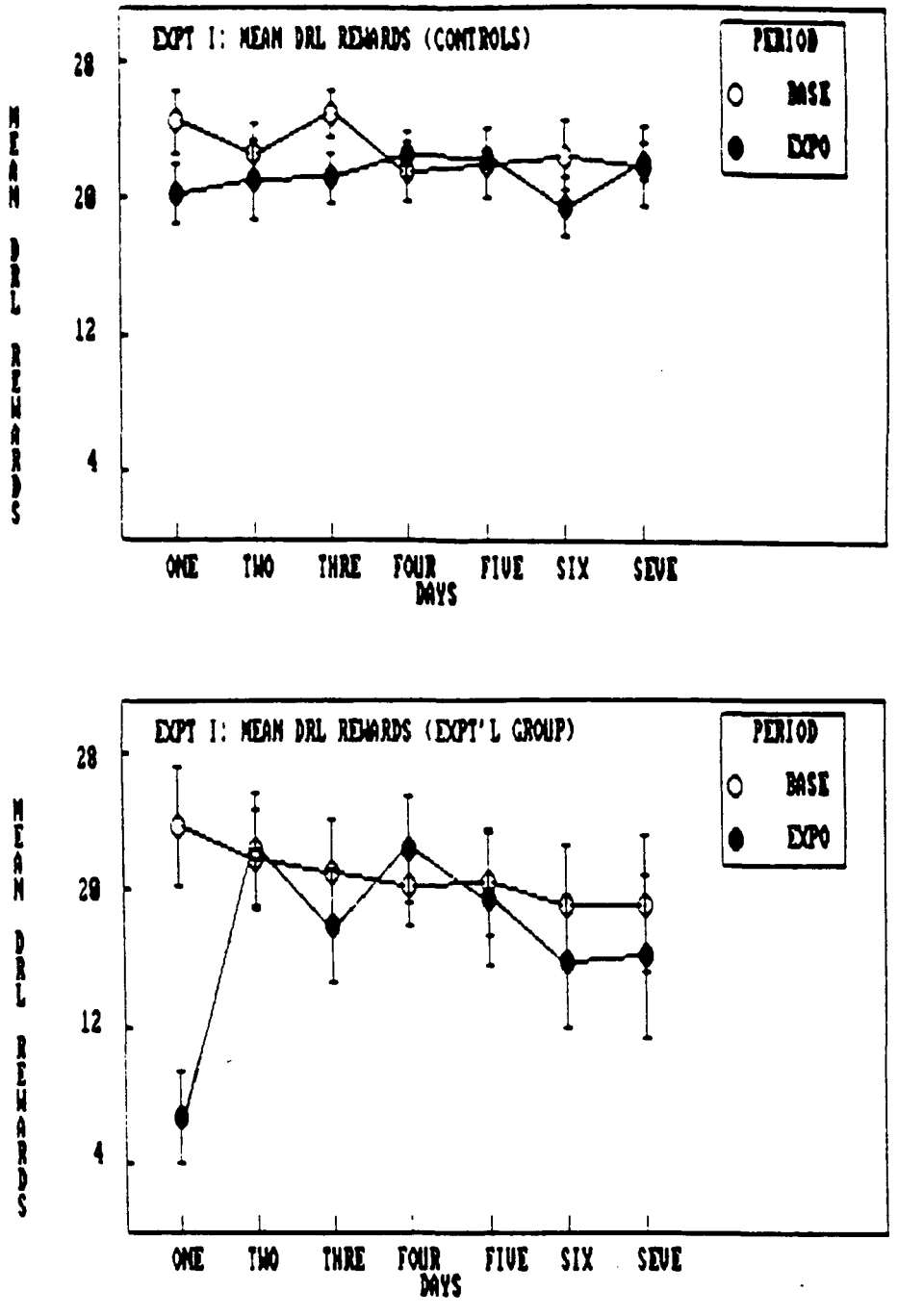


Figure XII.8. Mean DRL rewards per component for Control (upper panel) and Experimental animals during the last seven days of Pre-Exposure and first seven days of Exposure during Experiment I (30 kV/m).

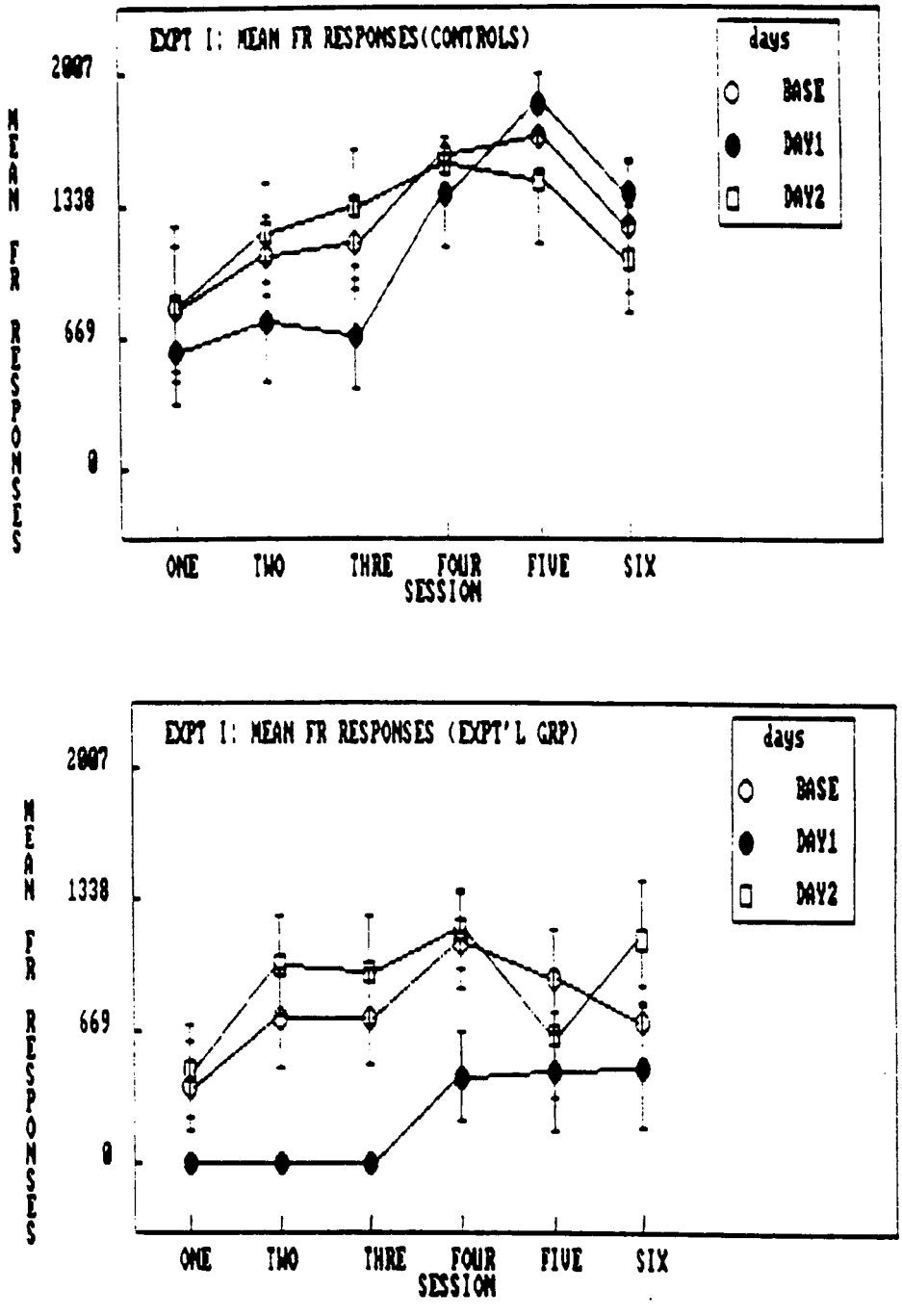


Figure XII.9. Mean FR responses per component plotted by Session during the first two days of electric field exposure in Experiment I (30 kV/m). The upper panel is for the Control group, and the lower panel is for the Experimental group. The mean performance of the two groups over the last seven days of Baseline also is given.

Table XII.10

ANOVA Summary Table for Daily DRL Rewards
Data from Experiment I (30 kV/m)

Factor	df	MS	F	P<
Group	1	380	.924	NS
Error	10	411		
Period	1	270	10.0	.01
G×P	1	42	1.6	.24
Error	10	27		
Days	6	39	2.5	.04
G×D	6	36	2.3	.05
Error	60	16		
P×D	6	95	6.4	.00
G×P×D	6	39	2.6	.03
Error	60	15		

animals show the expected "inverted U" shaped function during Pre-Exposure. Responding by the Control group on the first three Sessions of the first day of electric field exposure for the Experimental animals seems reduced slightly, but for the remainder of the first day and for the entire second day, the Control group responded normally despite the introduction of the electric field at the other end of the facility. The Experimental group made no responses during the first three Sessions of the first day of their exposure to the 60 Hz electric field, and mean performance on the last three Sessions was reduced. Performance on the second day was generally similar to the average performance of this group of animals during Pre-Exposure.

The facility was deliberately designed to be "open" so that Control and Experimental animals could be exposed in the same manner to all environmental factors other than the electric field itself. As a practical necessity of cost, the operant and social groups share the same grate at each end of the facility. One reason for relatively poor performance during the first few Sessions is that the Experimental group operant animals watched the social group which behaved in an unusual manner following initial introduction of the electric field. It also is possible that the Control animals were, at first, distracted slightly by the "excitement" occurring at the other end of the facility.

5. Summary

The results from Experiment I indicate that exposure of nonhuman primates to 30 kV/m 60 Hz electric fields definitely does produce changes in operant performance. However, the behavioral effects occur only during the first few hours (or perhaps days) of electric field exposure. It is very important to note that the animals show no lasting changes which might suggest the possibility of adverse effects resulting from their exposure to electric fields. The reaction to field introduction appears to be a temporary cessation of responding which occurs as the animals react to a novel environmental event. In operant terms, the field produces competing behaviors or responses which temporarily interfere with performance of the operant task.

B. Results of Experiment IA (30 kV/m)

1. Introduction

We used the same two approaches to the data from Experiment IA (30 kV/m) as were used in Experiment I (30 kV/m). The only difference is in the number of Periods and the number of Weeks. In Experiment IA, there were only two Periods (Pre-Exposure and Exposure), and each Period was three weeks in duration. The data from weeks 4, 5, and 6 of the Post-Exposure Period of Experiment I served as the Pre-Exposure Period of Experiment IA.

2. Analyses by Weeks

Data array.-- The data array for each ANOVA consists of 72 data points, 12 rows by 6 columns, giving mean performance for each of 12 subjects (six Experimental group and six Control group) for six different weeks. Means for weeks One, Three, Four, and Six are based on approximately 42 points while, because of cage washing and mapping, means in weeks Two and Five are based on approximately 30 points.

ANOVA.-- The mixed, repeated measures ANOVA includes one between factor, Groups, and two within factors, Period and Weeks. Thus, a total of seven F ratios are computed as summarized below (Table XII.11). The ANOVA model is like that used to analyze Experiment I data by weeks (Table XII.1), but the degrees of freedom (df) are considerably less in this case.

Homogeneity.-- In this set of analyses, the only variable requiring use of the common log (base 10) transformation was the SD of the DRL Efficiency, and the transformation achieved the desired result (Table XII.12).

Major means.-- Inspection of the principal means from the ANOVAs indicates few large differences (Table XII.13). The Experimental group tended to make more FR and DRL responses, but these "East end" animals also had done that during Experiment I when they served as the Control group. Thus, electric field exposure seems to have had relatively little effect on the animals responding. The SDs are relatively large and tend to be proportional to the means. The means for the Pre-Exposure and Exposure periods are quite similar.

ANOVA summary.-- ANOVA detected relatively few statistically significant F ratios for this data set (Table XII.14).

FR responding.-- The mean number of FR responses for the Experimental group (1442) was significantly ($P<.03$) greater than that (906) for the Control group. The cell means for the Period × Week interaction are indicated below:

Period	Week 1	Week 2	Week 3	Mean
Pre-Exposure	1,184	1,048	1,299	1,175
Exposure	1,002	1,249	1,268	1,173
Mean	1,093	1,146	1,283	

Table XII.11

Generalized Example of ANOVA Summary Table for Analyses of Experiment IA Data (30 kV/m) by Weeks (Collapsed Across Sessions)

Source	SS	df	MS	F	P
Between Groups					
GROUP	XX	1	YY	Z.Z	<.XX
Error	XX	10			
Within Groups					
PERIOD	XX	1	YY	Z.Z	<.XX
GROUP × PERIOD	XX	1	YY	Z.Z	<.XX
Error	XX	10			
WEEKS	XX	2	YY	Z.Z	<.XX
GROUP × WEEKS	XX	2	YY	Z.Z	<.XX
Error	XX	20			
PERIOD × WEEKS	XX	2	YY	Z.Z	<.XX
GROUP × PERIOD × WEEKS	YY	2	YY	Z.Z	<.XX
Error	YY	20			
Total	YYY	71			

Table XII.12

Summary of Results of F Max Tests of 12 Treatment Variances for Experiment IA (30 kV/m) by Weeks

Variable	Raw Scores	Log Transform
Mean of FR Res.	4.4	NA@
SD FR Res.	9.4	NA
Mean of DRL Res.	12.3	NA
SD DRL Res.	7.4	NA
Mean of DRL Rew.	5.7	NA
SD DRL Rew.	6.1	NA
Mean of DRL Eff.	11.8	NA
SD DRL Eff.	275	11.0#

@ Not applicable.
# Used in ANOVA.

Table XII.13

Summary of Principal Means from ANOVAs of Experiment IA (30 kV/m) Data by Weeks

	Group		Period	
Variable	Control	Exper.	Pre.	Exposure
Mean FR Res.	906	1,442	1,175	1,173
SD FR Res.	643	671	621	693
Mean DRL Res.	54	74	64	64
SD DRL Res.	49	45	44	50
Mean DRL Rew.	19	21	21	20
SD DRL Rew.	11	9	10	11
Mean DRL Eff.	3.0	3.6	3.2	3.4
SD DRL Eff.	1.9	1.7	1.5	2.1

Table XII.14

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment IA (30 kV/m) Data by Weeks (Collapsed over Sessions)

Variable	Group	Period	G×P	Week	G×W	P×W	G×P×W
FR Resp.	.03	NS@	NS	.02	NS	.03	.07
SD Resp.	NS	.05	NS	NS	NS	NS	NS
DRL Resp.	NS	NS	NS	NS	NS	.03	NS
SD Resp.	NS	NS	NS	NS	.06	NS	NS
DRL Rew.	NS	NS	NS	NS	NS	.02	NS
SD Rew.	NS	NS	NS	NS	NS	.09	NS
DRL Eff.	NS	NS	NS	NS	NS	NS	NS
SD Eff.	NS	NS	NS	NS	NS	NS	NS

@ Not significant.

Visual examination of the means for FR responses per component by the Control group (Figure XII.10) indicates little difference between the weekly means during Pre-Exposure and (sham) Exposure periods. The Experimental group seems to have a low mean FR response rate during the first week of Exposure, but the mean for the second week of Pre-Exposure was just as low. Thus, there seems to be no large, systematic effect of electric field exposure on FR responding.

The SD for FR responding was significantly ($P<.05$) greater during the Exposure (693) period than during the Pre-Exposure (621) period, but the interaction between Group and Period was not significant. Thus, the difference in

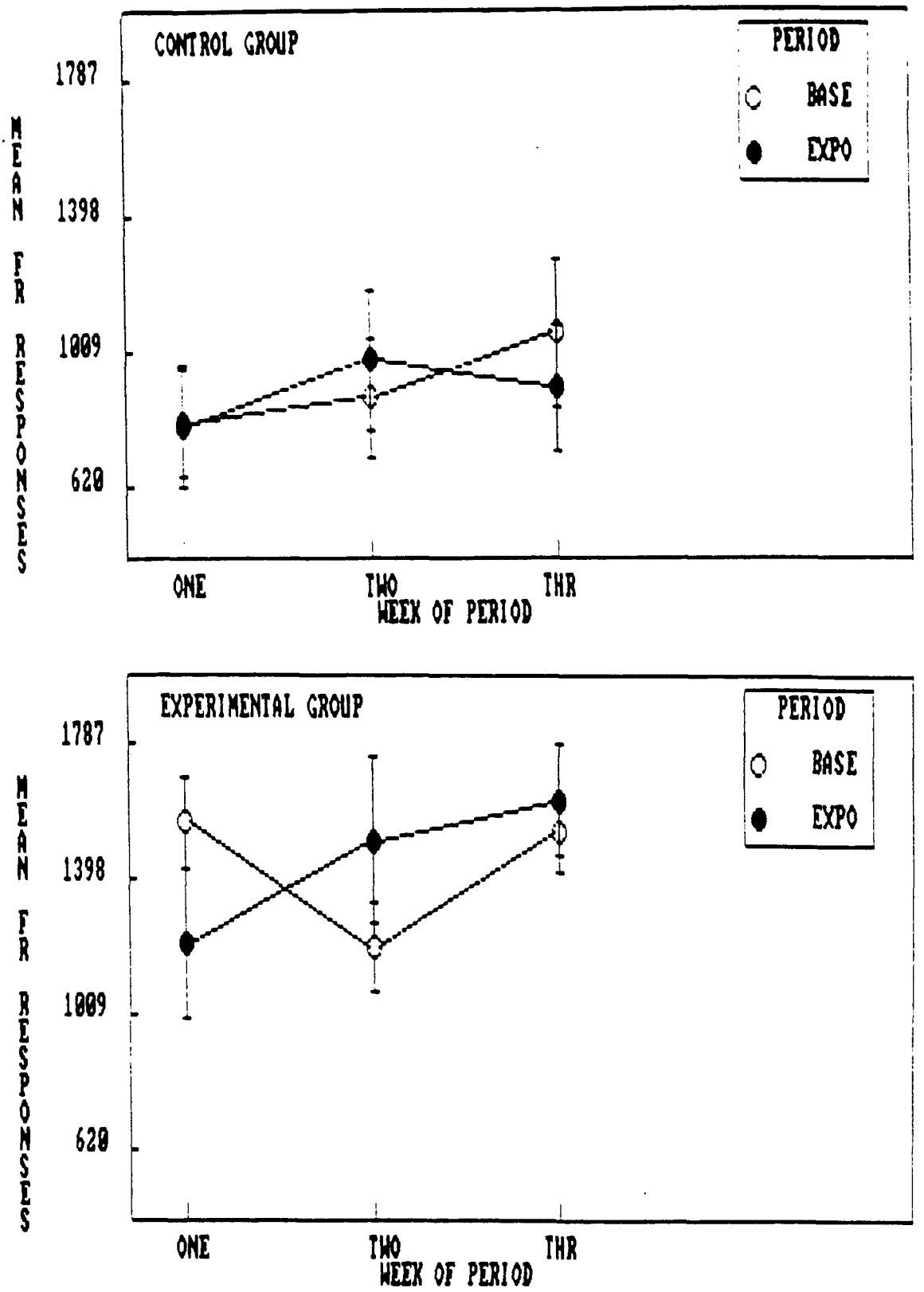


Figure XII.10. Mean FR responses per component by Period (Pre-Exposure and Exposure) and Week (One, Two, or Three) for Experimental (n = 6) and Control (n = 6) group subjects of Experiment IA (30 kV/m). The vertical bars give the standard error (SEM) of the means.

variability between Periods occurred to the same extent for both groups, indicating that electric field exposure had no detectable effect on the variability of FR responding.

DRL responses.-- The ANOVA for mean DRL responses per component detected a significant Period × Weeks interaction; the cells mean for this effect are given below:

Period	Week 1	Week 2	Week 3	Mean
Pre-Exposure	66	56	70	64
Exposure	56	71	65	64
Mean	61	63	67	

During the first week of the Exposure period, the mean DRL rate was relatively low, but it was equally low during the second week of Pre-Exposure. The absence of an interaction with Group once again suggests that electric field exposure had little effect on the number of DRL responses per component. The F ratio for the Groups × Week interaction for SD of DRL responses had a probability value of .06, slightly greater than the conventional "cutoff" of .05.

DRL rewards.-- A Period × Weeks interaction also was detected for mean DRL rewards:

Period	Week 1	Week 2	Week 3	Mean
Pre-Exposure	21	20	21	21
Exposure	18	21	19	20
Mean	19	21	20	

Once again, in the context of 60-Hz bioeffects research, this result is of little interest because it does not seem to involve an influence of electric field.

3. Analyses by Sessions

Data array.-- In these analyses, each point in the data array is based on the data from 19 working days accumulated during a three-week period. The data array for each ANOVA consists of the data from 12 subjects (six Experimental and six Control) for six Sessions under two Periods. Thus, the data includes 12 rows and 12 columns or 144 points.

ANOVA design.-- The statistical design (Table XII.15) is like that used to analyze Experiment I data by Sessions, but there are fewer df. However, the Experiment IA "session" design does have more df than the Experiment IA "weeks" design.

Table XII.15

Generalized Example of ANOVA Summary Table for Analyses of Experiment IA (30 kV/m) Data by Session (Collapsed Across Weeks)

Source	SS	df	MS	F	P
Between Groups					
GROUPS	XX	1	YY	Z.Z	<.XX
Error	XX	10			
Within Groups					
PERIOD	XX	1	YY	Z.Z	<.XX
GROUPS × PERIOD	XX	1	YY	Z.Z	<.XX
Error	XX	10			
SESSION	XX	5			<.XX
GROUPS × SESSION	XX	5			<.XX
Error		50			
PERIOD × SESSION	XX	5	YY	Z.Z	<.XX
GROUPS × PERIOD × SESSION	XX	5	YY	Z.Z	<.XX
Error	XX	50			
Total	XXX	143			

Table XII.16

Summary of Results of F Max Tests for 24 Treatment Variances in Experiment IA (30 kV/m) Data by Session

Variable	Raw Score	Log Trans.	Square Root
Mean of FR Res.	8.6#	NA	NA
SD FR Res.	7.8#	NA	NA
Mean of DRL Res.	59	17.8#	NA
SD DRL Res.	19.6#	NA	NA
Mean of DRL Rew.	308#	3787	856
SD DRL Rew.	5.0#	NA	NA
Mean of DRL Eff.	25.1#	NA	NA
SD DRL Eff.	93	NA	25.3#

Used in the ANOVA.

Homogeneity.-- As described previously, the homogeneity of the treatment variances was examined using Hartley's F max test (Table XII.16). Neither the log nor square root transformations achieved homogeneity for the mean of DRL variable. Because the data set for mean DRL responses per component included some "ones" and "zeros," the value of 0.5 was added to each score before the log transformation was made.

ANOVA summary.-- Once again, few statistically significant effects were found (Table XII.17), and few of these involved interactions indicative of an electric field effect on operant behavior. Most of the statistically significant F ratios involved Session effects: in these instances, the F ratios were of a magnitude which had a very low probability of occurring by chance.

Table XII.17

Summary of Largest Probability Values from ANOVAS of Experiment IA (30 kV/m) Operant Data by Sessions

Variable	Group	Period	G×P	Session	G×S	P×S	G×P×S
FR Resp.	.03	NS@	NS	.001	NS	NS	NS
SD Resp.	NS	.01	NS	NS	NS	.01	NS
DRL Resp.	NS	NS	NS	.001	NS	.03	NS
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	NS	NS	NS	.001	NS	NS	NS
SD Rew.	NS	.04	NS	NS	NS	NS	NS
DRL Eff.	NS	NS	NS	.03	NS	NS	NS
SD Eff.	NS	NS	NS	NS	NS	.02	NS

@ Not significant.

FR responses.-- As noted when the data were analyzed by Weeks, significantly more responses were made by the Experimental (1442) group than the Control (902) group. The mean number of responses differed significantly ($P<.01$) among Sessions: the cell means were 697, 1141, 1281, 1567, 1563, and 784, respectively, for Sessions One through Six.

The ANOVA for the SD of FR responding revealed the presence of statistically significant Period and Period × Session effects. The mean SD for the Pre-Exposure (451) Period was significantly ($P<.01$) less than the mean (588) during the Exposure Period. The cell means for the Period × Session effect ($P<.01$) were:

Period	One	Two	Three	Four	Five	Six	Mean
Pre-Exposure	401	448	509	369	379	602	451
Exposure	514	628	622	627	588	549	588
Mean	457	538	565	498	483	576	

Once again, it is clear that the operant behavior of nonhuman primates working in multiple sesssions a day under conditions of very mild food deprivation shows considerable variation. This is a "natural" feature of the data. Furthermore, it is hard to detect an electric field effect on the normal processes, whatever they are, which produce this temporal variation.

DRL responses.-- To illustrate the form of the results from this class of ANOVAs, the data for mean DRL responses per component are given in Figure XII.11. This figure shows the typical "inverted U" shape seen when the data are displayed by Session: the animals have a strong tendancy to perform most poorly in the first and last sessions of the day. However, for both the Control and the Experimental groups, the mean for Pre-Exposure and Exposure periods generally are quite similar for each Session.

Statistically significant Session ($P<.001$) and Period × Session ($P<.03$) effects were detected. The means for Sessions One through Six were: 37, 36, 42, 37, 40, and 32. The cell means for interaction were:

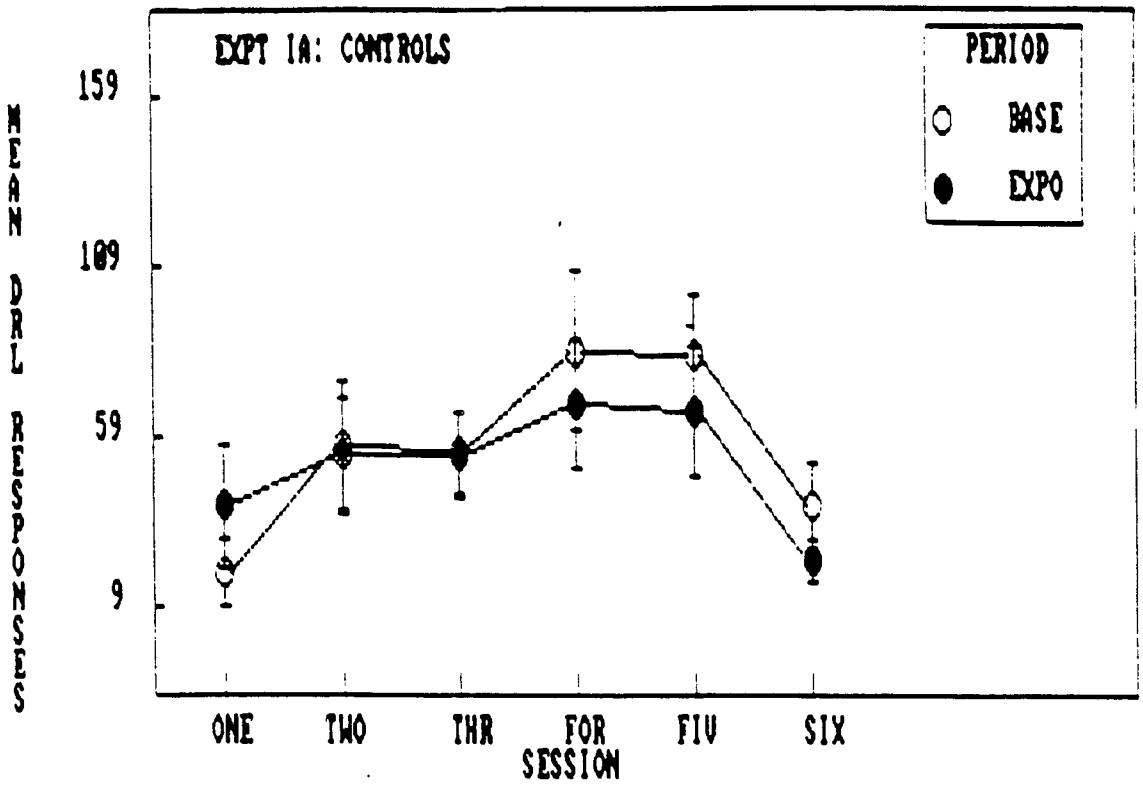
Period	One	Two	Three	Four	Five	Six	Mean
Pre-Exposure	25	32	40	37	45	31	35
Exposure	49	40	45	37	36	32	40
Mean	37	36	42	37	40	32	

Once again, inability to detect statistically significant interactions involving Group × Period or Group × Period × Session is disappointing if electric field effects are expected. No statistically significant effects involving the SD of mean DRL responses per component were detected.

DRL rewards.-- Two statistically significant F ratios were observed during the analyses of data on DRL rewards received per session. The Session effect for DRL rewards was significant ($P<.001$): the means were 12, 20, 20, 26, 23, and 14. As observed repeatedly, performance is poorest in Session 1, good through the afternoon, and relatively poor again Session 6. With respect to the SD of DRL rewards, the Period effect was significant ($P<.04$). The means were 6.7 and 8.9 during Pre-Exposure and Exposure periods.

DRL efficiency.-- The mean DRL efficiency score varied significantly ($P<.03$) with Session; the means for Sessions One through Six were: 3.3, 3.3, 3.1, 3.8, 3.7, and 2.7. The SD of the mean DRL efficiency score exhibited a significant ($P<.02$) Period × Session interaction. The cell means were:

Period	One	Two	Three	Four	Five	Six	Mean
Pre-Exposure	1.0	1.4	1.3	1.4	1.9	1.2	1.35
Exposure	4.2	1.8	1.4	2.4	1.6	1.4	2.14
Mean	2.6	1.6	1.4	1.9	1.7	1.3	



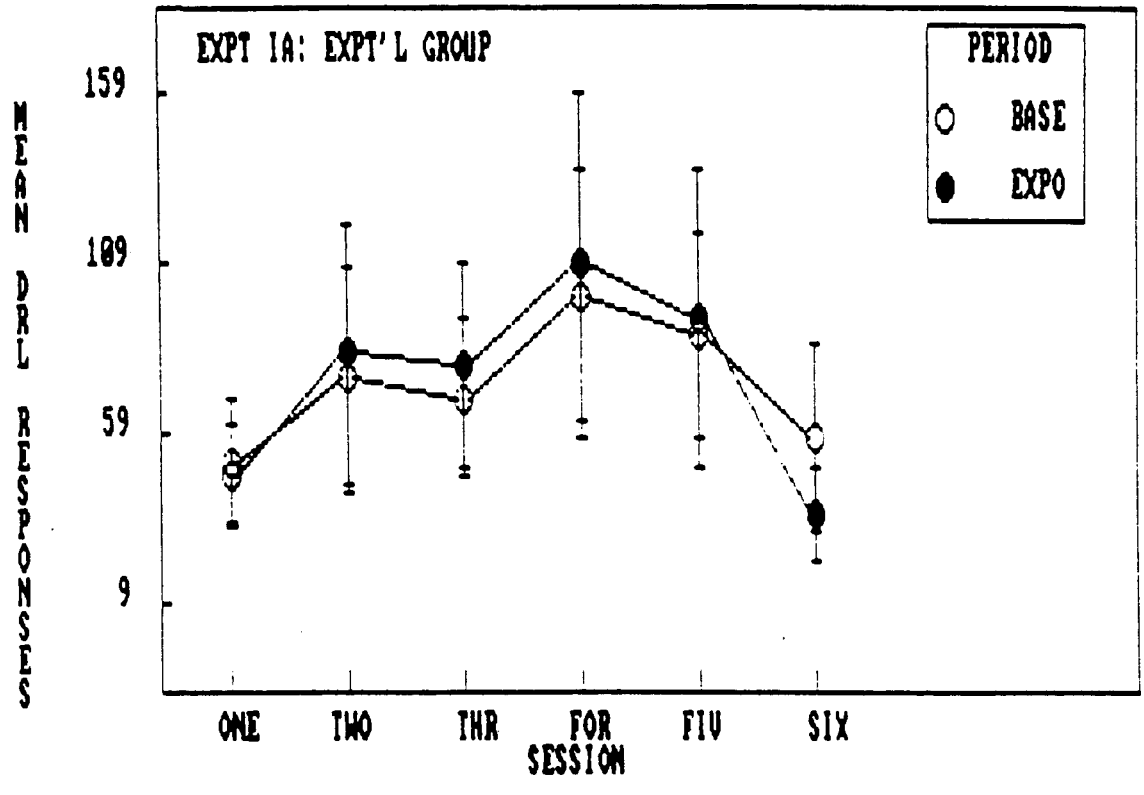


Figure XII.11. Mean DRL responses per component for Experimental (n = 6) and Control (n = 6) subjects during Pre-Exposure and Exposure periods of Experiment IA (30 kV/m). The vertical bars give the standard error (SEM) of the means.

Probably the most salient feature of this data is the relatively large SD occurring during Session One of the Exposure Period. Electric field exposure seems to have produced an effect at a time when the animals' normal activity cycle was just beginning.

C. Initial Description of Results of Experiment II (60 kV/m)

1. Introduction

On Monday, February 20, 1987, we officially began Experiment II (60 kV/m). The staff was told that the experiment had begun on the previous Monday, and all aspects of the protocol were followed beginning on Monday, February 13. The data from this week of "pseudo-baseline" were not used in the formal data analyses for Experiment II. The week of "pseudo-baseline" served to sharpen the training of the staff and to "blind" the observers to the date of initiation of Exposure. (The observers knew the general design of the experiment, but they were not told which side was to be used for exposure.)

2. Analyses by Weeks

FR.-- A plot of mean FR rewards earned per day (Figure XII.12) shows that the two groups, Exposed (East) and Control (West) were relatively similar during Pre-Exposure (weeks 1 through 6); perhaps the East group responded more frequently than the West group. At the beginning of week 7, the time of electric field introduction, the Exposed group showed a sudden drop in responding. With one important exception, these results are similar to those observed previously; the animals stopped responding when the 60 kV/m field was first introduced, but as the day went by, the animals began to work. On the next day, they tended to work well earlier in the day, and on the third day they were working in a nearly normal manner.

However, in this experiment, one baboon (#1225) never responded when the electric field was on (see below). Thus, although the Exposed animals' performance improved dramatically relative to the first day of Exposure, it looks as though the mean for the Exposed group will be slightly less than that of the Control group during the Exposure period if the only difference between Exposed and Control groups were that one animal stopped responding completely during Exposure. If the five other animals were completely unaffected, the mean would drop by one sixth or 17 percent.

It is easier to see the general pattern of results when the data are expressed as weekly means (Figure XII.13). The East animals did slightly better in Pre-Exposure, and they seemed to be recovering this "advantage" as Exposure progressed.

DRL.-- The data for mean DRL rewards per day (Figure XII.14) are similar to the FR data. Overall, the groups were comparable during Pre-Exposure. The first day of Exposure produced a noticeable drop in mean responding, but the animals recovered in a few days. For the remainder of the Exposure period for which data are available, the Exposed group means are slightly less than the Control group means. Animal #1225 made no DRL responses when the electric field was on. Figure XII.15 shows the data as weekly means.

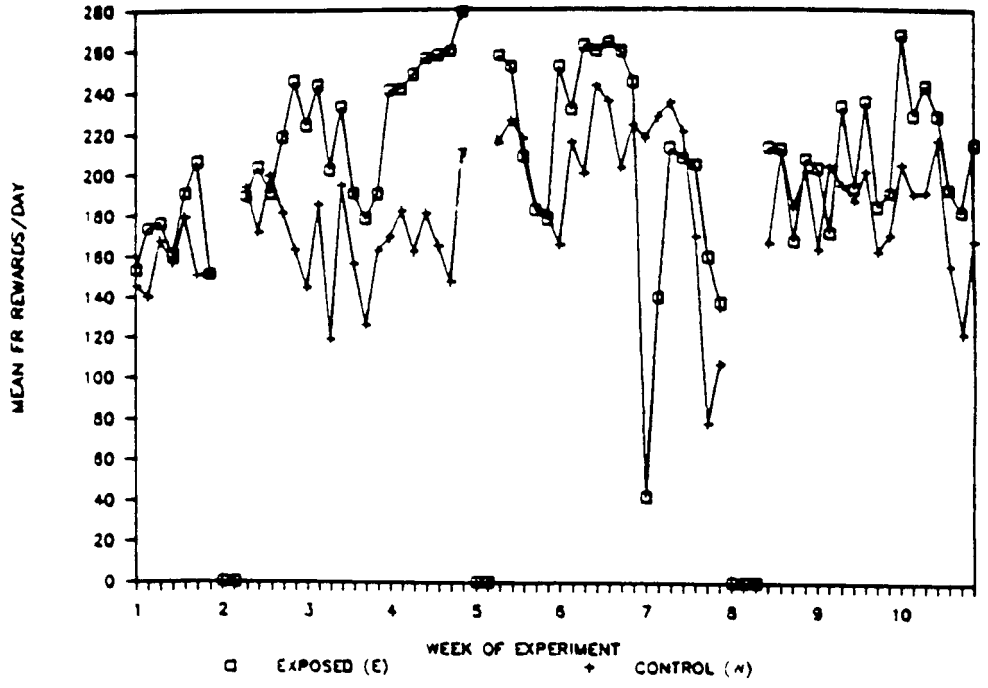


Figure XII.12. Mean FR rewards earned per day by the Experimental and Control groups during six weeks of Pre-Exposure and four weeks of Exposure of Experiment II (60 kV/m).

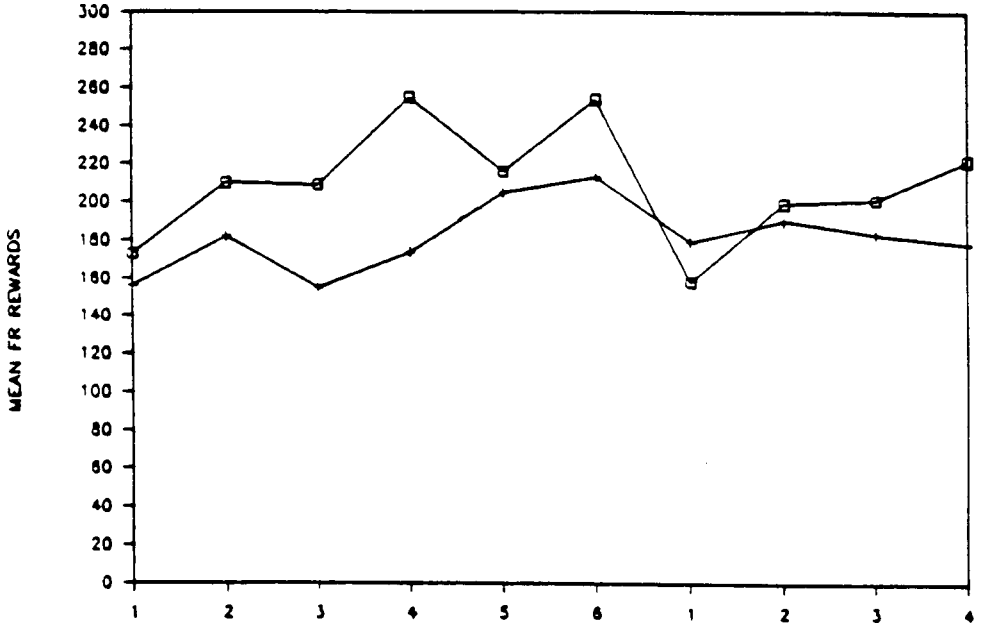


Figure XII.13. Weekly means for mean FR rewards earned per day by the Experimental and Control groups during six weeks of Pre-Exposure and four weeks of Exposure in Experiment II (60 kV/m).

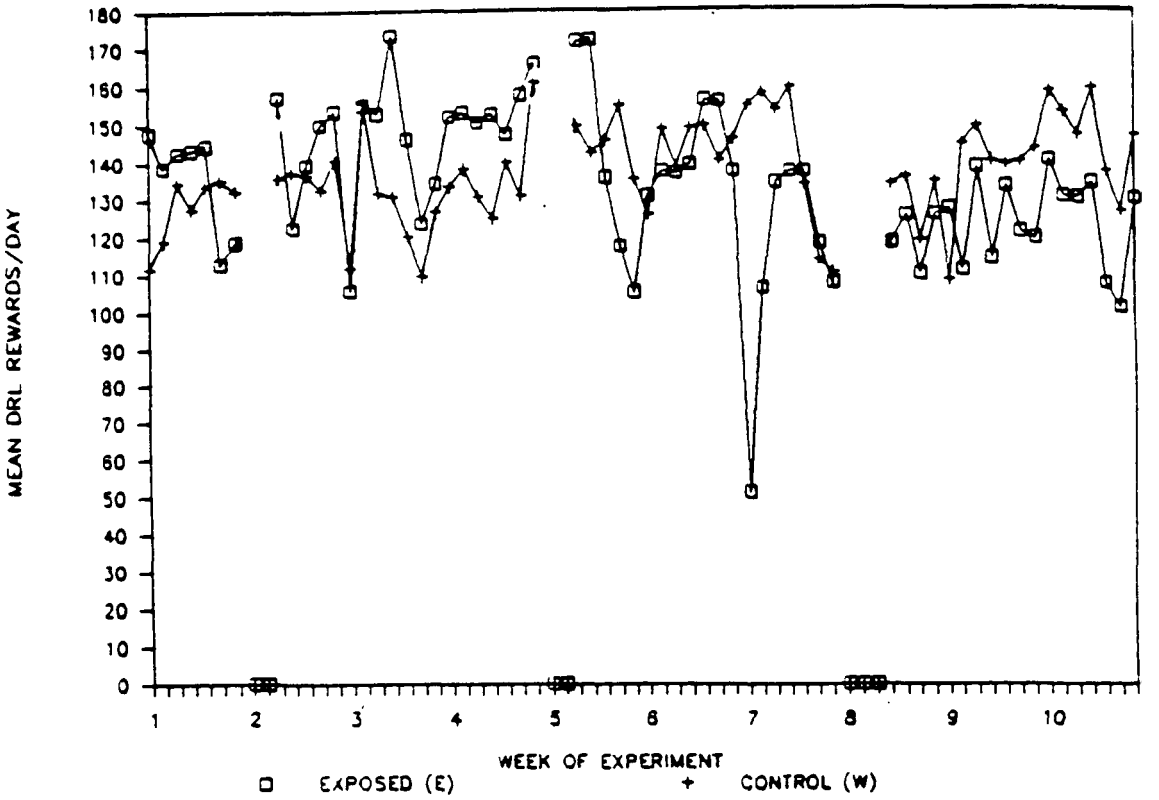


Figure XII.14. Mean DRL rewards earned per day by the Experimental and Control groups during six weeks of Pre-Exposure and four weeks of Exposure during Experiment II (60 kV/m).

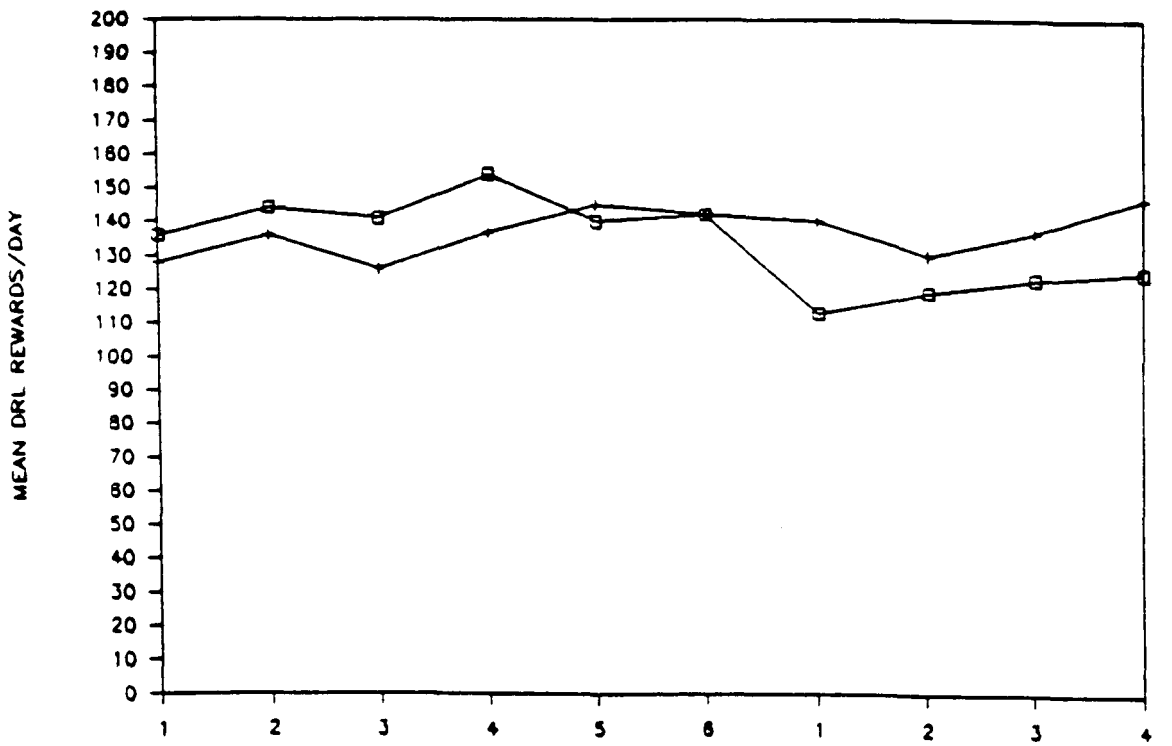


Figure XII.15. Weekly means for mean DRL rewards earned per day by the Experimental and Control groups during six weeks of Pre-Exposure and four weeks of Exposure of Experiment II (60 kV/m).

In weeks 2 and 5 of the Pre-Exposure, Exposure, and Post-Exposure periods, we conducted the two-day cage mapping and washing exercise as per the protocol. Thus, no behavioral data were collected on those days. Note that there are no behavioral data for the first three days of the second week of Exposure. We had difficulty in transformer operation on Monday, and we conducted the cage mapping and washing exercise scheduled for this week on Tuesday and Wednesday.

3. First Few Days

Initial exposure data.-- It appears that the initial effects of 60 kV/m are similar to those observed at 30 kV/m. As indicated in Figure XII.12, mean FR rewards earned per day by the East (Exposed) group was extremely low on day 43, the first day of electric field exposure. On day 44, the second day of exposure, the mean number of FR rewards earned was almost within the normal range, and on the third and fourth days of exposure the performance of the East group once again was equivalent to that of the West (Control) group. Although the East and West groups were equivalent during the first two weeks of Pre-Exposure, during the next few weeks of Pre-Exposure the East group tended to earn more FR rewards than did the West group. This apparent difference occurred before introduction of the electric field and probably is a chance result related to relatively poor performance by one of the monkeys in the West group. The data for mean DRL rewards is very similar (Figure XII.14).

Examination of the data from the first day of exposure session by session (Table XII.18) indicates that once animals resumed operant responding, they appeared to work relatively normally thereafter. (For simplicity, the number of rewards earned on the FR and DRL components of each session have been summed.) Some animals resumed responding more rapidly than others: during the first day, four animals were responding during the third session. On the second day, four animals responded during the first session, and on the third day, five of the six Experimental animals responded during the first session.

4. Baboon 1225

Introduction.-- The behavior of animal 1225 is particularily interesting. When the field came on, he climbed to the top of his cage and stayed there. When the field was off, the animal came down from the cage bars and moved about the cage normally. This behavior pattern continued throughout the six-week Exposure period. As described more completely below, we confirmed that this animal worked very well on both FR and DRL during periods when the electric field was not on. Thus, we know that the animal is motivated and functional. Although we can offer a variety of speculations concerning the behavior of 1225, at this point we do not know the mechanisms involved in his unusual behavior.

Baboon 1225.-- This animal climbs to the top of its cage and remains there whenever the electric field is on. This response is incompatible with bar pressing because the animal cannot reach the operant apparatus. On April 6, 7, and 8, the animal made no responses and earned no food (Table XII.19). On April 9, we tested the animal's performance during a period when the field was off, and he worked well. In fact, the animal was working as the field was turned on, and he jumped to the top of his cage as the field came on. Over the

Table XII.18

Total Responses per Session on the First Day of Field Exposure in Experiment II (60 kV/m)

Day	Group	Animal	One	Two	Three	Four	Five	Six	Sum
1	West	1176	37	67	58	72	64	71	369
		1174	94	88	85	74	53	93	487
		1178	18	76	48	87	77	88	394
		1141	13	26	27	29	30	31	156
		1256	88	85	1	97	91	113	475
		1149	44	47	62	62	62	73	350
			--	--	--	--	--	--	---
		Mean	49	65	47	70	63	78	372
	East	1147	0	0	4	26	14	21	65
		1279	0	0	23	97	57	104	281
		1191	0	6	1	15	0	22	44
		1156	0	0	9	74	41	0	124
		1138	0	0	0	3	16	29	48
		1225	0	0	0	0	0	0	0
			--	--	--	--	--	--	---
		Mean	0	1	6	36	21	29	94
2	West	1176	72	49	66	58	87	68	400
		1174	81	95	57	83	74	62	452
		1178	68	62	82	72	85	89	458
		1141	0	25	36	34	37	31	163
		1256	5	83	93	88	101	105	475
		1149	56	65	67	68	69	42	367
			--	--	--	--	--	--	---
		Mean	47	63	67	67	76	66	386
	East	1147	1	2	1	59	59	48	170
		1279	13	22	45	63	68	104	315
		1191	0	23	39	47	42	72	223
		1156	0	95	83	112	113	110	513
		1138	6	47	47	54	50	50	254
		1225	0	0	0	0	0	0	0
			--	--	--	--	--	--	---
		Mean	3	32	36	56	55	64	246

Table XII.18 (Cont'd)

Day	Group	Animal	One	Two	Three	Four	Five	Six	Sum
3	West	1176	11	74	63	78	75	70	371
		1174	79	74	65	76	60	87	441
		1178	0	80	70	75	79	84	388
		1141	0	23	31	36	41	30	161
		1256	85	93	76	49	94	100	547
		1149	42	74	61	87	82	72	418
			--	--	--	--	--	--	---
		Mean	36	70	61	67	72	74	388
	East	1147	55	51	59	64	59	65	353
		1279	40	68	61	96	84	101	450
		1191	24	74	73	92	92	93	448
		1156	55	85	110	105	91	108	554
		1138	40	43	42	46	50	52	273
		1225	0	0	0	0	0	0	0
			--	--	--	--	--	--	---
		Mean	36	54	58	67	63	70	346

Table XII.19

Summary of Special Experiments with Baboon 1225
during Exeriment II (60 kV/m)

	Old Box		New Box	
Date	FR	DRL	FR	DRL
04/09	49	13	-	-
04/10	19	7	-	-
04/11	0	0	-	-
04/12	13	7	-	-
04/13	-	-	-	-
04/14	-	-	-	-
04/15	-	-	-	-
04/16	0	0	-	-
04/17	22	16	-	-
04/18	10	18	-	-
04/19	34	5	-	-
04/20	30	30	-	-
04/21	31	10	-	-
04/22	33	20	-	-
04/23	22	11	0	5
04/24	43	15	-	-
04/25	21	9	0	0
04/26	35	18	-	-
04/27	-	-	2	4
04/28	-	-	0	19
04/29	-	-	0	16
04/30	-	-	0	14
05/01	18	11	-	-
05/02	44	16	-	-
05/03	28	17	-	-
05/04	15	8	0	7
05/06	27	22	0	18
05/07	-	-	-	-
05/08	-	-	-	-
05/09	-	-	0	3
	--	--	-	--
Mean	26	13	0	10

next few days, until the "shutdown" in week 2, the animal performed reasonably well when the field was off but made no responses when the field was on. This pattern continued for the end of week 2 and the beginning of week 3.

Guessing that the animal would work if he could stay up off the grate and still reach the operant panel, we attempted to make a minimally field perturbing operant box which could be mounted on the cage bars where the animal could reach it. On the morning of April 23, we tried this "new" box for

the first time. The session began in the DRL component, and the animal made a few responses. Then it made no more responses; some of the staff think the animal "jerked" its hand away from the box as if it had received a shock. Later in the day, we gave #1225 a chance to work on the "old" box when the field was off, and it did well.

On April 27, we reintroduced the "new" box, which had been modified to preclude receipt of another shock by including within it more conductive materials (which presumably would affect the field near the box). The animal still refused to work on the "new" box with the field off, but it worked very well on the "old" box when the field was off. We alternated several times between "old" and "new" boxes, always with the same result. However, as we worked the animal on one (or two) 10-minute sessions a day during the afternoon (or evening) "breaks," the animal began to do poorly on the FR component. Note that either the "old" or "new" operant box always was present during the exposure periods as per protocol.

Animal #1225 would not work on any apparatus when the field was on. He worked normally on the original ("old") apparatus when the field was off, and he would work (less readily) on the alternative "new" apparatus when the field was off. (Apparently there was some negative transfer from the "old" apparatus to the "new.") The fact that he did well when the field is off established that he was motivated and capable, indicating that whatever the nature of the process occurring when the field was on, it did not affect the subject when the field was off. He also worked very well when serving as a control (sham exposed) subject in Experiment IIB.

D. Results of Experiment II (60 kV/m)

1. Introduction

Data analysis methods for Experiment II are just like those used, and described above, in Experiment I. The data arrays, the ANOVA models, the tests for homogeneity of variance, etc. are the same, and the results are presented in the same format in the following sections. The ANOVAs for the SD data will be completed in a few days, so the results are not available for inclusion in this report.

2. Analyses by Weeks

Homogeneity.-- The raw score data were used for all four ANOVAs, although the F max test at the $P<.05$ level was not achieved for DRL rewards and efficiency (Table XII.20). The most common transformations did not improve the F max result; however, due to the robust nature of the ANOVA, a ratio of 31 or 32 among the largest and smallest of the 36 treatment variances should not affect the results. (It takes an F max value of 54 to reject the hypothesis of homogeneity at the $P<.01$ level.)

Means.-- The principal means do not suggest the occurrence of electric field effects (Table XII.21). In general, the Experimental group did slightly "better" on all four dependent variables. They made a few more FR responses than the Control group and were slightly more efficient on the DRL. The two groups were equivalent for the number of DRL rewards received. Comparison of the means for the Pre-Exposure, Exposure, and Post-Exposure periods

Table XII.20

Summary of Results of F Max Tests for
Experiment II (60 kV/m) Analysis by Weeks

Variable	Raw Score	Log	Square Root
Mean FR Resp.	4.9#	NA	NA
SD of FR Resp.	4.3#	NA	NA
Mean DRL Resp.	19.4#	NA	NA
SD of DLR Resp.	109.6	12.3#	27.6
Mean DRL Rew.	31.9#	158	44.5
SD of DLR Rew.	15.8#	NA	NA
Mean DRL Eff.	31.0#	39.0	98.5
SD of DLR Eff.	551.4	126.4#	211.0

Used in the ANOVA.

Table XII.21

Summary of Principal Means from ANOVA of
Experiment II (60 kV/m) Data by Weeks

	Group		Period		
Variable	Contrl	Exptl	Pre.	Expo.	Post
Mean FR Resp.	1041	1177	1011	1030	1286
SD of FR Resp.	488	430	461	446	470
Mean DRL Resp.	58	45	60	45	49
SD of DRL Resp.	37	27	43	23	31
Mean DRL Rew.	23	24	23	23	24
SD of DRL Rew.	8	6	8	7	7
Mean DRL Eff.	2.6	1.9	2.8	2.0	2.0
SD of DRL Eff.	1.5	1.3	2.0	0.8	1.4

indicates only one interesting result; during the Exposure period, the mean number of DRL responses was reduced by about 25 percent. However, the mean number of DRL rewards was not reduced during Exposure. In effect, the animals became more efficient.

Graphs.--For both Experimental and Control groups, FR responding during Pre-Exposure and Exposure was equivalent but somewhat higher during Post-Exposure (Figure XII.16). Mean DRL responses per component appeared to be a little bit lower during Exposure for the Experimental animals, but the differences do not appear to be large enough to be statistically significant (Figure XII.17). Mean DRL rewards per component look even more likely to be reduced

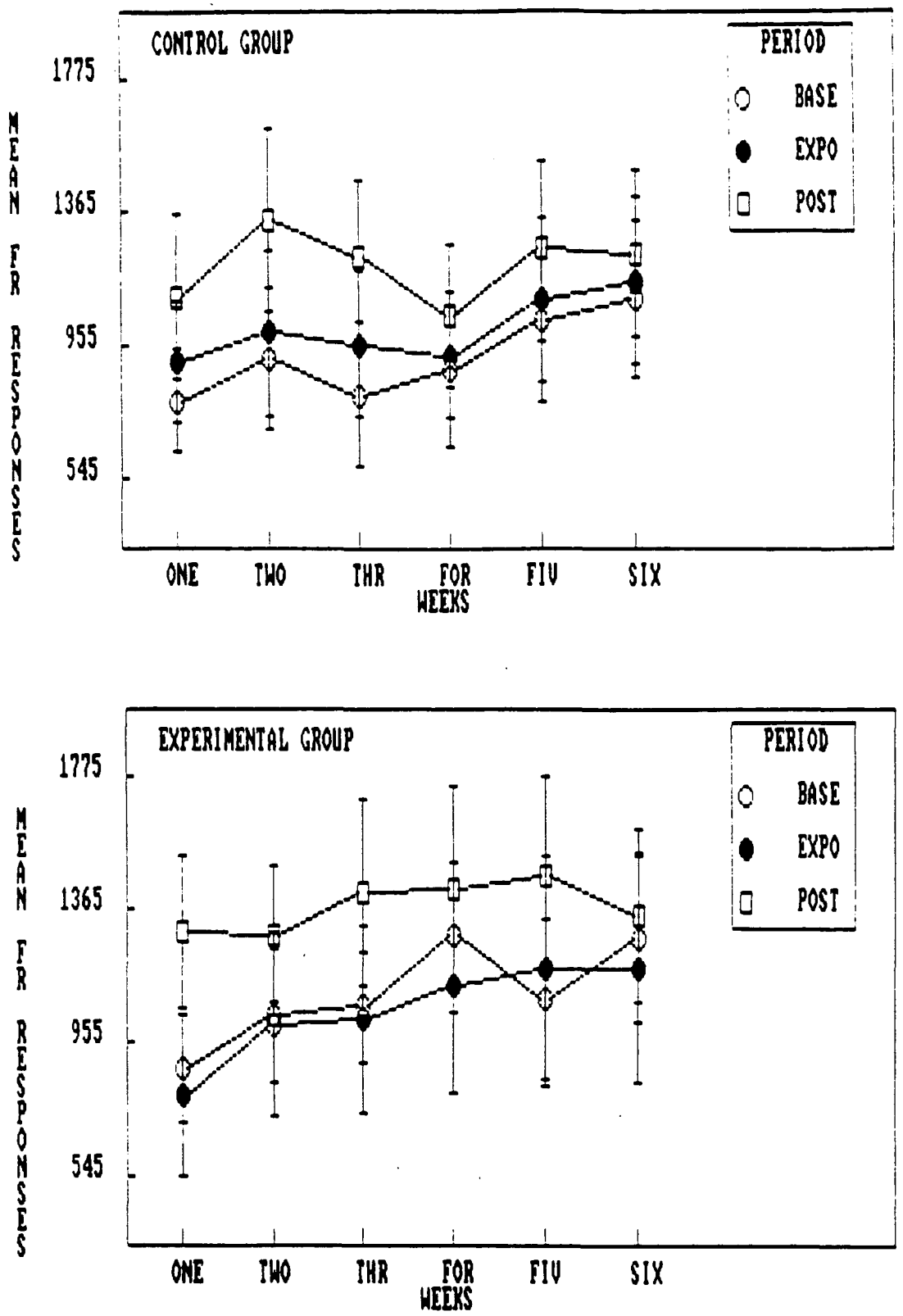


Figure XII.16. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

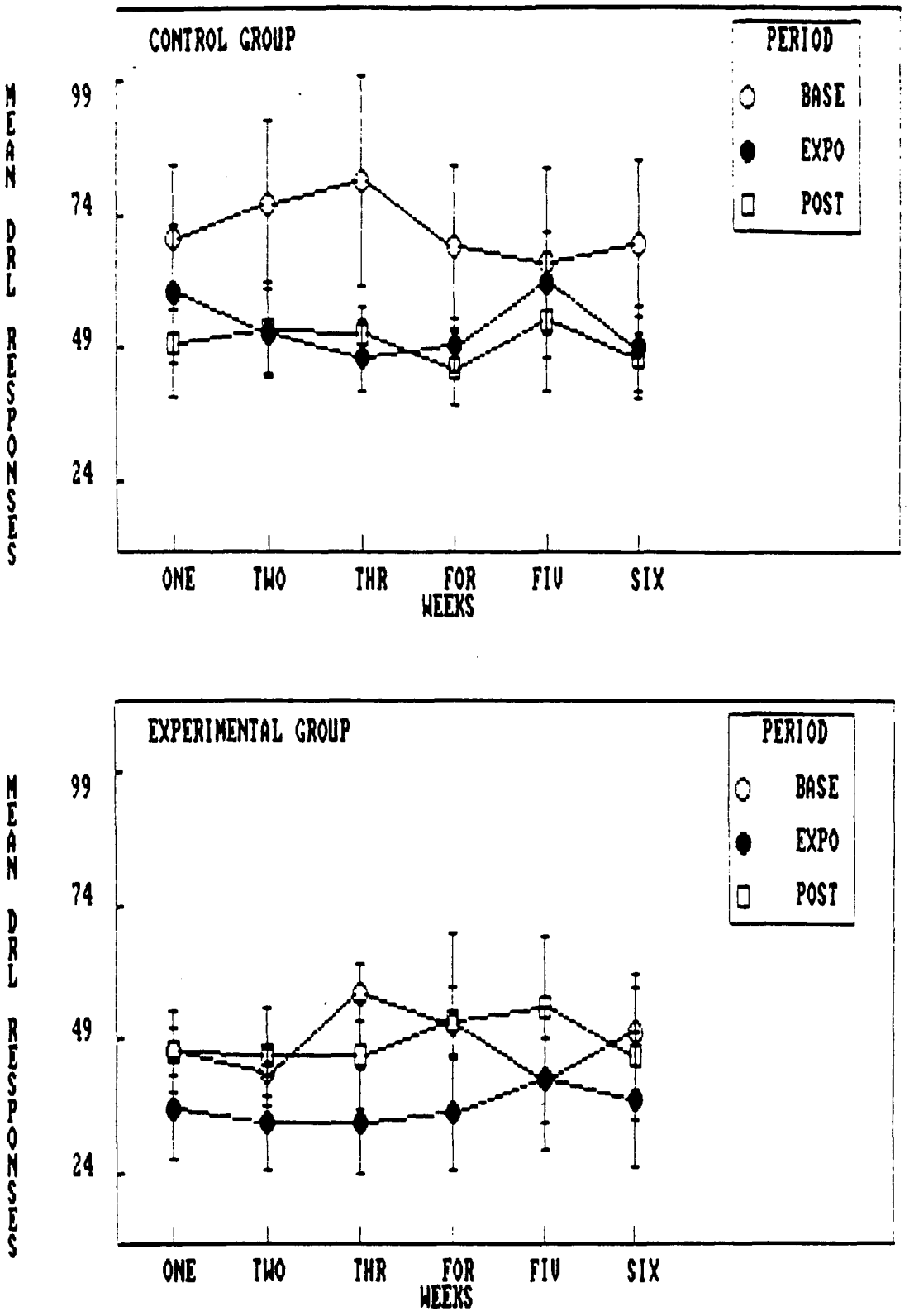


Figure XII.17. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

during the first three or four weeks of Exposure in the experimental group (Figure XII.18). However, DRL efficiency does not appear to be affected during Exposure (Figure XII.19). The Control animals were relatively inefficient during Pre-Exposure but equivalent to the Experimental animals during Exposure and Post-Exposure.

ANOVA.-- There were no Group effects in the ANOVA results There were several week effects but they are of interest only if the field-related interactions are significant. The Groups × Weeks interaction is not important, but the "triple" interaction is.

There were no statistically significant Period effects, although the DRL efficiency effect was at $P<.06$ (Table XII.22). There were no Group effects, and there were no Group by Period interactions. As with Experiment I, analysis of the data from the entire experiment suggest no sign of a "chronic" electric field effect on operant responding of nonhuman primates.

Table XII.22

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment II (60 kV/m) Data by Weeks

Variable	Group	Period	G×P	Week	G×W	P×W	G×P×W
FR Res.	NS	NS	NS	.001	.10	.10	NS
SD Resp.	NS	NS	NS	NS	NS	.09	NS
DRL Res.	NS	NS	NS	NS	NS	NS	NS
SD Resp.	.10	.02	NS	.05	NS	.06	NS
DRL Rew.	NS	NS	NS	NS	NS	.10	.09
SD Rew.	NS	NS	NS	.04	NS	.08	.04
DRL Eff.	NS	.06	NS	NS	NS	.09	NS
SD Eff.	NS	.01	NS	NS	NS	NS	NS

3. Analyses by Sessions

The raw scores were suitable for analysis directly for mean number of both FR responses and DRL rewards per 15-minute component (Table XII.23). The log transformation was used for DRL efficiency and the square root for DRL responses.

Graphs.-- FR responses were very similar in Pre-Exposure and Exposure for the Experimental group (Figure XII.20). The Session effect is less "curved" than it was in Experiment I; the Experiment II animals responded better in the sixth session than did the Experiment I animals. Mean DRL responses were very consistent in the Experimental group during all three Periods (Figure XII.21). DRL reward appears to be somewhat lower during Exposure for the Experimental animals (Figure XII.22), but given the degree of variability indicated by the SEMs (error bars) the difference is not likely to

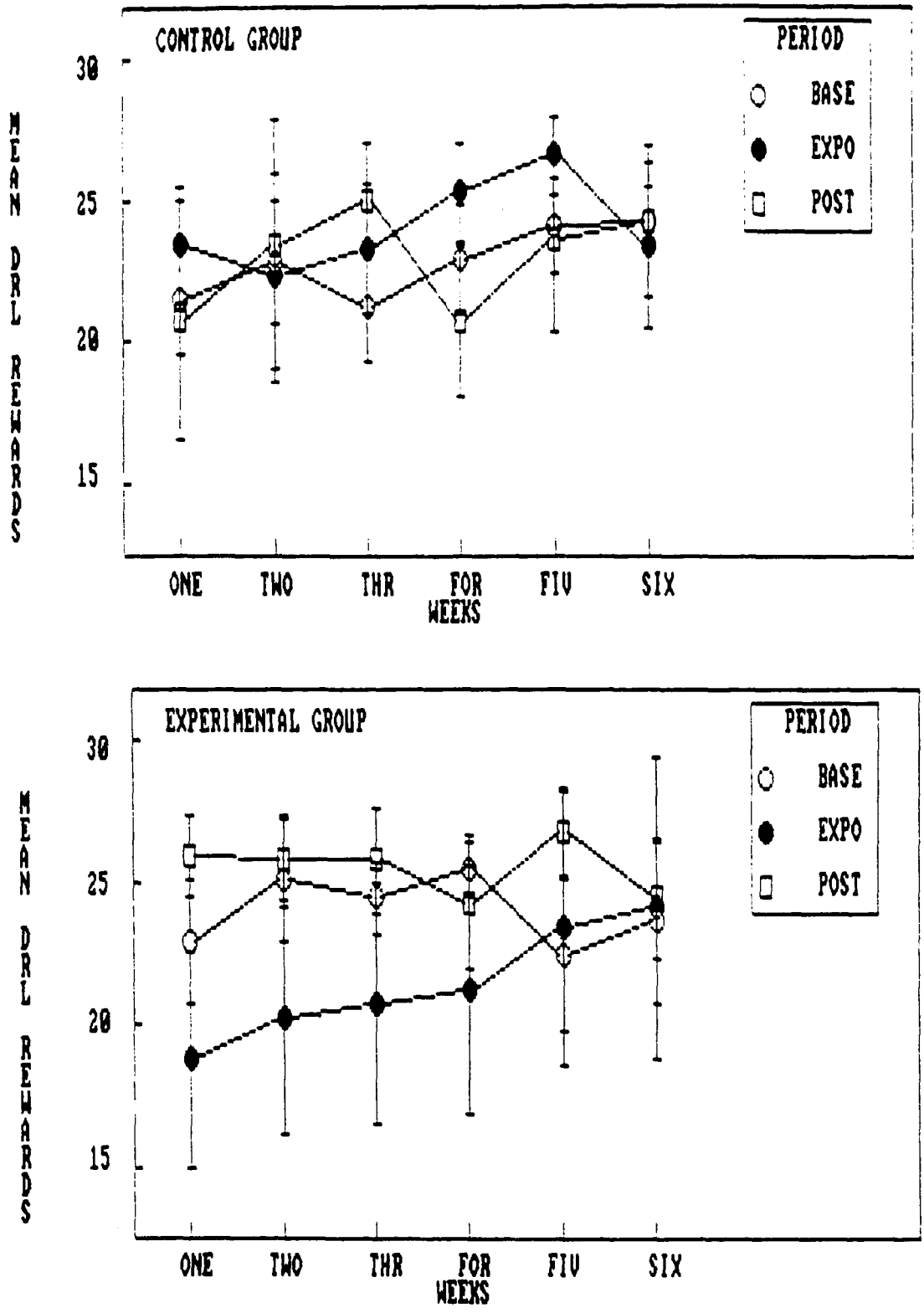
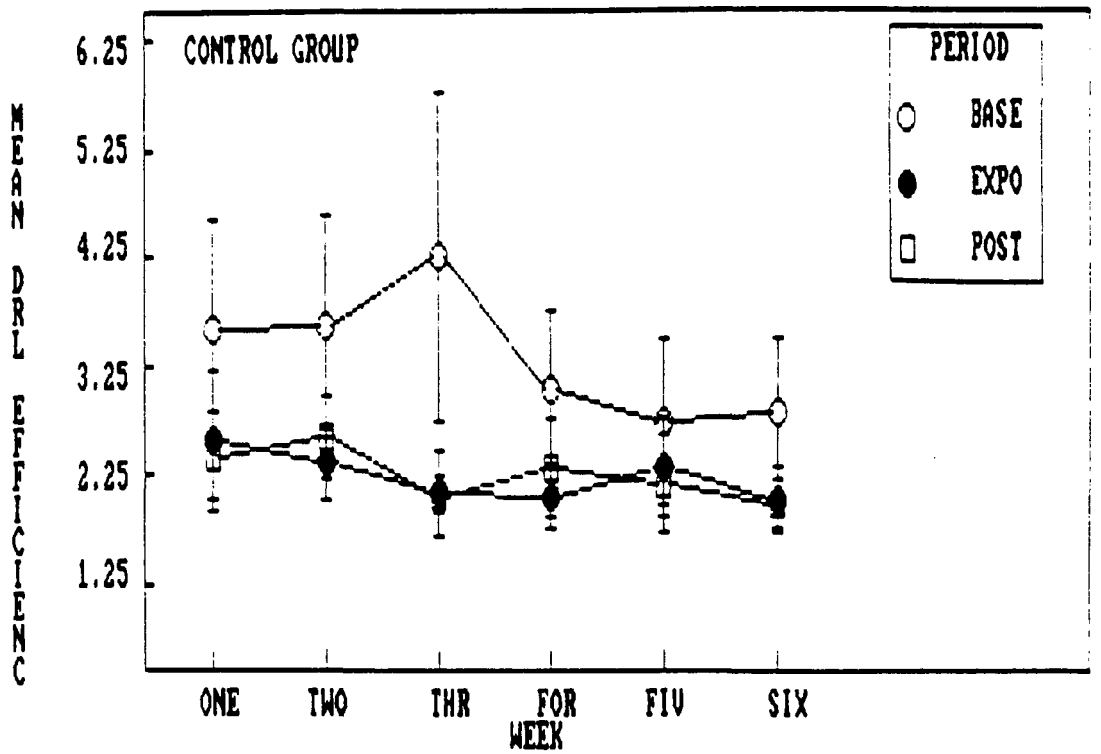


Figure XII.18. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).



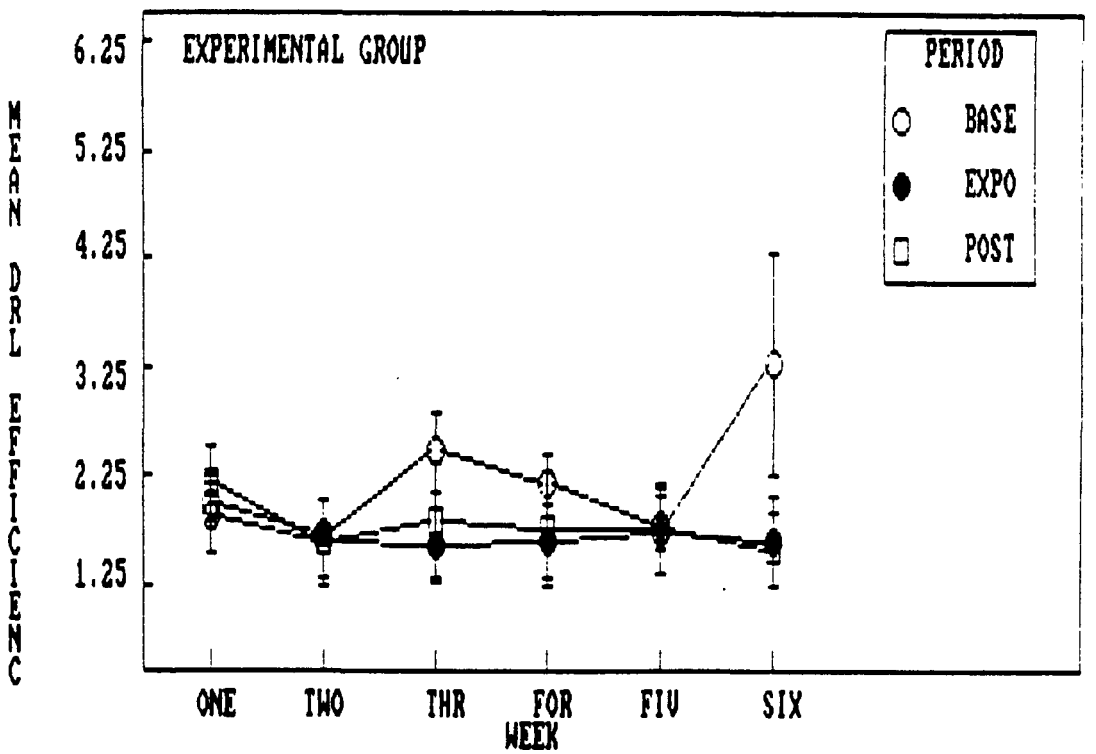


Figure XII.19. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

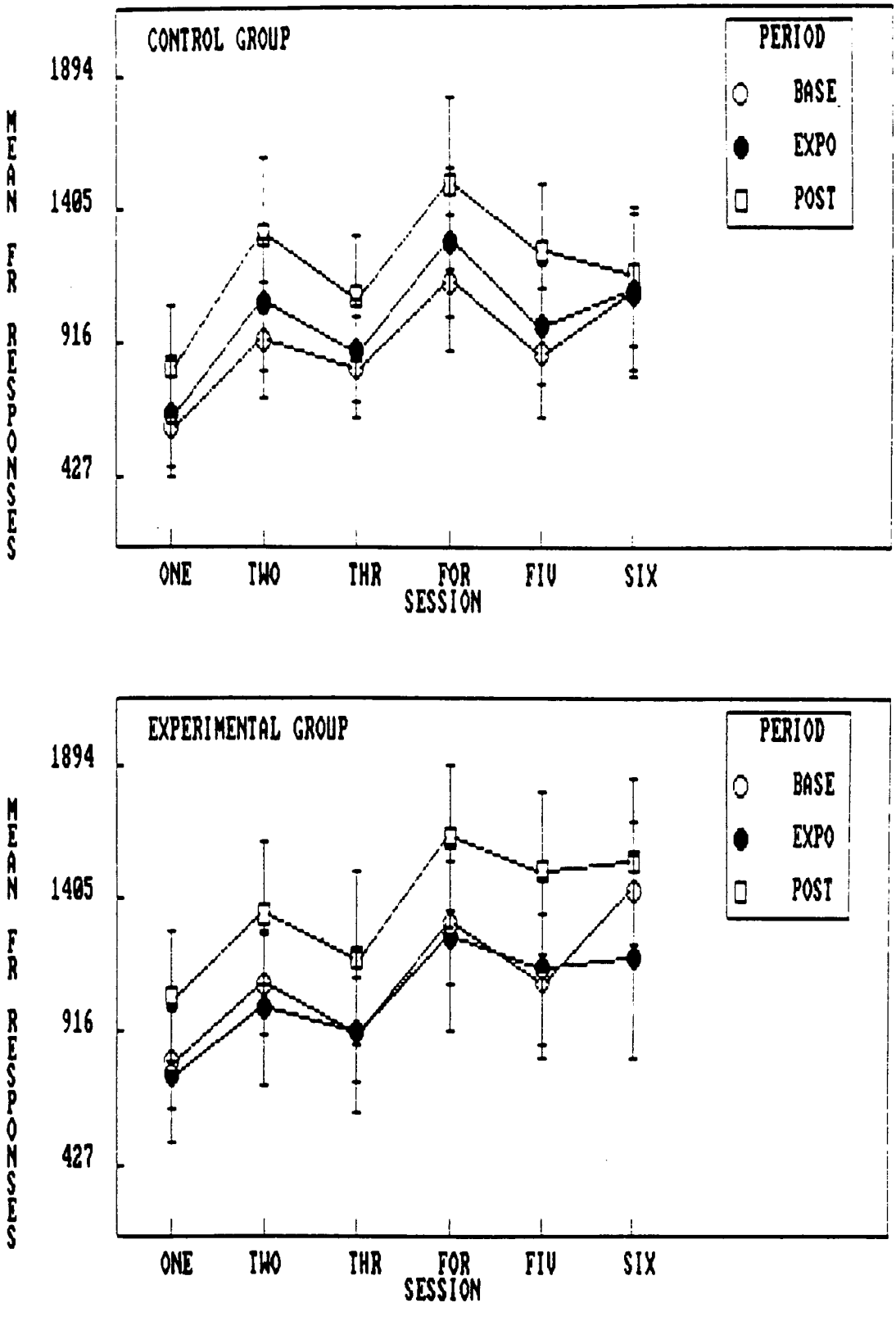


Figure XII.20. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

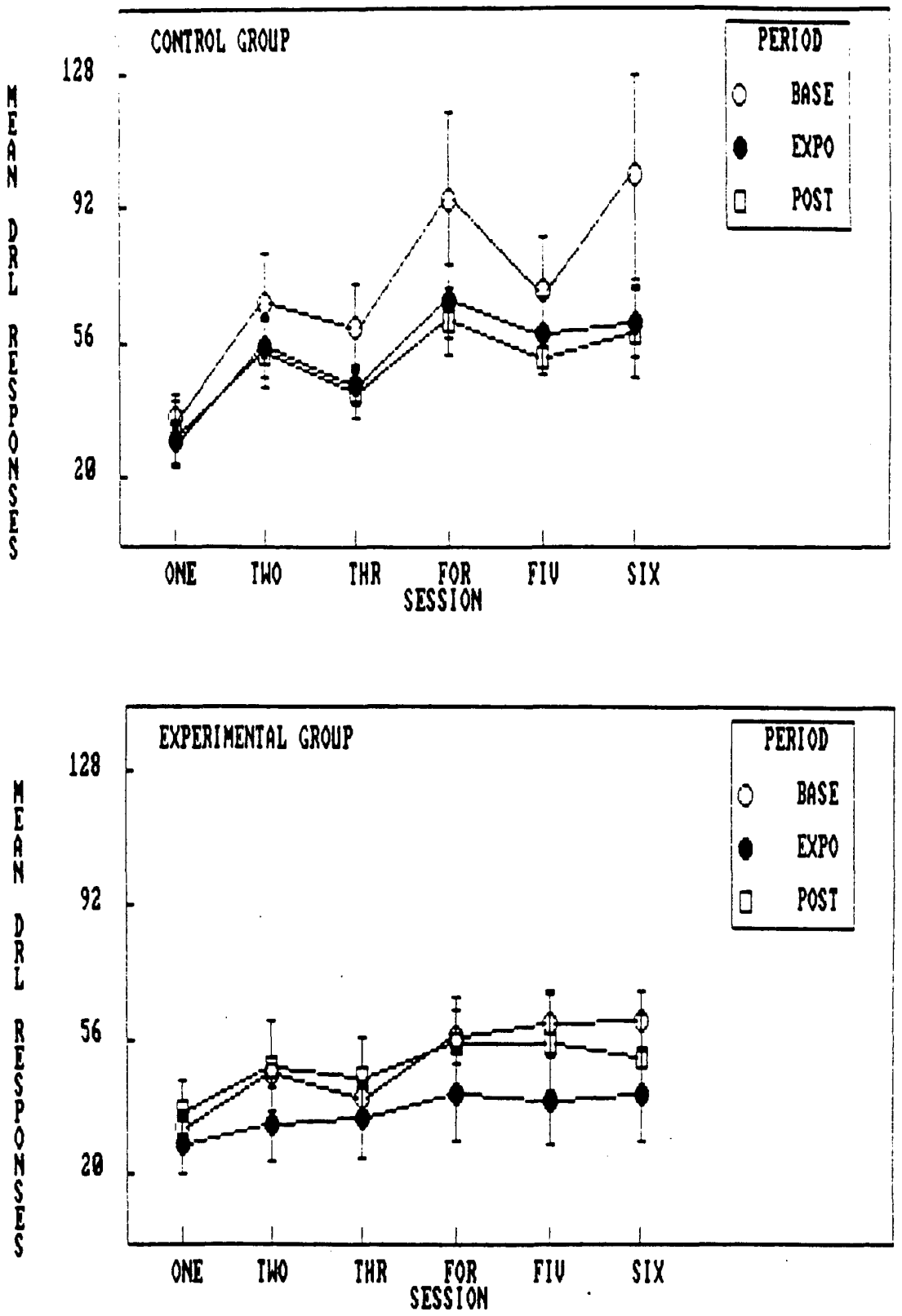


Figure XII.21. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

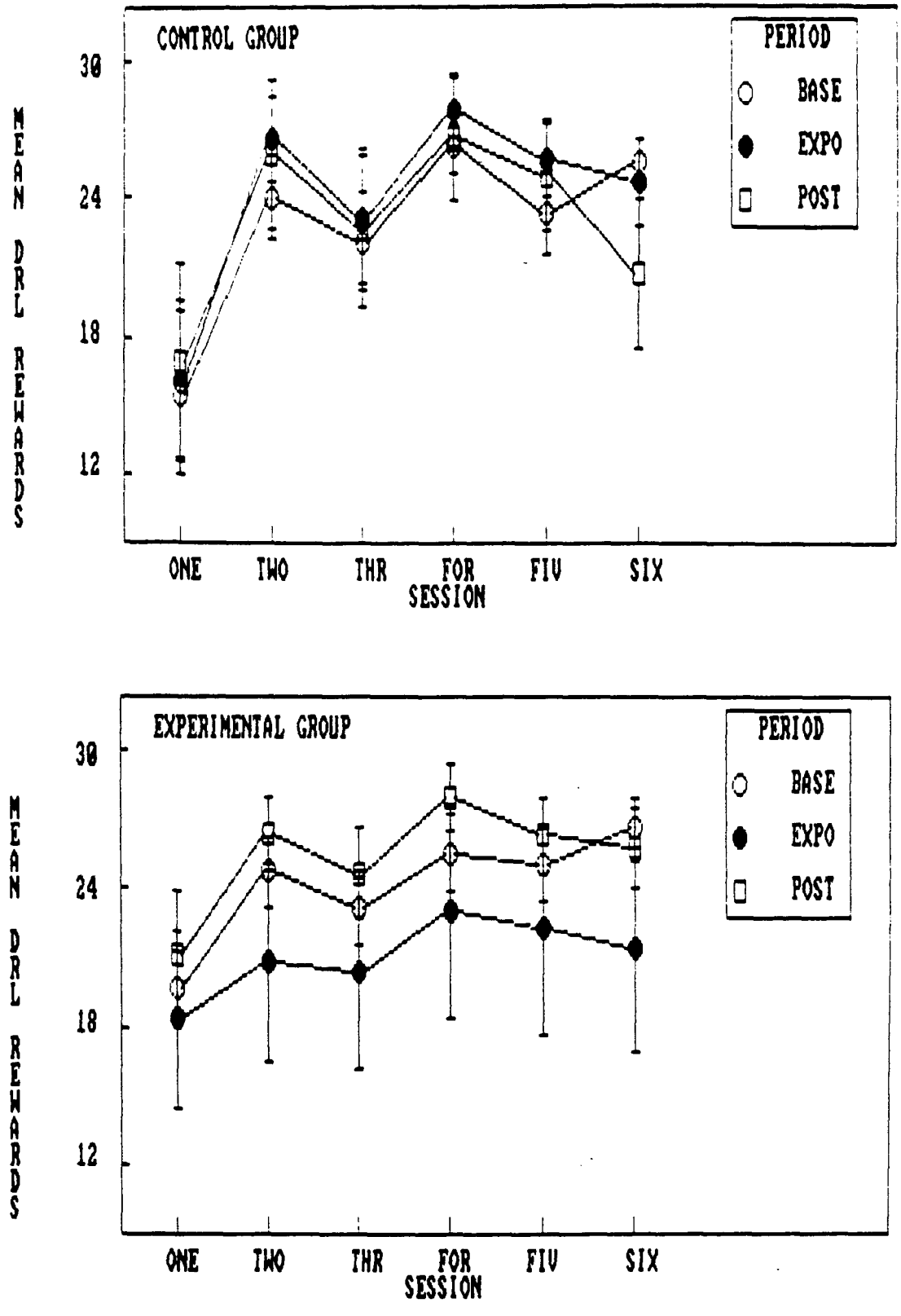


Figure XII.22. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

Table XII.23

Summary of Results of F Max Tests for
Experiment II (60 kV/m) Analyses by Sessions

Variable	Raw Score	Log	Square Root
Mean FR Resp.	4.2#	NA	NA
SD of FR Resp.	5.8#	NA	NA
Mean DRL Resp.	70.3	52.0	27.8#
SD of DRL Resp.	230	53.0#	92.7
Mean DRL Rew.	24.9#	NA	NA
SD of DRL Rew.	13.5#	NA	NA
Mean DRL Eff.	96.2	20.1#	40.4
SD of DRL Eff.	5452	89.1#	130.8

Used in ANOVA.

be statistically significant. DRL efficiency for the Experimental animals was quite consistent across Sessions during Exposure and Post-Exposure (Figure XII.23).

ANOVA.-- As expected from Experiment I, the Session effect was statistically significant ($P<.001$) for each variable analyzed (Table XII.24). The Group × Period × Session interaction was not significant for any variable, nor was the Group × Period interaction. The interactions involving Period × Session were almost significant. The statistically significant Period effect ($P<.02$) indicates that Mean DRL efficiency was highest in Pre-Exposure and equivalent in Exposure and Post-Exposure. The six Session means for FR responding were: 912, 997, 1188, 1110, 1045, and 1373. The animals made fewest FR responses in the 8:30 a.m. session and most in the 9:00 p.m. session.

Table XII.24

Summary of Lowest Probabilities for F Ratios in
Analyses of Experiment II (60 kV/m) Data by Sessions

Variable	Group	Period	G×P	Ses	G×S	P×S	G×P×S
FR Res.	NS	NS	NS	.001	NS	.02	NS
SD Resp.	NS	NS	NS	.001	NS	.05	NS
DRL Res.	NS	NS	NS	.001	.04	.008	NS
SD Resp.	.10	.03	NS	.001	NS	NS	NS
DRL Rew.	NS	NS	NS	.001	NS	.002	NS
SD Rew.	NS	NS	NS	.001	NS	.03	NS
DRL Eff.	NS	.02	NS	.001	NS	NS	NS
SD Eff.	NS	.001	NS	.01	NS	NS	NS

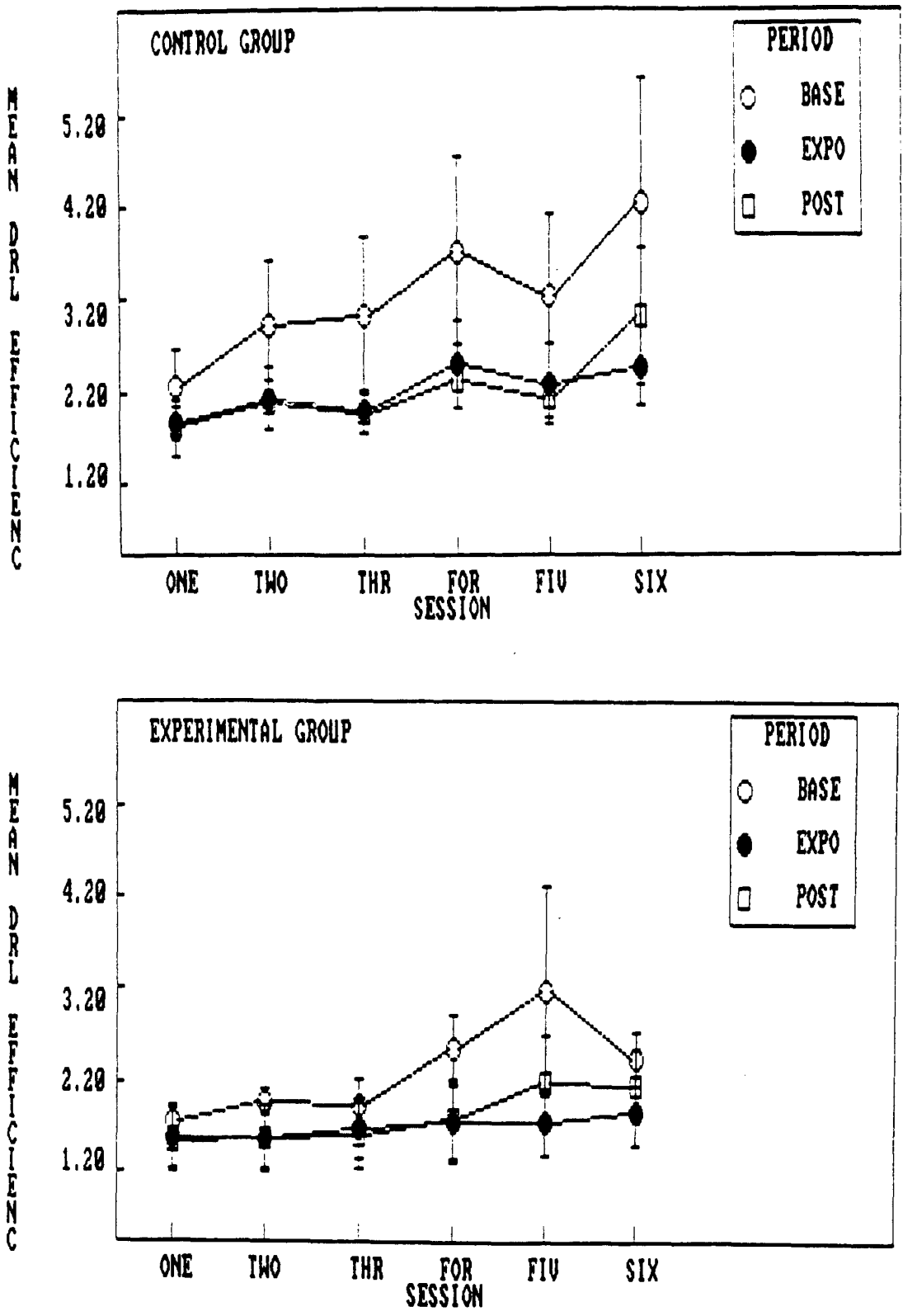


Figure XII.23. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), Exposure (Expo), and Post-Exposure (Post) of Experiment II (60 kV/m).

4. Analyses by Days within First Week

Introduction.-- As in Experiment I, analysis of the data for the entire six-week Exposure period detected few signs of electric field effects on operant responding. However, the results of Experiment I and our experience in Experiment II suggest that introduction of the electric field did affect the animals' behavior on the first day (or two or three) of Exposure. To detect these effects, we analyzed the data from the last week of Pre-Exposure and the first week of Exposure.

The ANOVA (Table XII.25) included the between groups factor Group (Control or Experimental) and the within groups factors Period (Pre-Exposure or Exposure) and Day (One through Seven). The data array included 14 scores for each of 12 subjects, and each score was the mean of the six sessions run per day.

Table XII.25

Summary of ANOVA Model for Analysis of Experiment II (60 kV/m) Data by Days

Source	df
GROUPS	1
Error	10
PERIOD	1
GROUPS × PERIOD	1
Error	10
DAYS	6
GROUPS × DAYS	6
Error	60
PERIOD × DAYS	6
GROUPS × PERIOD × DAYS	6
Error	60

Homogeneity.-- The ANOVAs were conducted using raw scores for mean FR responses and DRL rewards per 15-minute component, but the square root transformation was used for DRL responses and efficiency (Table XII.26). As noted above, the $P<.05$ value used in the evaluation of the F max statistic was 26.5.

Means.-- The only variable for which the Group means differed appreciably was DRL responses (Table XII.27). The mean for the experimental Group was reduced 32 percent relative to the control Group mean. Comparison of Period means indicates that a 28 percent reduction in FR responding and a 19 percent reduction in DRL responding occurred in Exposure relative to Pre-Exposure.

Table XII.26

Summary of Results of F Max Tests for
Experiment II (60 kV/m) Analyses by Days

Variable	Raw Score	Log	Square Root
Mean FR Resp.	10.7#	NA	NA
SD of FR Resp.	7.2#	NA	NA
Mean DRL Resp.	135	NA	20.4#
SD of DRL Resp.	740	17.5#	120
Mean DRL Rew.	15.6#	NA	NA
SD of DRL Rew.	6.3#	NA	NA
Mean DRL Eff.	1656	26.1#	168
SD of DRL Eff.	30,075	131.6#	373

Used in ANOVA.

Table XII.27

Summary of Principal Means from ANOVA of
Experiment II (60 kV/m) Data by Days

	Group		Period	
Variable	Contrl	Exptl	Pre.	Expo.
Mean FR Resp.	997	1,033	1,184	847
SD of FR Resp.	402	381	399	384
Mean DRL Resp.	63	43	59	48
SD of DRL Resp.	26	24	30	21
Mean DRL Rew.	24	21	24	21
SD of DRL Rew.	6.8	5.7	6.3	6.1
Mean DRL Eff.	2.7	2.8	3.3	2.2
SD of DRL Eff.	0.8	2.0	2.0	0.7

Comment.-- The fact that the two groups were so equivalent in operant responding is remarkable because one experimental animal, baboon 1225, was not responding at all. This implies either that the other five experimental animals increased their performance rate by about one sixth (17 percent), allowing the means to remain equivalent, or that one of the Control animals also stopped responding. This latter alternative is partially true. Animal 1141 worked poorly from the third week of Baseline through the rest of the Experiment. The animal's apparatus and health were carefully checked, and nothing unusual was detected. Careful examination of the Period means for the Experiment (and Control) groups will tell if the remaining five Experimental

animals increased their responding if the Control group performance also declined.

ANOVA.-- Although none of the Group × Period interactions were statistically significant, all of the Group × Period × Day, three of the four Period × Day, and two of the four Group x Day interactions were statistically significant (Table XII.28). This indicates that when viewed over Periods of seven days, introduction of the electric field effect had many effects on operant responding. None of the Group effects were significant, but two of the Period effects were.

Table XII.28

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment II (60 kV/m) Data by Days

Variable	Group	Period	G×P	Days	G×D	P×D	G×P×D
FR Res.	NS	.04	NS	.001	.007	.026	.001
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Res.	NS	NS	NS	.08	NS	.03	.006
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	NS	NS	NS	.001	.001	.015	.051
SD Rew.	NS	NS	NS	.02	.008	NS	NS
DRL Eff.	NS	.05	NS	.09	NS	NS	.02
SD Eff.	NS	.10	NS	NS	NS	NS	NS

Figures.-- The daily plots of FR responses show clearly that the responding of the experimental animals was reduced on the first day of exposure (Figure XII.24). It also was less on the remaining six days of the week due to the absence of responding by 1225. The same effect occurred for DRL responding (Figure XII.25) except here there was no difference on the next six days despite the lack of responding by 1225. The data on DRL rewards (Figure XII.26) for the experimental group show the same pattern, a big reduction (relative to Pre-Exposure) on the first day of Exposure followed by similar scores in Pre-Exposure and Exposure for the remainder of the first week. The data for DRL efficiency (Figure XII.27) also show the "first day" effect. In each case, the data from the Control animals show the degree of "normal variation" in the performance of primates. Because each score in the "daily" data is the average of only six components, the means are more variable than are the means of "weekly" scores which are averages of 42 (or 30 during weeks 2 and 5 of each Period) components.

To further illustrate the performance of the animals session by session, we plotted the percentage of the six animals "working" on each session. (By definition, an animal earning rewards was "working" on that session.) Data for both Experimental and Control group animals on the three days prior to electric field exposure and the first three days of 60 kV/m are provided

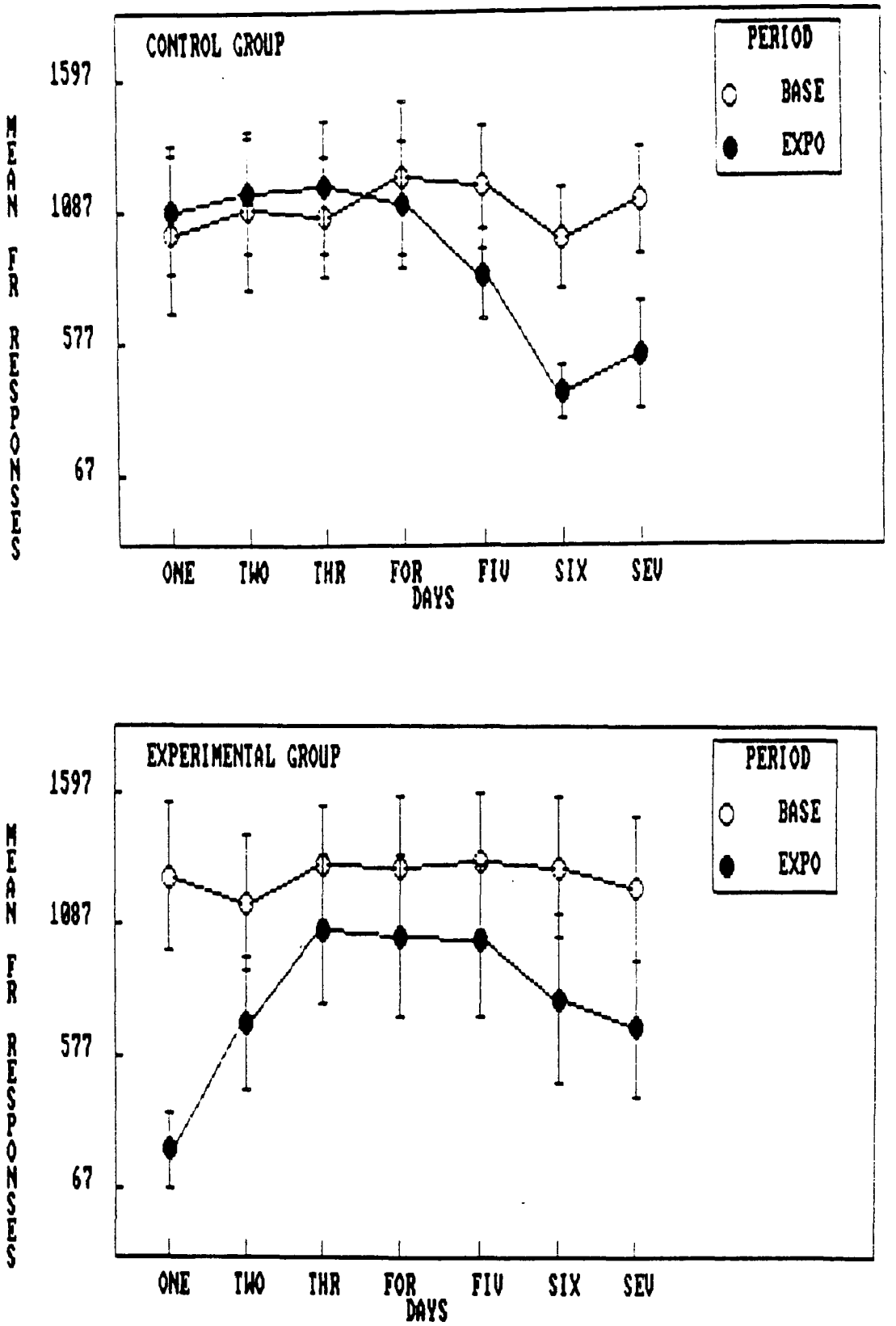


Figure XII.24. Mean FR responses per component for the Control group (upper panel) and Experimental group during the last week of Pre-Exposure (Base), and the first week of Exposure (Expo) of Experiment II (60 kV/m).

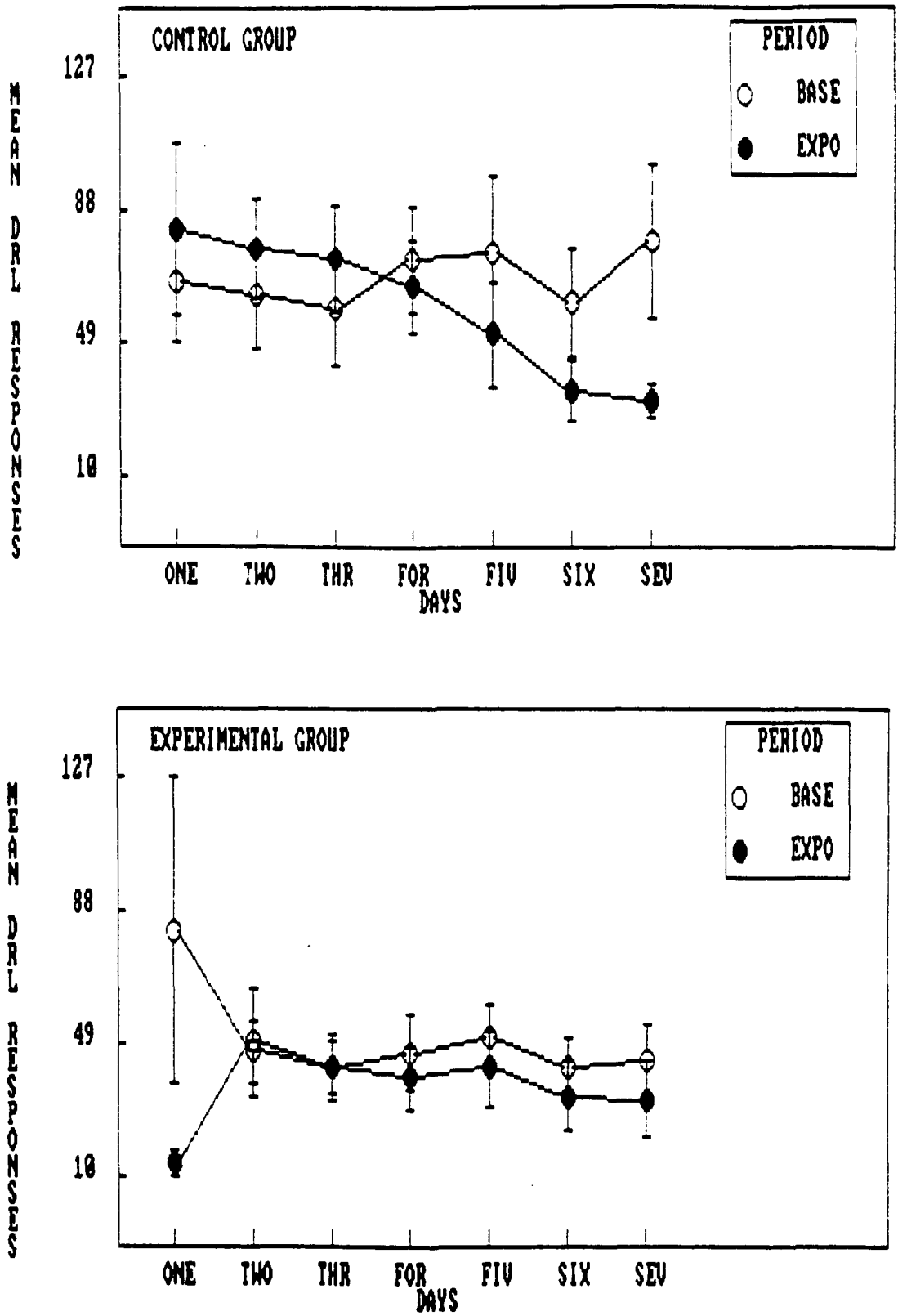


Figure XII.25. Mean DRL responses per component for the Control group (upper panel) and Experimental group during the last week of Pre-Exposure (Base), and the first week of Exposure (Expo) of Experiment II (60 kV/m).

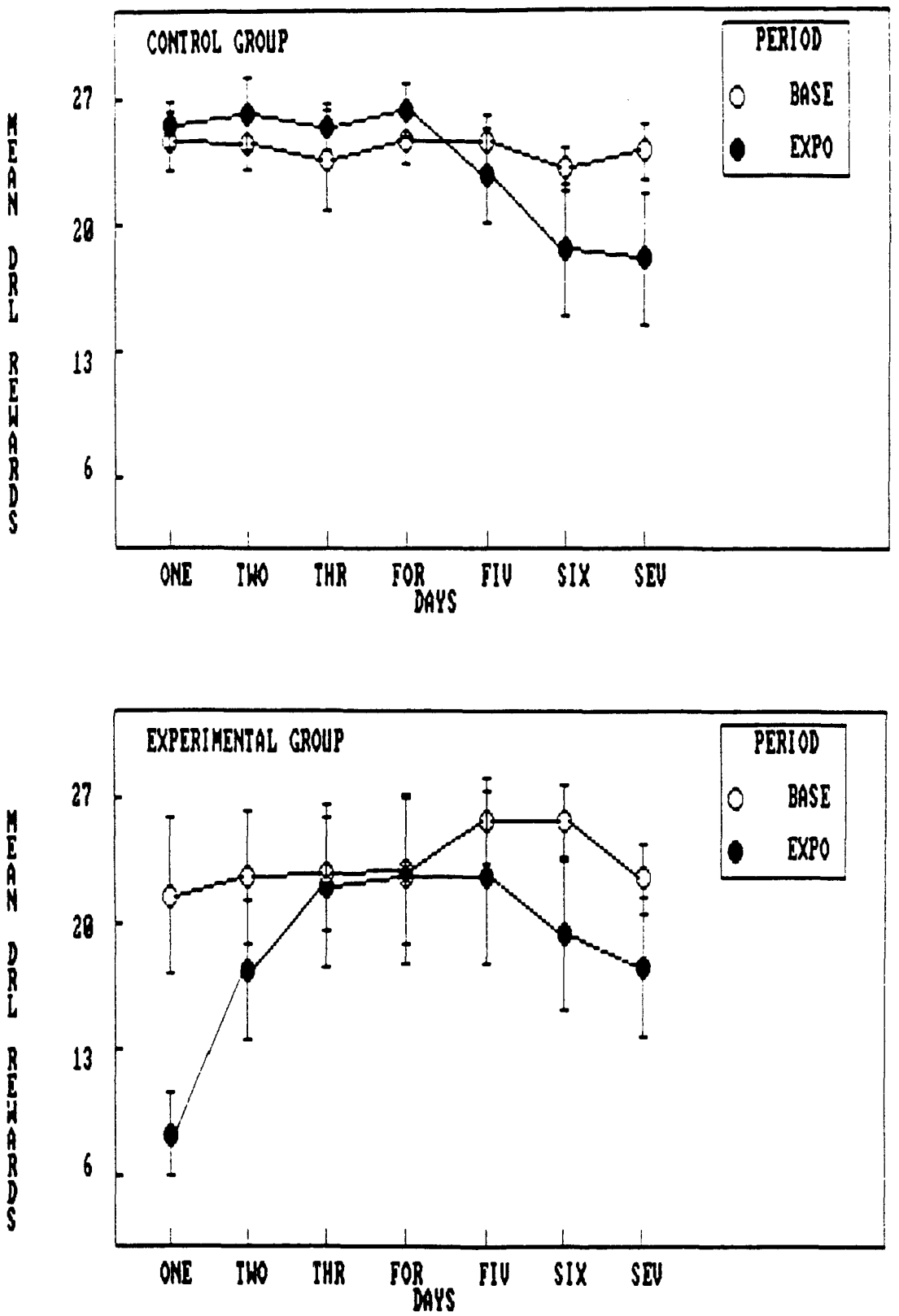


Figure XII.26. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during the last week of Pre-Exposure (Base), and the first week of Exposure (Expo) of Experiment II (60 kV/m).

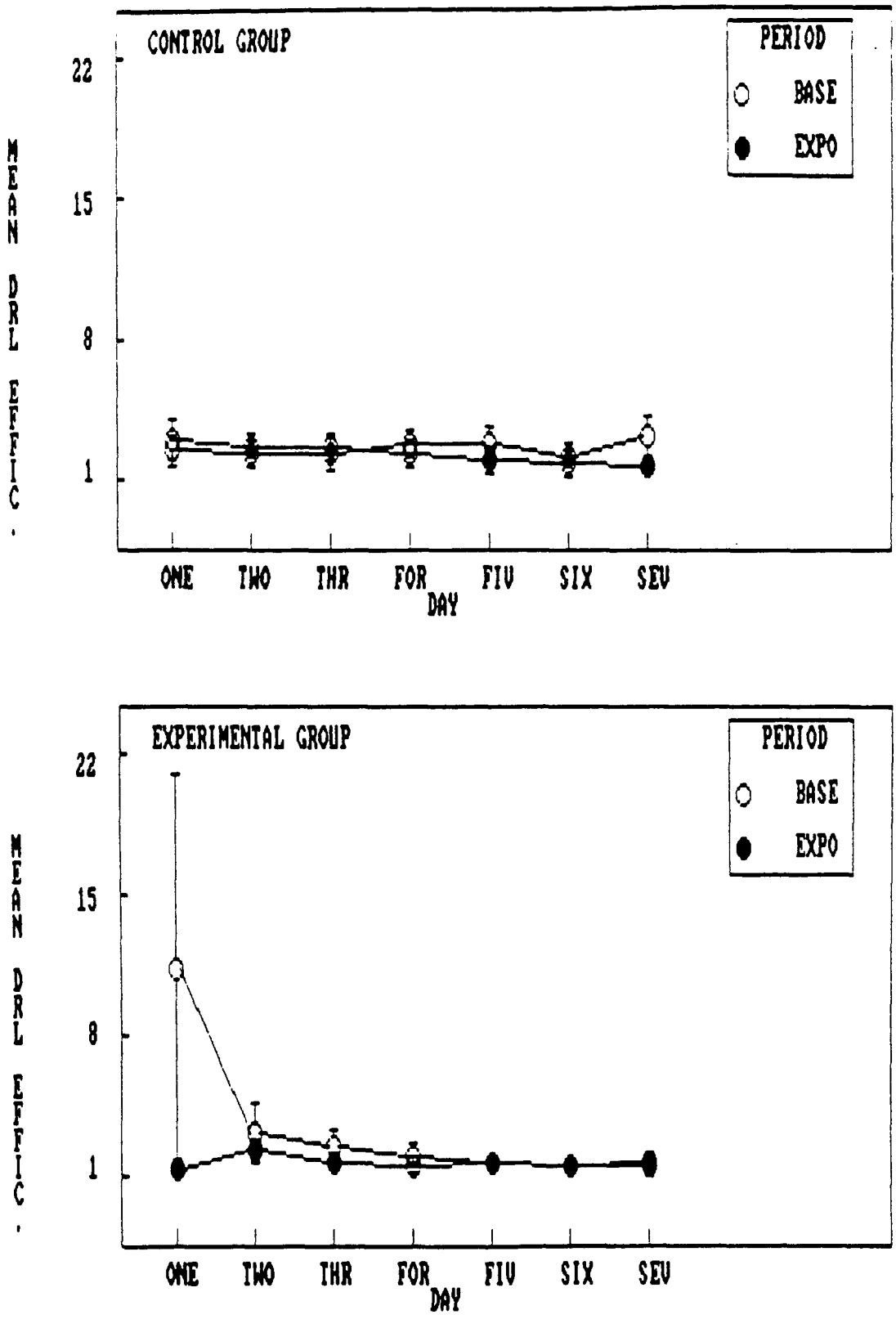


Figure XII.27. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during the last week of Pre-Exposure (Base), and the first week of Exposure (Expo) of Experiment II (60 kV/m).

for both FR (Figure XII.28) and DRL (Figure XII.29) responding. FR responding was reduced on the first day, but the percentage was not changed much on the third day. Baboon 1225 made no responses during electric field exposure. DRL responding also was reduced on the first day, but by the third day all Experimental animals other than 1225 worked consistently.

5. Analyses by Sessions Within the First Week

The ANOVA (Table XII.29) model included the between group factor group (Control or Experimental) and the within groups factors Period (Pre-Exposure and Exposure) and Session (One through Six). The data array included 12 scores for each of 12 subjects, and each score was the mean of data for the seven days of the week.

Table XII.29

Summary of ANOVA Model for Analysis by Sessions
First Week of Experiment II (60 kV/m)

Source	df
Groups	1
Error	10
Period	1
Groups × Period	1
Error	10
Days	5
Groups × Days	5
Error	50
Period × Days	5
Groups × Period × Days	5
Error	50

Homogeneity.-- The raw score data for mean FR responses per component and mean DRL rewards per component were used in the ANOVA (Table XII.30). The square root transformation produced homogeneity for DRL responses, and the log transformation produced homogeneity for DRL efficiency. Neither of the

ANOVA.-- The Session variable was significant ($P<.003$) for each of the four variables, but none of the Groups × Session interactions were significant (Table XII.31). One Period × Day interaction (DRL rewards) and one Groups × Periods × Session interaction (FR responses) also were detected.

Graphs.-- Figures XII.30 through XII.33 show the plots of the principal means.

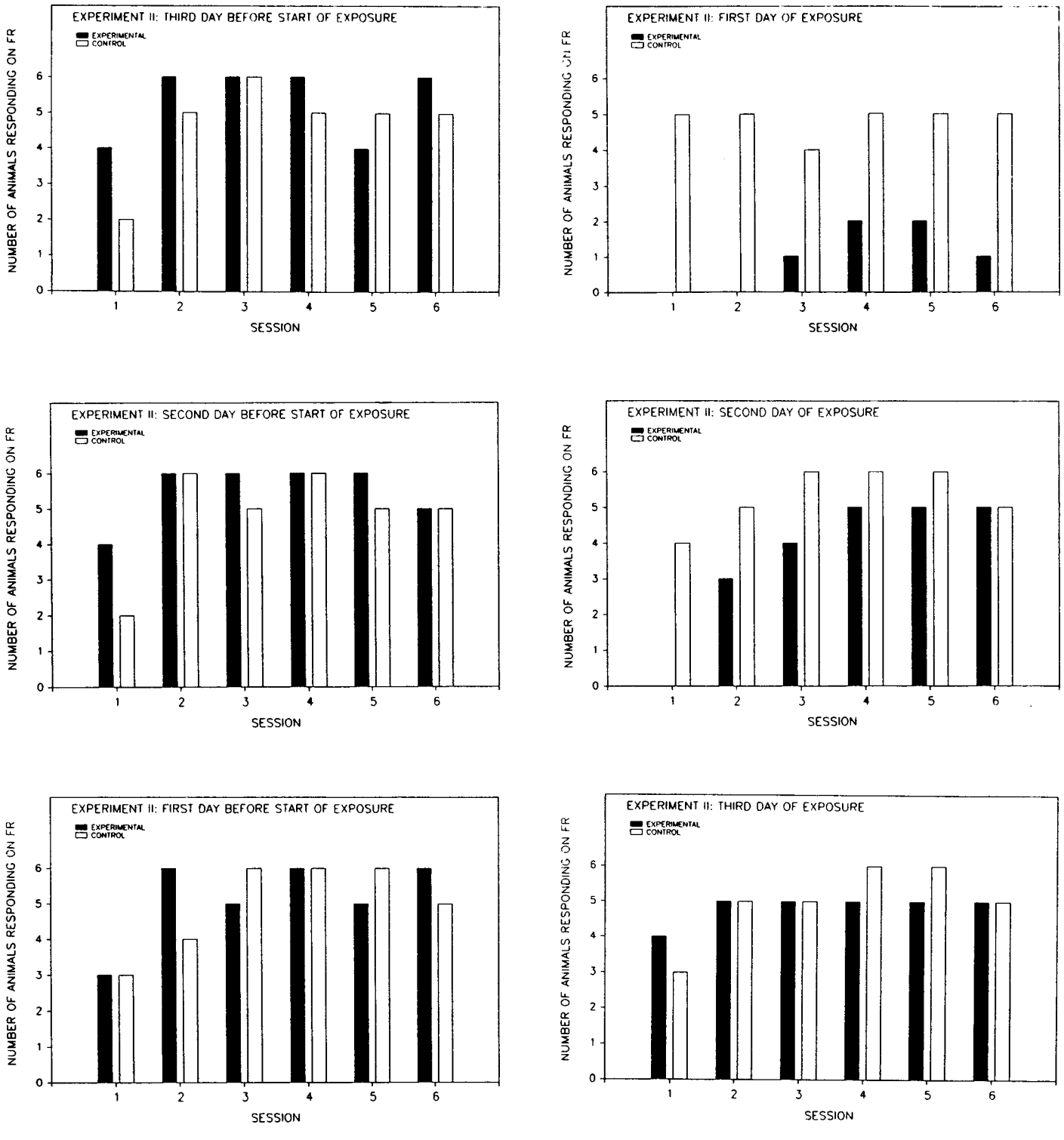


Figure XII.28. Percentage of the six Control and six Experimental subjects earning six or more rewards on the FR task during the six daily Sessions for the last three days of Pre-Exposure and first three days of 60 kV/m exposure in Experiment II (60 kV/m).

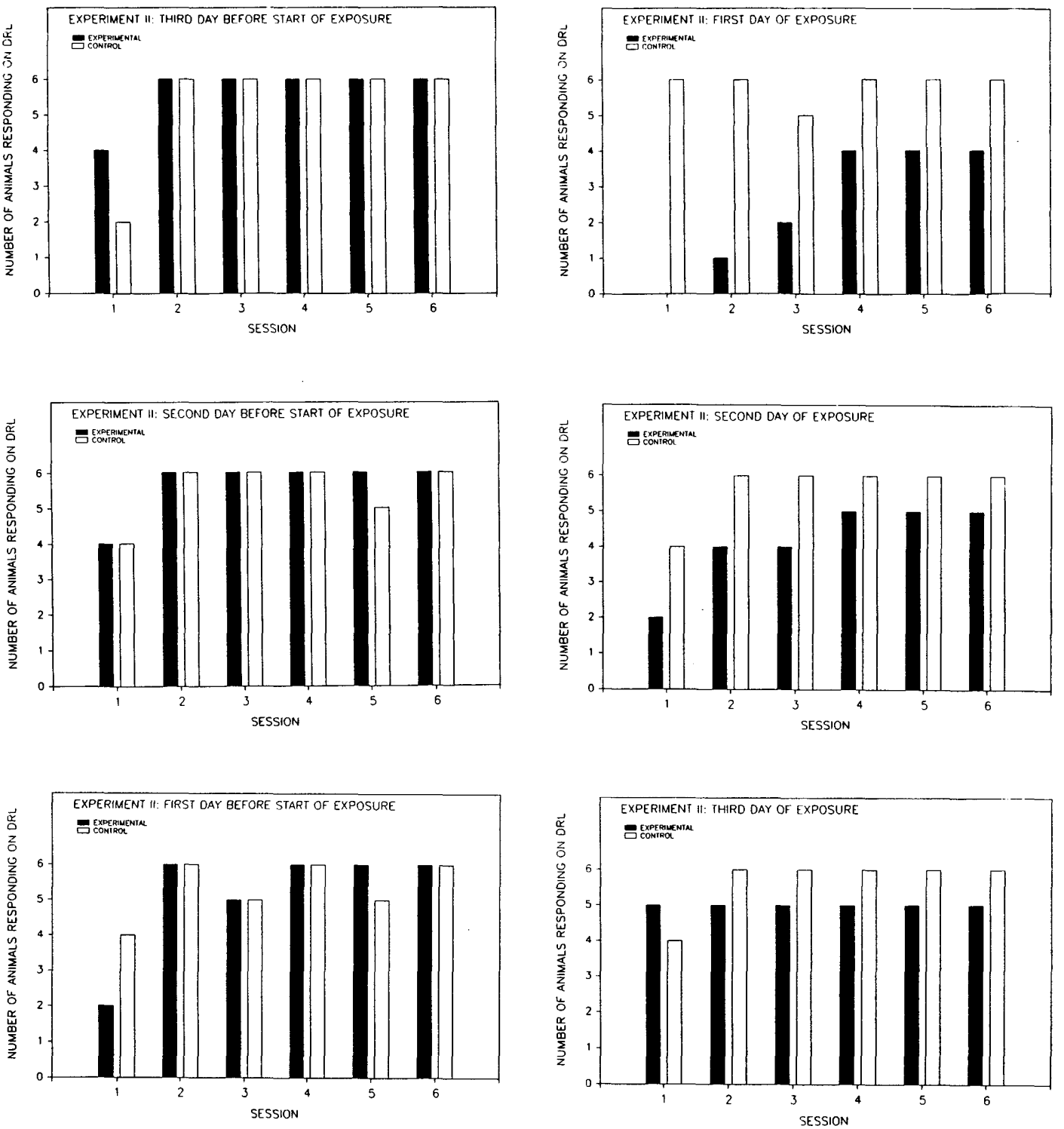


Figure XII.29. Percentage of the six Control and six Experimental subjects earning six or more rewards on the DRL task during the six daily Sessions for the last three days of Pre-Exposure and first three days of 60 kV/m exposure in Experiment II (60 kV/m).

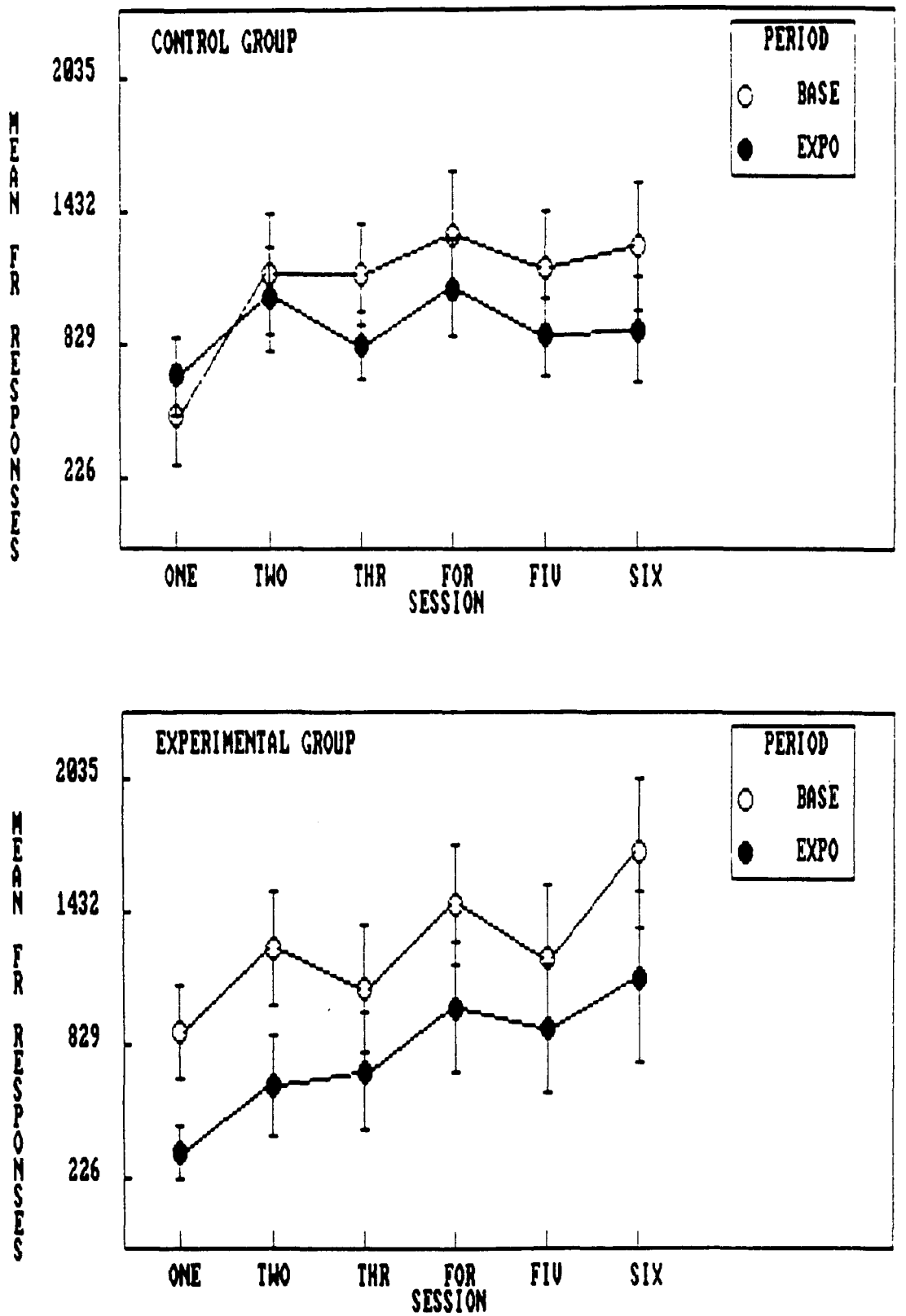


Figure XII.30. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) of Experiment II (60 kV/m).

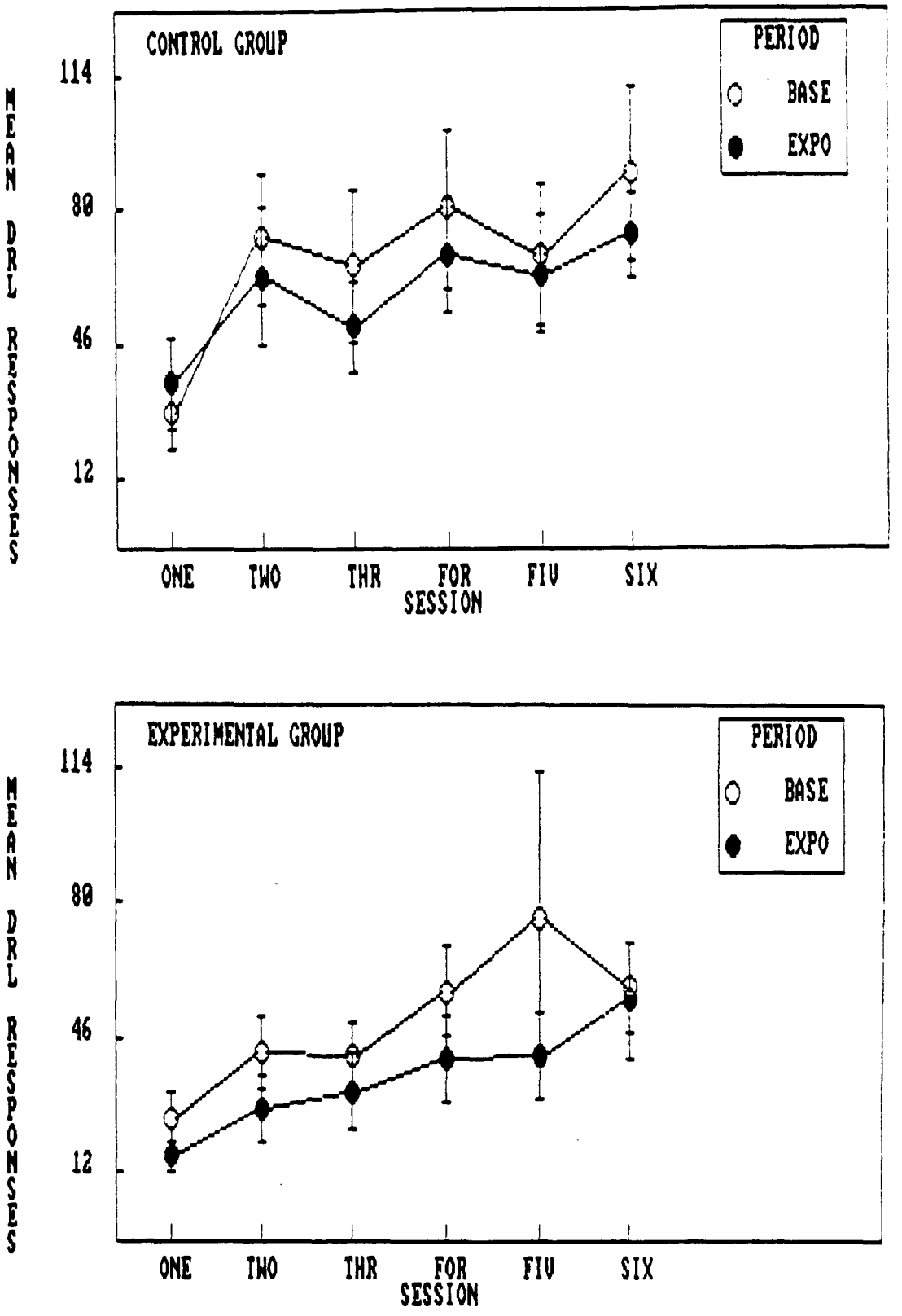


Figure XII.31. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) of Experiment II (60 kV/m).

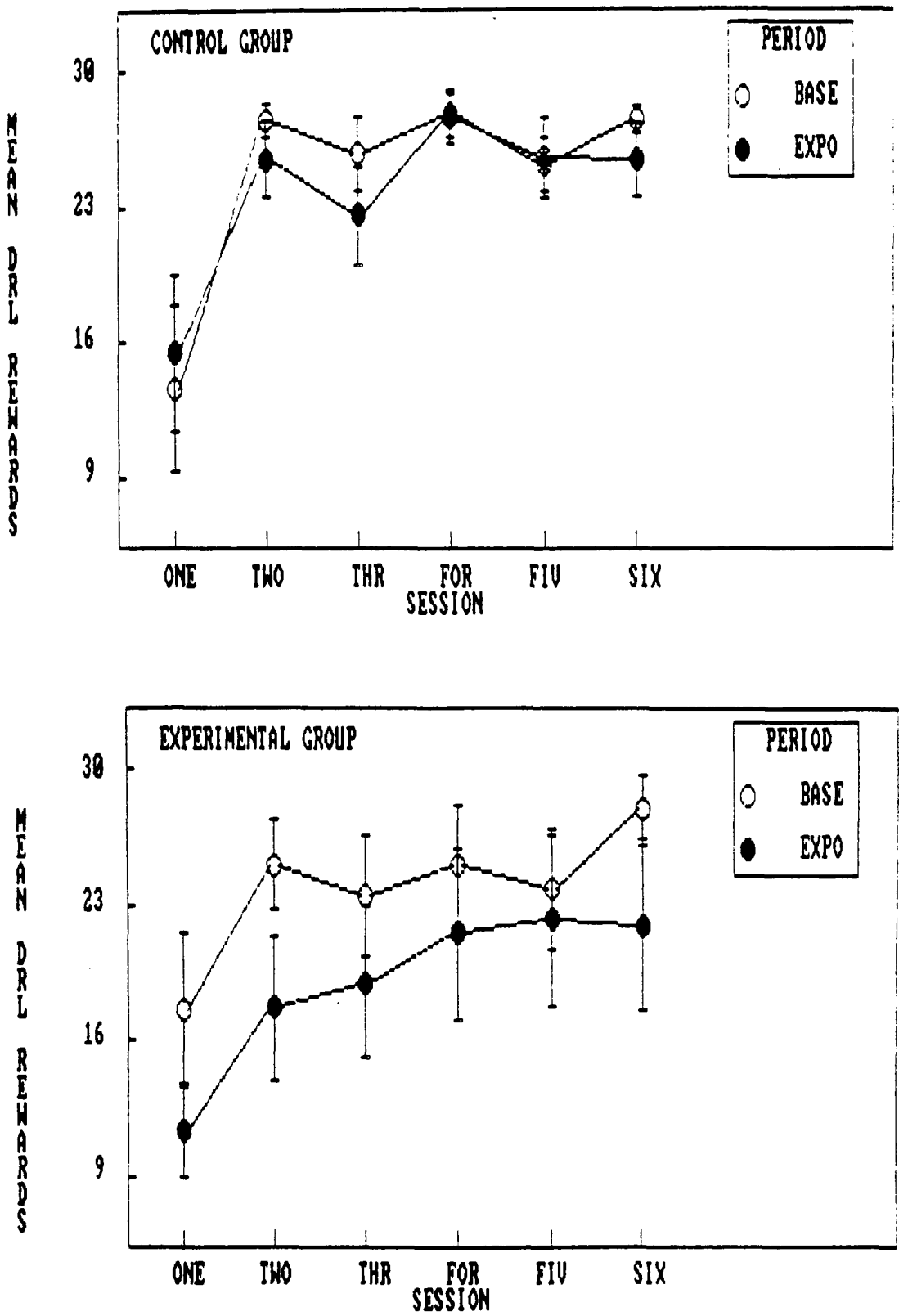


Figure XII.32. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) of Experiment II (60 kV/m).

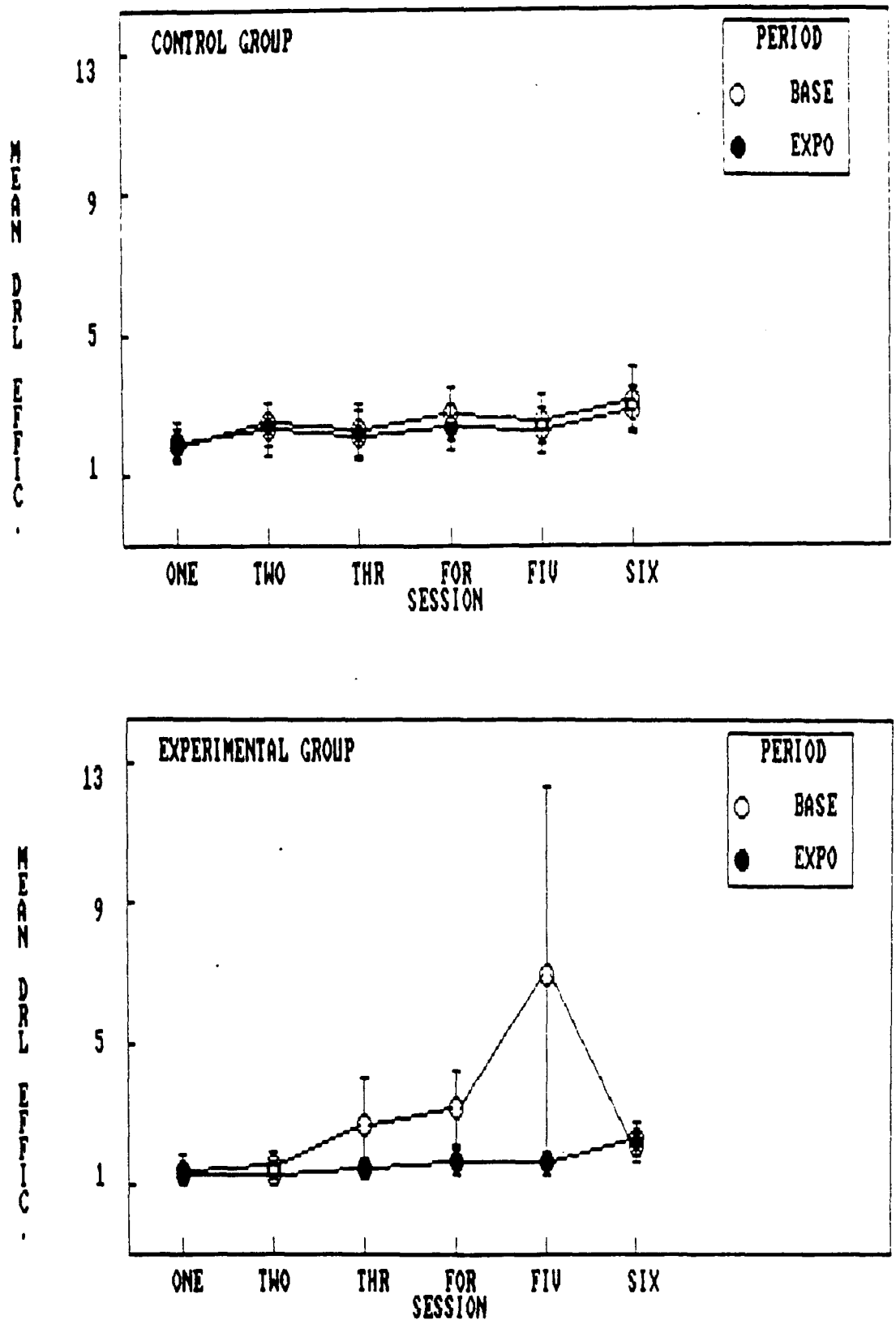


Figure XII.33. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) of Experiment II (60 kV/m).

Table XII.30

Summary of Results of F Max Tests Experiment II (60 kV/m)
Analyses by Sessions During the First Week

Variable	Raw Score	Log	Square Root
Mean FR Resp.	10.3#	NA	NA
SD of FR Rest.	21.1#	NA	NA
Mean DRL Resp.	90	NA	10.7#
SD of DRL Rest.	884	5.9#	75.2
Mean DRL Rew.	46.7#	310	98
SD of DRL Rew.	43.3	NA	20.0#
Mean DRL Eff.	356	16.2#	75
SD of DRL Eff.	37,362	318#	692

Used in ANOVA.

Table XII.31

Summary of Lowest Probabilities for F Ratios in Analyses of
Experiment II (60 kV/m) Data by Sessions during the First Week

Variable	Group	Period	G×P	Sess	G×S	P×S	G×P×S
FR Res.	NS	.04	NS	.001	NS	.07	.01
SD Resp.	NS	.04	NS	NS	NS	NS	NS
DRL Res.	NS	NS	NS	.001	NS	NS	NS
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	NS	NS	NS	.001	NS	.04	NS
SD Rew.	NS	.06	NS	.001	NS	NS	NS
DRL Eff.	NS	.05	NS	.003	NS	NS	NS
SD Eff.	NS	NS	NS	NS	NS	NS	NS

6. Summary

The results of Experiment II are very consistent with those of Experiment I. Introduction of a strong electric field of either 30 or 60 kV/m causes nonhuman primates to stop performing operant tasks for about one day. We detected no sign of effects on operant behavior during either the rest of the six-week exposure period or the six-week Post-Exposure period. There is some suggestion that electric field exposure improves the efficiency of DRL responding.

F. Results of Experiment IIA (60 kV/m)

In Experiment IIA, the Experimental group was re-exposed to a 60 kV/m electric field for a period of nine days. The group had been exposed for six weeks but had received no further electric field exposure for the six-week duration of the Post-Exposure period. The data from the last nine days of the Post-Exposure period were used as Baseline for this experiment.

1. Analyses by Days

The ANOVA model included the between groups factor Group (Experimental and Control) and the within groups factors Period (Baseline and Exposure) and Day (One through Nine). The data were collapsed across sessions. The data array included 18 scores from each of 12 subjects. Each score is the mean of the six components run on each day. The ANOVA table is summarized in Table XII.32.

Table XII.32

Summary of ANOVA Model for Analysis of Experiment II (60 kV/m) Data by Days

Source	df
GROUPS	1
Error	10
PERIOD	1
GROUPS × PERIOD	1
Error	10
DAYS	8
GROUPS × DAYS	8
Error	80
PERIOD × DAYS	8
GROUPS × PERIOD × DAYS	8
Error	80

Homogeneity.-- The treatment variances were homogeneous for FR responses and DRL rewards (Table XII.33). For DRL responses the square root transformed scores were used, and the log (base 10) transformed scores were used for the DRL efficiency data. Neither of the transformed scores had F max statistics of $P<.05$, but both were $P<.01$. Given the robust nature of ANOVA with respect to homogeneity of variance, these two ANOVAs can be accepted with confidence.

Table XII.33

Summary of Results of F Max Tests for
Experiment IIA (60 kV/m) Data by Days

Variable	Raw Score	Log	Square Root
Mean FR Resp.	4.0#	NA	NA
SD of FR Resp.	12.4#	NA	NA
Mean DRL Resp.	81.3	54.3	48.4#
SD of DRL Resp.	408	29.4#	74.8
Mean DRL Rew.	8.7#	NA	NA
SD of DRL Rew.	7.1#	NA	NA
Mean DRL Eff.	155	30.3#	63.7
SD of DRL Eff.	9724	272#	471

Used in ANOVA.

Means.-- The primary summary means from the ANOVA suggest that very little happened in Experiment IIA (Table XII.34).

Table XII.34

Summary of Principal Means from ANOVA of
Experiment IIA (60 kV/m) Data by Days

	Group		Period	
Variable	Exptl	Contrl	Pre.	Expo.
Mean FR Resp.	1,173	1,141	1,295	1,019
SD of FR Resp.	381	429	390	420
Mean DRL Resp.	43.4	45.5	47.3	41.7
SD of DRL Resp.	19.7	21.2	18.0	22.9
Mean DRL Rew.	22	23.6	24.2	21.1
SD of DRL Rew.	21.7	7.8	6.7	7.2
Mean DRL Eff.	1.9	2.0	1.8	2.1
SD of DRL Eff.	0.8	0.7	0.5	1.0

ANOVA.-- Only two significant F ratios, the Period × Days interactions for FR and DRL responses, related to electric field exposure were detected (Table XII.35). The Day effect was significant for each of the four variables.

Graphs.-- Mean FR responses per component by the Experimental group during Experiment IIA seem a bit lower than during Baseline (Figure XII.34), but many of the error bars overlap, so a significant effect is unlikely. Baboon 1225 responded well during Pre-Exposure but did not respond during

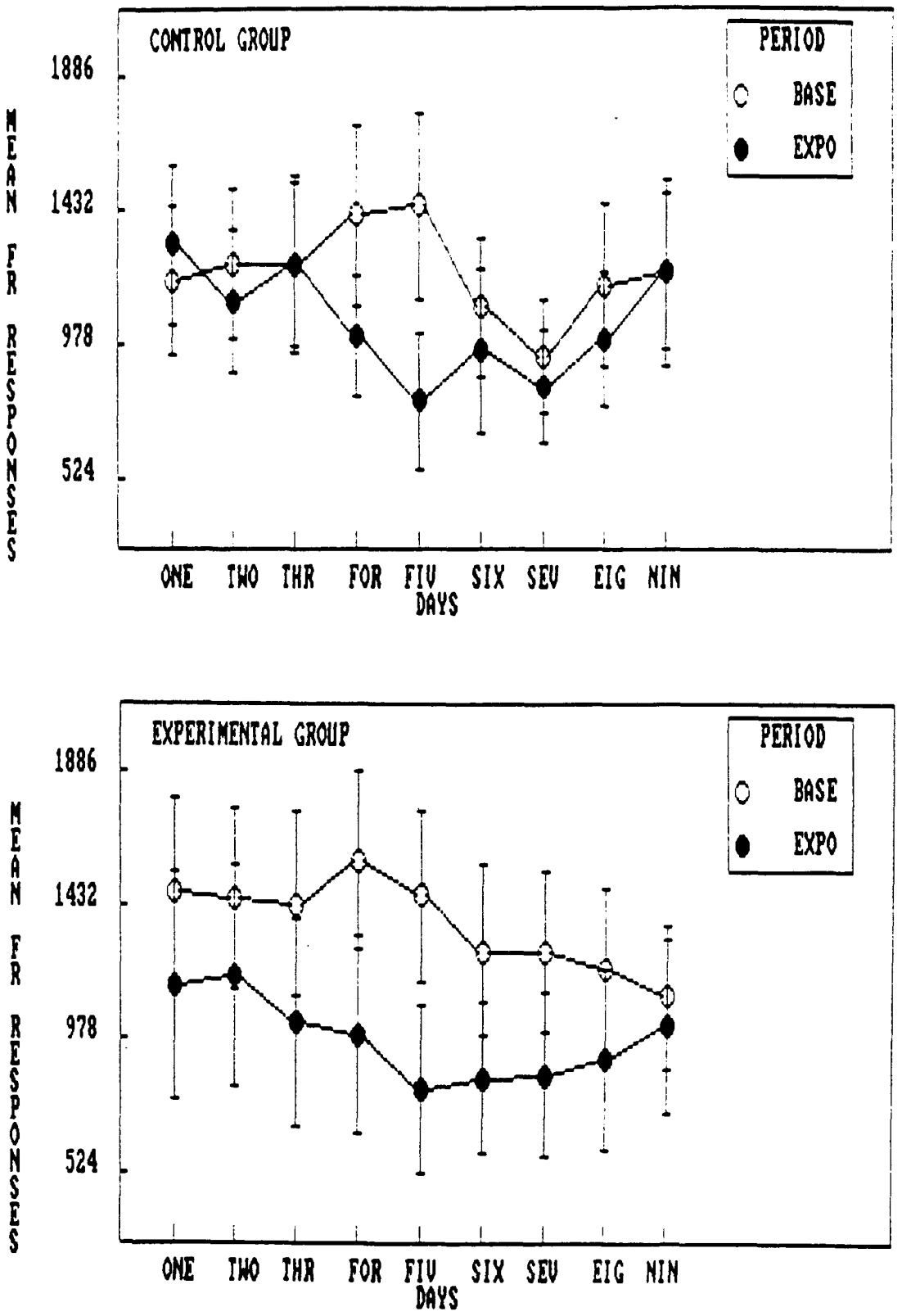


Figure XII.34. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) during Experiment IIA (60 kV/m).

Table XII.35

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment IIA Data by Days

Variable	Group	Period	G×P	Days	G×D	P×D	G×P×D
FR Res.	NS	.08	NS	.001	NS	.004	NS
SD Resp.	NS	NS	NS	NS	NS	.02	NS
DRL Res.	NS	NS	NS	.001	NS	.04	NS
SD Resp.	NS	NS	NS	NS	NS	.03	NS
DRL Rew.	NS	NS	NS	.005	NS	NS	.09
SD Rew.	NS	NS	NS	.01	NS	NS	NS
DRL Eff.	NS	NS	.09	.02	NS	.11	NS
SD Eff.	NS	NS	NS	.03	NS	.06	NS

Exposure. Mean DRL responses seemed less affected (Figure XII.35), but mean DRL rewards were reduced somewhat (Figure XII.36). With the exception of the first and fourth days, mean DRL efficiency of the Experimental group seemed quite unaffected by electric field exposure (Figure XII.37).

2. Analyses by Sessions

For this set of analyses, the data were collapsed across the nine days of each Period so that the Sessions (One through Six) within days could be examined. The data array consisted of 12 scores for each of 12 subjects; each score is the mean of components on nine days. The ANOVA model (Table XII.36)

Table XII.36

Summary of ANOVA Model for Analysis by Sessions for Experiment IIA (60 kV/m)

Source	df
GROUPS	1
Error	10
PERIOD	1
GROUPS × PERIOD	1
Error	10
DAYS	5
GROUPS × DAYS	5
Error	50
PERIOD × DAYS	5
GROUPS × PERIOD × DAYS	5
Error	50

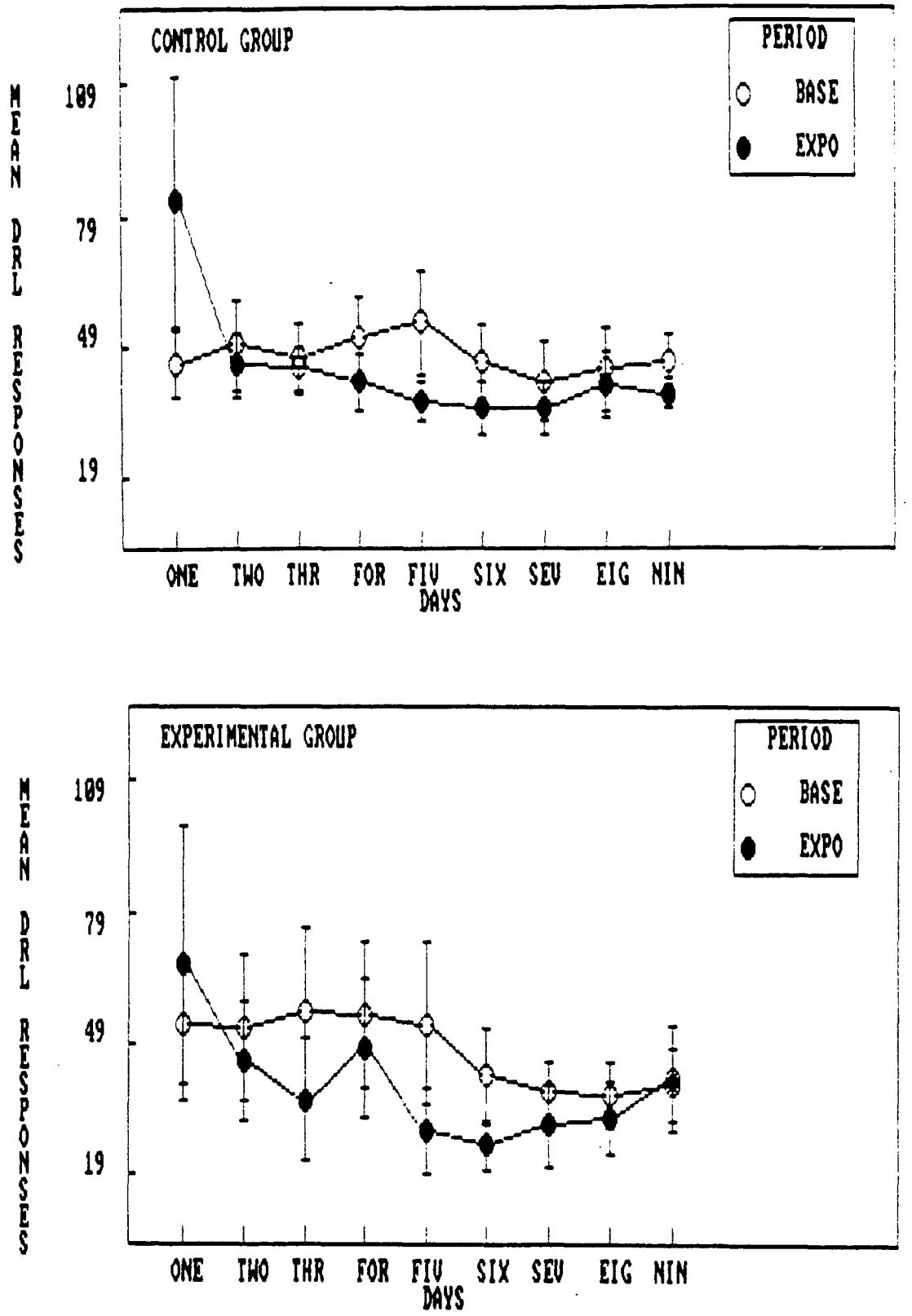


Figure XII.35. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) during Experiment IIA (60 kV/m).

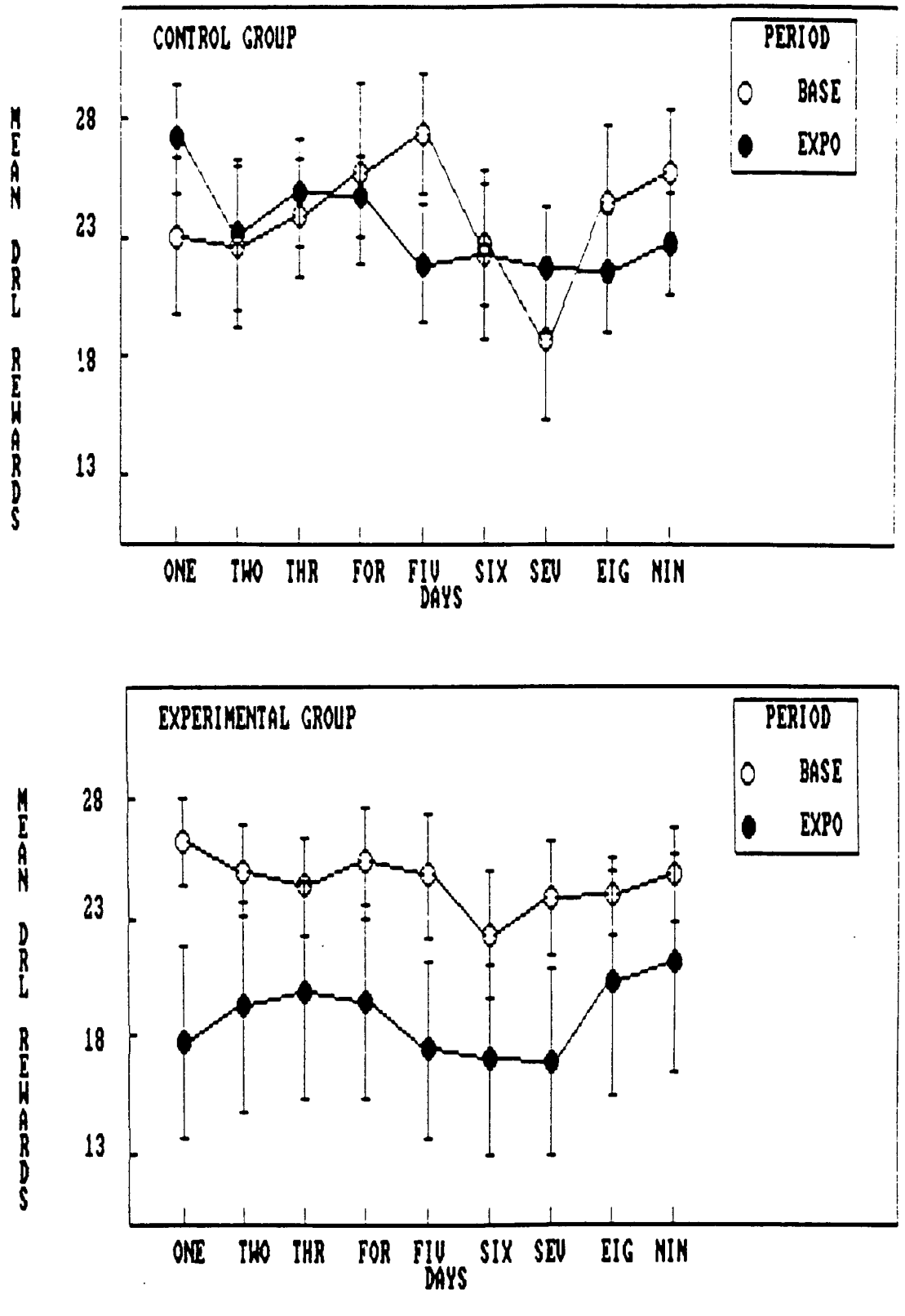


Figure XII.36. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) during Experiment IIA (60 kV/m).

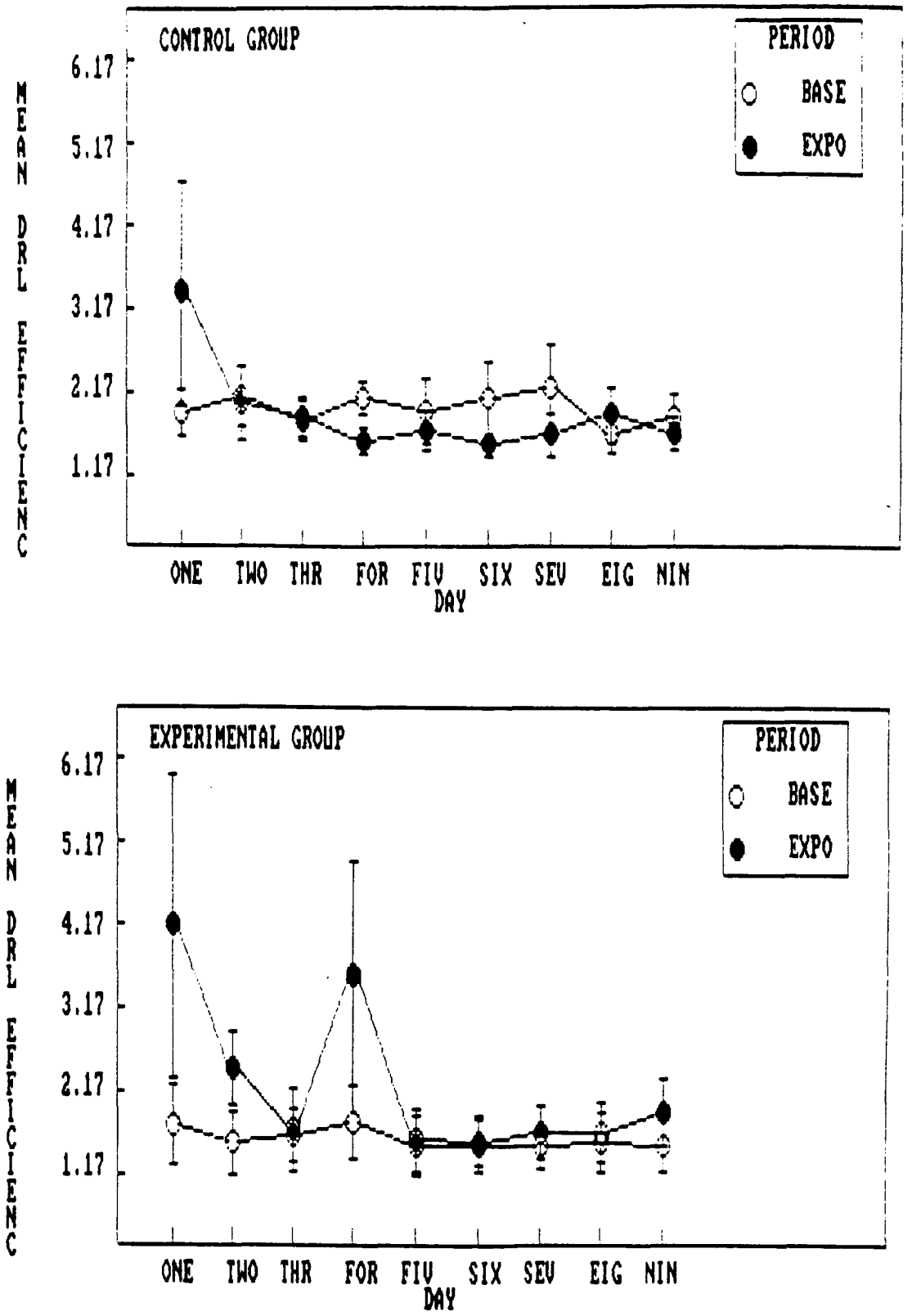


Figure XII.37. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base) and Exposure (Expo) during Experiment IIA (60 kV/m).

included the between groups factor Groups (Experimental and Control) and the within subjects factors Period (Baseline and Exposure) and Session (One through Six).

Homogeneity.-- The raw scores were suitable for FR and DRL responses (Table XII.37). The raw score data were used for DRL rewards although the F max statistic slightly exceeded the $P<.05$ criterion; the log and square root transforms merely accentuated the mild inhomogeneity of this data set. The square root and log transforms of the DRL efficienty data have not yet been completed.

ANOVA.-- Other than the expected Session effects, no statistically significant ($P<.05$) F ratios were detected (Table XII.38).

Table XII.37

Summary of Results of F Max Tests for Experiment IIA (60 kV/m) Analyses by Sessions

Variable	Raw Score	Log	Square Root
Mean FR Resp.	4.2#	NA	NA
SD of FR Resp.	27.6	NA	13.9#
Mean DRL Resp.	24.3#	NA	NA
SD of DRL Resp.	193	17.0#	43.7
Mean DRL Rew.	27.9#	770	47.1
SD of DRL Rew.	15.4#	NA	NA
Mean DRL Eff.	72.0	15.4#	31.4
SD of DRL Eff.	5,556	446	235#

Used in ANOVA.

Table XII.38

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment IIA Data by Sessions

Variable	Group	Period	G×P	Ses	G×S	P×S	G×P×S
FR Res.	NS	.07	NS	.001	NS	NS	NS
SD Resp.	NS	NS	NS	.01	NS	.10	NS
DRL Res.	NS	NS	NS	.001	NS	NS	NS
SD REsp.	NS	NS	NS	.06	.10	NS	NS
DRL Rew.	NS	NS	NS	.001	NS	NS	.11
SD Rew.	NS	NS	NS	.001	NS	NS	NS
DRL Eff.	NS	NS	.10	.05	NS	NS	NS
SD Eff.	NS	.10	NS	NS	NS	NS	NS

Graphs.-- As indicated in Figures XII.38 through XII.41, the means for the Experimental group during Exposure are usually less than the means for the same group during Baseline, but the error bars usually overlap. Thus, statistically, there was no electric field effect.

The percentage of the six Experimental and six Control group subjects responding on each of the six Sessions per day is summarized in Figures XII.42 and XII.43. Figure XII.42 shows the FR responding on the last three days prior to re-introduction of the electric field. Although there is some variation across days, usually two thirds or more of the animals work on each session. On the first day of electric field exposure, FR responding was reduced dramatically only on the first session. Both exposed and control groups appear to work a lot less on the next two days. The effect of field re-introduction on DRL responding is even less noticeable (Figure XII.43).

Summary.-- Very few statistically significant effects were detected in Experiment IIA. This indicates that once animals have been exposed to the electric field and "adapted" in the first day or two, they fully retain their "adaptation" when exposed again six weeks later.

F. Results of Experiment IIB (60 kV/m)

In this experiment, the "crossover" design of Experiment I was used again. To use the East end of the exposure facility as the exposure side, the animals were moved "end to end," placing the previous control group into the East end where they became the Experimental group. A period of six days was allowed to allow the animals to compensate for the move. Then they were exposed to the 60 kV/m electric field for a period of nine days.

1. Analyses by Days

The data from six days of Baseline and six days of Exposure were used in these analyses. The Baseline data came from the six days between the end of electric field exposure in Experiment IIA and the start of electric field exposure in Experiment IIB. The data array consisted of 12 scores, each the mean of six components run per day, for each of 12 subjects. For these ANOVA (Table XII.39), the between factor was Group (Control or Experimental) and the between factors were Period (Baseline and Exposure) and Days (One through Six).

Homogeneity.-- The raw score data were suitable for the ANOVA on FR responses amd DRL rewards (Table XII.40). The square root transformation succesfully achieved homogeneity of the DRL response data.

Means.-- The group means indicate appreciable differences between Experimental and Control groups for FR and DRL responses, DRL rewards, and DRL efficiency (Table XII.41). Comparisons of the Period means indicate that relatively large differences between Baseline and Exposure occurred on all four measures.

ANOVA.-- Although there were no statistically significant Group effects, the Period means differed for FR and DRL responses (Table XII.42). The Day effects were significant in every case. The Group × Day interactions

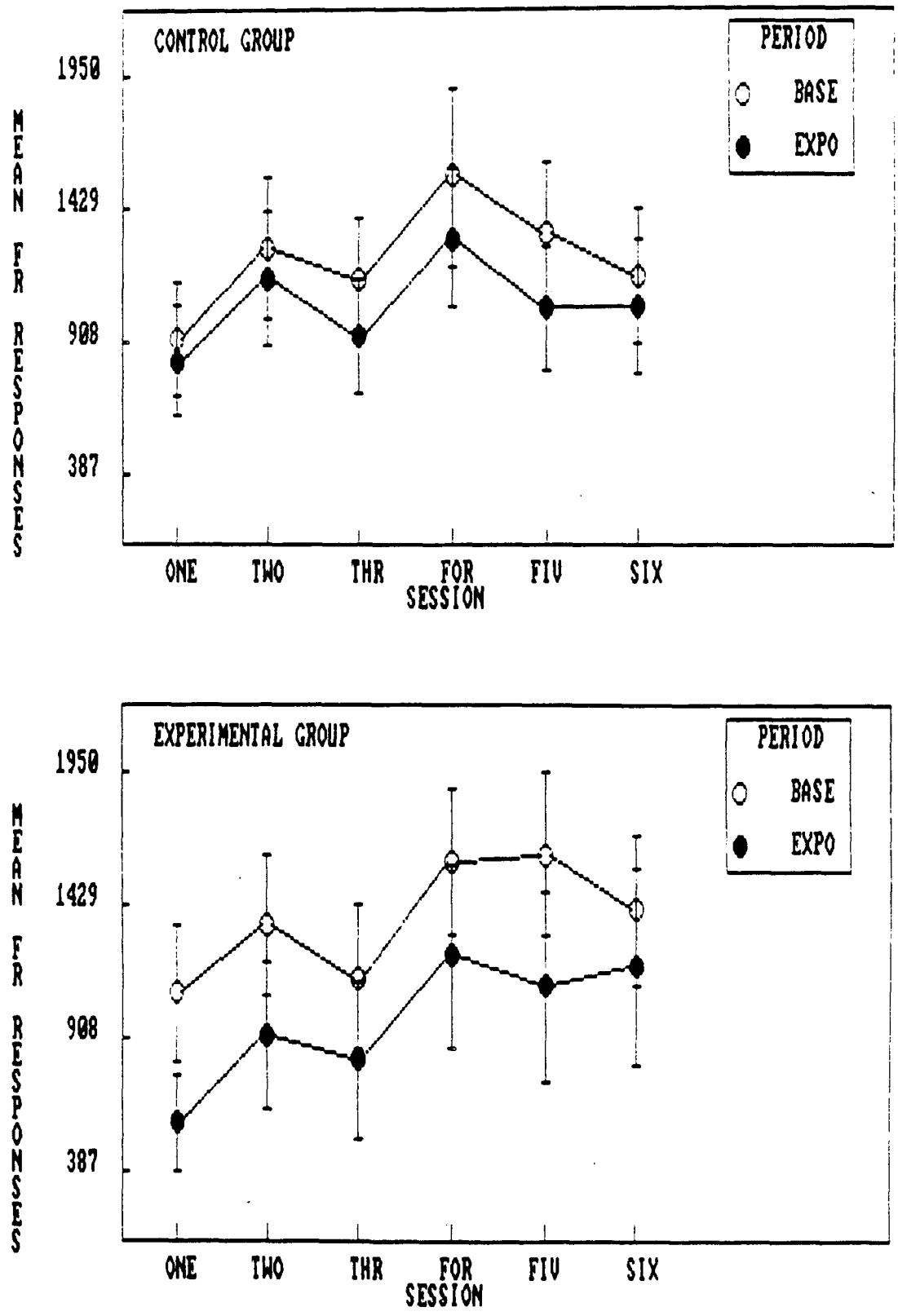


Figure XII.38. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIA (60 kV/m).

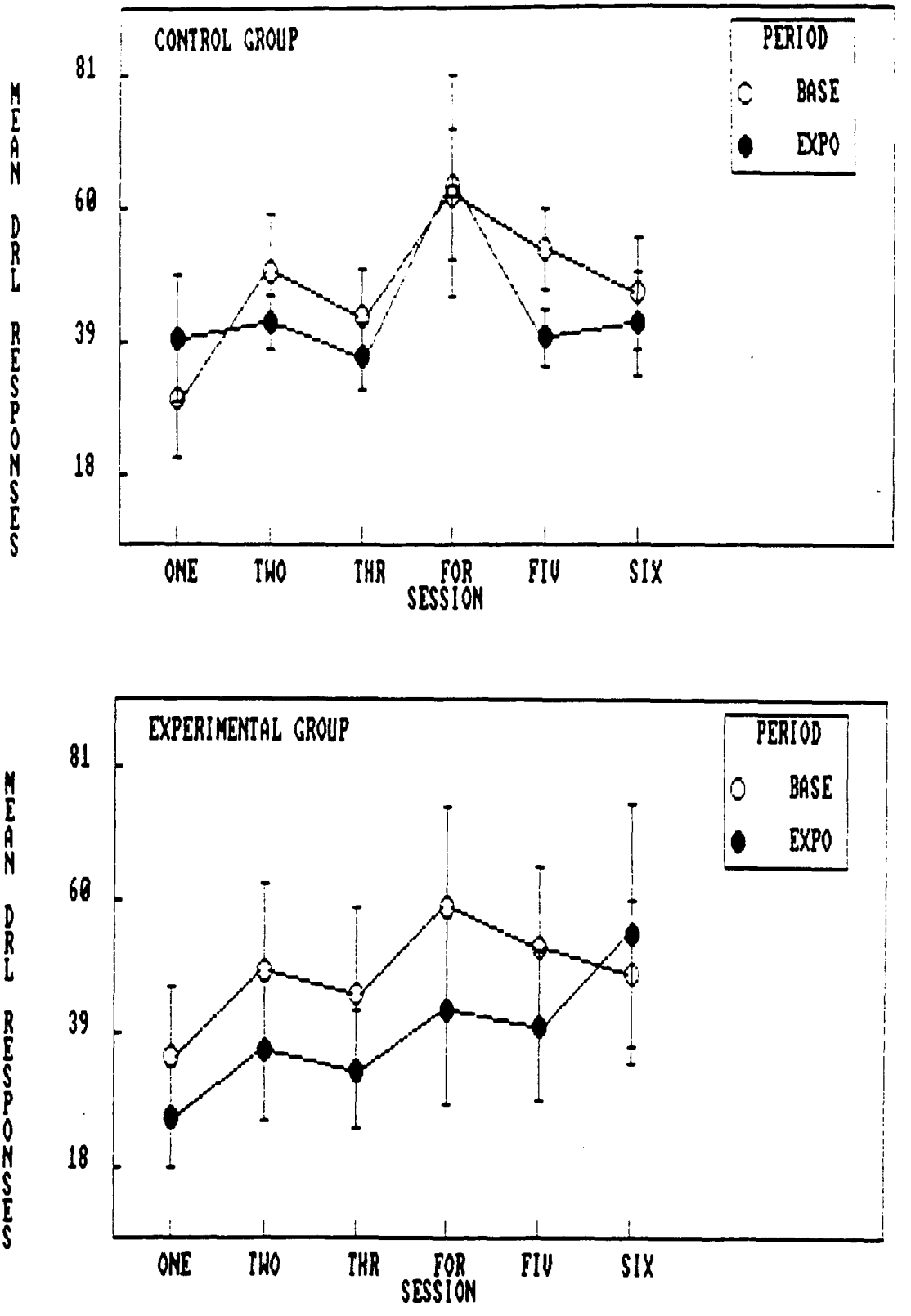
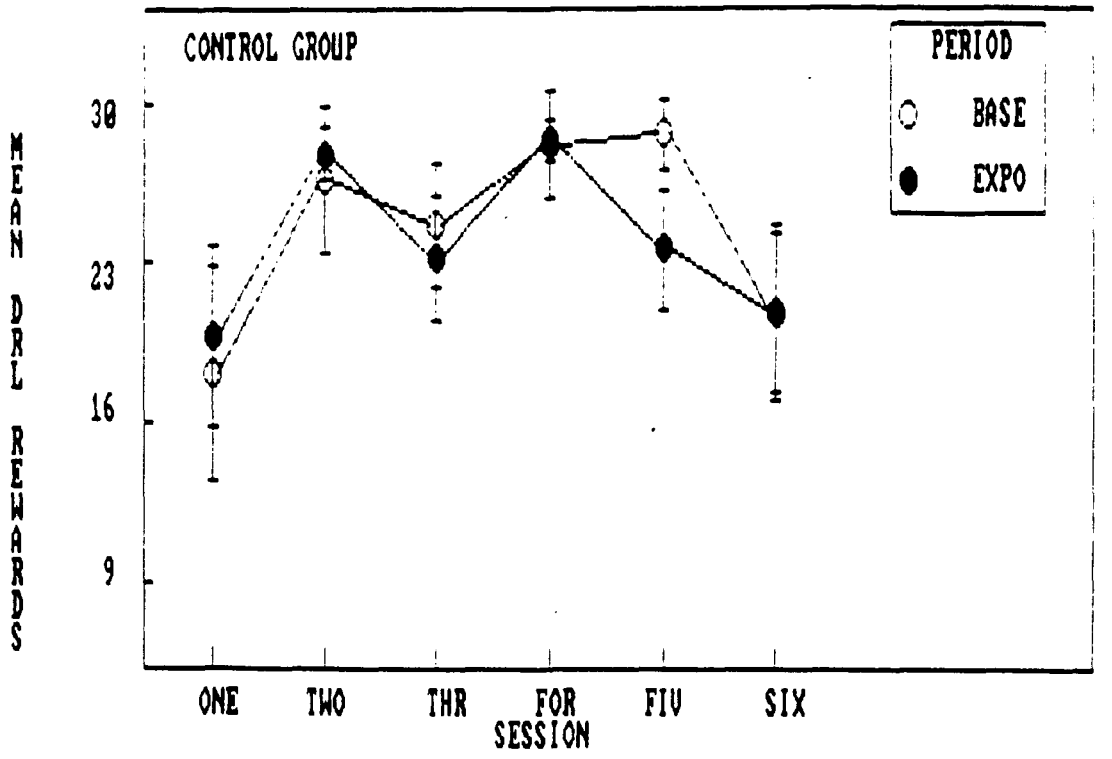


Figure XII.39. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIA (60 kV/m).



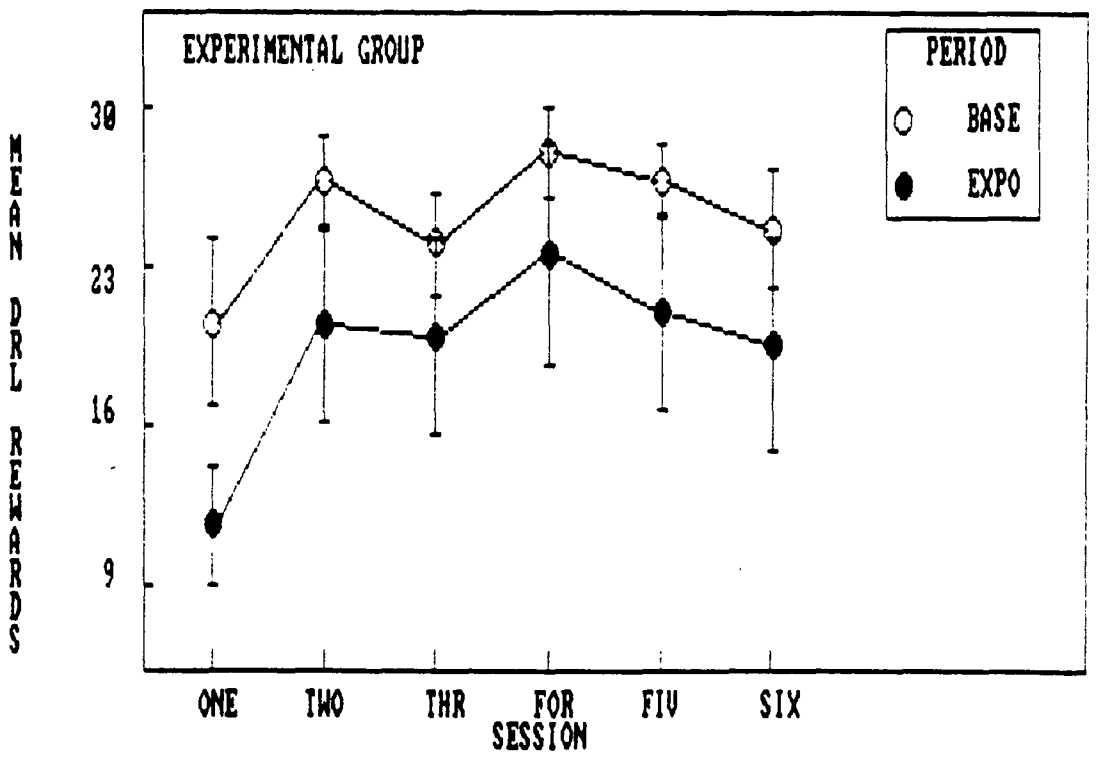


Figure XII.40. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIA (60 kV/m).

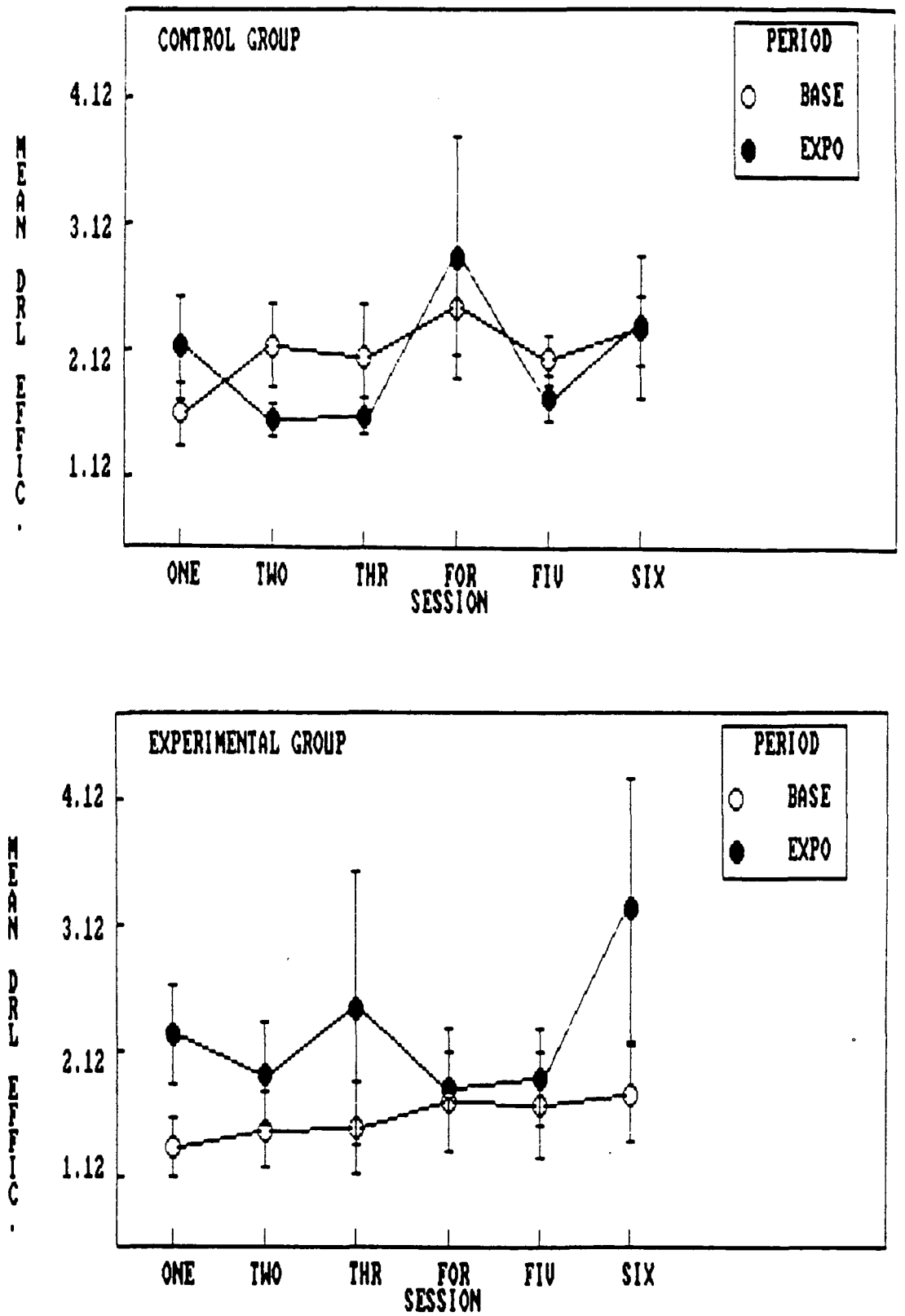


Figure XII.41. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo), during Experiment IIA (60 kV/m).

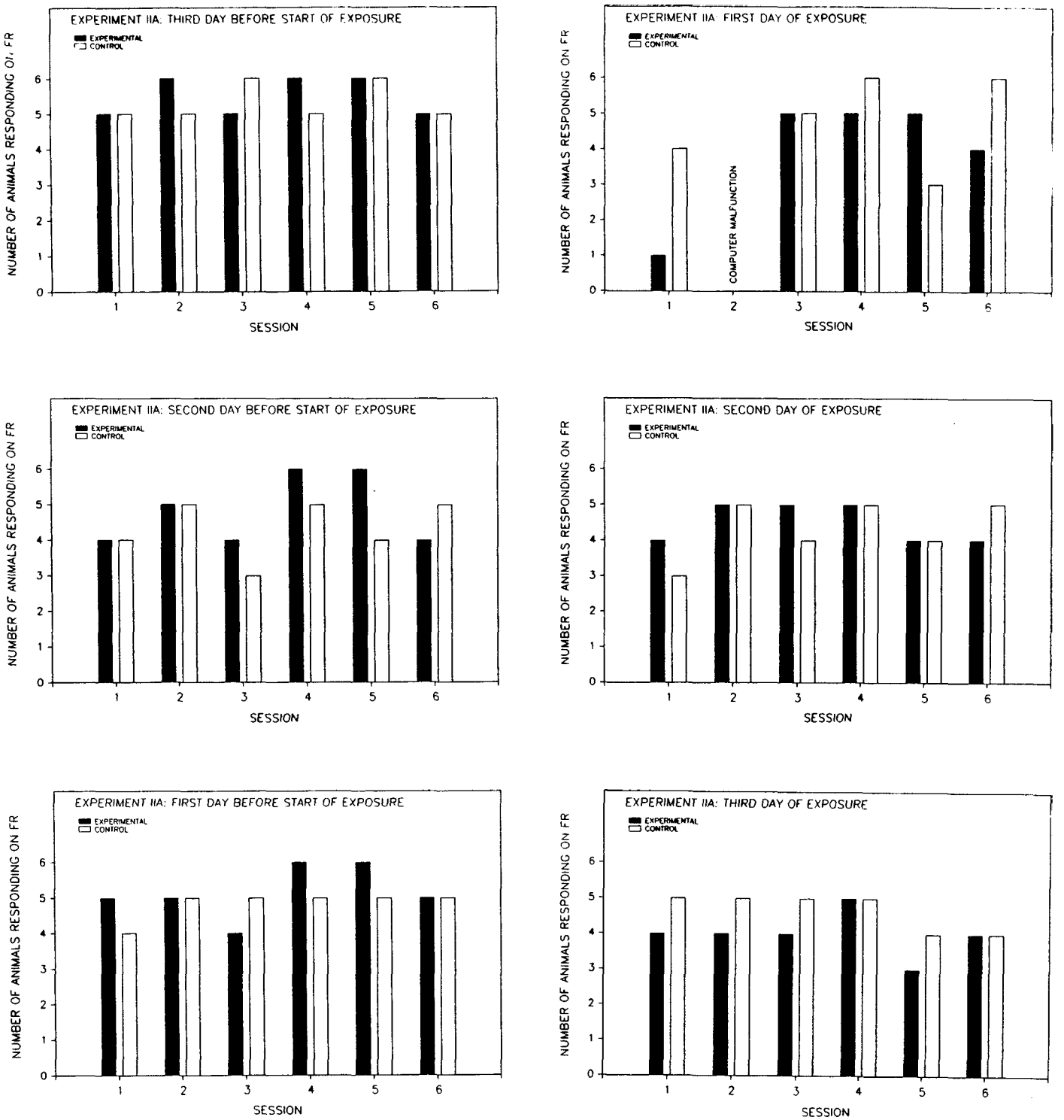


Figure XII.42. Percentage of Control and Experimental group subjects responding on the FR task during each of six daily sessions for the last three days before reintroduction of the electric field and for the first three days of electric field exposure in Experiment IIA (60 kV/m).

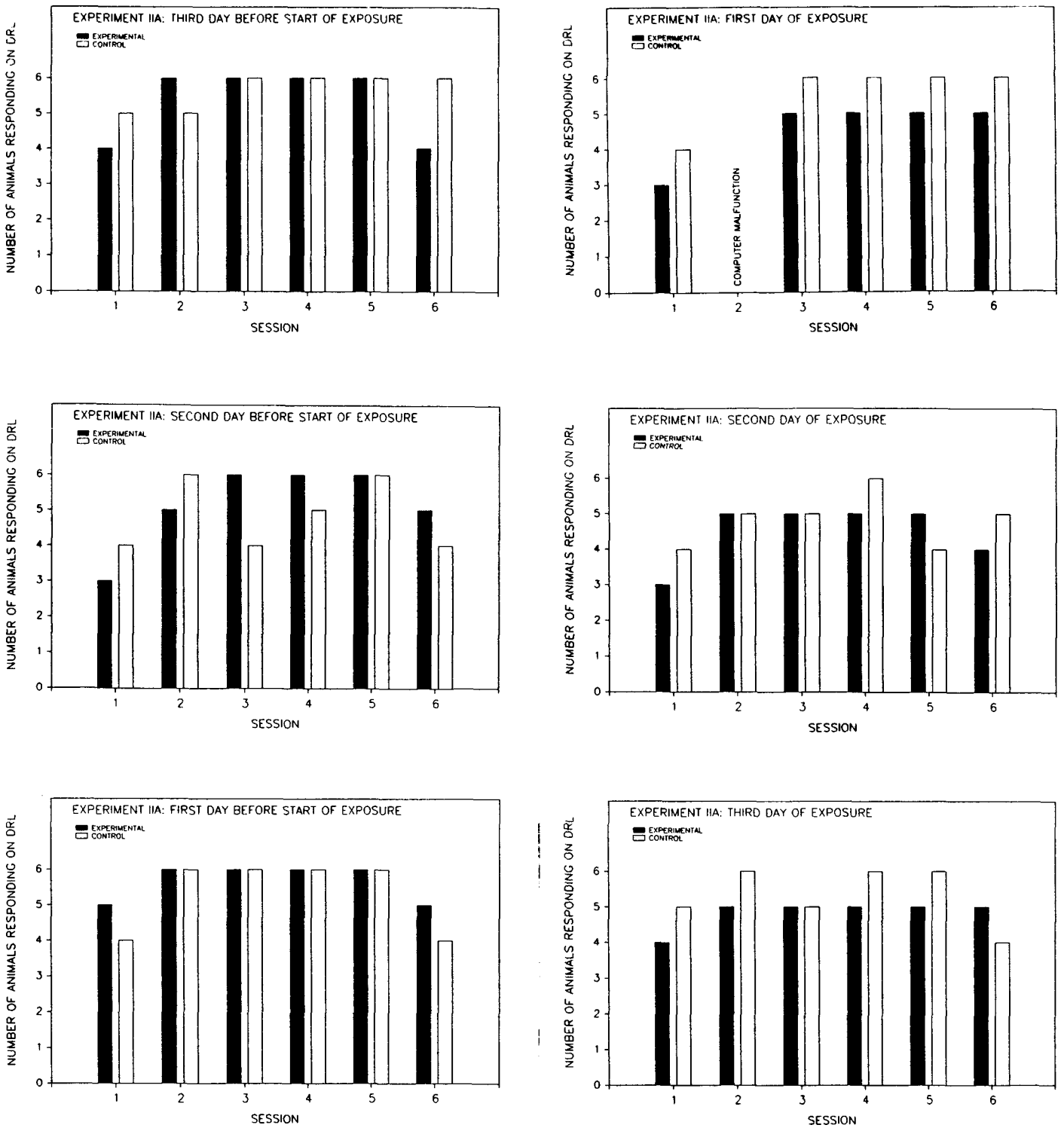


Figure XII.43. Percentage of Control and Experimental group subjects responding on the DRL task during each of six daily sessions for the last three days before reintroduction of the electric field and for the first three days of electric field exposure in Experiment IIA (60 kV/m).

Table XII.39

Summary of ANOVA Model for Analysis of ExperimentII (60 kV/m) by Days

Source	df
GROUPS	1
Error	10
PERIOD	1
GROUPS × PERIOD	1
Error	10
DAYS	5
GROUPS × DAYS	5
Error	50
PERIOD × DAYS	5
GROUPS × PERIOD × DAYS	5
Error	50

Table XII.40

Summary of Results of F Max Tests for Experiment II (60 kV/m) Data Analyzed by Group

Variable	Raw Score	Log	Square Root
Mean FR Resp.	24.9#	NA	NA
SD of FR Resp.	28.5	NA	18.0#
Mean DRL Resp.	35.2	NA	19.6#
SD of DRL Resp.	141	9.0#	29.0
Mean DRL Rew.	6.8#	NA	NA
SD of DRL Rew.	11.3#	NA	NA
Mean DRL Eff.	1007	919	160#
SD of DRL Eff.	6,833	26.1#	311

Used in ANOVA.

Table XII.41

Summary of Principal Means from ANOVA of Experiment IIB (60 kV/m) Data by Days

Variable	Group		Period	
	Contrl	Exptl	Pre.	Expo.
Mean FR Resp.	1,209	1,059	1,321	948
SD of FR Resp.	353	417	369	402
Mean DRL Resp.	63	47	63	48
SD of DRL Resp.	1.2	1.2	1.2	1.1
Mean DRL Rew.	22	23	24	21
SD of DRL Rew.	5.2	7.3	6.1	6.4
Mean DRL Eff.	3.4	2.1	3.2	2.2
SD of DRL Eff.	1.2	0.9	1.5	0.6

Table XII.42

Summary of Lowest Probabilities for F Ratios in Analyses of Experiment IIB (60 kV/m)Data by Days

Variable	Group	Period	G×P	Days	G×D	P×D	G×P×D
FR Res.	NS	.01	NS	.001	NS	.001	NS
SD Resp.	NS	NS	NS	.001	NS	.01	NS
DRL Res.	NS	.02	NS	.001	NS	.001	NS
SD REsp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	NS	.09	NS	.001	NS	.001	NS
SD Rew.	.07	NS	NS	NS	NS	NS	NS
DRL Eff.	NS	NS	NS	NS	NS	.09	NS
SD Eff.	NS	NS	NS	NS	NS	.07	NS

were not significant, but the Period × Day interactions were. The latter indicates an electric field effect on operant behavior. None of the triple interactions were significant.

Graphs.-- The data from Experiment IIB are particularily interesting because they clearly show the "echo effect." On FR responding, the Experimental group showed reduced performance on the first and second day (Figure IV.44); performance was the same as in Baseline on days Four through Six. The Control group also showed reduced responding on the first and second day even though they were not in the electric field themselves and had not responded to any important degree when the were re-exposed in Experiment IIA.

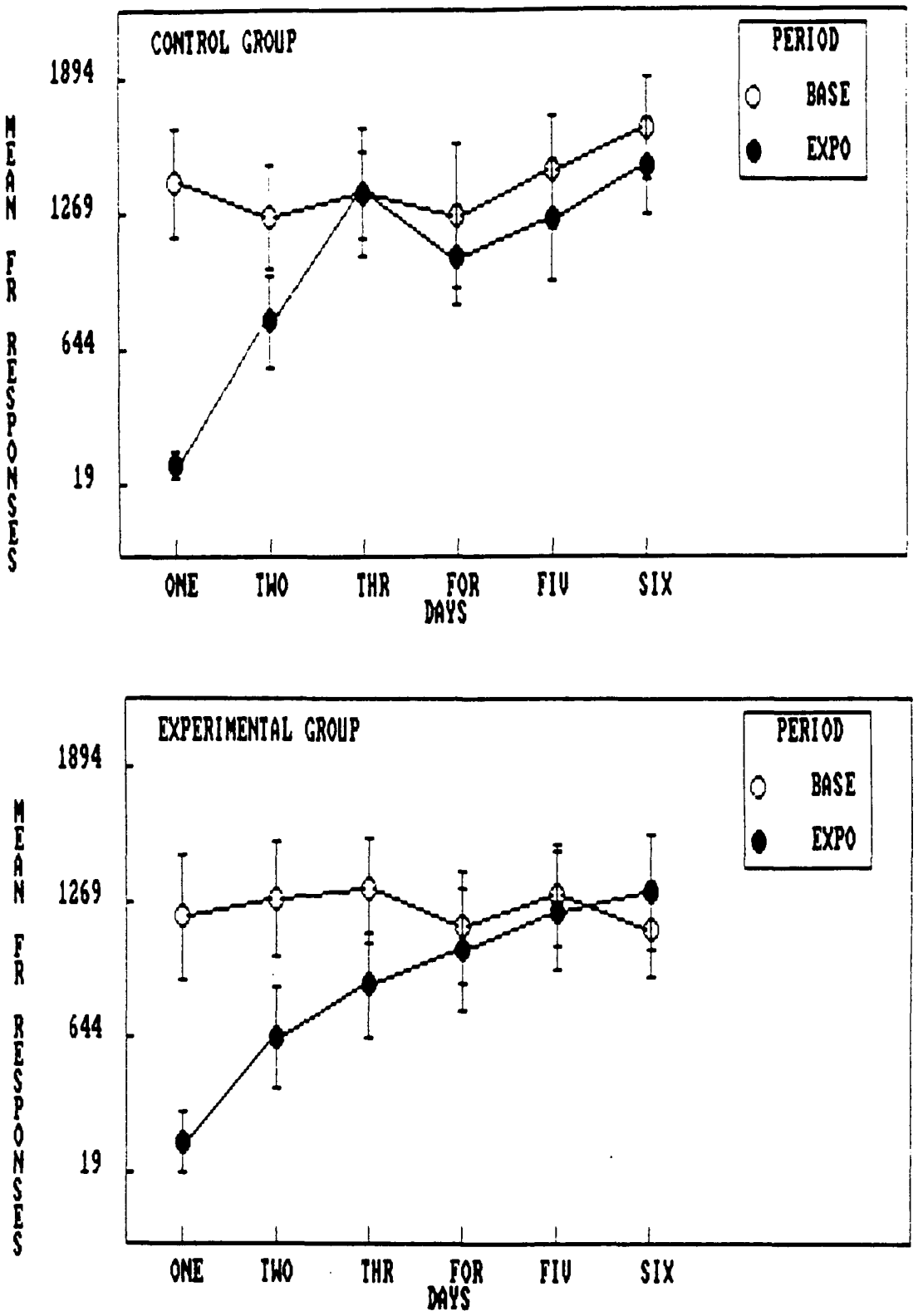


Figure XII.44. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

On DRL responses, the Experimental animals showed reduced perfomance on the first day of Exposure, as did the Control animals (Figure IV.45). The same pattern is apparent for DRL rewards (Figure IV.46). The effect on DRL efficiency was much more modest (Figure IV.47) and was more noticeable for the Control group.

Introduction of the 60 kV/m electric field in Experiment IIB clearly suppressed FR responding on the first day, and the effect was noticeable even on the third day (Figure IV.48). The percentage of animals working on the DRL task was affected less (Figure IV.49). Recovery was faster on the first day, and the performance of the group on the third day was only slightly less than at the end of the Pre-Exposure.

2. Analyses by Sessions

As done consistently throughout the data analyses for this project, the data were examined by Sessions as well as by Days. Here the data were collapsed over the six Days of the two experimental Periods but kept separate for the six Sessions of each day. The ANOVA model (Table XII.43) is as previously used.

Table XII.43

Summary of ANOVA Model for Analysis of Experiment IIB (60 kV/m) by Sessions

Source	df
GROUPS	1
Error	10
PERIOD	1
GROUPS × PERIOD	1
Error	10
DAYS	5
GROUPS × DAYS	5
Error	50
PERIOD × DAYS	5
GROUPS × PERIOD × DAYS	5
Error	50

Homogeneity.-- The raw scores were used for the ANOVA of the data on mean FR responses and mean DRL rewards (Table XII.44). For mean DRL responses, the square root transformation was used. The analysis of the data for DRL efficiency is not yet complete.

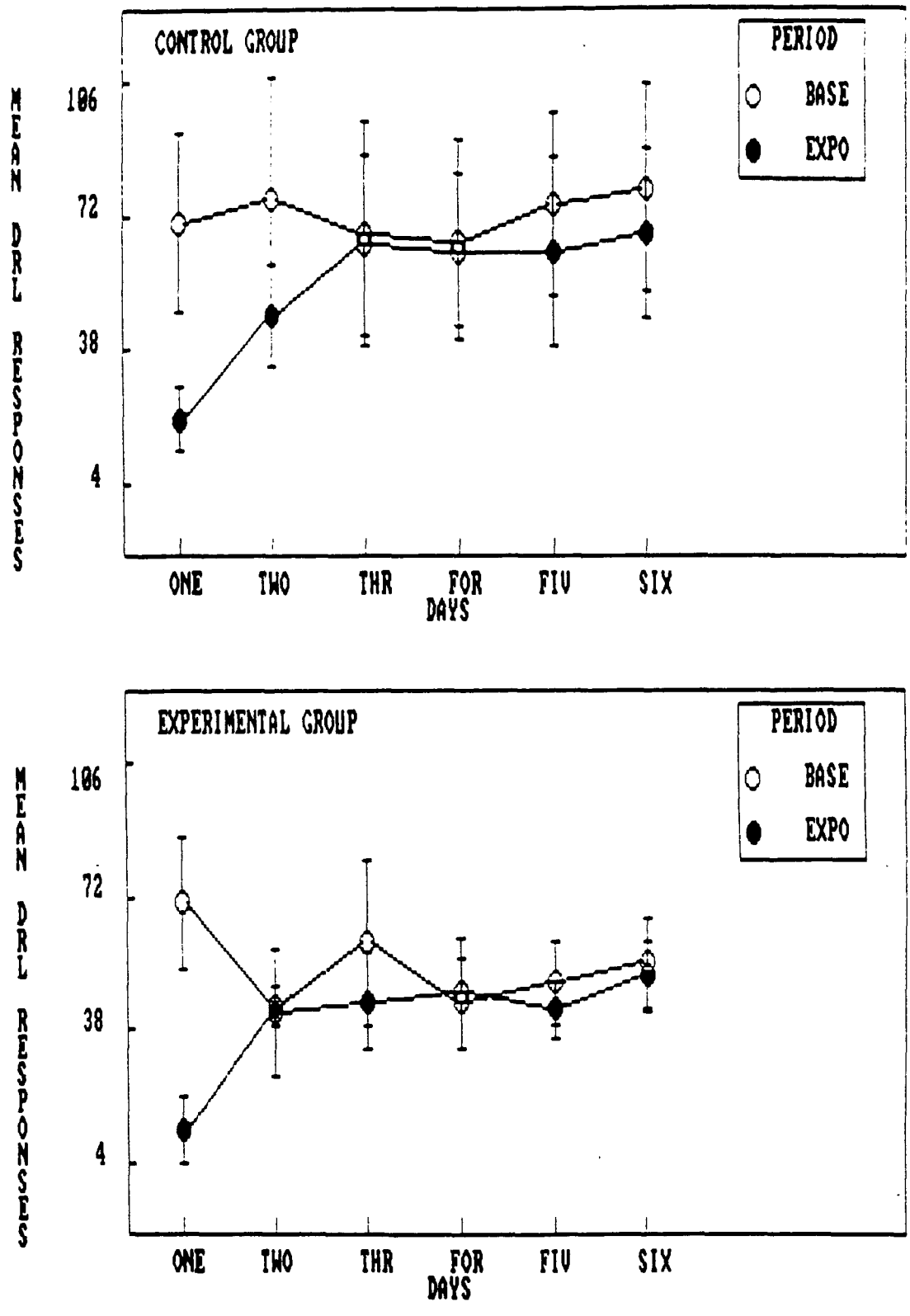


Figure XII.45. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

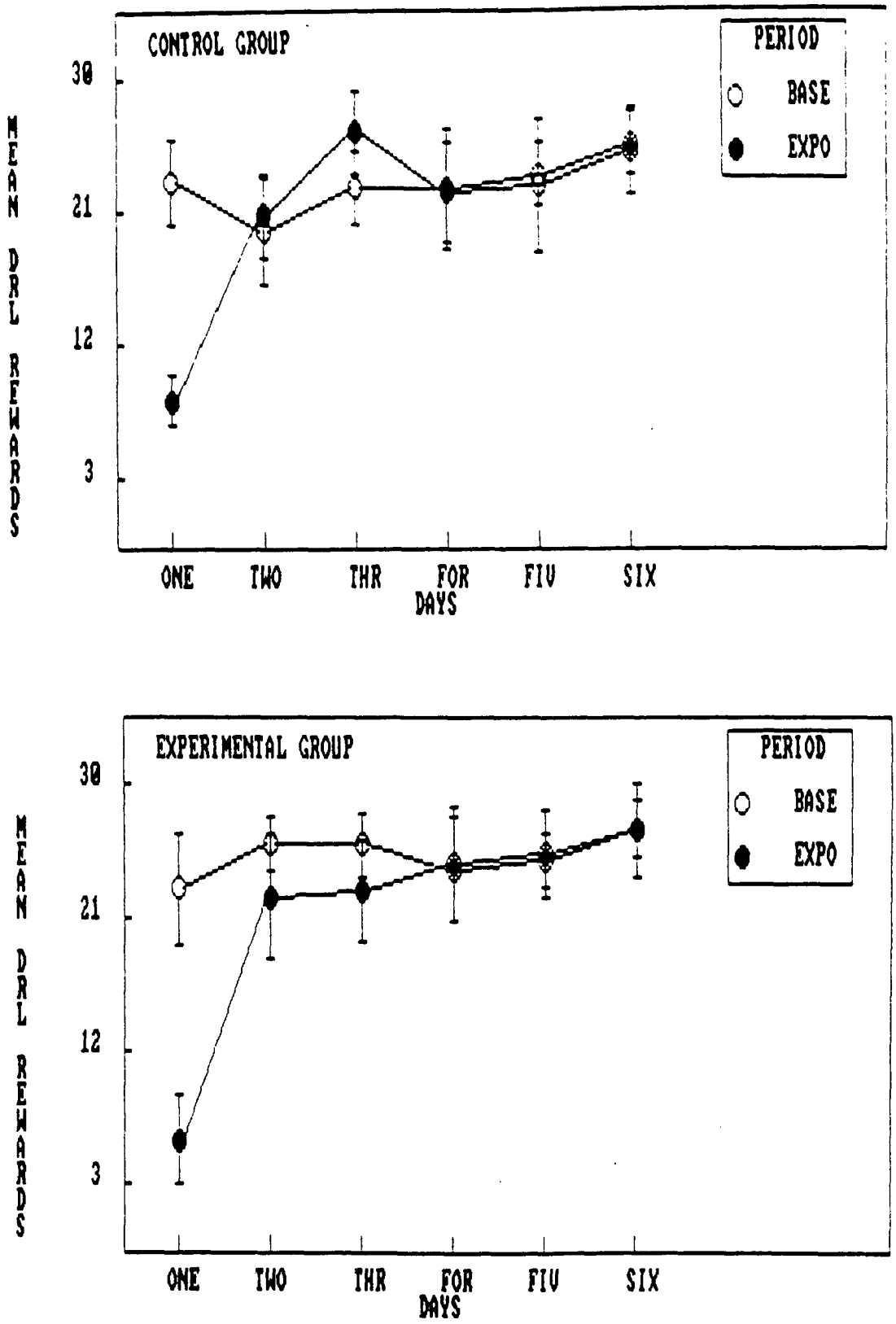


Figure XII.46. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

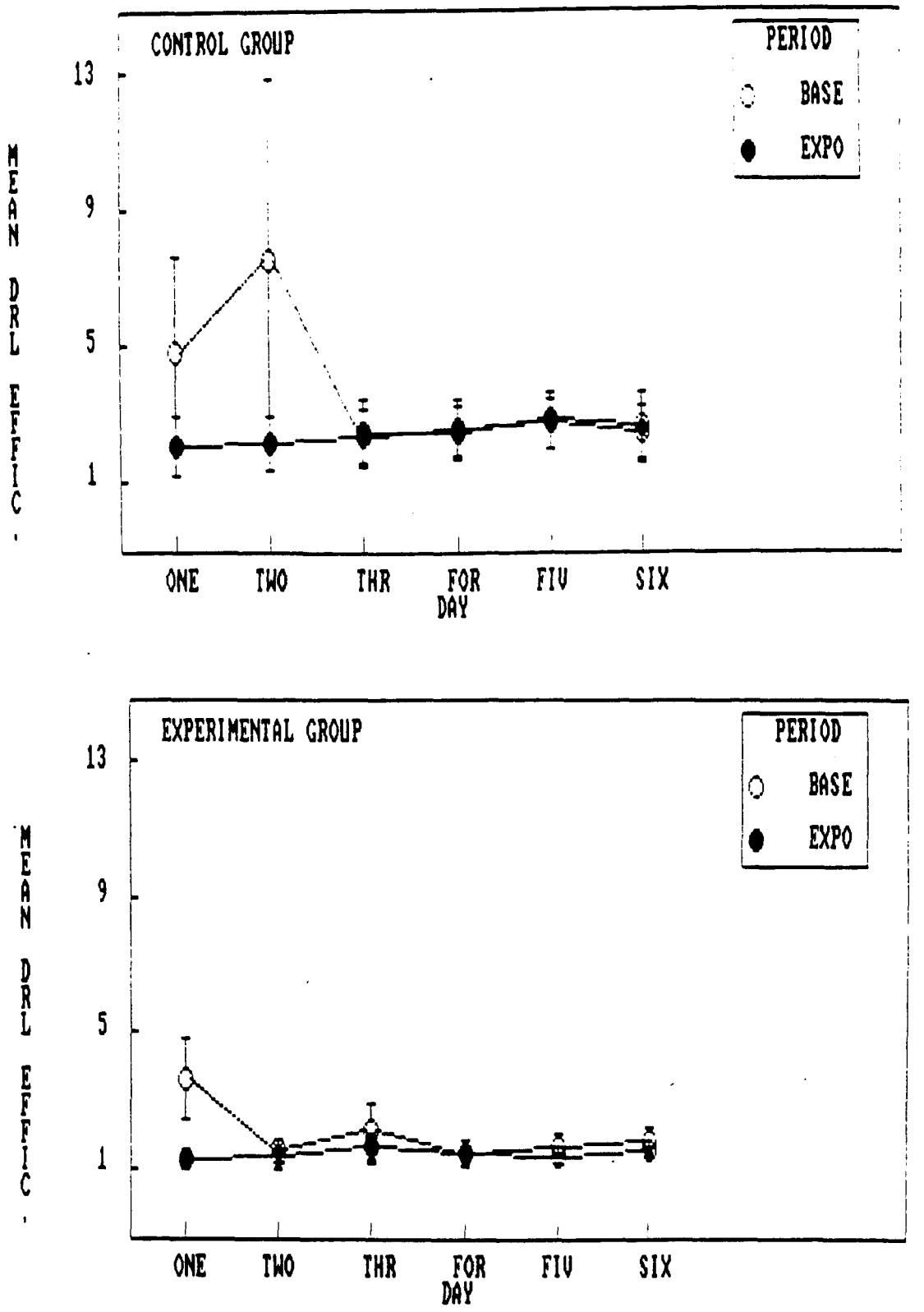


Figure XII.47. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

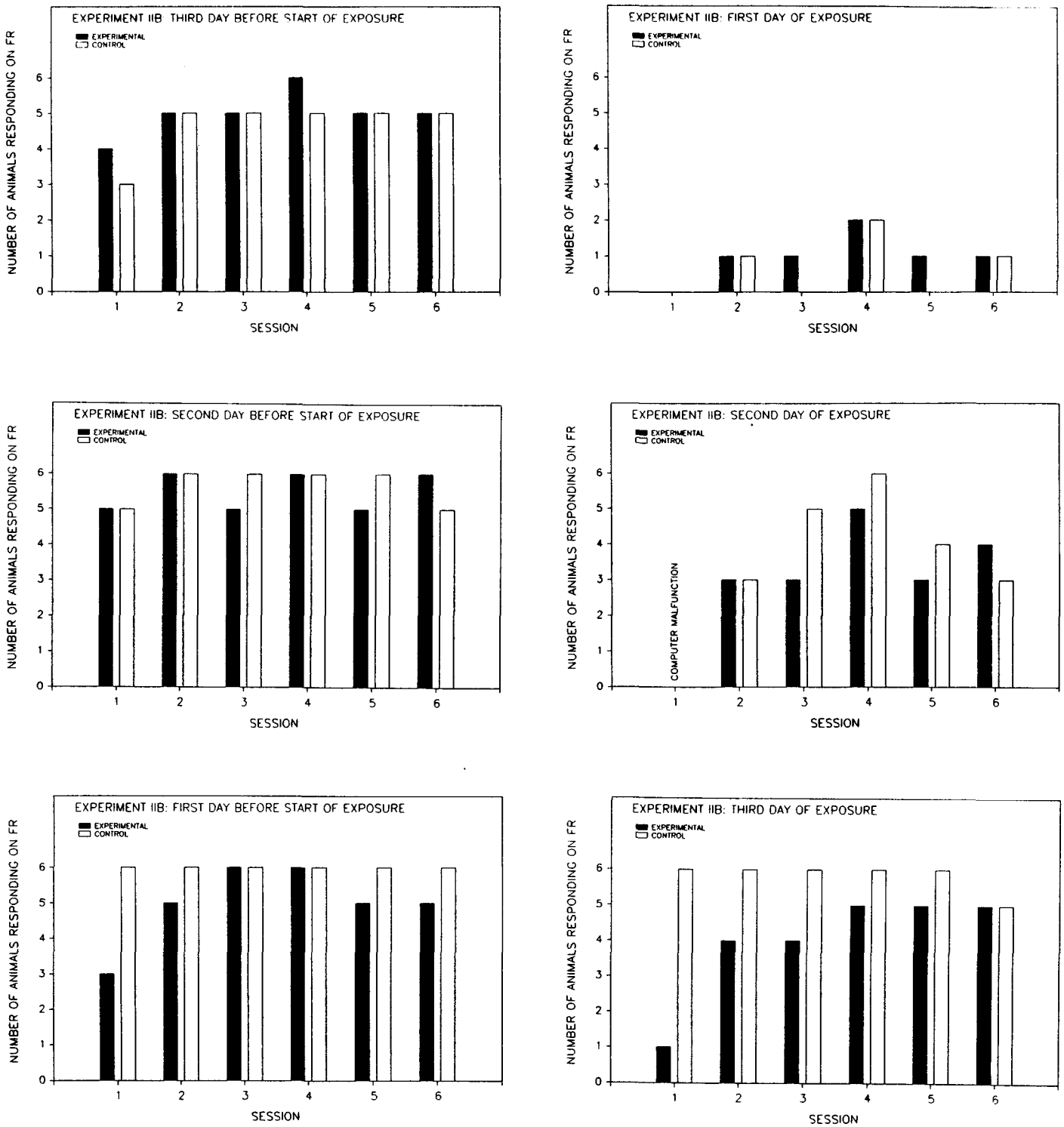


Figure XII.48. Percentage of Control and Experimental group animals performing the FR task on six daily sessions for the last three days of Pre-Exposure and first three days of Exposure to 60 kV/m in Experiment IIB.

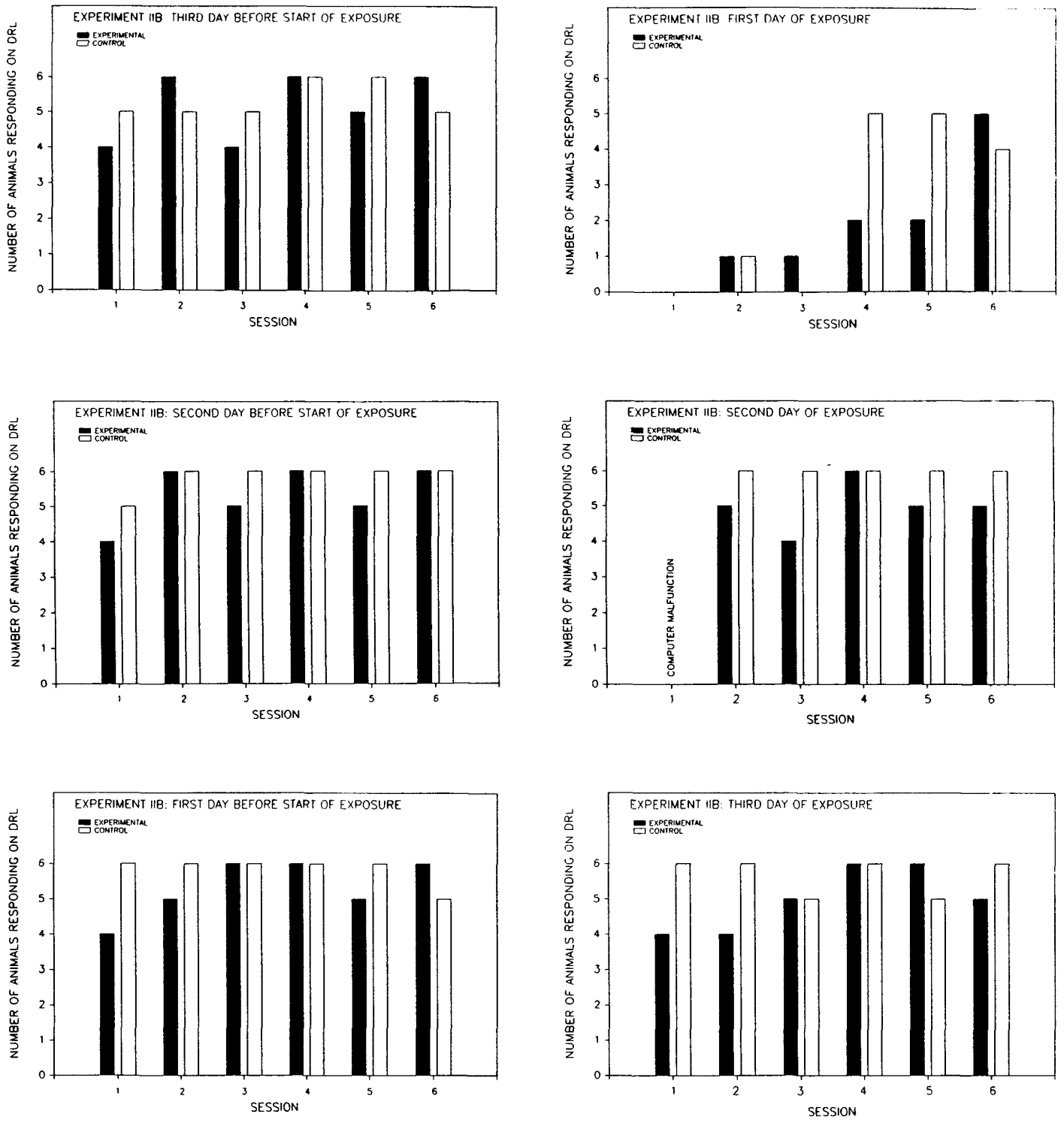


Figure XII.49. Percentage of Control and Experimental group animals performing the DRL task on six daily sessions for the last three days of Pre-Exposure and first three days of Exposure to 60 kV/m in Experiment IIB.

Table XII.44

Summary of Results of F Max Tests for
Experiment IIB (60 kV/m) Data by Sessions

Variable	Raw Score	Log	Square Root
Mean FR Resp.	6.3#	NA	NA
SD of FR Resp.	21.2#	NA	NA
Mean DRL Resp.	51.2	NA	14.4#
SD of DRL Resp.	160	30.9#	48.2
Mean DFRL Rew.	13.9#	NA	NA
SD of DRL Rew.	10.5#	NA	NA
Mean DRL Eff.	358	21.0#	75.9
SD of DRL Eff.	4,113	154	73.5#

Used in ANOVA.

ANOVA.-- All of the Session and Period effects were statistically significant ($P<.05$), but none of the important interaction terms were significant (Table XII.45).

Table XII.45

Summary of Lowest Probabilities for F Ratios in
Analyses of Experiment IIB (60 kV/m) Data by Sessions

Variable	Group	Period	GxP	Ses	GxS	PxS	GxPxS
FR Res.	NS	.008	NS	.001	NS	NS	.11
SD REsp.	NS	.01	NS	NS	NS	.01	NS
DRL Res.	NS	.03	NS	.001	NS	NS	NS
SD Resp.	NS	NS	NS	NS	NS	NS	NS
DRL Rew.	NS	.06	NS	.001	NS	NS	NS
SD Rew.	NS	.01	NS	.001	NS	NS	NS
DRL Eff.	NS	NS	NS	NS	NS	NS	NS
SD Eff.	NS	NS	NS	NS	NS	NS	NS

Graphs.-- The data for both Control and Experimental groups appear similar; during Exposure the means are less than the means during Baseline, but the error bars usually overlap (Figure XII.50). The DRL response data also are similar for both groups, and there is less of a suggestion of a reduction in responding during the Exposure period (Figure XII.51). The differences between Control and Experimental groups appear a little larger for DRL rewards (Figure XII.52), but the error bars overlap once again. The figure for DRL efficieny has not been made yet (Figure XII.53).

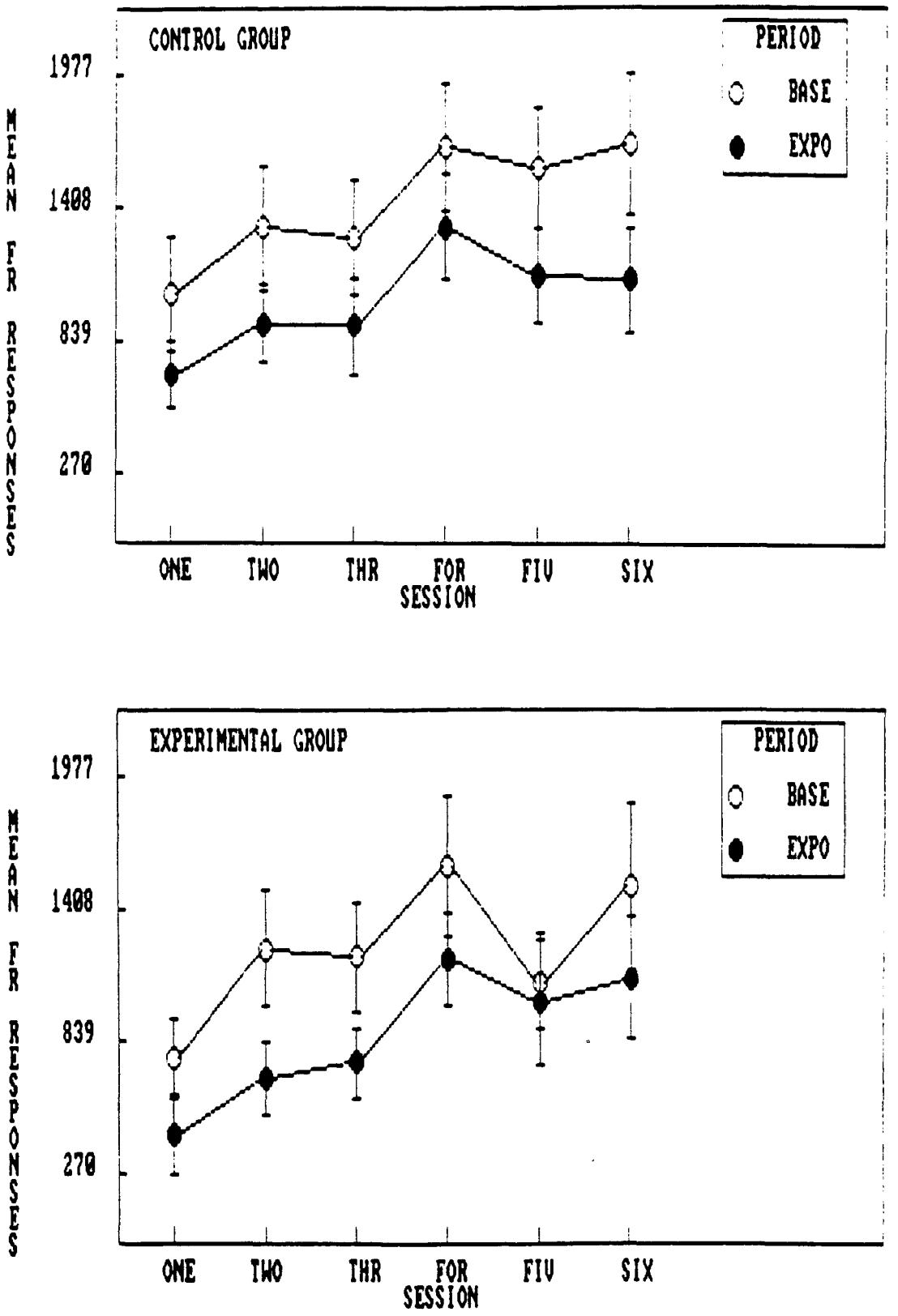


Figure XII.50. Mean FR responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

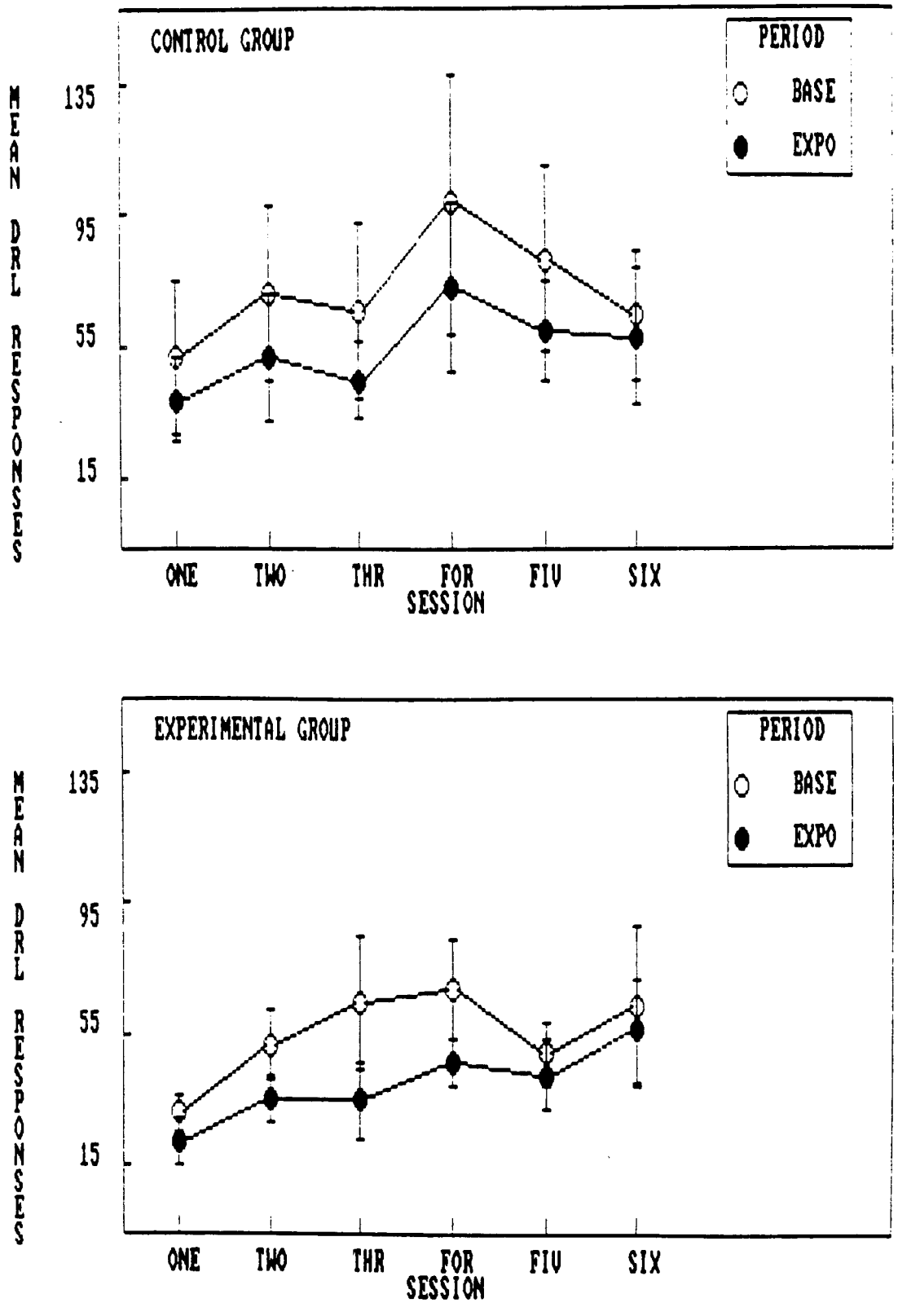


Figure XII.51. Mean DRL responses per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

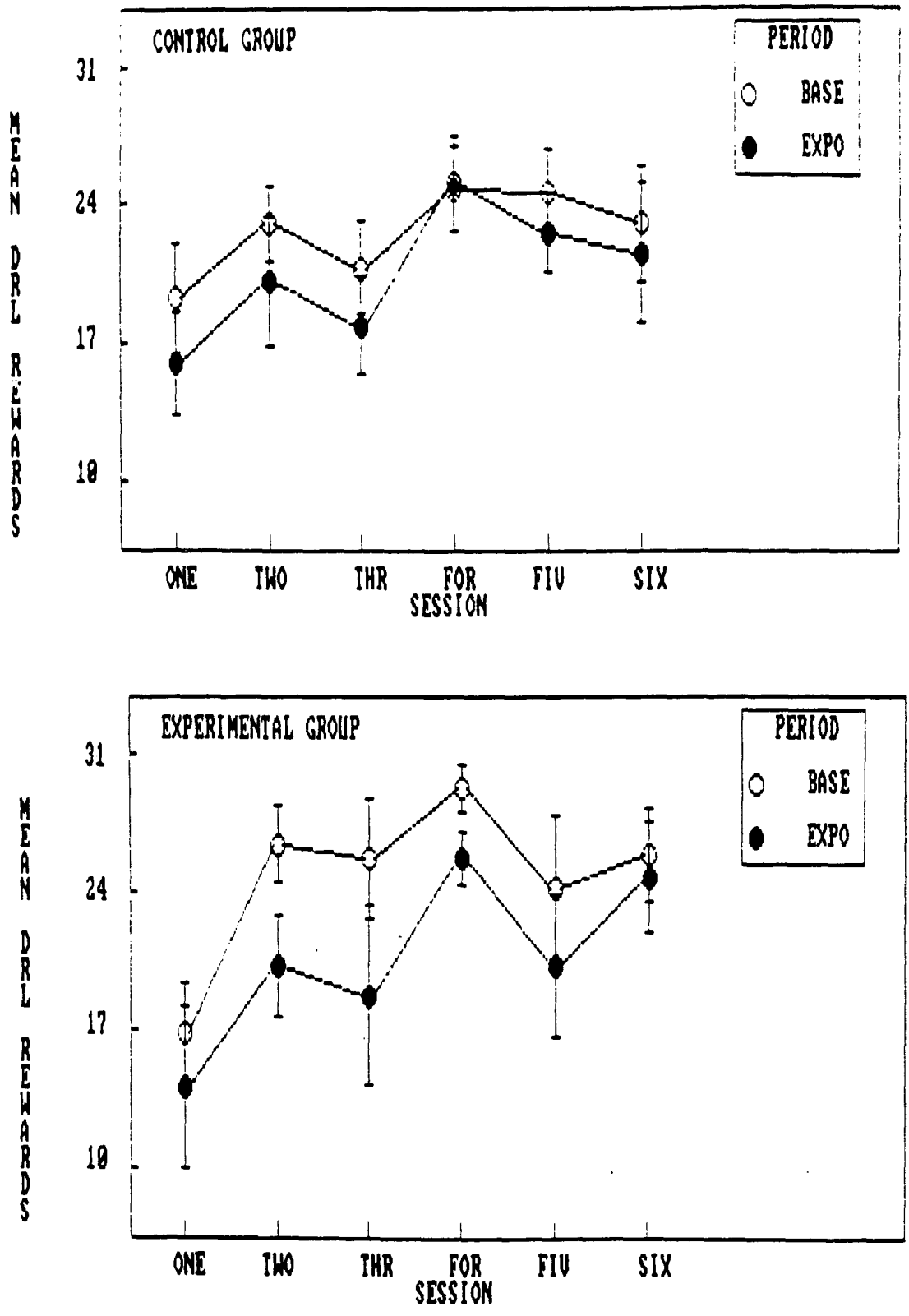


Figure XII.52. Mean DRL rewards per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

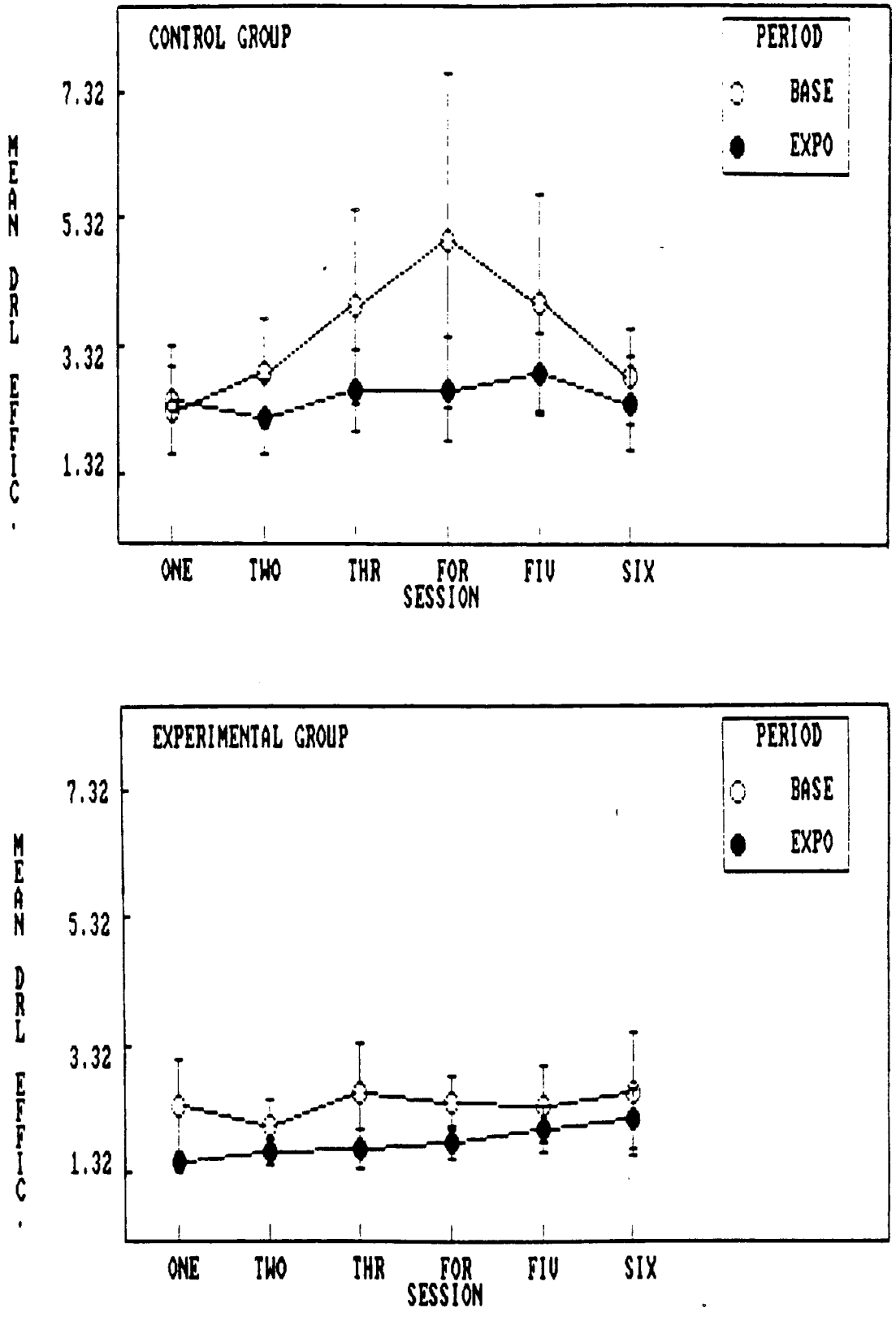


Figure XII.53. Mean DRL efficiency per component for the Control group (upper panel) and Experimental group during Pre-Exposure (Base), and Exposure (Expo) during Experiment IIB (60 kV/m).

G. Combined Analyses of Data from Experiments I and II

1. Introduction

Because we used the same experimental design in both Experiments I (30 kV/m) and II, it was possible to combine the data from the two experiments for analysis in a single ANOVA. This has two principal advantages; it increases the sample size for comparisons of experimental groups, and it allows an statistical comparison of the 30 kV/m and 60 kV/m data.

2. Statistical Methods

Once again, a three factor ANOVA was used. The factors were Group (Experimental or Control), Field (30 or 60 kV/m), and Day (One through Seven). The daily performance data during the first Week of Exposure were expressed as "per cent of baseline" where the mean performance for each animal during the last week of the Pre-Exposure period provided the baseline estimate of average performance for each subject. Thus for each of the first seven days of the Exposure period, each daily mean was divided by the mean for the last week of the Pre-Exposure period. The "per cent of baseline" approach has the additional advantage of reducing inter-subject variability due to different mean levels in performance among subjects during the baseline period. Separate analyses were performed for each of the four operant dependent variables. Despite the use of square root and log transformations, the F max values for the four ANOVAS were 50 (DRL efficiency), 64 (DRL responses), 68 (FR responses), and 211 (DRL rewards).

3. Results

On none of the four measures of operant performance was there a statistically significant difference between the 12 Experimental group subjects and the 12 Control group subjects during the first week of electric field exposure (Table XII.46). In addition, there were no differences between the 12 subjects in the 30 kV/m experiment and the 12 subjects in the 60 kV/m experiment. In other words, the main effects of Group and Field were not

Table XII.46

Summary of Lowest Probability Values for F Ratios in Combined Analyses of Experiments I (30 kV/m) and II (60 kV/m) Data

Variable	Group	Field	G×F	Day	G×D	F×D	G×F×D
FR Res.	NS	NS	NS	.01	.01	.03	.02
DRL Res.	NS	NS	NS	NS	.01	.02	NS
DRL Rew.	NS	NS	NS	.01	.01	NS	.03
DRL Eff.	NS	NS	NS	NS	.01	.01	NS

significant. In addition, none of the Group × Field interactions were significant, indicating that the differences between Experimental and Control groups was the same at both 30 kV/m and 60 kV/m.

However, these results do not indicate that the electric fields had no effect whatsoever on operant responding. All of the Group × Day interactions were significant, indicating that the pattern of the seven daily means differed between Experimental and Control groups, presumably because of poor performance on the first day of electric field exposure by the Experimental group. In addition, either the Field × Day or the Group × Field × Day interaction was significant on each of the four measures. These results suggest subtle differences between the 30 kV/m and 60 kV/m results.

For FR responding (Figure XII.54) the response suppression in the Experimental group was the same on the first day at 30 kV/m and 60 kV/m, but the performance of the 30 kV/m group was more variable across the days of the week. In addition, the magnitude of the changes observed in the Experimental group are not much greater than the changes across days displayed by the Control subjects in the 60 kV/m experiment.

DRL responding displays a similar pattern (Figure XII.55). Performance was very poor on the first day of exposure for both the 30 kV/m and 60 kV/m Experimental groups, but variation over subsequent days for the Experimental groups does not appear greater than the variations displayed by the Control groups. The number of DRL rewards earned by the Control groups was relatively more stable (Figure XII.56), and other than the first day of electric field exposure, the Experimental groups performed at about the same levels as did the Control groups.

DRL efficiency stayed at about 2.0 ± 0.15 for the Control groups (Figure XII.57). The Experimental groups were only a little less efficient on the first day of exposure, indicating that once animals began doing the DRL task, they worked with normal efficiency, even on the first day of electric field exposure at either 30 or 60 KV/m.

4. Summary

These analyses show that even with the additional statistical power provided by doubling the number of subjects (from 12 to 24), the only detectable effect of introduction of either a 30 kV/m or a 60 kV/m electric field is disruption of operant performance on the first day with no detectable effects observed thereafter. In addition, the effects of 30 kV/m and 60 kV/m are essentially the same: there is little sign of a dose-response relationship over this rang of field strengths.

If the mechanism for the temporary cessation of responding is related to field perception, the effect appears to be produced by the perception of a novel stimulus; the intensity of the novel stimulus seems to be unimportant. However, although we know that the average detection threshold for baboons is 12 kV/m, more should be known about the ability of baboons to discriminate between different field intensities. Furthermore, although we also know that repeated exposure to fields of 65 kV/m does not appear to be aversive, we cannot rule out the possibility that a very transient aversion response is not the mechanism of the effects observed on the first day.

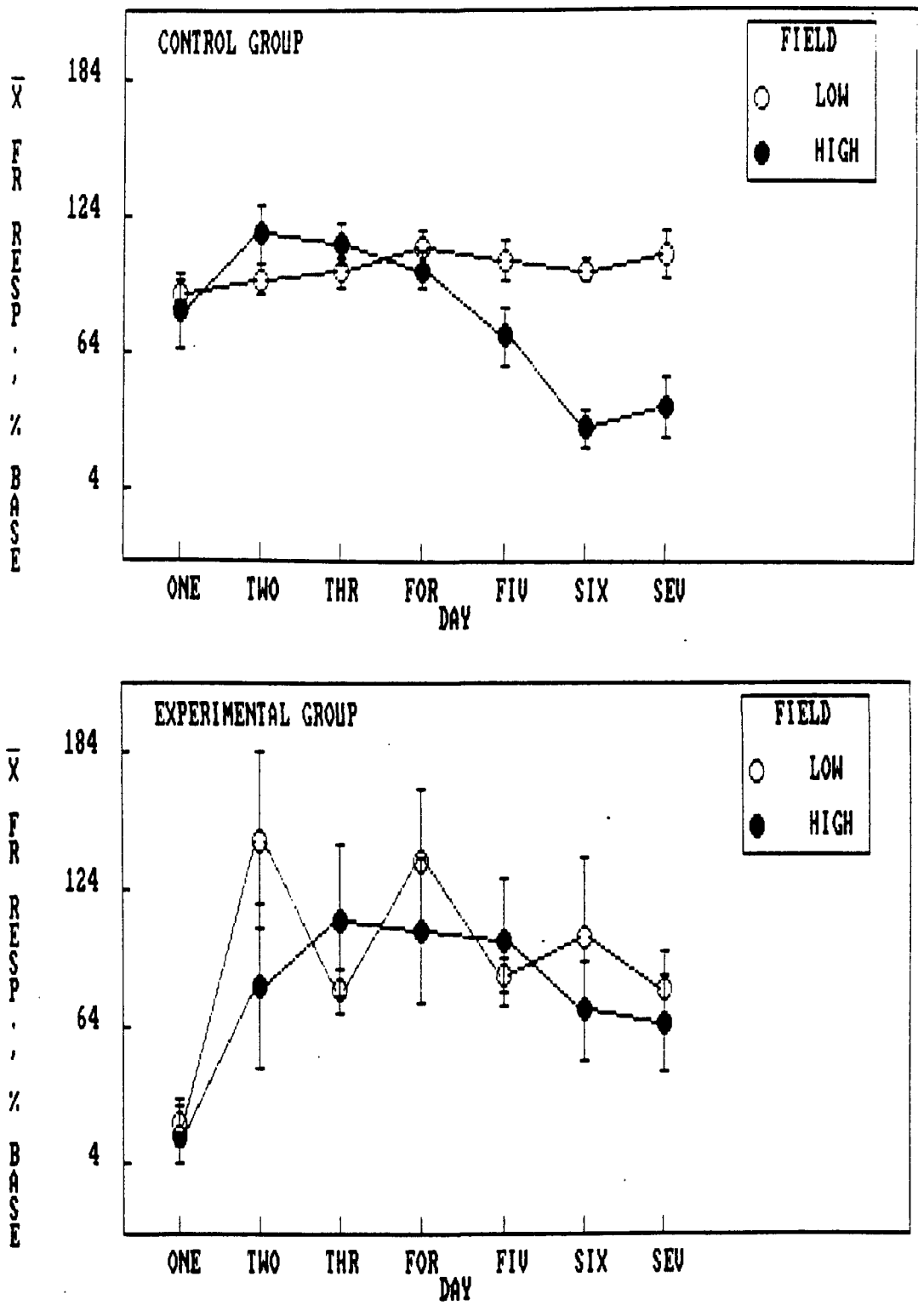


Figure XII.54. Mean percent of baseline number of FR responses for the Control groups (upper panel) and the Experimental groups (lower panel) during Experiment I ("low" field strength = 30 kV/m) and Experiment II ("high" field strength = 60 kV/m).

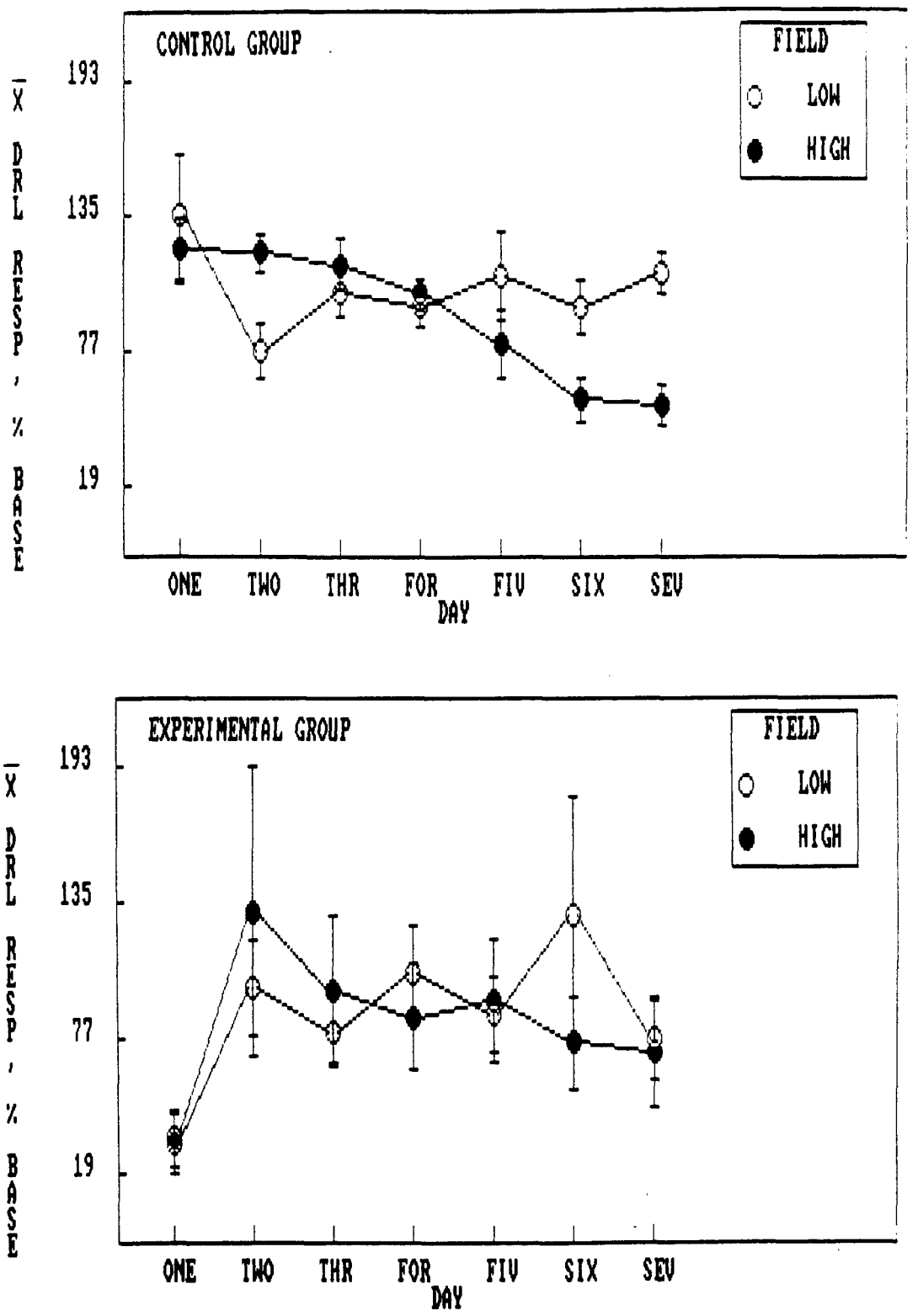


Figure XII.55. Mean percent of baseline number of DRL responses for the Control groups (upper panel) and the Experimental groups (lower panel) during Experiment I ("low" field strength = 30 kV/m) and Experiment II ("high" field strength = 60 kV/m).

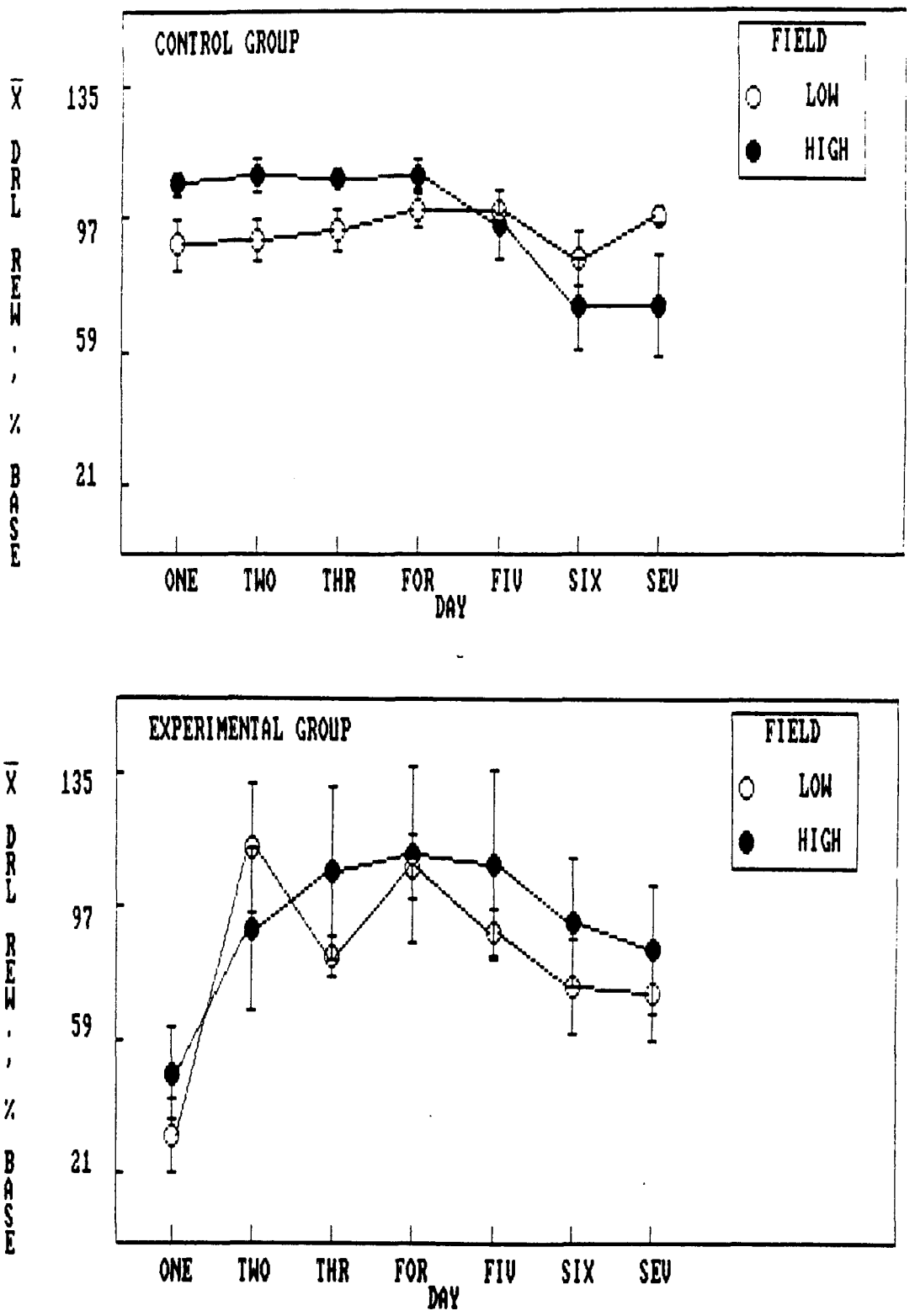


Figure XII.56. Mean percent of baseline number of DRL rewards for the Control groups (upper panel) and the Experimental groups (lower panel) during Experiment I ("low" field strength = 30 kV/m)) and Experiment II ("high" field strength = 60 kV/m).

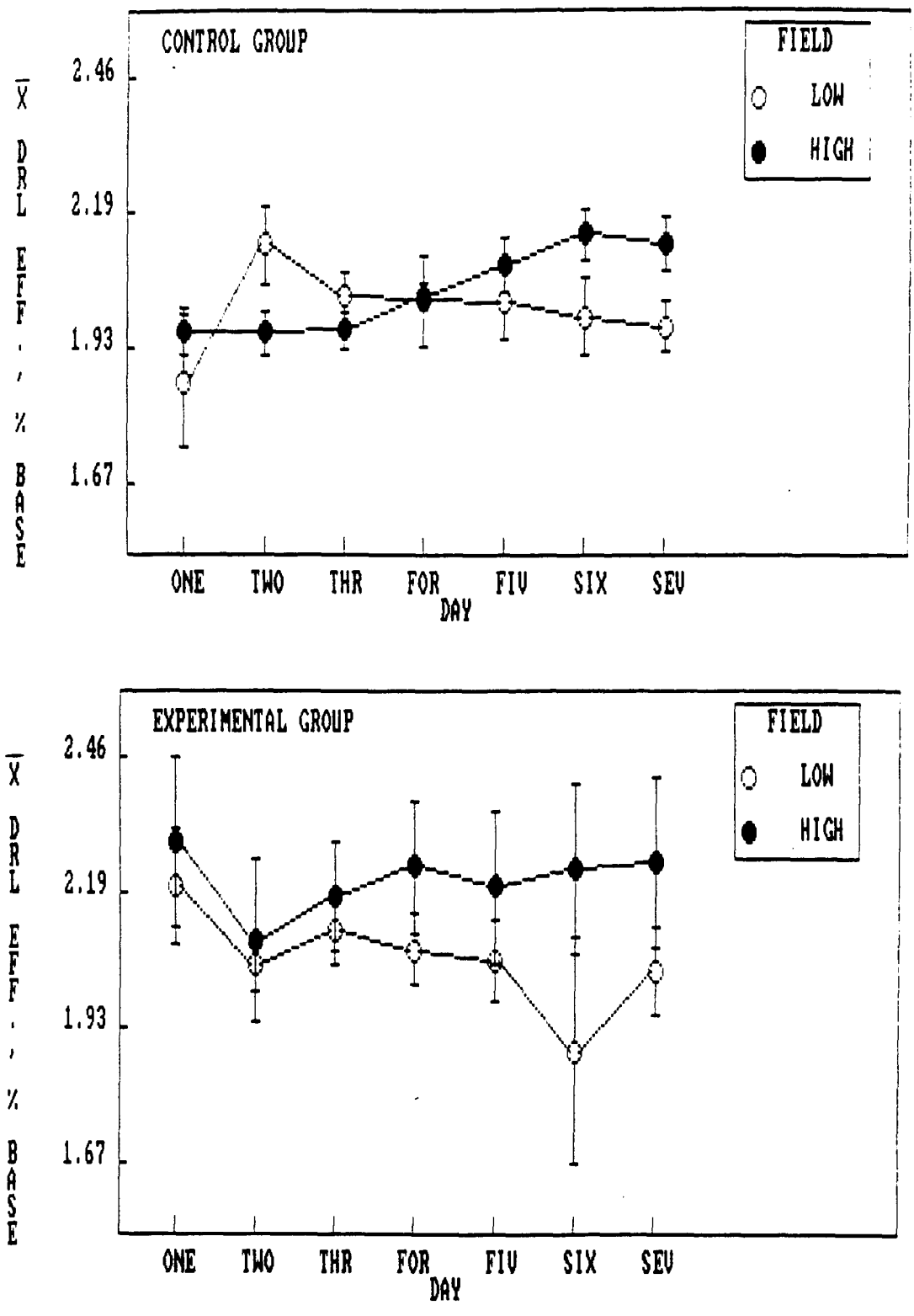
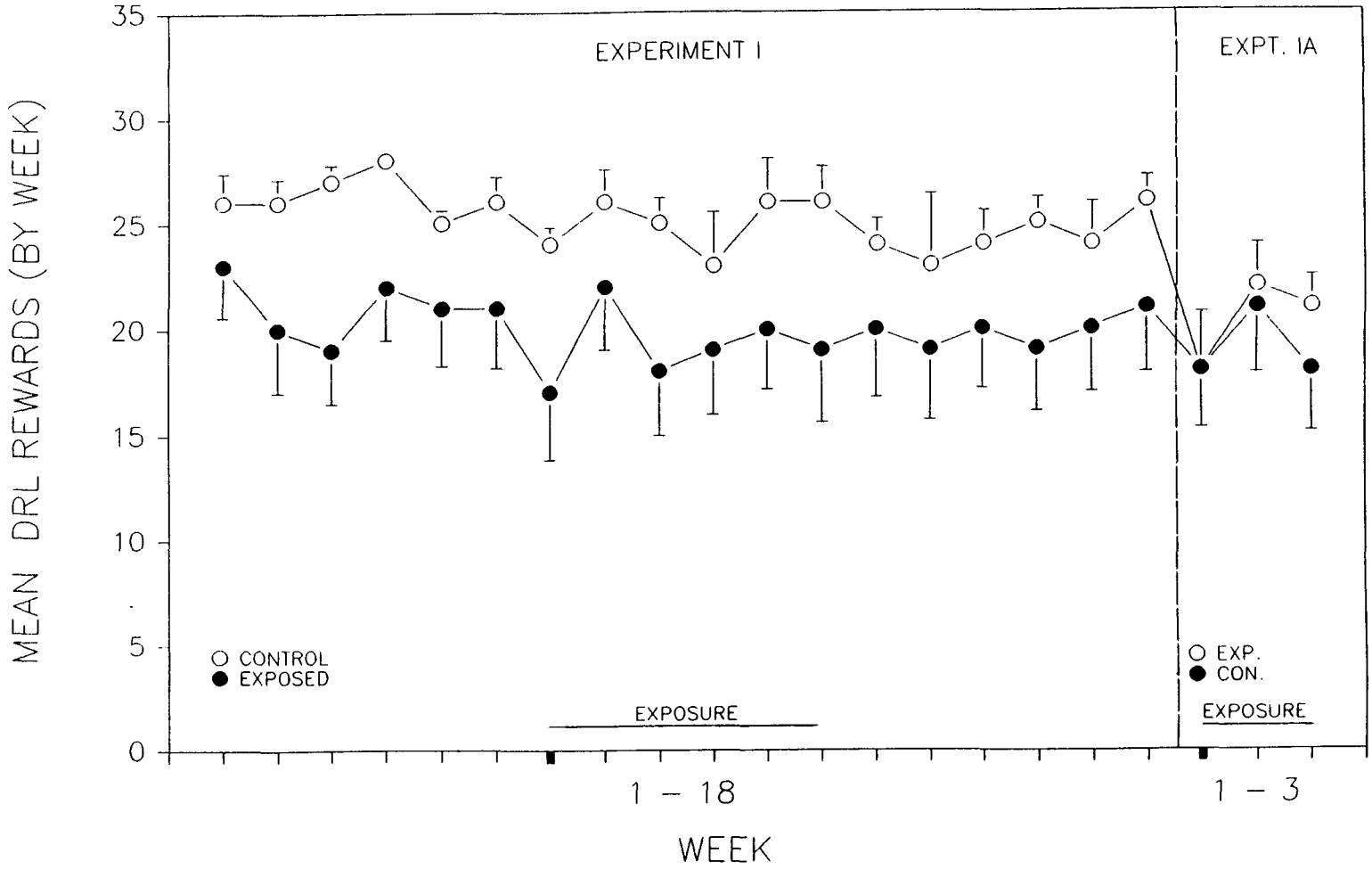
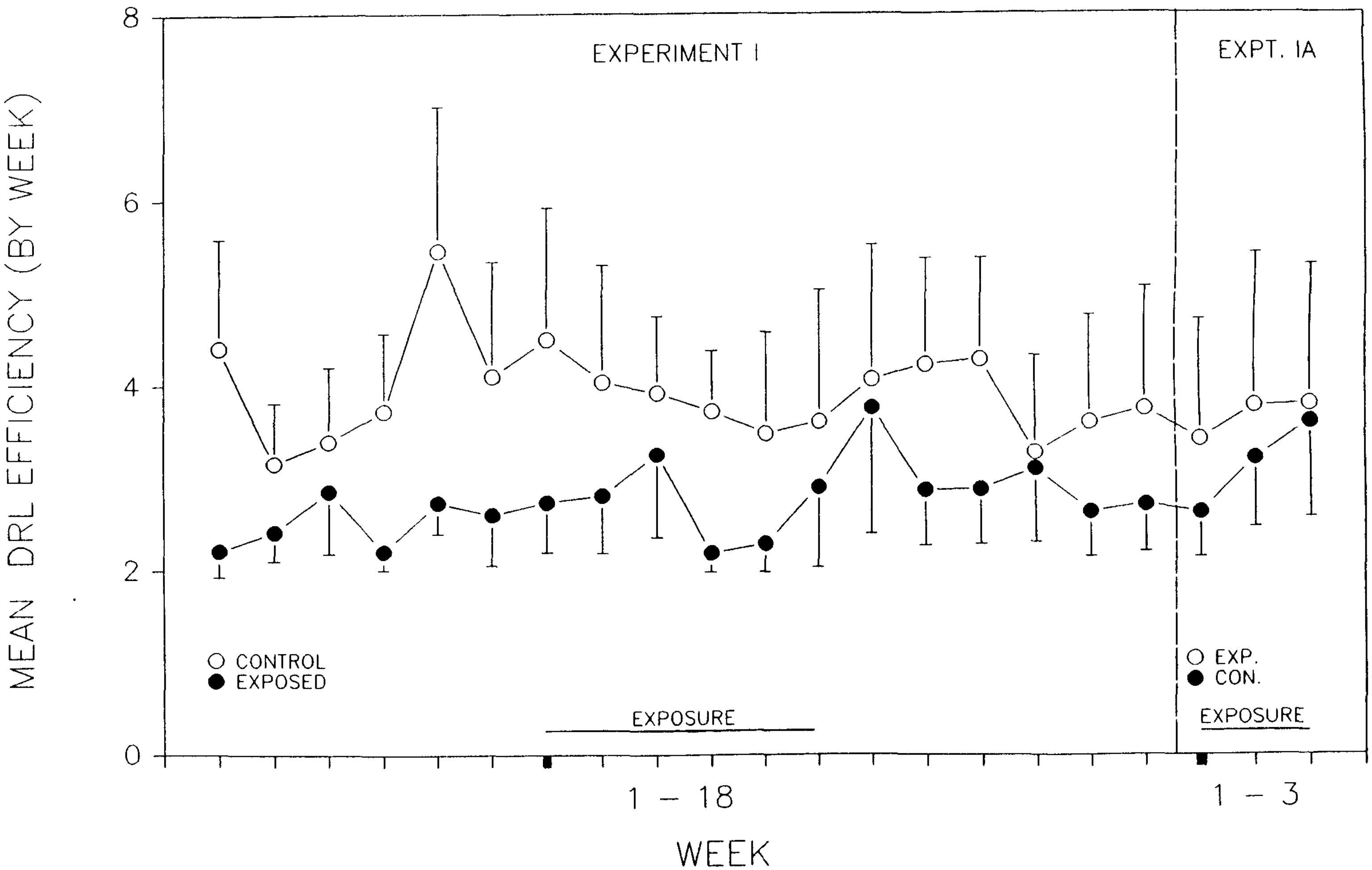


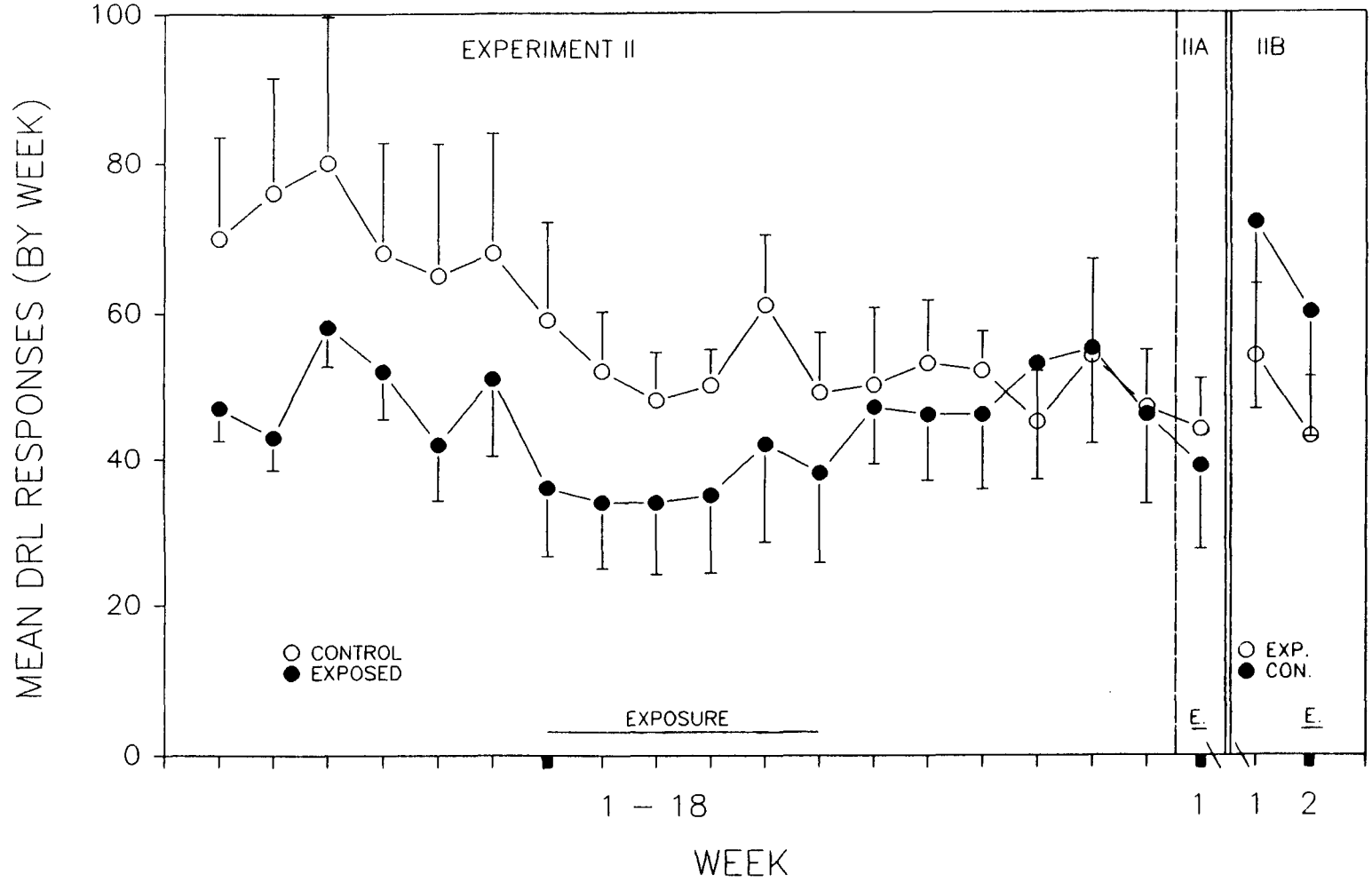
Figure XII.57. Mean percent of baseline DRL efficiency for the Control groups (upper panel) and the Experimental groups (lower panel) during Experiment I ("low" field strength = 30 kV/m) and Experiment II ("high" field strength = 60 kV/m).

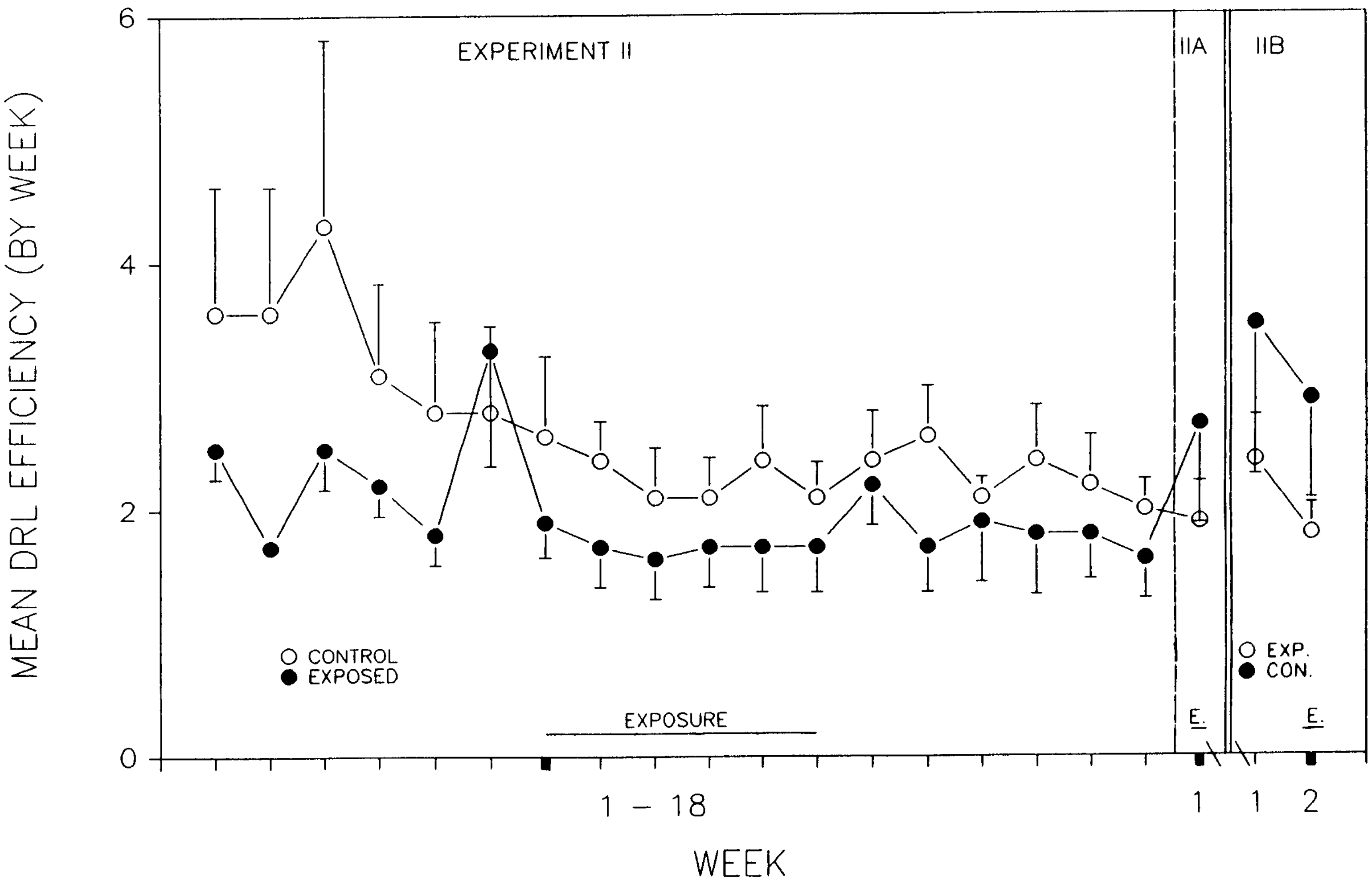
H. Additional Figures

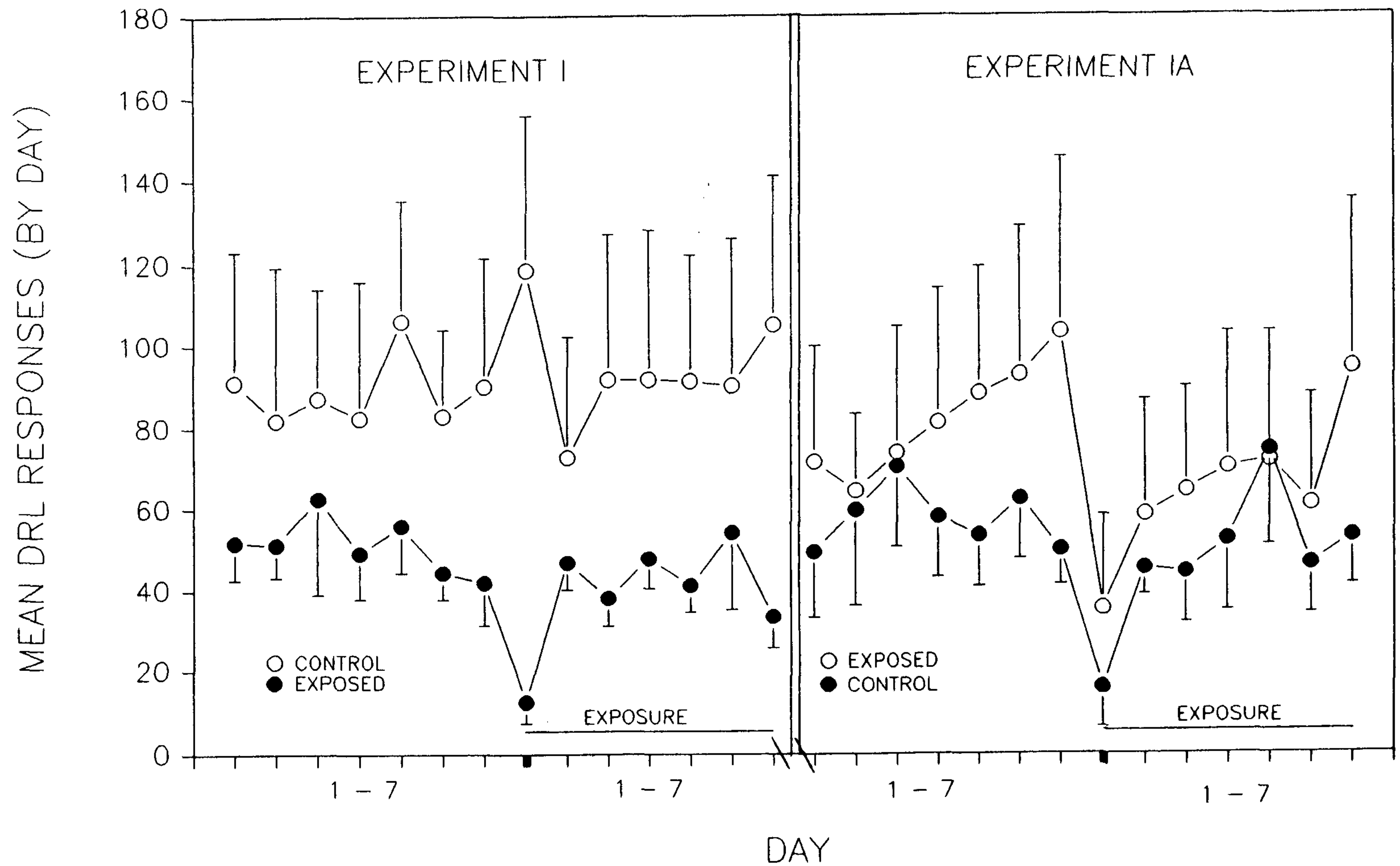
Following completion of the ANOVA, which provided the figures necessary for interpretation of results, we used another computer program (SigmaPlot) to make a series of 24 graphs which are aesthetically more pleasing. They are based on the means computed as part of the ANOVAs. Some of these graphs were used as Figures in Section IV, and the remainder are given on the following pages.

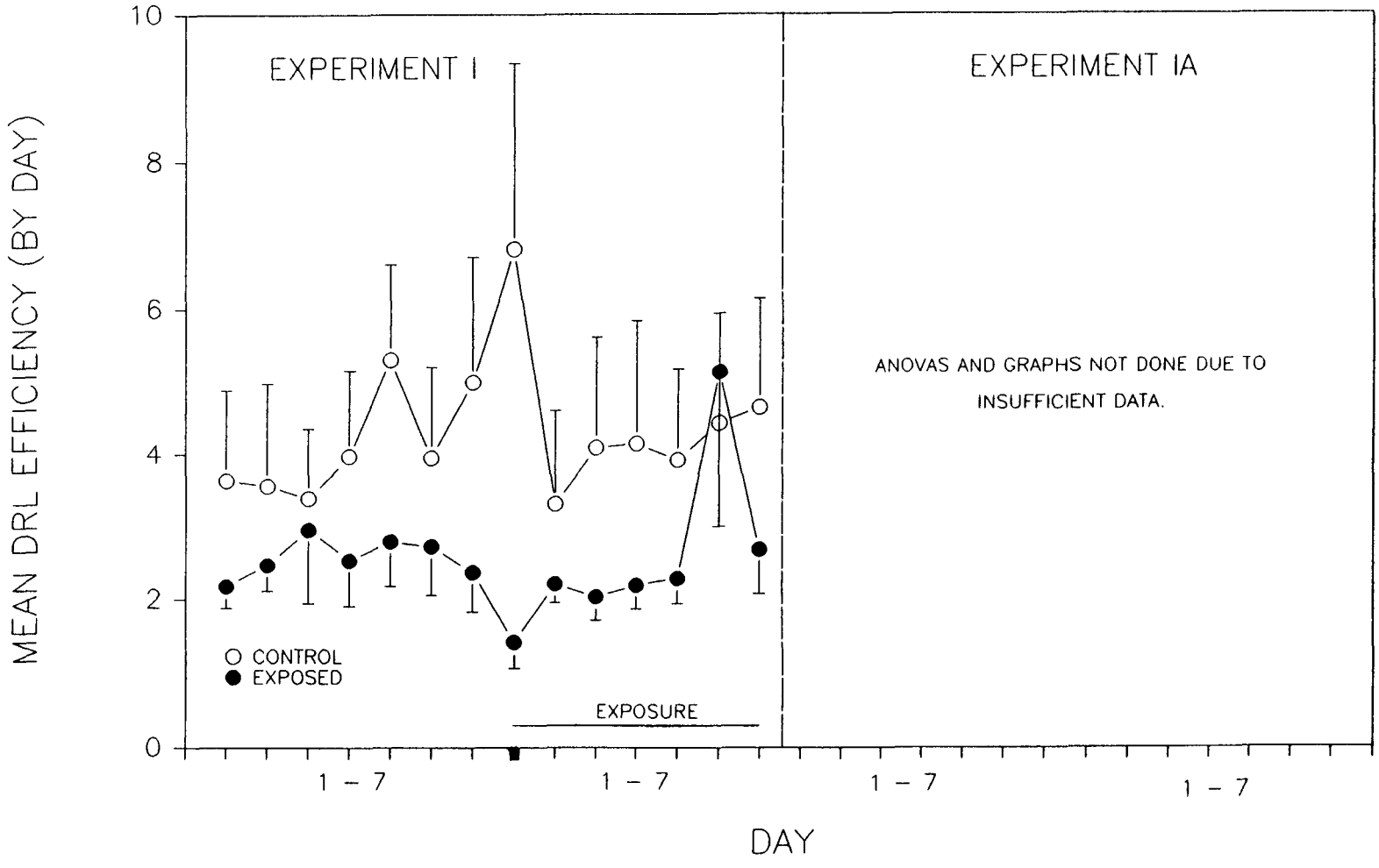

MEAN DRL REWARDS (BY WEEK)
35
30
25
20
15
10
5
0
EXPERIMENT I
EXPT. IA
CONTROL
EXPOSED
EXPOSURE
EXP.
CON.
EXPOSURE
1 – 18
1 – 3
WEEK

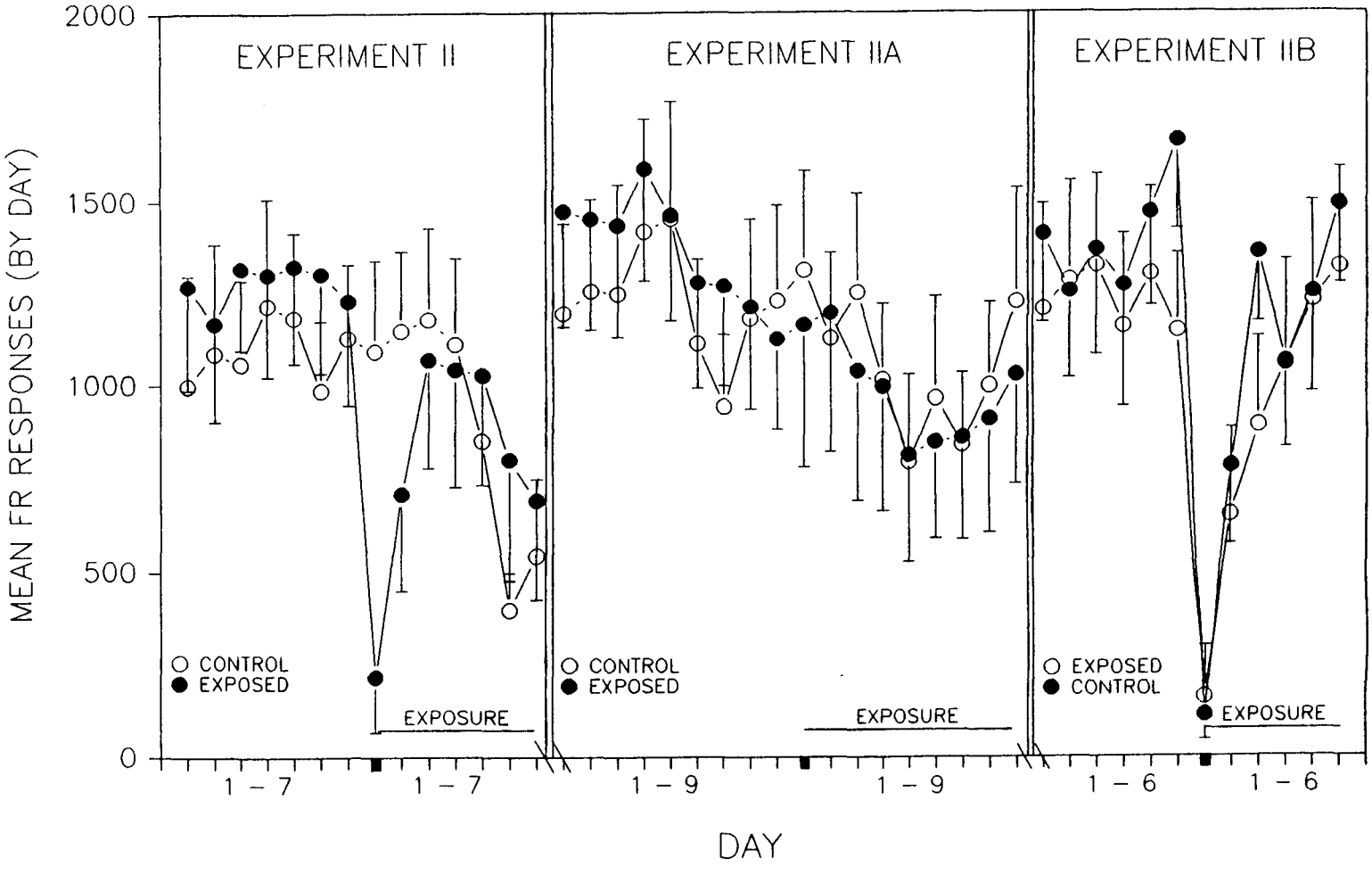

EXPERIMENT I
EXPT. IA
MEAN DRL EFFICIENCY (BY WEEK)
8
6
4
2
0
CONTROL
EXPOSED
EXP.
CON.
EXPOSURE
EXPOSURE
1 – 18
1 – 3
WEEK

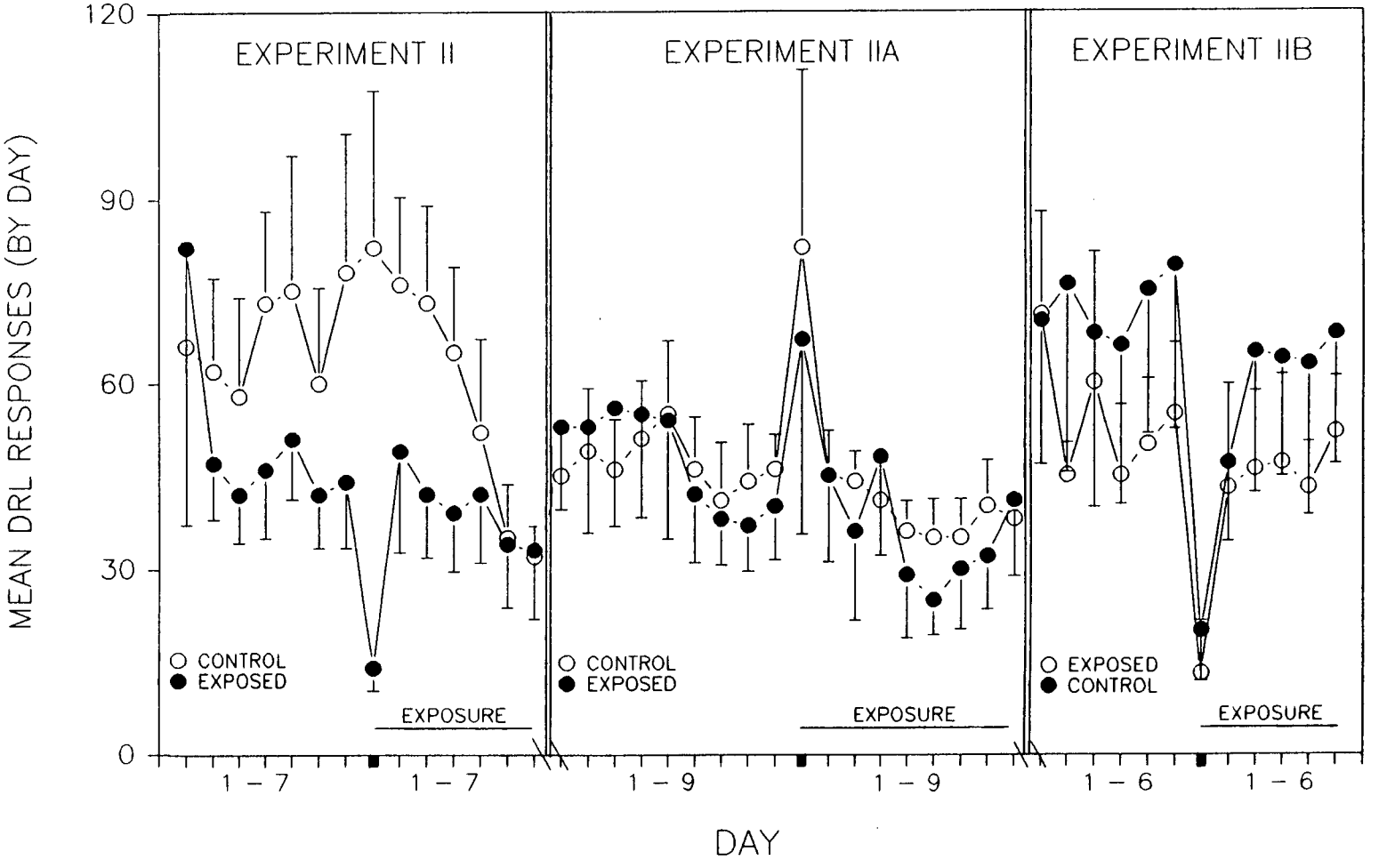

EXPERIMENT II
IIA
IIB
MEAN DRL RESPONSES (BY WEEK)
100
80
60
40
20
0
CONTROL
EXPOSED
EXPOSURE
EXP.
CON.
E.
E.
1 – 18
1
1
2
WEEK

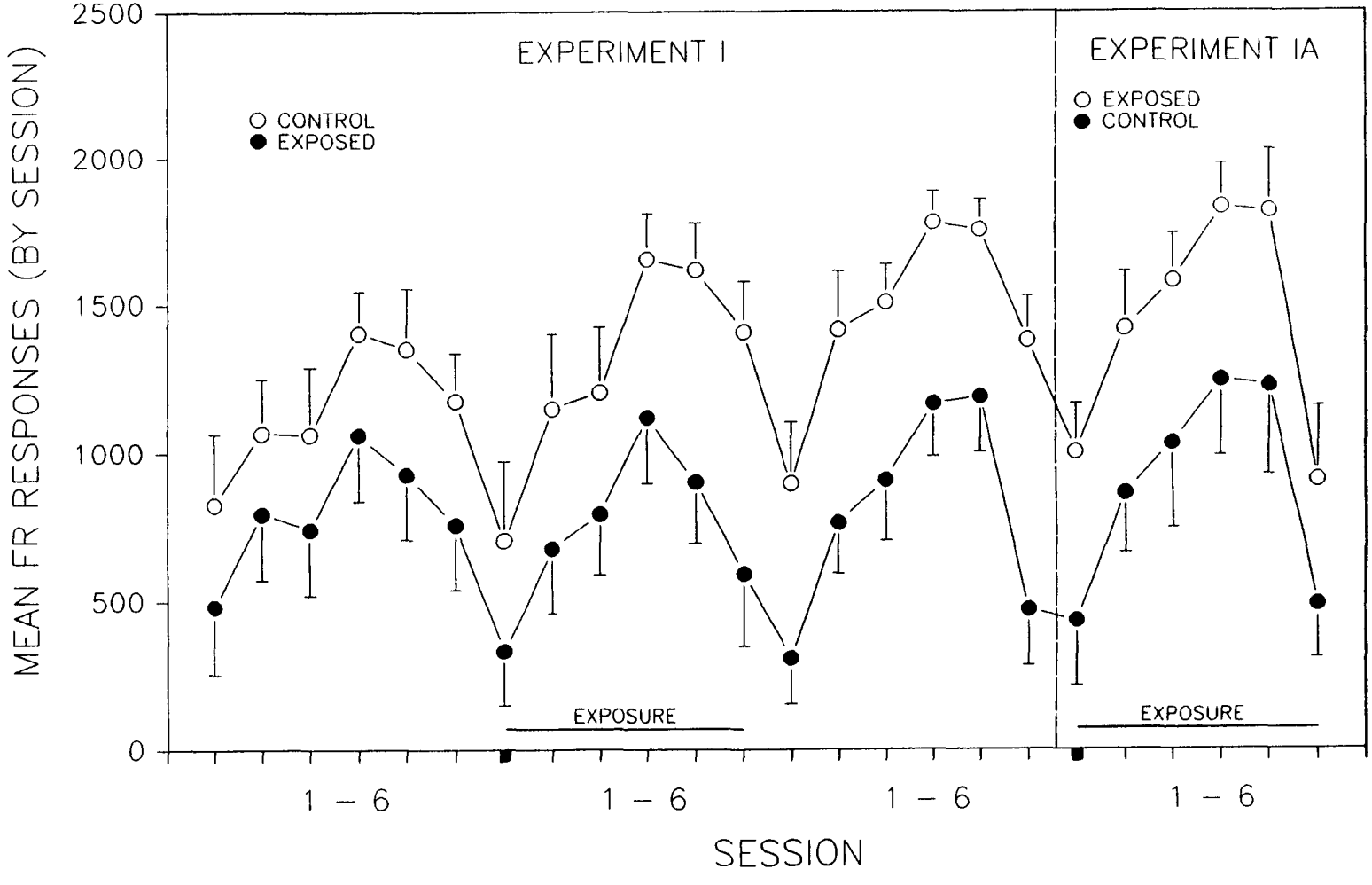

EXPERIMENT II
IIA
IIB
MEAN DRL EFFICIENCY (BY WEEK)
6
4
2
0
CONTROL
EXPOSED
EXP.
CON.
EXPOSURE
E.
E.
1 – 18
1
1
2
WEEK

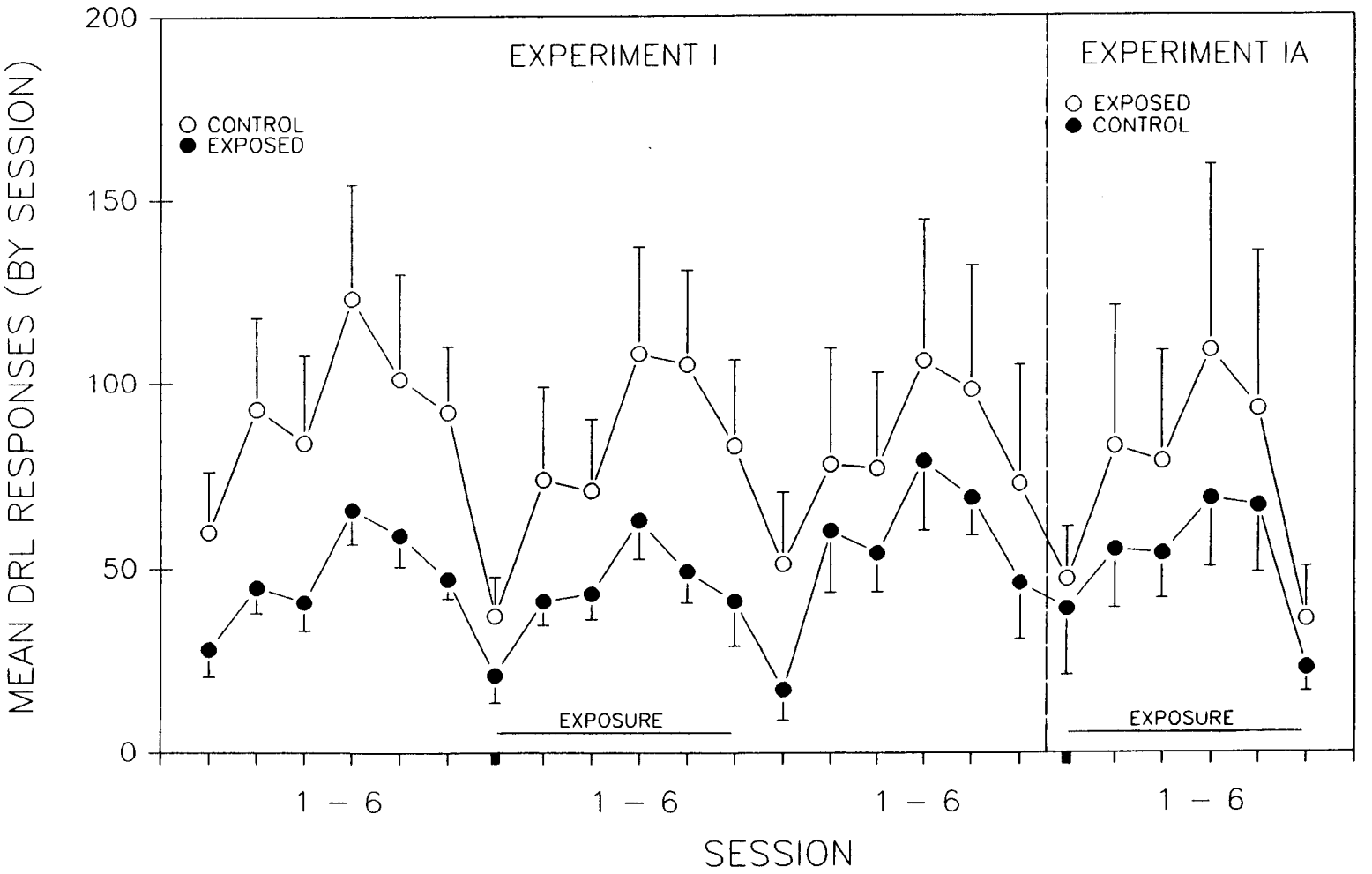

EXPERIMENT I
EXPERIMENT IA
MEAN DRL RESPONSES (BY DAY)
180
160
140
120
100
80
60
40
20
0
CONTROL
EXPOSED
EXPOSURE
EXPOSED
CONTROL
EXPOSURE
1 – 7
1 – 7
1 – 7
1 – 7
DAY

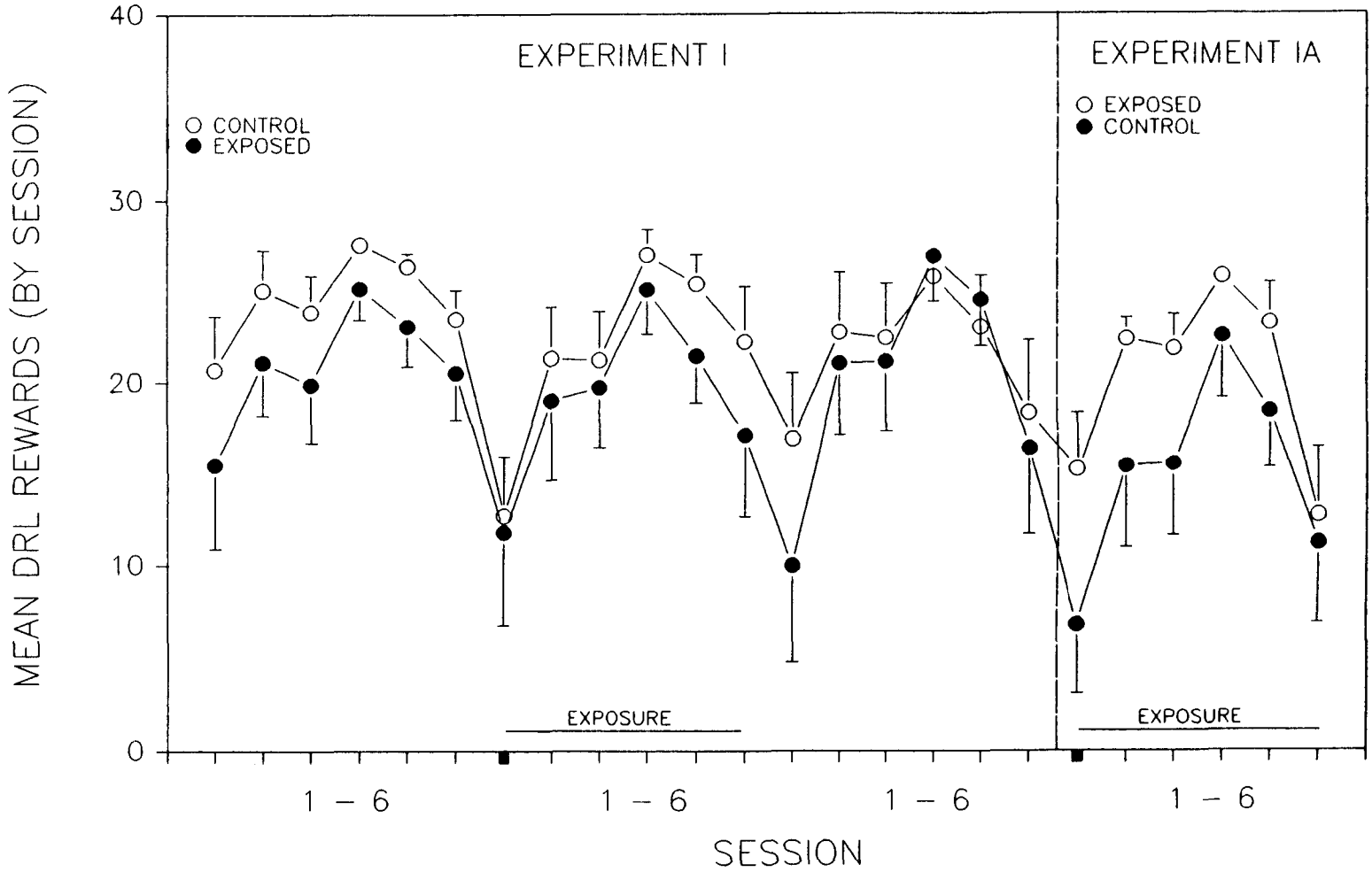

MEAN DRL EFFICIENCY (BY DAY)
10
8
6
4
2
0
EXPERIMENT I
EXPERIMENT IA
ANOVAS AND GRAPHS NOT DONE DUE TO
INSUFFICIENT DATA.
CONTROL
EXPOSED
EXPOSURE
1 - 7
1 - 7
1 - 7
1 - 7
DAY

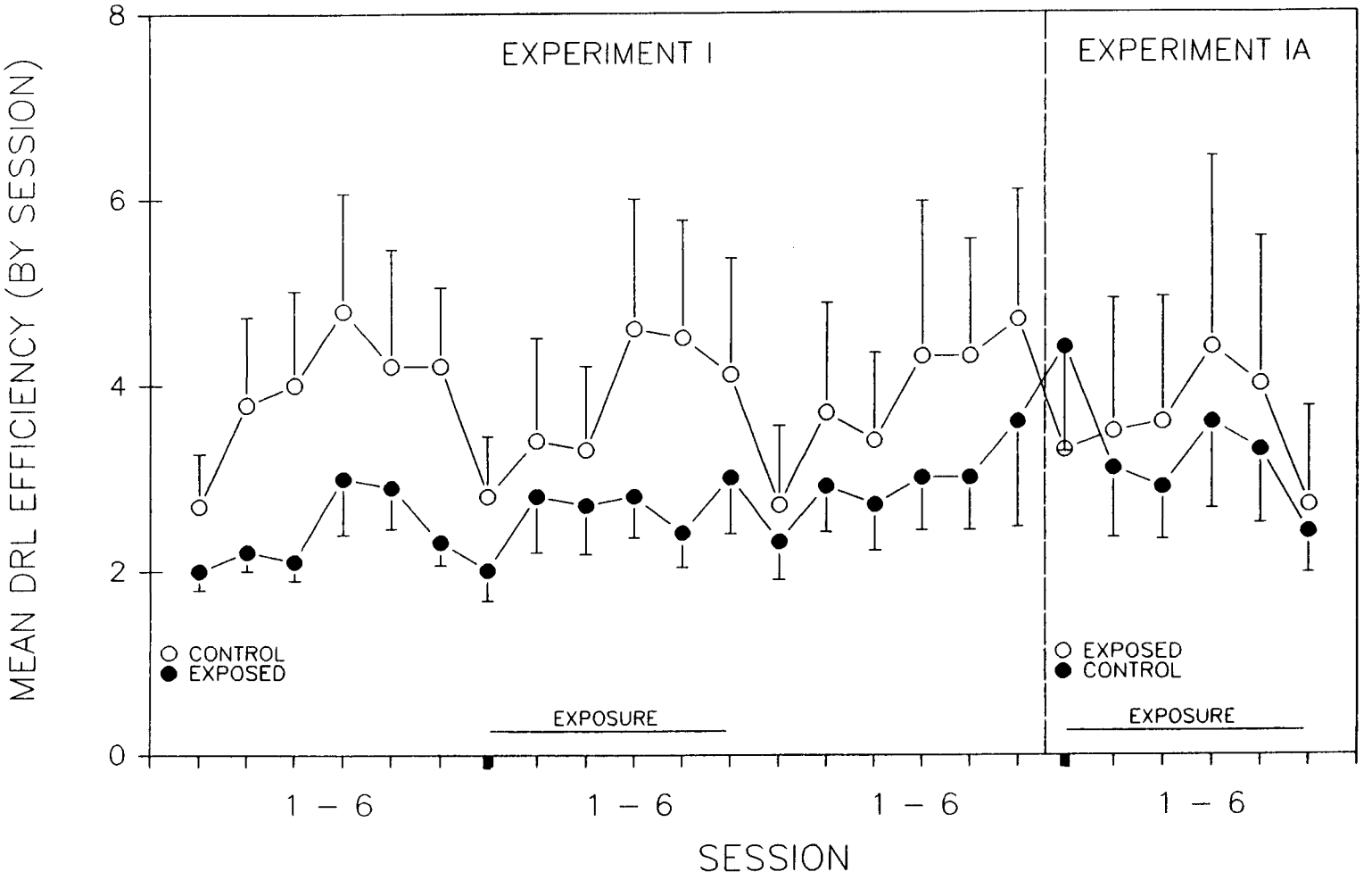

EXPERIMENT II
EXPERIMENT IIA
EXPERIMENT IIB
MEAN FR RESPONSES (BY DAY)
2000
1500
1000
500
0
CONTROL
EXPOSED
EXPOSURE
CONTROL
EXPOSED
EXPOSURE
EXPOSED
CONTROL
EXPOSURE
1 – 7
1 – 7
1 – 9
1 – 9
1 – 6
1 – 6
DAY

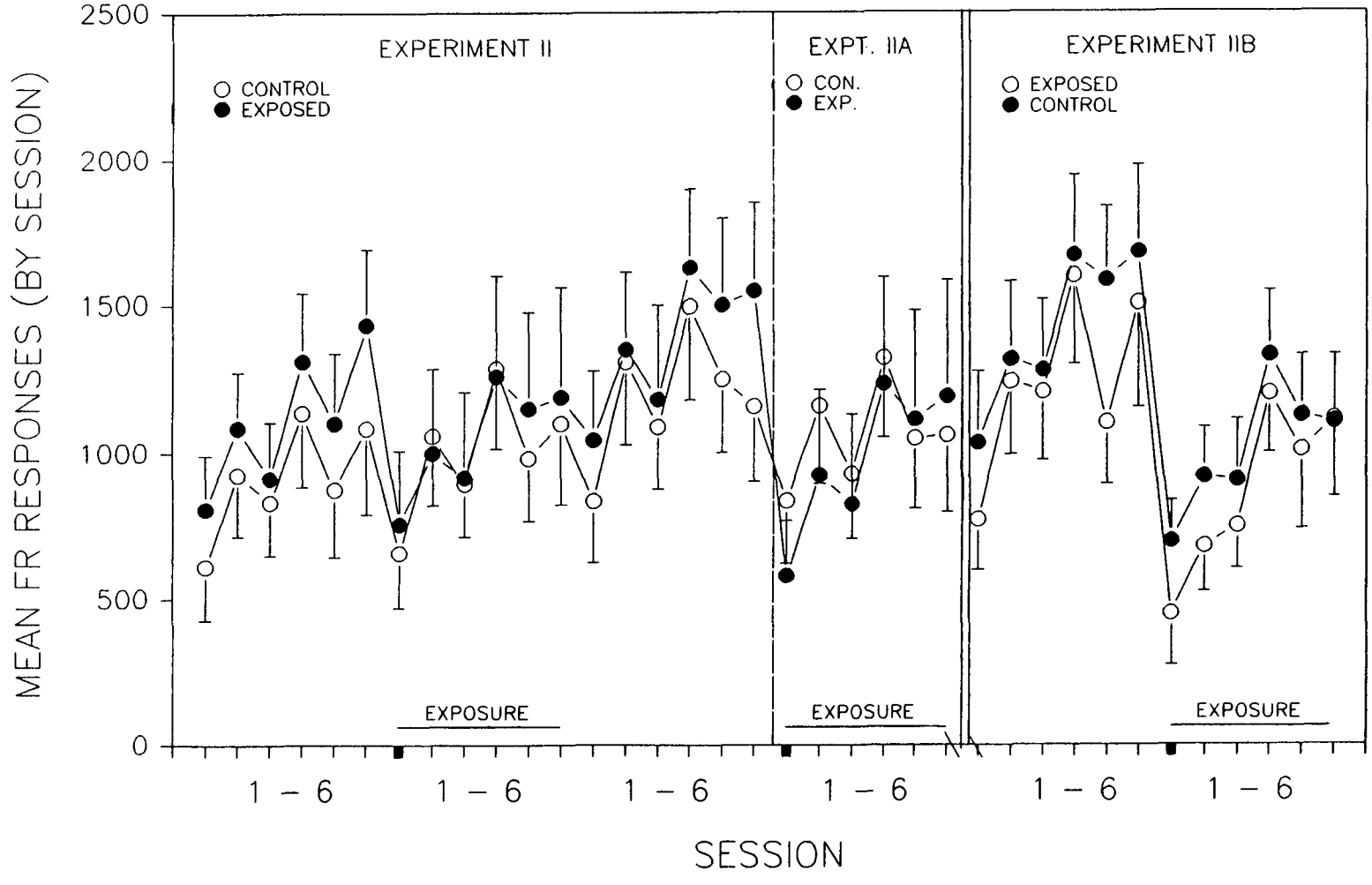

EXPERIMENT II
EXPERIMENT IIA
EXPERIMENT IIB
MEAN DRL RESPONSES (BY DAY)
120
90
60
30
0
CONTROL
EXPOSED
EXPOSURE
EXPOSED
CONTROL
1 – 7
1 – 7
1 – 9
1 – 9
1 – 6
1 – 6
DAY

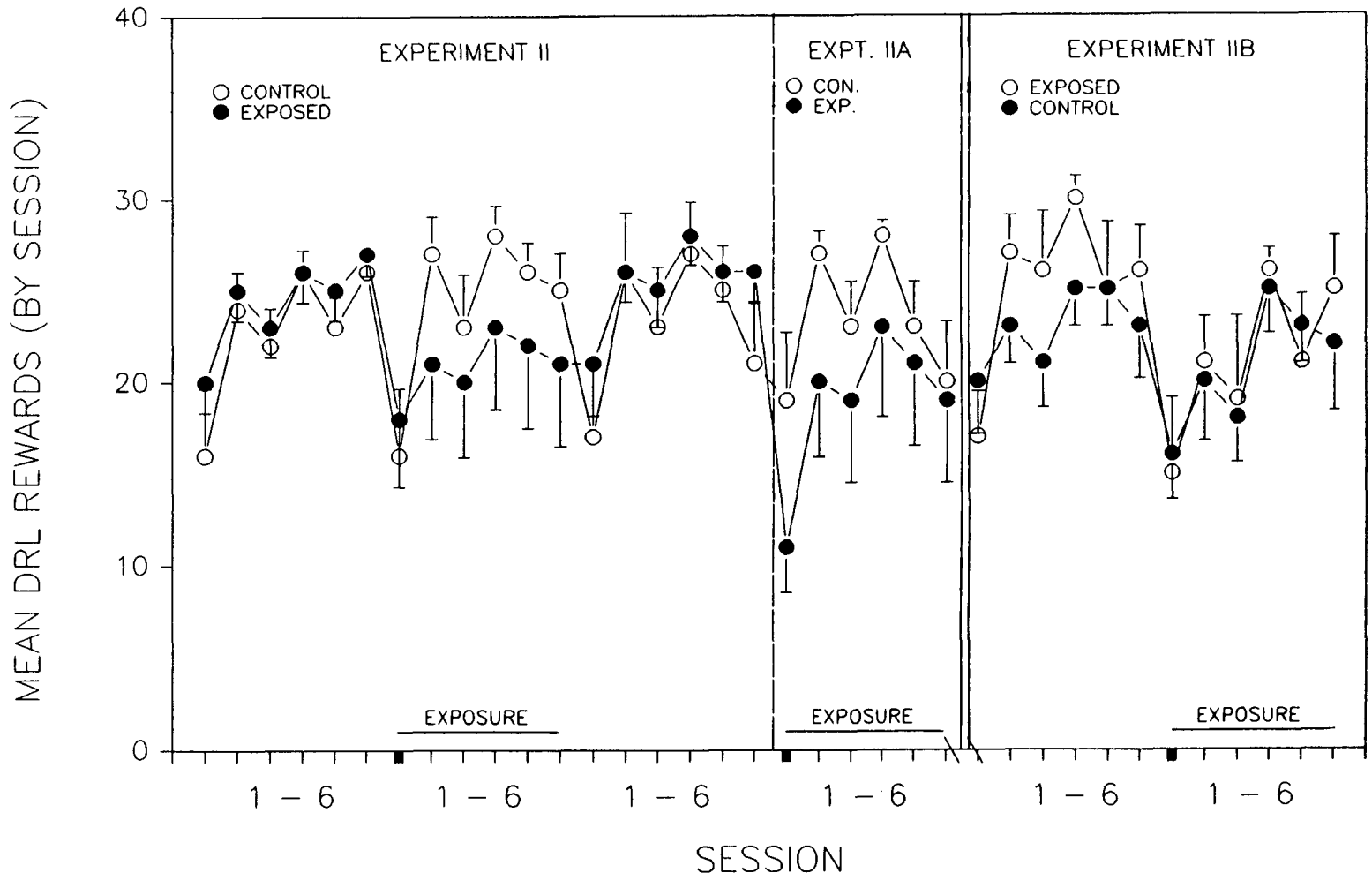

EXPERIMENT I
EXPERIMENT IA
CONTROL
EXPOSED
EXPOSED
CONTROL
MEAN FR RESPONSES (BY SESSION)
2500
2000
1500
1000
500
0
EXPOSURE
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
SESSION

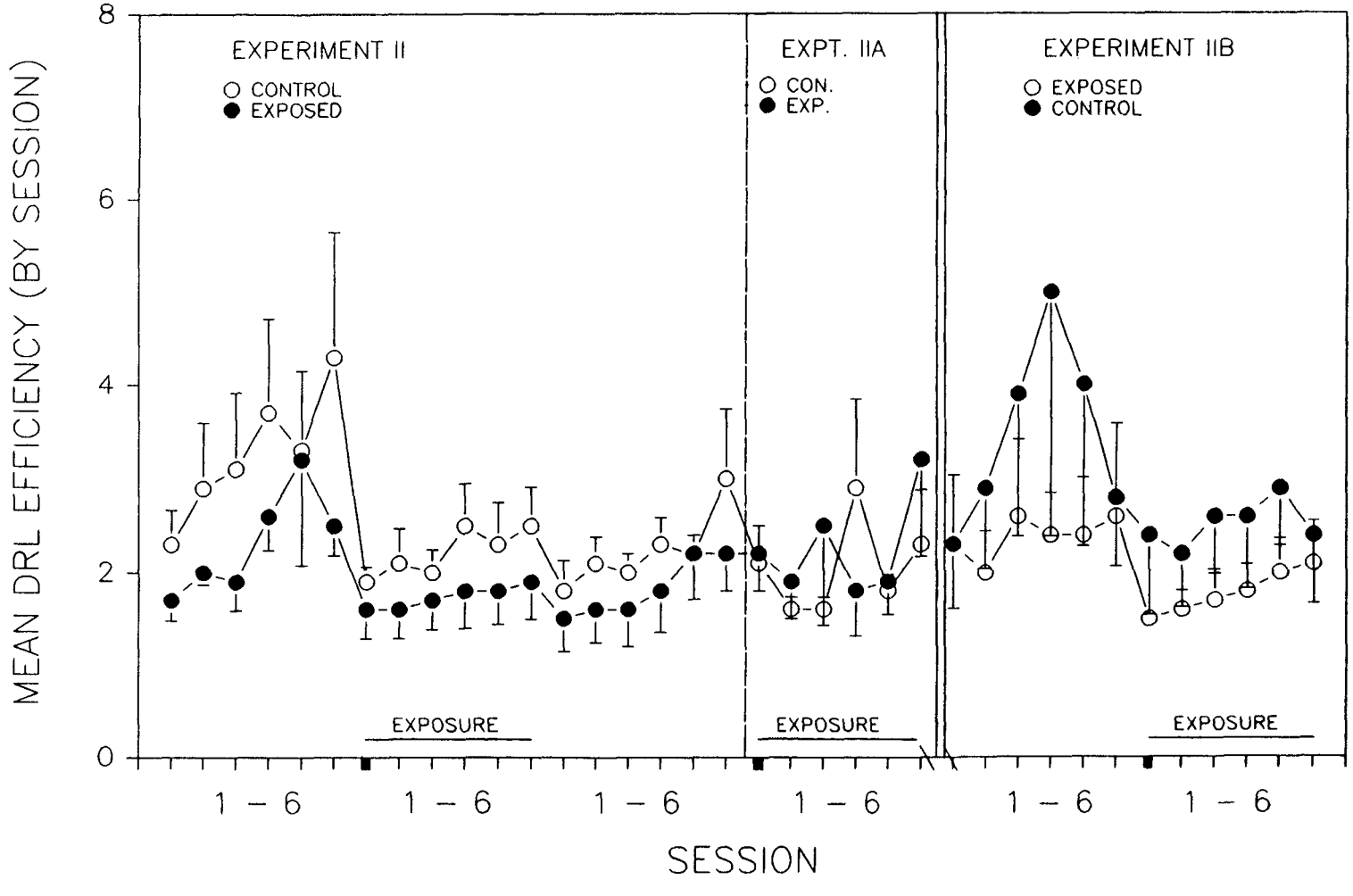

EXPERIMENT I
EXPERIMENT IA
CONTROL
EXPOSED
EXPOSED
CONTROL
MEAN DRL RESPONSES (BY SESSION)
200
150
100
50
0
EXPOSURE
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
SESSION


EXPERIMENT I
EXPERIMENT IA
CONTROL
EXPOSED
EXPOSED
CONTROL
MEAN DRL REWARDS (BY SESSION)
40
30
20
10
0
EXPOSURE
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
SESSION


EXPERIMENT I
EXPERIMENT IA
MEAN DRL EFFICIENCY (BY SESSION)
8
6
4
2
0
CONTROL
EXPOSED
EXPOSURE
EXPOSED
CONTROL
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
SESSION


EXPERIMENT II
EXPT. IIA
EXPERIMENT IIB
CONTROL
EXPOSED
CON.
EXP.
EXPOSED
CONTROL
MEAN FR RESPONSES (BY SESSION)
2500
2000
1500
1000
500
0
EXPOSURE
EXPOSURE
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6
SESSION


MEAN DRL REWARDS (BY SESSION)
40
30
20
10
0
EXPERIMENT II
CONTROL
EXPOSED
EXPT. IIA
CON.
EXP.
EXPERIMENT IIB
EXPOSED
CONTROL
EXPOSURE
EXPOSURE
EXPOSURE
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6
SESSION


EXPERIMENT II
CONTROL
EXPOSED
EXPT. IIA
CON.
EXP.
EXPERIMENT IIB
EXPOSED
CONTROL
EXPOSURE
EXPOSURE
EXPOSURE
MEAN DRL EFFICIENCY (BY SESSION)
SESSION
0
2
4
6
8
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6
1 – 6

XIII. APPENDIX C - ADDITIONAL DETAILS ON PROJECT 4 RESULTS

A. Results of Experiment I (30 kV/m)

Illustrations of the results for each behavior category and group, except for TENSION (Figure V.4), PASSIVE AFFINITY (Figure V. 5) and STEREOTYPY (Figure V.6) which were presented in Section V, are presented in Figures XIII.1 through XIII.7. The results of the 30 kV/m experiment are presented in the upper portion of each figure, and the results of the 60 kV/m experiment are presented in the lower portion of each figure. In Experiment I the West group was exposed to the electric field and the East group was the control group. In Experiment II, the East group was exposed to the electric field and the West group was the control group.

1. Repeated Measures Analyses of Variance

The complete data set for both groups and all three periods was analyzed using a repeated measures analysis of variance model (Winer, B.J., Statistical Principles in Experimental Design, 2nd Ed., McGraw-Hill, New York, 1971). The main effects of GROUP (East vs. West groups) and the main effects of period (Pre-Exposure vs. Exposure vs. Post-Exposure) were evaluated, as was the interaction between the GROUP factor and the PERIOD factor. The repeated measures were on the PERIOD factor in this design, because each animal was sampled during each period. In this type of model, subjects serve as their own controls for the within group analyses. The results of the repeated measures ANOVA are presented in Table XIII.1.

Table XIII.1

Summary of Results of Experiment I Two Factor, Repeated Measures ANOVAs: F Ratios and Two-Tailed Probabilities

Behavior Category	Group Effect		Period Effect		Gp × Per	
	F	P	F	P	F	P
TENSION	0.46	0.51	8.26	0.01*	5.87	0.00*
THREAT	3.29	0.09	4.85	0.01*	1.66	0.20
ATTACK	3.85	0.07	1.20	0.31	0.63	0.53
PASSIVE AFFINITY	1.00	0.33	52.82	0.00*	16.61	0.00*
ACTIVE AFFINITY	0.02	0.88	6.57	0.00*	0.87	0.43
APPROACH	0.58	0.46	7.87	0.00*	0.17	0.84
STEREOTYPY	12.01	0.01*	31.59	0.00*	4.44	0.02*
MANIPULATE	1.53	0.24	4.71	0.01*	0.52	0.59
FORAGE	0.44	0.52	8.93	0.00*	2.57	0.09
POSTURE	6.73	0.02*	2.74	0.08	0.09	0.91

* $P<.05$

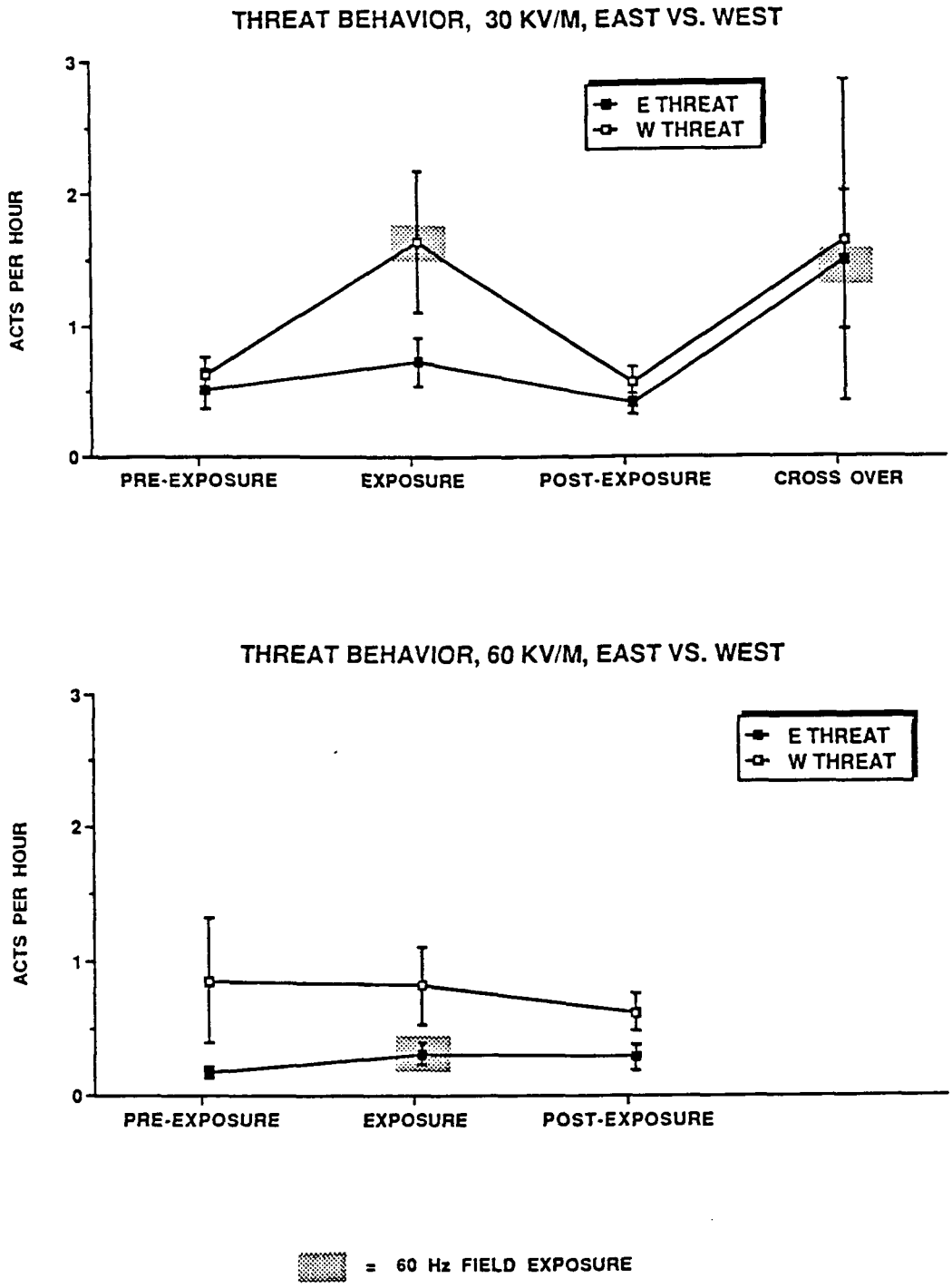


Figure XIII.1. Mean frequency occurrence of THREAT behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

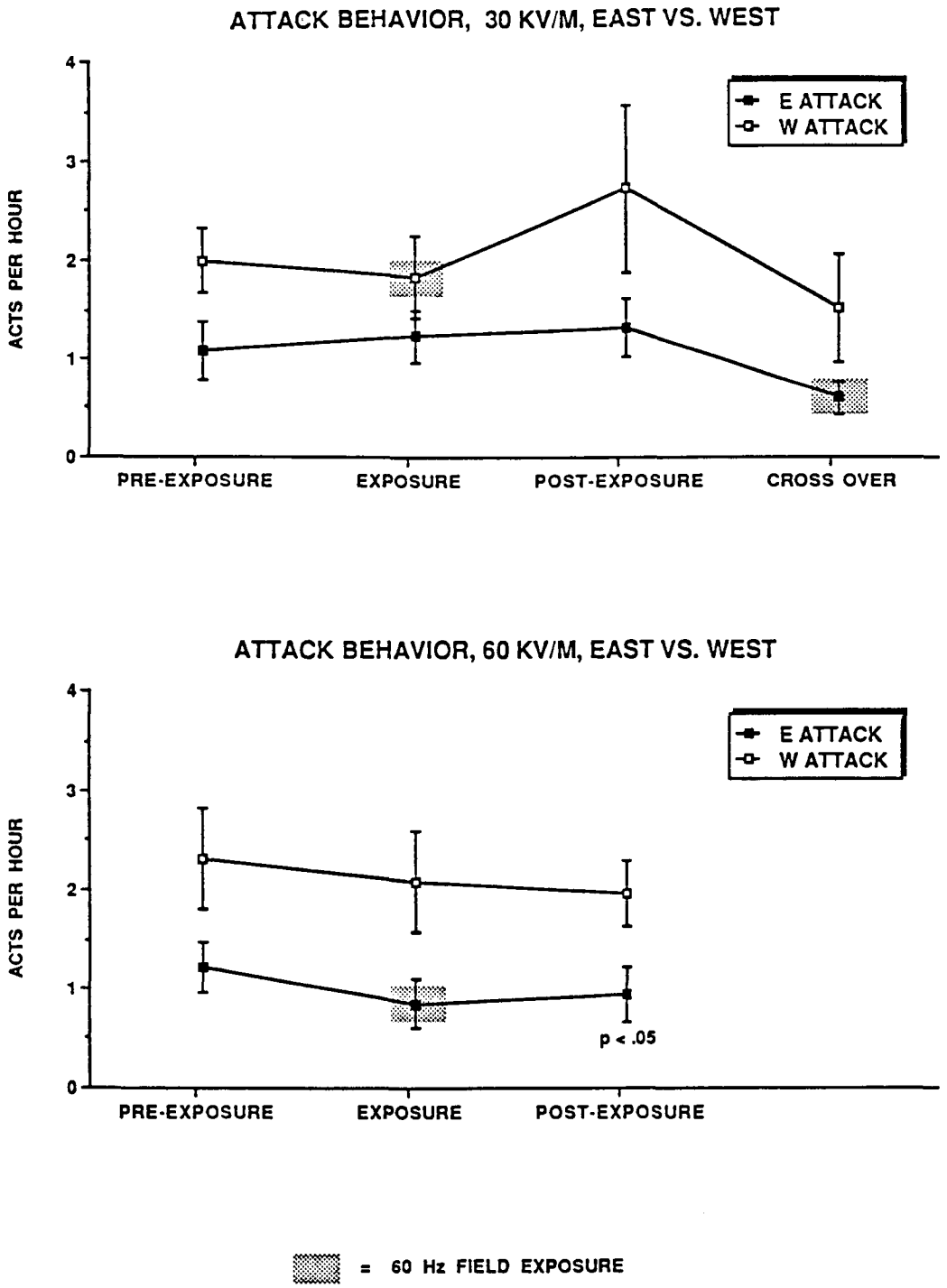


Figure XIII.2. Mean frequency of occurrence of ATTACK behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

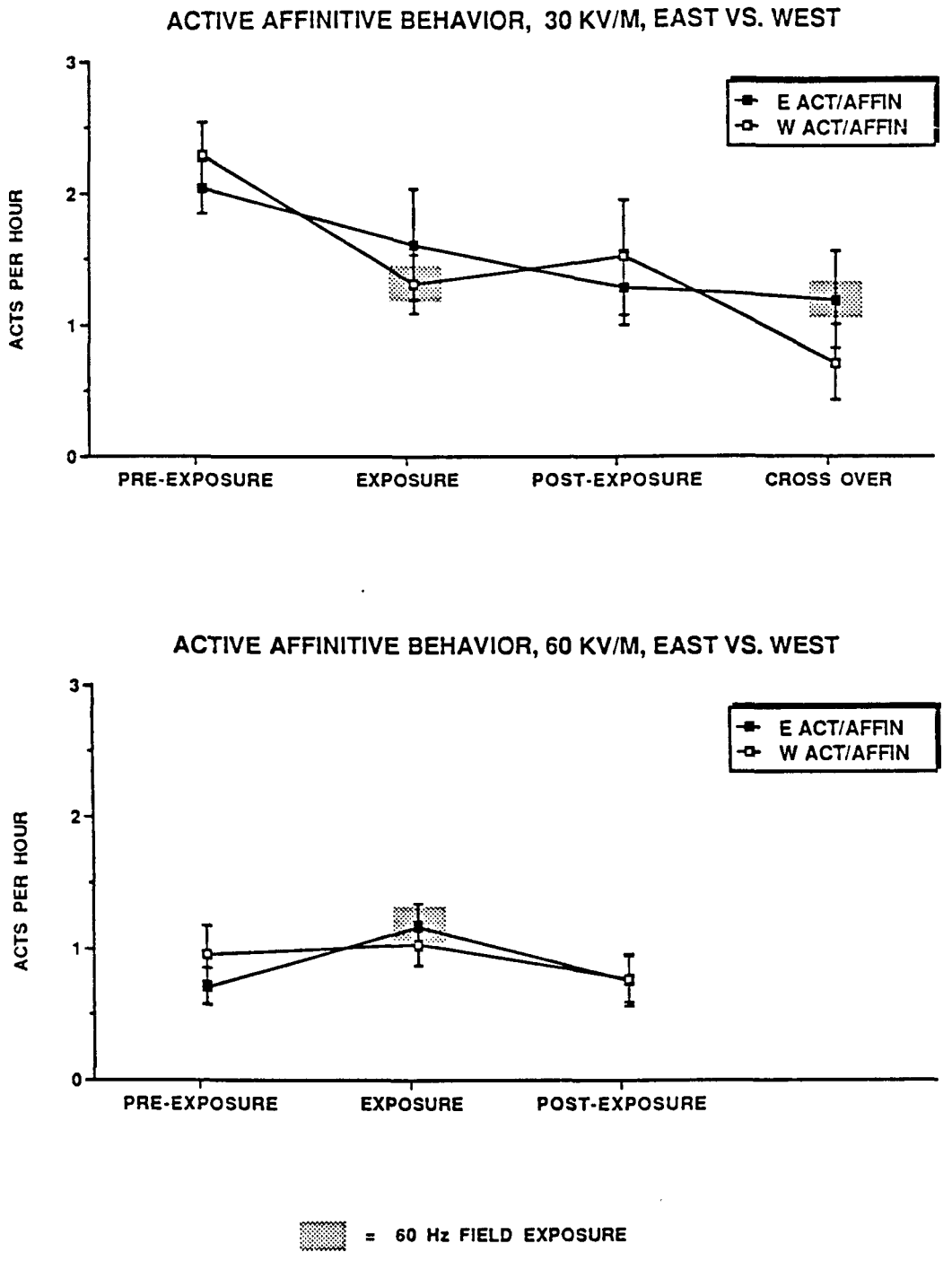


Figure XIII.3. Mean frequency of occurrence of ACTIVE AFFINITY behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

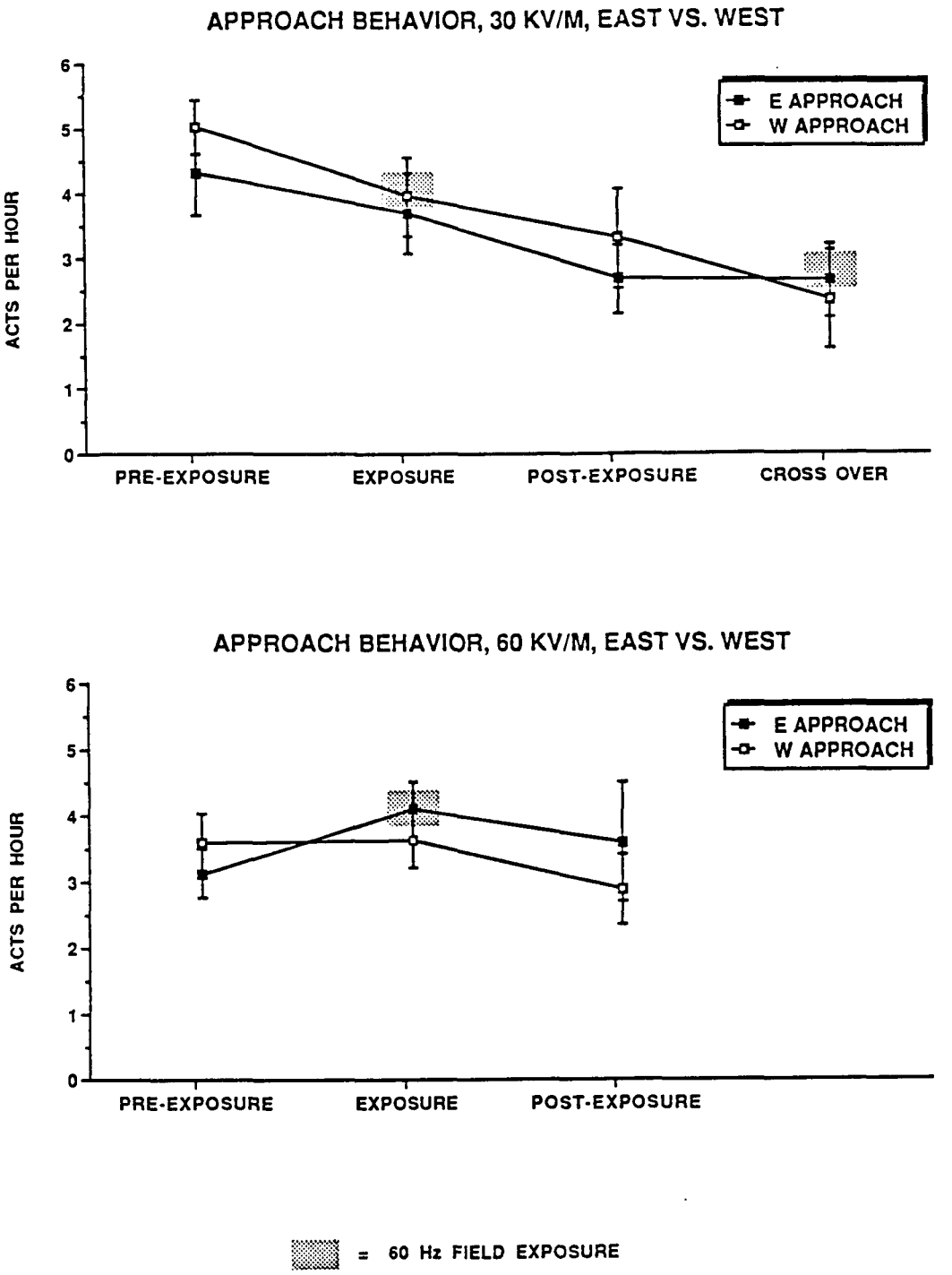


Figure XIII.4. Mean frequency of occurrence of APPROACH behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

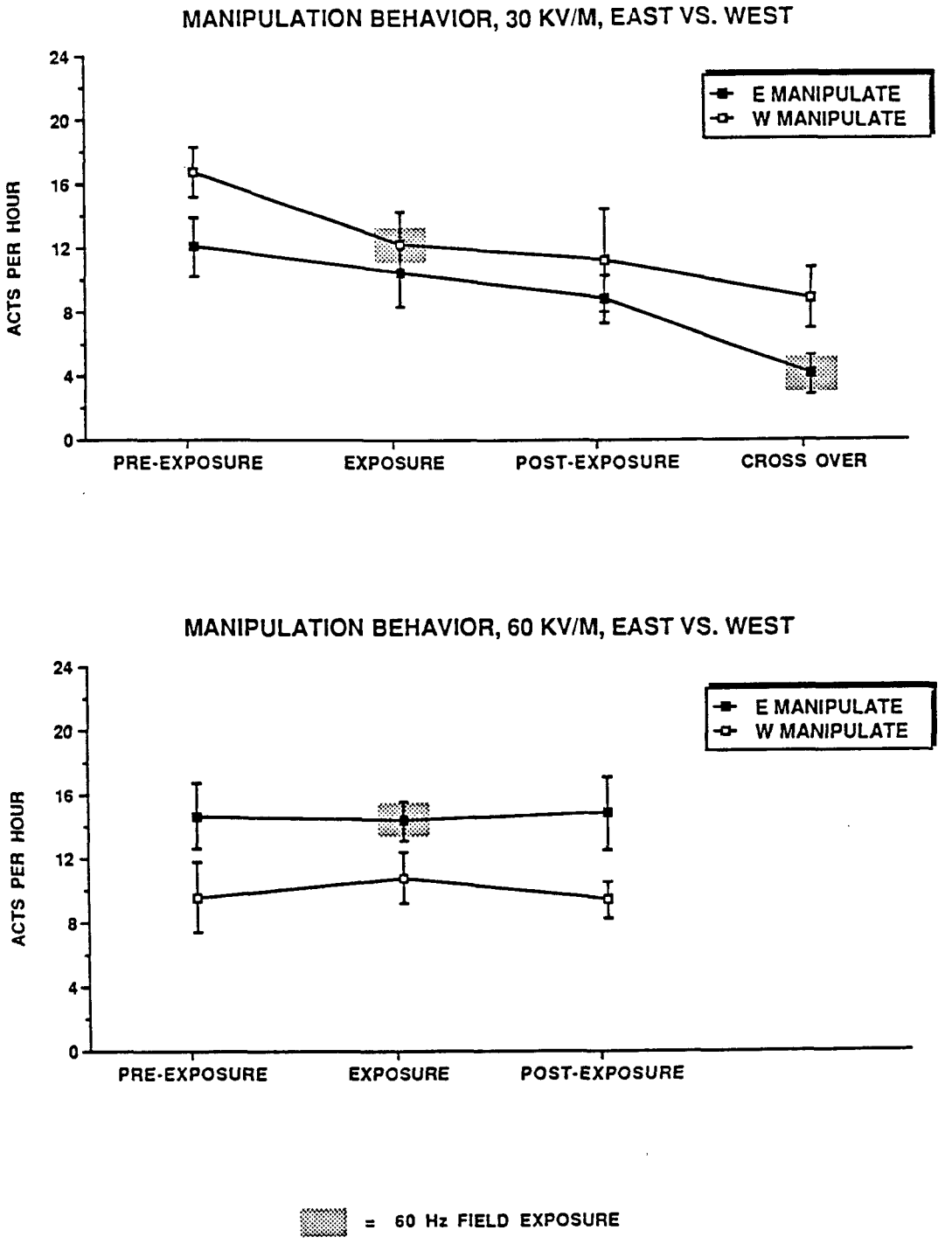


Figure XIII.5. Mean frequency of occurrence of MANIPULATION behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

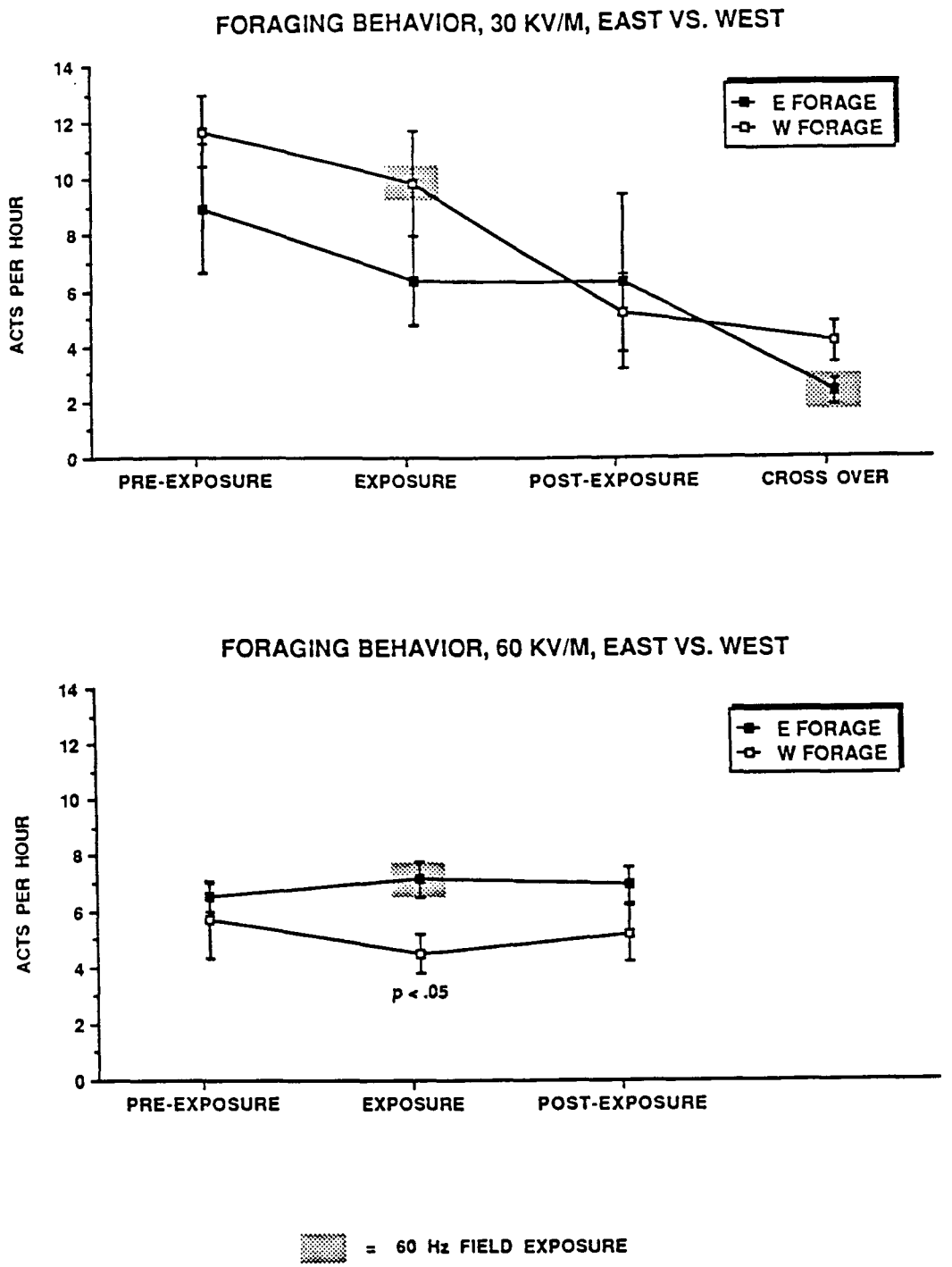


Figure XIII.6. Mean frequency of occurrence of FORAGING behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

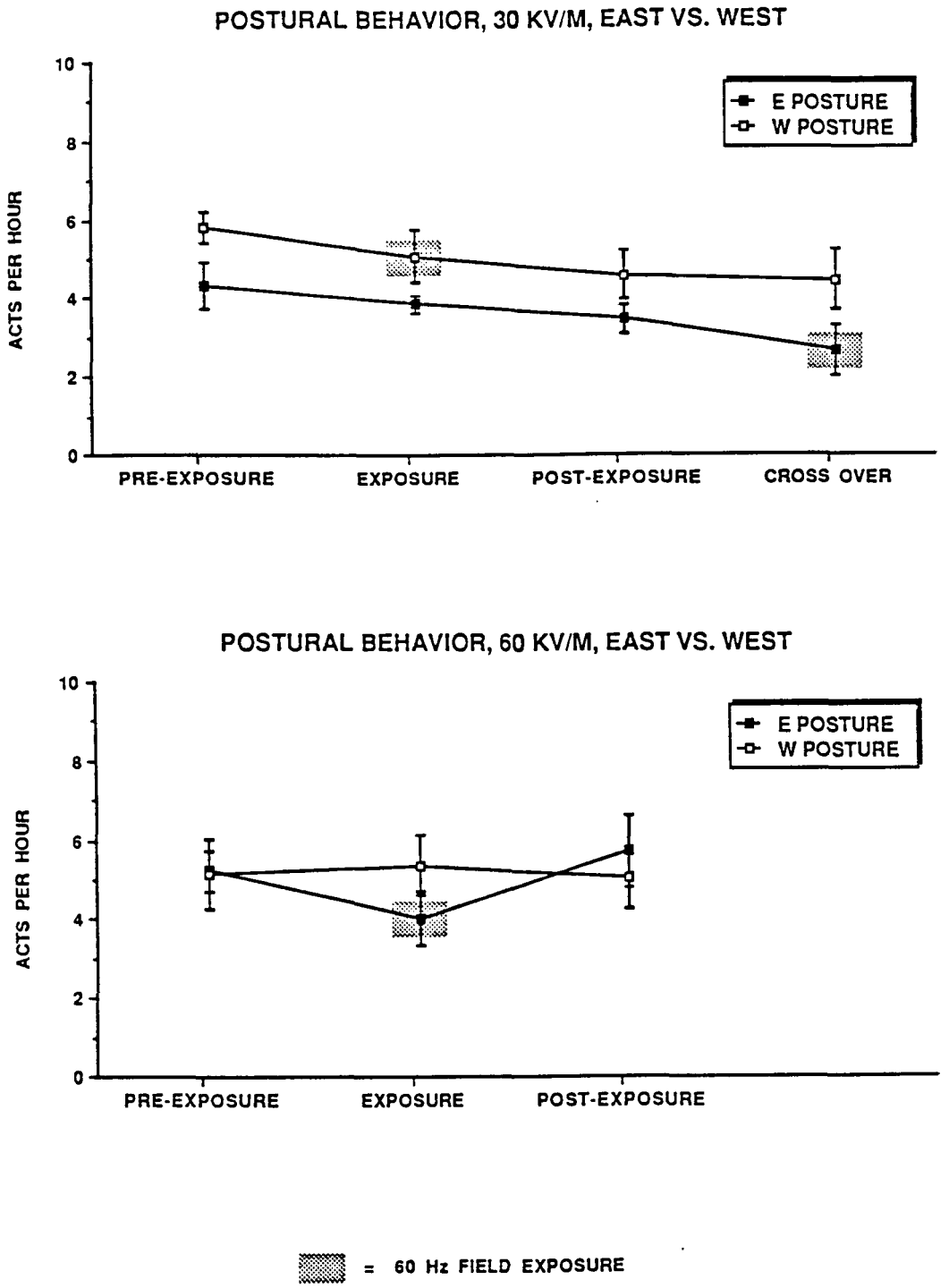


Figure XIII.7. Mean frequency of occurrence of POSTURAL behavior by experimental periods. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

Group.-- Analysis of the main effects of GROUP (East vs. West group) demonstrates that only two of the behavioral categories (both are nonsocial categories), POSTURE and STEREOTYPY, exhibited significant differences between the exposed group and the control group over the course of Experiment I (Table XIII.1). The West (exposed) group showed consistently higher rates of behavior than the East group in these categories. However, no significant between-group differences were found for any other categories, particularly the social behavior categories, when comparing the data for all three periods using the GROUP factor as the independent variable. The data demonstrate an overall similarity in behavioral performance rates between groups over the combination of all three time periods.

Period.-- Analysis of the main effects of PERIOD, which combines data from both groups together and evaluates the change in performance rate from Pre-Exposure to Exposure to Post-Exposure, indicates that there were several behavioral categories that showed significant change from Pre-exposure through Post-exposure (Table XIII.1). Only ATTACK and POSTURE showed no significant change over time. Data from both groups combined illustrate a trend for most categories during Experiment I that was downward, which is in accord with a priori expectations about behavioral change over time in baboons of this age class.

Interaction.-- The portion of the repeated measures ANOVA which tests for interactions between GROUP and PERIOD was the most crucial for the overall objectives of this experiment. We found significant F-ratios for the PERIOD × GROUP interaction for three behavioral categories: PASSIVE AFFINITY, TENSION, and STEREOTYPY. The F-ratios and significance values for the PERIOD × GROUP interaction are presented in Table XIII.1. These indicate that the profiles for each group over the three periods were significantly different and that there were significant between-group differences when both the GROUP factor and the PERIOD factor were used simultaneously as independent variables. This analysis indicates a specific effect of exposure to electric field on these three categories of behavior.

The occurrence of significant interactive effects of PERIOD with GROUP prompted the need for additional repeated measures ANOVAs on the PERIOD factors within each GROUP (Tables XIII.2 and XIII.3). These additional analyses were used to identify the nature of the changes which occurred over time within each treatment group (i.e., they illustrate simple effects). The results of these analyses indicate that there were significant changes over three periods in the East (control) group for TENSION, PASSIVE AFFINITY, ACTIVE AFFINITY, APPROACH, and STEREOTYPY. Figures V.4 through V.6 and XIII.1 through XIII.7 illustrate that the direction of the change in behavioral frequency for the East group was downward through time. This pattern of change is typical for animals of this age class.

The West (exposed) group exhibited significant change in performance rates of TENSION, PASSIVE AFFINITY, APPROACH, STEREOTYPY, and FORAGE. In the West (exposed) group, only APPROACH and FORAGE demonstrated consistent decreases over the three periods. PASSIVE AFFINITY increased significantly from the Pre-exposure to the Exposure period. TENSION exhibits a similar time trend although the change was not significantly different. However, TENSION AND PASSIVE AFFINITY exhibited significant decreases from the Exposure to Post-Exposure periods. During the Post-Exposure period the rate of TENSION

performance was similar to the rate observed during Pre-Exposure, while PASSIVE AFFINITY was significantly lower in Post-Exposure than at Pre-Exposure.

Table XIII.2

Summary of Results of Experiment I One Factor, Repeated Measures ANOVAs: F Ratios and Two-Tailed Probabilities

Behavior Category	East Group F	East Group P	West Group F	West Group P
TENSION	7.23	0.00*	6.81	0.00*
THREAT	2.01	0.17	3.42	0.06
ATTACK	0.41	0.67	0.99	0.39
PASSIVE AFFINITY	26.83	0.00*	40.70	0.00*
ACTIVE AFFINITY	4.68	0.02*	3.34	0.06
APPROACH	3.77	0.04*	4.28	0.03*
STEREOTYPY	29.24	0.00*	15.31	0.00*
MANIPULATE	2.03	0.16	2.88	0.08
FORAGE	1.51	0.25	12.98	0.00*
POSTURE	1.29	0.30	1.49	0.25

* P<.05

Table XIII.3

Summary of Experiment I Paired Comparison, Within Group t-Tests for the East (Control) Group: P<.05 Results

Behavior Category	Pre-Exposure vs. Exposure	Exposure vs. Post-Exposure	Pre-Exposure vs. Post-Exposure
TENSION	0.04*	----	0.01
THREAT	----	----	----
ATTACK	----	----	----
PASSIVE AFFINITY	0.01	0.00	0.00
ACTIVE AFFINITY	----	----	0.00
APPROACH	----	----	0.01
STEREOTYPY	0.00	0.00	0.00
MANIPULATE	----	----	----
FORAGE	----	----	----
POSTURE	----	----	----

*P value
---- = not significant (P>.05)

The West (exposed) group's mean rates of performing TENSION and PASSIVE AFFINITY, during the Post-Exposure period, were similar to the mean rates performed by the East group during the Post-Exposure period. The nonsocial behavior STEREOTYPY tended to remain elevated during the Exposure period, then dropped precipitously from Exposure to Post-Exposure to a level similar to the East group.

2. Within Group Comparisons By Period

Paired comparison t-tests for each group were calculated for each group and each behavior category, to compare the change in mean performance rate for Pre-Exposure vs. Exposure, Exposure vs. Post-Exposure and Pre-Exposure vs. Post-exposure (Tables XIII.3 and XIII.4). In the East group, ACTIVE AFFINITY and APPROACH significantly decreased from Pre-Exposure to Post-Exposure, but not from Pre-Exposure to Exposure or Exposure to Post-Exposure (Table XIII.4). TENSION decreased from Pre-Exposure to Exposure and from Pre-Exposure to Post-Exposure. PASSIVE AFFINITY and STEREOTYPY decreased from Pre-Exposure to Exposure, Exposure to Post-Exposure and Pre-Exposure to Post-Exposure.

Table XIII.4

Summary of Experiment I Paired Comparison, Within Group t-Tests for the West (Experimental) Group: P<.05 Results

Behavior Category	Pre-Exposure vs. Exposure	Exposure vs. Post-Exposure	Pre-Exposure vs. Post-Exposure
TENSION	----	0.00	----
THREAT	----	----	----
ATTACK	0.00	----	----
PASSIVE AFFINITY	0.00	0.00	0.00
ACTIVE AFFINITY	0.01	----	----
APPROACH	----	----	----
STEREOTYPY	----	0.00	0.00
MANIPULATE	0.00	----	----
FORAGE	----	0.02	0.00
POSTURE	----	----	----

---- = not significant (P>.05)

There were no instances where the mean performance rate of the East (control) group rate increased significantly from one period to the next. In all cases, the mean performance rate either declined significantly or remained essentially unchanged. This pattern was different from that of the West (exposed) group, whose profiles for TENSION, STEREOTYPY, and FORAGE remained at high levels during the Exposure period. Subsequently their mean performance values decreased significantly from the Exposure period to the Post-Exposure period. STEREOTYPY and FORAGE were significantly lower in the Post-

Exposure period than in the Pre-Exposure period. PASSIVE AFFINITY increased significantly from Pre-Exposure to Exposure , decreased significantly from Exposure to Post-Exposure, and was significantly lower in Post-Exposure than in Pre-Exposure. ACTIVE AFFINITY and MANIPULATE declined significantly from Pre-Exposure to Exposure and then remained relatively stable.

For the three behavioral categories (TENSION, PASSIVE AFFINITY, and STEREOTYPY) that showed the most obvious effects of exposure in the repeated measures analysis, it is clear that there was a very different pattern of within-group change in performance rate. The East (control) group declined steadily and significantly over time in all three categories. However, the mean performance rates of the West (exposed) group during the Exposure period were either significantly increased - in the case of PASSIVE AFFINITY - or remained very near their relatively high Pre-Exposure values, as in the case of TENSION and STEREOTYPY. Moreover, all three behavior categories decreased significantly to levels that were very similar to the East (control) group in the Post-Exposure period. These results reinforces in a simplified manner the conclusion indicated by the repeated measures analysis of variance, i.e., the animals in the West (exposed) group exhibited a significant behavioral stress response during the Exposure period.

Tables XIII.5 through XIII.7 present the mean values of each group at each time period. Figures V.4 through V.6 and XIII.1 through XIII.7 present the results across the time periods. The two sample t-tests for differences between group means for each of the time periods indicate that East (control) and West (exposed) groups were different in the mean performance rates of TENSION, PASSIVE AFFINITY and STEREOTYPY during the exposure period. When performance was analyzed over three periods by group, the pattern observed in the West (exposed) group was atypical in its temporal pattern. The observed changes in pattern reflect a stress response to exposure to the 30 kV/m electric field.

Table XIII.5

Experiment I Two Sample t-Tests of Differences *
Between Group Means During the Pre-Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION	4.65	0.79	3.48	0.47
THREAT	0.46	0.15	0.58	0.13
ATTACK	1.00	0.30	1.91	0.32
PASSIVE AFFINITY	12.76	1.16	11.26	1.16
ACTIVE AFFINITY	1.98	0.20	2.22	0.26
APPROACH	4.17	0.64	4.89	0.41
STEREOTYPY	17.35	1.43	22.83	2.31
MANIPULATE	11.59	1.77	16.27	1.50
FORAGE	8.60	2.30	11.36	1.27
POSTURE	4.12	0.59	5.61	0.39

* No $P<.05$ differences

Table XIII.6

Experiment I Two Sample t-Tests of Differences
Between Group Means During the Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION*	2.71	0.36	4.57	0.62
THREAT	0.67	0.18	1.57	0.53
ATTACK	1.15	0.27	1.74	0.41
PASSIVE AFFINITY*	9.07	0.83	15.01	1.57
ACTIVE AFFINITY	1.55	0.42	1.25	0.22
APPROACH	3.57	0.62	3.82	0.60
STEREOTYPY*	11.38	0.63	21.65	2.22
MANIPULATE	9.99	2.05	11.79	2.03
FORAGE	6.06	1.57	9.46	1.84
POSTURE	3.66	0.23	4.87	0.67

* P<.05

Table XIII.7

Experiment I Two Sample t-Tests of Differences *
Between Group Means During the Post-Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION	2.14	0.40	2.52	0.31
THREAT	0.34	0.08	0.51	0.11
ATTACK	1.23	0.29	2.61	0.83
PASSIVE AFFINITY	6.03	0.77	5.55	0.83
ACTIVE AFFINITY	1.22	0.27	1.45	0.43
APPROACH	2.55	0.51	3.16	0.74
STEREOTYPY	8.38	0.59	10.61	1.81
MANIPULATE	8.29	1.44	10.73	3.19
FORAGE	5.98	3.06	4.87	1.37
POSTURE	3.26	0.36	4.38	0.61

* no P<.05 differences

B. Crossover Study: Experiment IA (30 kV/m)

Introduction.-- A brief Crossover experiment was completed to deliver if the results from the first three weeks of Experiment I could be duplicated.

It was expected that any changes in the behavior (either augmentation or depression in the frequency of acts per hour of sampling) of baboons occurring during the first three weeks of electric field exposure also would be readily apparent in Experiment IA. In other words, Experiment IA (30 kV/m) provides an independent replication of the first three weeks of Experiment I (30 kV/m).

Methods.-- We employed the same subjects, sampling methods, and data analysis procedures used in Experiment I. Unlike the previous experiment, however, the Crossover experiment had only one period, Exposure. The exposure and control groups were reversed so that the former experimental social group (East) now became the control group and vice versa.

Data collection on the Crossover experiment was begun on Monday, October 27, 1986 and concluded on Friday, November 14, 1986. We collected an average of 16 time samples per day per observer (two samples per animal per day). Unfortunately, cage cleaning and field mapping were scheduled in Week 2 as per the main protocol for Experiment I, meaning behavioral observations could not be made for two days during the relatively brief exposure and sampling period. (No tests were collected during the days the baboons were removed from the facility for purposes of cleaning and mapping.) This restricted the sample size of data obtained during the Crossover study and compromised our ability to provide an unambiguous evaluation of the data during a three-week crossover experiment.

Results.-- The mean performance rates of the two groups were compared statistically and the results of the two sample t-tests are presented in Table XIII.8. Figures V.4 through V.6 and XIII.1 through XIII.7 illustrate the results in comparison to those data from Pre-Exposure through the Crossover periods. The general trend of the Crossover experiment is towards replication of the results of Experiment I. There was a significant elevation in PASSIVE AFFINITY. There were no other significant differences in the behavior of the field-exposed group (East) during Crossover in comparison with the social behavior and nonsocial behavior of the sham-exposed group (West). The instances of difference between these two experiments may be attributed to the fact that during Experiment I (30 kV/m), the animals were exposed for six weeks whereas in Experiment IA (30 kV/m) the animals were exposed for only three weeks. The smaller sample size obtained in three weeks has less power to detect differences than does the larger sample size accumulated over six weeks.

C. Results of Experiment II (60 kV/m)

Illustrations of the results for each behavior and group are presented in Figures V.4 through V.6 and XIII.1 through XIII.7. The results of the 30 kV/m experiment are presented in the upper portion of each figure, and the results of the 60 kV/m experiment are presented in the lower portion of each figure. In Experiment II the East group was exposed to the electric field and the West group was the control group.

1. Repeated Measures Analyses of Variance

The Experiment II data set was analyzed using a repeated measures analysis of variance model (Winer, 1971). The main effects of GROUP (East vs. West groups) and the main effects of PERIOD (Pre-Exposure vs. Exposure vs.

Table XIII.8

Experiment IA Two Sample t-Tests of Differences Between Group Means During the Crossover Period

Behavior Category	East Group Mean	East Group SEM	West Group Mean	West Group SEM
TENSION	2.99	0.50	1.88	0.65
THREAT	1.42	0.51	1.57	1.20
ATTACK	0.52	0.16	1.42	0.54
PASSIVE AFFINITY*	18.60	1.25	6.75	0.98
ACTIVE AFFINITY	1.12	0.35	0.65	0.28
APPROACH	2.52	0.53	2.22	0.72
STEREOTYPY	14.68	2.90	8.87	1.84
MANIPULATE	3.63	1.23	8.35	1.88
FORAGE	2.04	0.44	3.82	0.72
POSTURE	2.45	0.61	4.22	0.76

* P<.05

Post-Exposure) were evaluated, as well as the interaction between the GROUP factor and the PERIOD factor. The repeated measures were on the PERIOD factor in this design; because of the nature of this type of model, subjects serve as their own controls for the within group analyses. The results of the repeated measures ANOVA are presented in Table XIII.9.

Table XIII.9

Summary of Results of Experiment II Two Factor, Repeated Measures ANOVAs: F Ratios and Two-Tailed Probabilities

Behavior Category	Group Effect F	Group Effect P	Period Effect F	Period Effect P	Gp x Per F	Gp x Per P
TENSION	0.28	0.60	7.31	0.00*	3.90	0.03*
THREAT	8.38	0.01*	0.10	0.90	0.25	0.78
ATTACK	10.02	0.00*	0.52	0.60	0.05	0.95
PASSIVE AFFINITY	4.34	0.05	40.09	0.00*	32.20	0.00*
ACTIVE AFFINITY	0.08	0.78	2.38	0.11	0.68	0.51
APPROACH	0.21	0.65	0.92	0.41	0.86	0.43
STEREOTYPY	0.24	0.62	8.14	0.00*	8.02	0.00*
MANIPULATE	4.88	0.04*	0.09	0.91	0.31	0.73
FORAGE	3.20	0.09	0.14	0.86	1.13	0.33
POSTURE	0.04	0.84	1.08	0.35	2.18	0.13

* P<.05

Group.-- Analysis of the main effects of GROUP (East vs. West group) demonstrates that three behavioral categories, THREAT, ATTACK and MANIPULATE, exhibited significant differences between the exposed group and the control group over the course of Experiment II (Table XIII.9). The East (exposed) group showed consistently higher rates of TENSION and MANIPULATE behaviors than did the West group. However, no significant between-group differences were found for other categories when comparing the data for all three periods using the GROUP factor as the independent variable. The data demonstrate an overall similarity in behavioral performance rates between groups over the combination of all three time periods.

Period.-- Analysis of the overall main effects of PERIOD, which combines data from both groups together and evaluates the change in performance rate from Pre-Exposure to Exposure to Post-Exposure, indicates that there were several behavioral categories that showed significant change from Pre-Exposure through Post-Exposure (Table XIII.9): TENSION, PASSIVE AFFINITY and STEREOTYPY each showed significant change over time.

Interaction.-- The portion of the repeated measures ANOVA which tests for the interaction between GROUP and PERIOD was the most crucial for the overall objectives of this experiment. Significant F-ratios for the PERIOD x GROUP interaction existed for three behavioral categories: TENSION, PASSIVE AFFINITY, and STEREOTYPY (Figures V.4, V.5, and V.6). The F-ratios and significance values for the PERIOD × GROUP interactions are presented in Table XIII.9. These indicate that the profiles for each group over the three periods were significantly different and that there were significant between-group differences when both the GROUP factor and the PERIOD factor were used simultaneously as independent variables. This analysis indicates a specific effect of exposure to electric field on these three categories of behavior.

The occurrence of significant interactive effects of PERIOD with GROUP prompted the need for additional repeated measures ANOVAS on the PERIOD factors within each GROUP (Table XIII.10). These additional analyses were used to identify the nature of the changes which occurred over time within each treatment group (i.e., they illustrate simple effects). The results of these analyses indicate that there were significant changes over three periods in the East (exposed) group for TENSION, PASSIVE AFFINITY, STEREOTYPY, and POSTURE. Figures V.4, V.5, and V.6 illustrate that the direction of the change in behavioral frequency for the West group was consistently downward through time. This pattern of change is normal for animals of this age class. However, the direction of change for the East (60 kV/m exposed) group did not show the normal pattern of maturational decline. The pattern of elevation among electric field exposed individuals was similar in both the 30 kV/m and 60 kV/m experiments.

In Experiment II, the East (exposed) group exhibited significant increase in performance rates of PASSIVE AFFINITY. This category of behavior increased significantly from the Pre-Exposure to the Exposure period. TENSION exhibits a similar time trend.

2. Within Group Comparisons by Period

Paired comparison t-tests for each group were calculated for each group and each behavior category, to compare the change in mean performance

Table XIII.10

Summary of Results of Experiment II One Factor, Within Groups Repeated Measures ANOVAs: F Ratios and Two-Tailed Probabilities

Behavior Category	East Group F	East Group P	West Group F	West Group P
TENSION	8.89	0.00*	3.29	0.06
THREAT	1.28	0.30	0.14	0.87
ATTACK	0.93	0.38	0.16	0.83
PASSIVE AFFINITY	42.25	0.00*	8.30	0.00*
ACTIVE AFFINITY	2.35	0.13	0.70	0.51
APPROACH	0.78	0.47	1.09	0.36
STEREOTYPY	14.22	0.00*	2.23	0.14
MANIPULATE	0.03	0.90	0.37	0.69
FORAGE	0.33	0.72	0.84	0.45
POSTURE	4.36	0.03*	0.08	0.92

* $P<.05$

rate for Pre-Exposure vs. Exposure, Exposure vs. Post-Exposure, and Pre-Exposure vs. Post-Exposure (Tables XIII.11 and XIII.12). It is in these behaviors that we find the most pronounced effects of exposure to electric field on the performance of behavior. When Pre-Exposure and Exposure periods are compared, the analyses indicate that significant differences occurred in the East (exposed) group's performance of TENSION, PASSIVE AFFINITY, ACTIVE AFFINITY, APPROACH, STEREOTYPY and POSTURE behaviors. However, the same statistical treatment for the West (control) group, who were not exposed, does not demonstrate any performance differences (Table XIII.12). Comparing the Exposure and Post-Exposure periods, we found that TENSION, PASSIVE AFFINITY, STEREOTYPY and POSTURE exhibited significant differences in the East (exposed) group (Table XIII.11) while the rate of TENSION and PASSIVE AFFINITY were significant in the West group (Table XIII.12). Comparing Pre-Exposure and Post-Exposure, we found that no behaviors were significantly different in the East (exposed) group. However, PASSIVE AFFINITY was significantly different in the West group; this difference probably reflects the normal maturational trend typical of this species.

There were no instances where the mean performance rate of the control group increased significantly from Pre-Exposure to Exposure periods. In all cases the mean performance rate remained essentially unchanged (Table XIII.12). This pattern was different from the exposed group, whose profiles changed from period to period. Their mean performance values tended to increase significantly from Pre-Exposure to Exposure periods and then significantly decrease from the Exposure to the Post-Exposure period (Table XIII.11).

Table XIII.11

Summary of Experiment II Paired Comparison, Within Group t-Tests for the East (Experimental) Group: P<.05 Results

Behavior Category	Pre-Exposure vs. Exposure	Exposure vs. Post-Exposure	Pre-Exposure vs. Post-Exposure
TENSION	0.02 *	0.01	----
THREAT	----	----	----
ATTACK	----	----	----
PASSIVE AFFINITY	0.00	0.00	----
ACTIVE AFFINITY	0.04	----	----
APPROACH	0.04	----	----
STEREOTYPY	0.00	0.00	----
MANIPULATE	----	----	----
FORAGE	----	----	----
POSTURE	0.04	0.01	----

* P value
---- = not significant (P>.05)

Table XIII.12

Summary of Experiment II Paired Comparison, Within Group t-Tests for the West (Control) Group: P<.05 Results

Behavior Category	Pre-Exposure vs. Exposure	Exposure vs. Post-Exposure	Pre-Exposure vs. Post-Exposure
TENSION	----	0.04	----
THREAT	----	----	----
ATTACK	----	----	----
PASSIVE AFFINITY	----	0.01	0.00
ACTIVE AFFINITY	----	----	----
APPROACH	----	----	----
STEREOTYPY	----	----	----
MANIPULATE	----	----	----
FORAGE	----	----	----
POSTURE	----	----	----

---- = not significant (P>.05)

Tables XIII.13 through XIII.15 present the mean values of each group at each time period. Figures V.4 through V.6 XIII.1 through XIII.7 present the results across the time periods. The two sample t-tests for differences between group means for each of the time periods indicate that the East (exposed) and

West groups were different in the mean performance rate of TENSION, PASSIVE AFFINITY and STEREOTYPY during the Exposure period. When performance was analyzed over three periods by group, the pattern of results observed in the East (exposed) group was atypical in its temporal pattern; the changes in pattern reflect a stress response to exposure to electric field.

Table XIII.13

Experiment II Two Sample t-Tests of Differences *
Between Group Means During the Pre-Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION	4.74	0.75	6.00	1.06
THREAT	0.12	0.04	0.79	0.45
ATTACK	1.13	0.25	2.23	0.51
PASSIVE AFFINITY	6.32	0.85	8.39	0.76
ACTIVE AFFINITY	0.65	0.13	0.90	0.21
APPROACH	3.00	0.36	3.47	0.43
STEREOTYPY	11.19	0.90	14.36	1.92
MANIPULATE	14.14	2.03	9.11	2.17
FORAGE	6.22	0.49	5.42	1.36
POSTURE	5.04	0.51	4.93	0.87

* no differences with P<.05

Table XIII.14

Experiment II Two Sample t-Tests of Differences
Between Group Means During the Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION	7.27	1.42	4.90	0.44
THREAT	0.25	0.08	0.76	0.28
ATTACK	0.76	0.24	2.00	0.51
PASSIVE AFFINITY*	17.69	2.26	7.97	0.80
ACTIVE AFFINITY	1.10	0.17	0.97	0.16
APPROACH	3.97	0.41	3.50	0.40
STEREOTYPY*	18.09	1.69	12.92	1.33
MANIPULATE	13.85	1.25	10.27	1.61
FORAGE*	6.84	0.65	4.17	0.66
POSTURE	3.81	0.66	5.15	0.76

* P<.05

Table XIII.15

Experiment II Two Sample t-Tests of Differences
Between Group Means During the Post-Exposure Period

	East Group		West Group	
Behavior Category	Mean	SEM	Mean	SEM
TENSION	3.88	0.56	3.46	0.40
THREAT	0.23	0.09	0.56	0.14
ATTACK*	0.86	0.27	1.88	0.33
PASSIVE AFFINITY	7.37	1.04	5.95	0.63
ACTIVE AFFINITY	0.68	0.18	0.71	0.18
APPROACH	3.48	0.89	2.75	0.53
STEREOTYPY	11.50	0.73	11.20	1.39
MANIPULATE	14.31	2.30	8.90	1.08
FORAGE	6.64	0.64	4.88	0.99
POSTURE	5.52	0.90	4.86	0.78

* $P<.05$

3. Summary of Data Analyses by Period

The most obvious and consistent effects of exposure that resulted in either the 30 kV/m or 60 kV/m experiments occurred in TENSION, PASSIVE AFFINITY, and STEREOTYPY. These behaviors appear to be the most sensitive to the effects of electric field exposure. In general the performance pattern of control groups in both experiments was that of a gentle decline in performance rate with time. However, the mean performance rates of exposed groups during the Exposure period were significantly increased or remained very near their relatively high Pre-Exposure values. During the Post-Exposure period, the behavior of exposed animals returned to levels that were similar to control group. This result reinforces in a simplified manner the conclusion indicated by the repeated measures analysis of variance, i.e., the animals in the exposed side of the facility exhibited a significant behavioral stress response during the Exposure period. These results clearly indicate that:

(1) The experimental and control groups were different in the mean performance rate of these behavior categories when performance was analyzed over three periods by group;

(2) The pattern of results observed in the exposed groups was atypical in its temporal pattern; and

(3) The changes in pattern reflect a stress response to electric field exposure.

D. Exploratory Analyses: Week-by-Week Comparisons

We have carried out exploratory data analysis describing week-by-week effects of exposure to 60-Hz electric fields on social behavior. Data

collected from the 30 kV/m and 60 kV/m experiments were analyzed for the entire 18 weeks of each experiment. This exploratory analysis was accomplished by application of t-test statistics to compare the control and exposed groups at each of the weeks in the experiment. This exploratory weekly analysis was intended to provide a preliminary temporal view of the possible behavioral responses to the effects of exposure to the 60-Hz fields as well as an overview of the similarities and differences between the two experiments.

Plots of mean weekly performance rates for the East and West groups in the 30 kV/m and 60 kV/m experiments for TENSION (V.7), PASSIVE AFFINITY, (V.8), and STEREOTYPY (V.9) were presented in Section V. The remaining behaviors are illustrated in Figures XIII.8 to XIII.14. In each of these figures the exposure period is represented as the shaded block encompassing weeks 7 through 12. The plots of the 30 kV/m experiment also include presentation of the crossover experiment of weeks 19 through 21. The results of the 30 kV/m experiment are presented in the upper portion of each figure, and the results of the 60 kV/m experiment are presented in the lower portion of each figure.

In the 30 kV/m experiment the West group was exposed to the electric field and the East group was the control group. In the 60 kV/m experiment the East group was exposed to the electric field and the West group was the control group.

1. Social Behavior Categories

TENSION behaviors exhibited a similar response pattern in both experiments (Figure V.7). There were no significant differences during the Pre-Exposure (weeks 1 through 6) and Post-Exposure (weeks 13 through 18) periods. However a behavioral response took place in week 7 of both experiments. The exposed group in the 30 kV/m experiment exhibited a two-fold increase in the rate of performance of these behaviors while the exposed group in the 60 kV/m experiment exhibited a three-fold increase in performance of TENSION behaviors. The 30 kV/m subjects appear to maintain a trend towards an elevation in weeks 8 and 9 that is not statistically significant. During the 30 kV/m crossover period the exposed subjects exhibited a statistically significant increase in performance of TENSION behaviors. The exposed group in the 60 kV/m experiment returns to the Pre-Exposure level during week 8, and for the remainder of the exposure period the two groups remains similar. THREAT behaviors (Figure XIII.8) exhibited a statistically significant elevation in week 7 of the 30 kV/m experiment. During week 12 the exposed group's mean performance rate was also elevated but the elevation was not significantly different. The lack of difference was due to high variability in the groups. During the Crossover period the exposed subjects exhibited an increase in performance of THREAT behaviors, as did the previously exposed animals who now served as controls for the Crossover. There were no significant differences between the two groups. There were no statistically significant differences in the 60 kV/m experiment. Performance of THREAT behavior remained at a low level throughout the 18 week experiment. ATTACK behavior did not demonstrate any statistically significant weekly response to either intensity of the 60-Hz field exposure (Figure XIII.9).

PASSIVE AFFINITIVE behaviors exhibited a similar response pattern in both of the experiments (Figure V.8). There were no significant differences during Pre-Exposure (weeks 1 through 6) or during Post-Exposure (weeks 13 through 18). However a behavioral response took place in week 7, at the

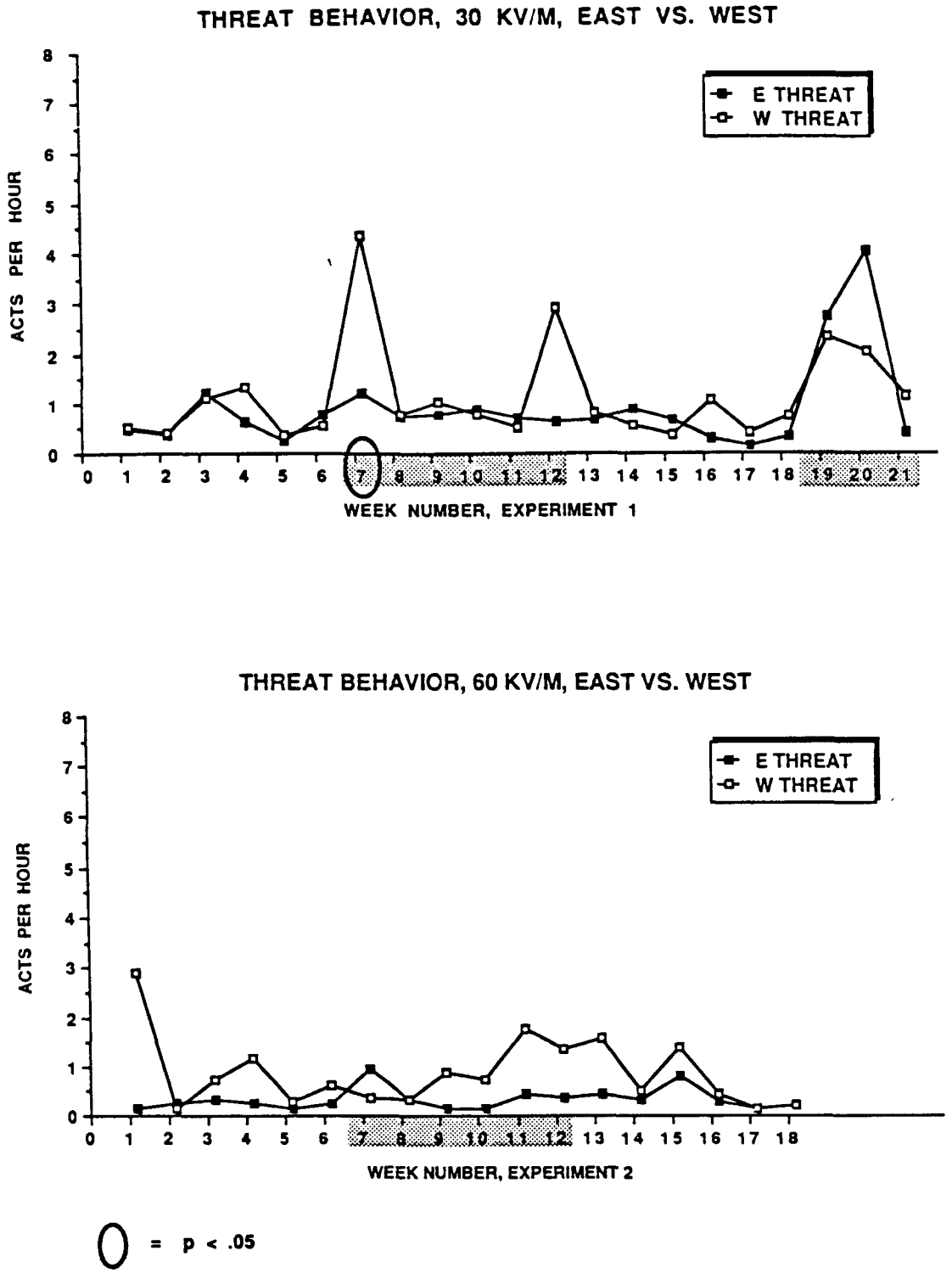
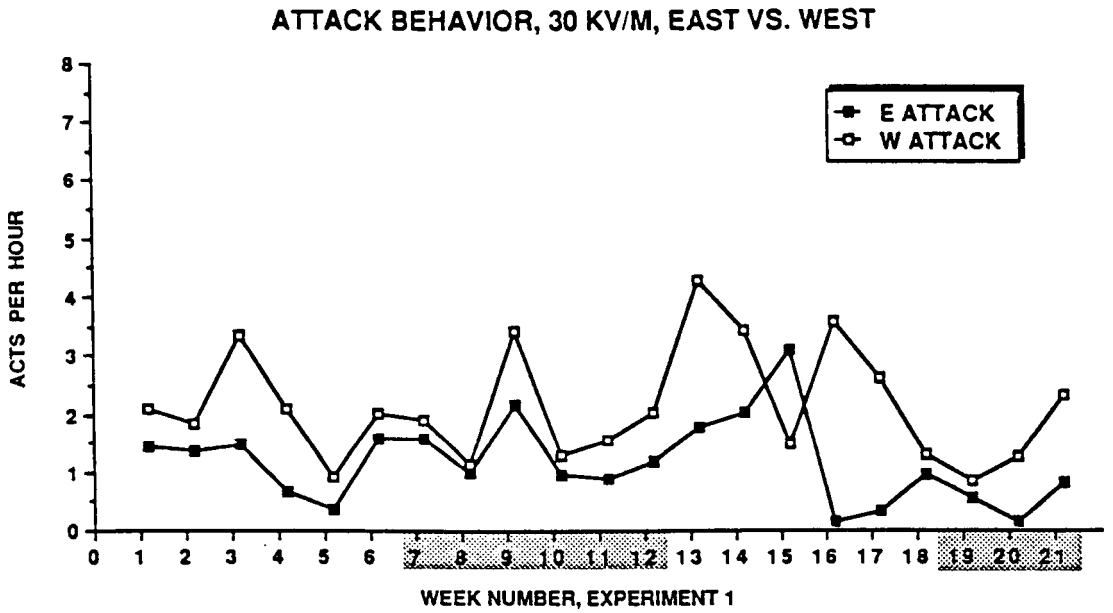


Figure XIII.8. Weekly means for frequency of occurrence of THREAT behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.



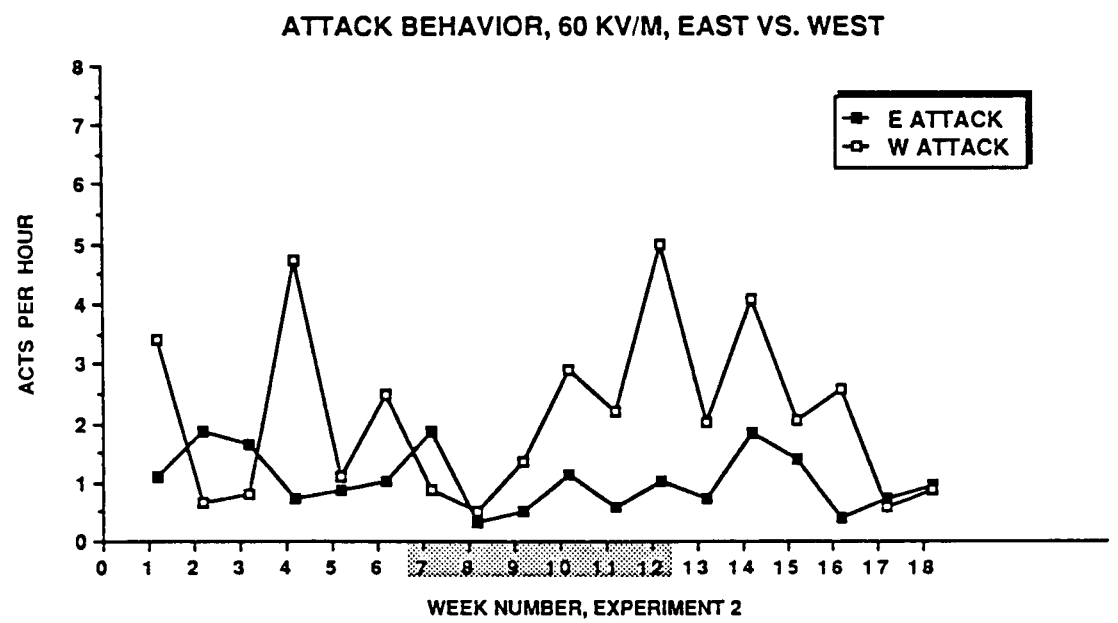


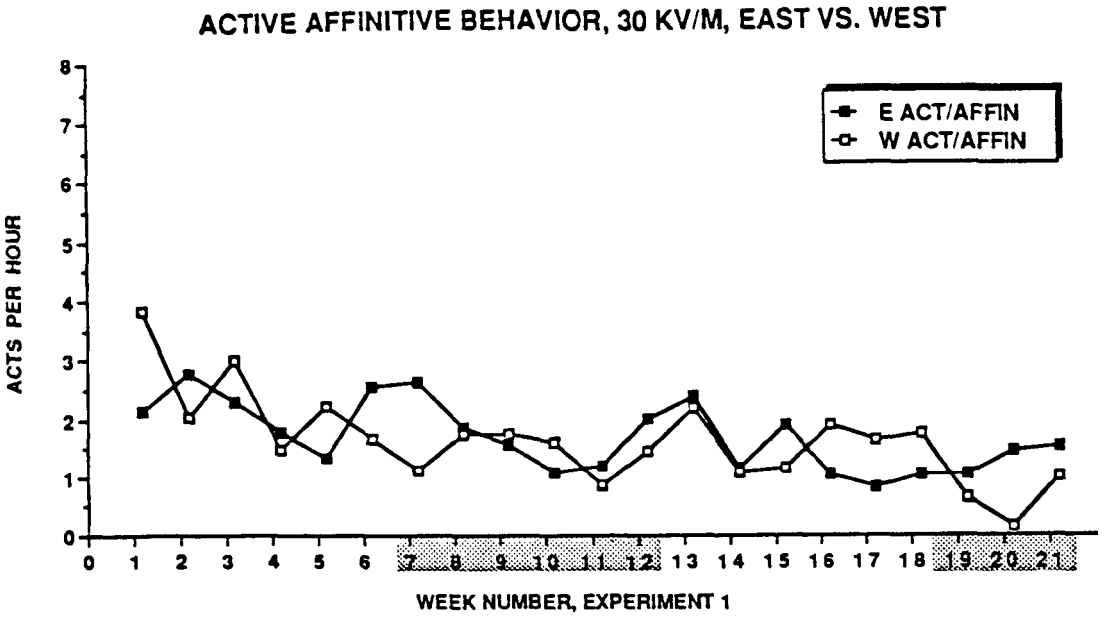
Figure XIII.9. Weekly means for frequency of occurrence of ATTACK behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

onset of the Exposure period, of both experiments. The exposed group in the 30 kV/m experiment exhibited an almost four-fold increase in performance of these behaviors. The 30 kV/m exposed group returns to the Pre-Exposure level during week 8, and the two groups remain similar for the remainder of the exposure period. During the Crossover experiment, PASSIVE AFFINITIVE behaviors were significantly higher in the exposed subjects during week 19. By week 20 both groups exhibited similar rates of performance. The exposed group in the 60 kV/m experiment also exhibited an almost four-fold increase in performance of PASSIVE AFFINITIVE behaviors in week 7. When the weekly means of the eight exposed and eight control subjects were compared by t-test, statistically significant differences between Exposed and Control groups occur in weeks 7, 8, and 11 of the 60 kV/m experiment. The mean rate of PASSIVE AFFINITY was greater for the exposed baboons (East group) in weeks 7, 8, and 11 than for the eight control baboons (West group). This is in contrast to the 30 kV/m experiment where the weekly means of the two groups differed only in week seven (the first week of Exposure). This would suggest that at 60 kV/m the animals did not adapt to field exposure as quickly and completely as the subjects in the 30 kV/m experiment. The 60 kV/m exposed subjects appear to maintain the trend towards elevated performance of this behavior category for a longer time than the 30 kV/m exposed subjects. ACTIVE AFFINITIVE behaviors did not demonstrate any statistically significant weekly response to the 60-Hz field exposure (Figure XIII.10). APPROACH behaviors were highly variable in both experiments, and no clear trend of responses was discernible (Figure XIII.11).

2. Nonsocial Behavior Categories

STEREOTYPIC behaviors (Figure V.9) exhibited a response pattern similar to TENSION and PASSIVE AFFINITIVE behaviors in both of the experiments. A behavioral response took place in week 7 of both Experiments I and II. The exposed group in the 30 kV/m experiment exhibited a two-fold increase in performance of these behaviors, and the 60 kV/m exposed animals exhibited an almost three-fold increase in performance of these behaviors. The 30 kV/m exposed group retains the elevated performance rate for several weeks; however, except for weeks 7 and 8, the other weeks are not statistically different from the performance rates of the control subjects. The two groups do not differ during the Post-Exposure period.

MANIPULATION, FORAGING, and POSTURE behaviors were highly variable in both experiments, and no clear response trend of was discernible (Figures XIII.12, XIII.13, and XIII.14, respectively).



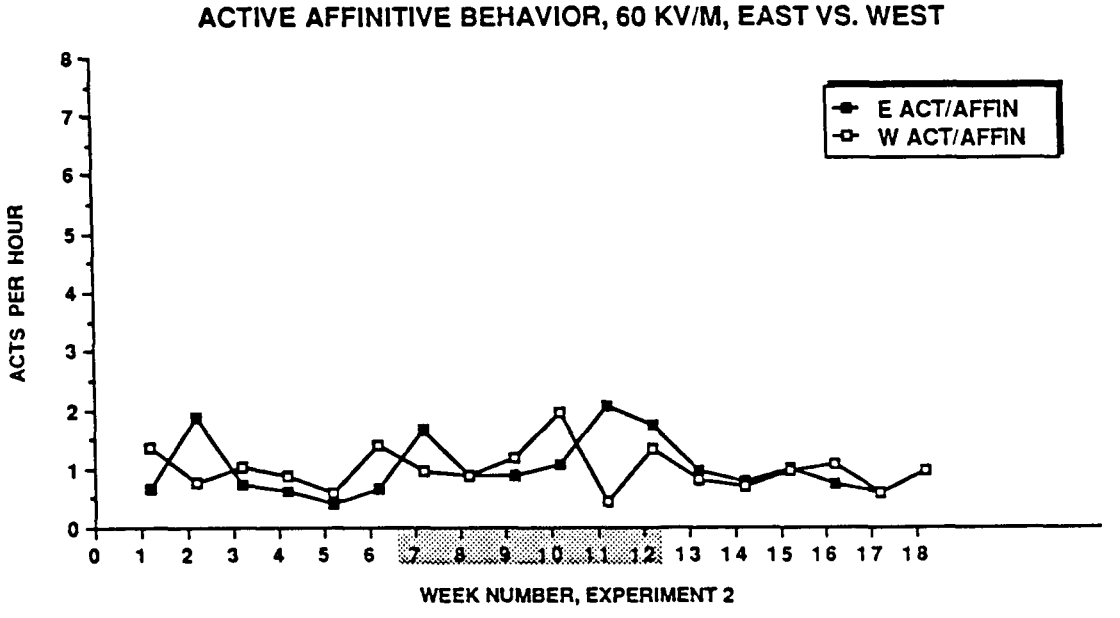


Figure XIII.10. Weekly means for frequency of occurrence of ACTIVE AFFINITIVE behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

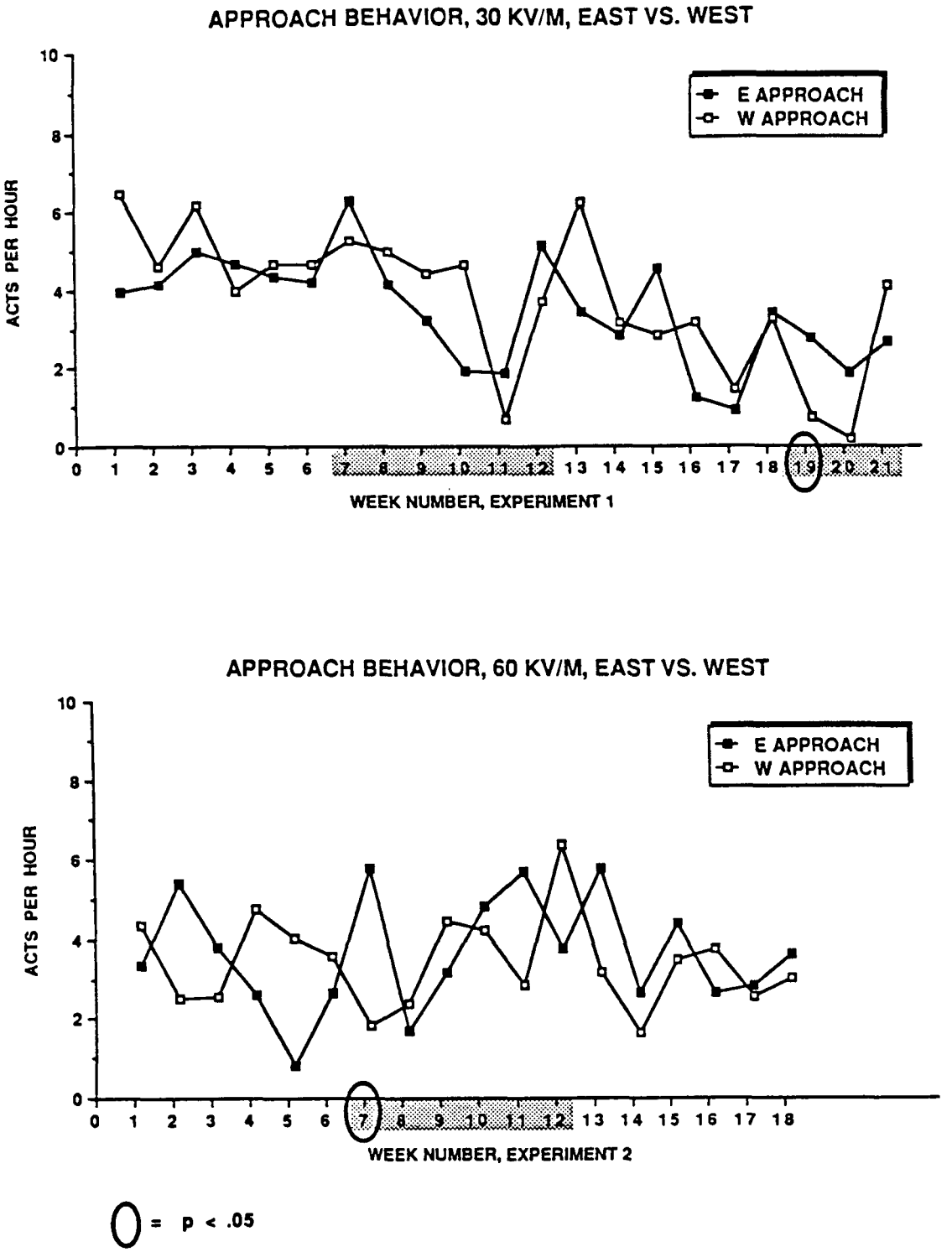


Figure XIII.11. Weekly means for frequency of occurrence of APPROACH behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

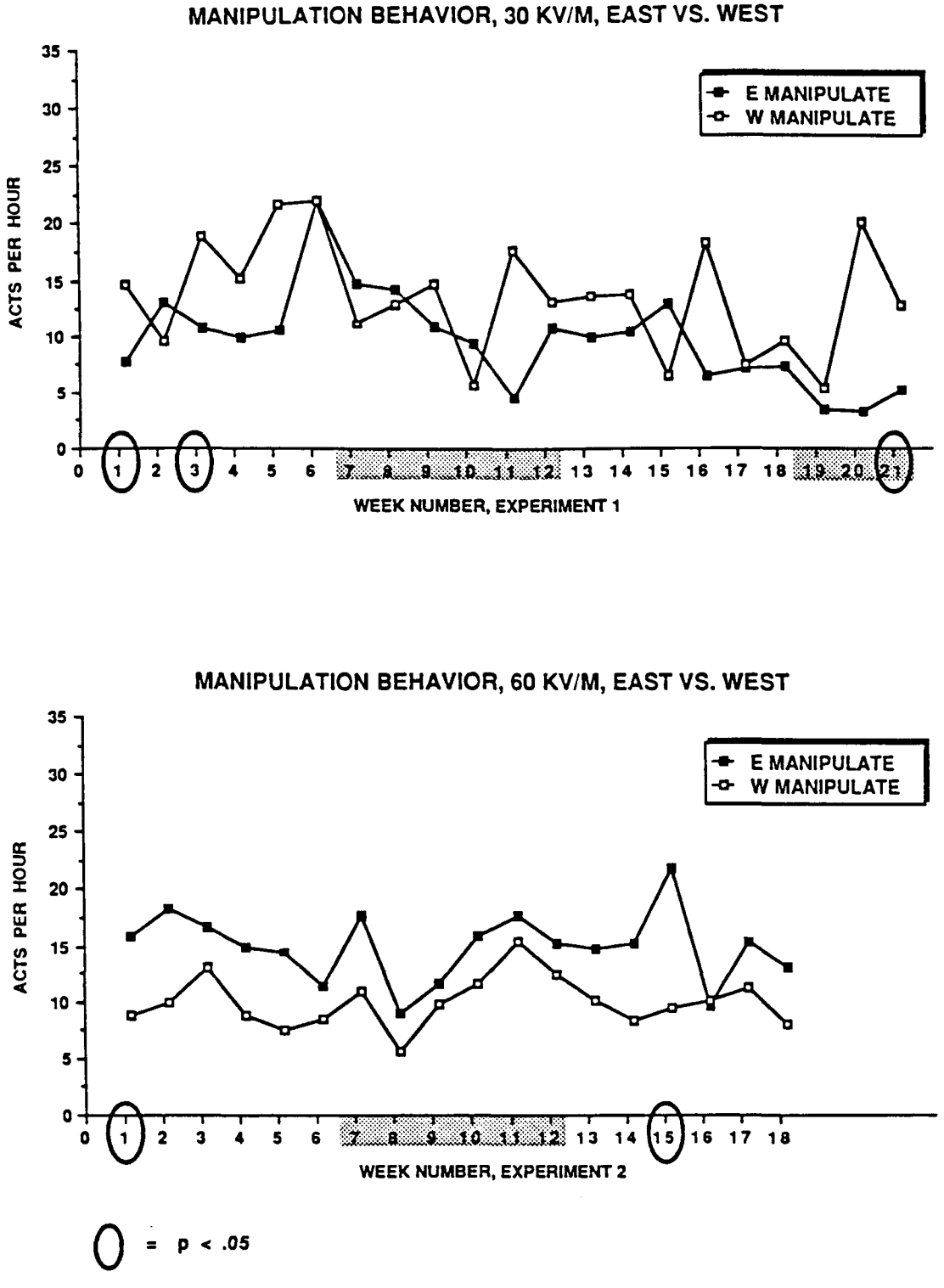


Figure XIII.12. Weekly means for frequency of occurrence of MANIPULATION behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

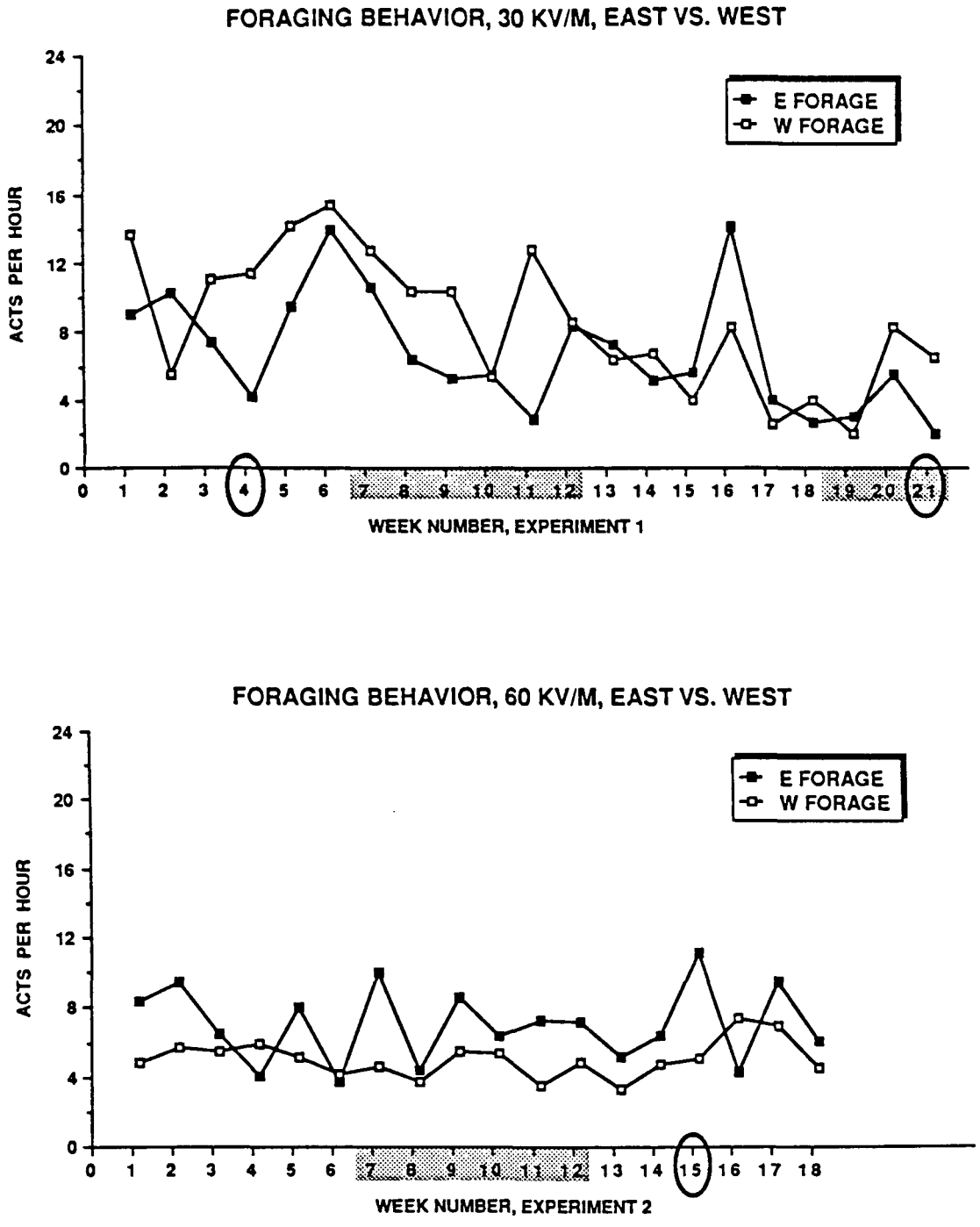


Figure XIII.13. Weekly means for frequency of occurrence of FORAGING behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

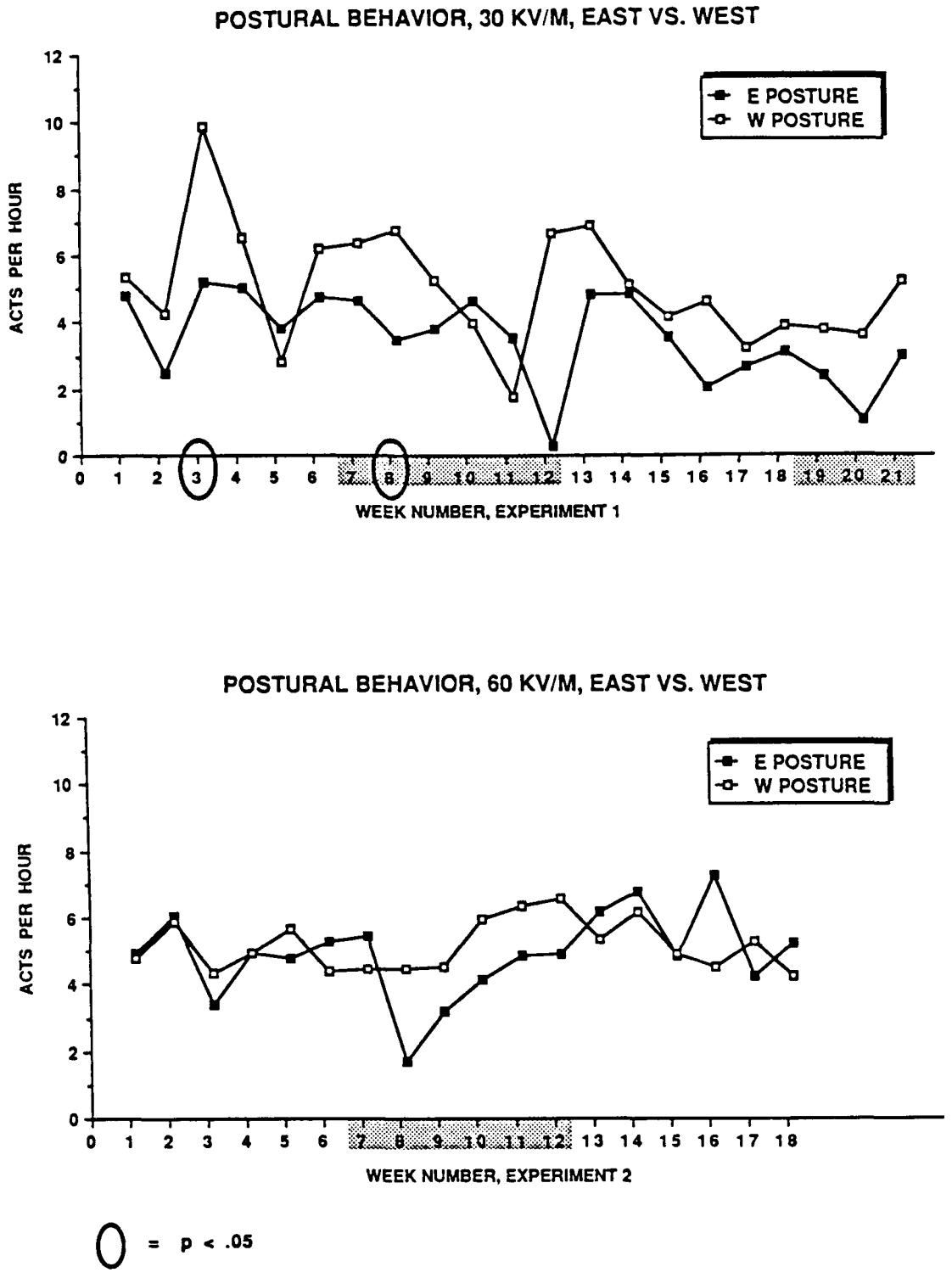


Figure XIII.14. Weekly means for frequency of occurrence of POSTURAL behavior. In Experiment I (30 kV/m) the West (W) group was exposed, and in Experiment II (60 kV/m) the East (E) group was exposed. During the crossover period (Expt. IA) of Experiment I, the East group was exposed to 30 kV/m electric fields.

XIV. APPENDIX D - ADDITIONAL DETAILS ON SCAN RESULTS

A. Experiment I (30 kV/m)

1. Between Group Comparisons

Positions.-- For reasons unknown, the use of cage locations (Tables XIV.1 and XIV.2) by the two groups differed during the Pre-Exposure period (χ^2 = 38.66, df = 5, P<.01) because of different patterns of use of the Right Rear (χ^2 = 5.19, df = 1, P<.03) and the Right Front (χ^2 = 30.72, df = 1, P<.01). The Control (East end) animals avoided the right end of the cage. The distribution of positions also differed during the Exposure period (χ^2 = 15.30, df = 5, P<.01) because of differences for Center Front (χ^2 = 9.87, P<.02). The use of the space within the cage by the two groups did not differ during Post-Exposure. When tested as a separate variable, χ^2 analysis showed that the number of times that the animals appeared to be "in contact" with the cage walls did not vary significantly (χ^2 = 2.37, df = 2, NS). We had wondered if the animals might come closer to the walls to achieve "shielding".

2. Within Group Comparisons

Posture.-- Besides comparing the Experimental and Control groups during each Period, we also used χ^2 statistics to compared the posture data across Periods within groups (Table XIV.3).

The Control group showed a relatively low use of Lie and Bipedal Stand, along with a relatively high use of Quadruhang, during Post-Exposure. The reason for the reductions in Lie and Bipedal Stand are not clear, but their occurrence certainly contributed to the between groups' differences detected for these behaviors during the Post-Exposure period.

The "cross Period" comparison for the Experimental Group supports the suggestion that use of Walk was increased during Exposure. The use of Lie was depressed during Exposure relative to both Pre-Exposure and Post-Exposure, suggesting a real effect also occurred on this behavior. Increases in the use of one behavior category are necessarily accompanied by a decrease in the use of another category. The animals apparently spent less time lying down and more time walking during the period of electric field exposure. This might be related to the observation that rats and pigs prefer to be in a shielded area when they sleep.

The Experimental group also did Bipedal stand more in the Post-Exposure period than in Exposure, and they used Quadrustand less in Exposure than they had during Pre-Exposure. The Experimental group began to hang on the front cage bars (Quadruhang) more frequently during Post-Exposure, but no between group differences were detected for this behavior. The frequency of Run was less in Exposure than it had been in Pre-Exposure.

To help assess the significance of group differences, we also compared the positional behavior of each group separately across the three Periods of the experiment. The Experimental group showed eight "temporal" changes

Table XIV.1

Frequency of Use of Various Cage Locations during the Pre-Exposure and Exposure Periods by Experimental and Control Group Subjects

	Pre-Exposure		Exposure		Post-Exposure	
Category	Con.	Exp.	Con.	Exp.	Con.	Exp.
Left Rear	243	253	240	259	236	222
Center Rear	202	188	177	179	153	195*
Right Rear	148	186*	202	252	216	233
Left Front	268	147	200	203	235	213
Center Front	155	128*	165	119*	159	129
Right Front	96	186	133	163	147	156
Bars	0	0	3	1	6	12
Sum	1112	1088	1120	1176	1152	1160
Contact	672	695	702	665	759	703

* P<.03.

Table XIV.2

Scan Data on Positions: Between Groups Comparisons by Periods

	Pre-Exposure		Exposure		Post-Exposure	
Category	Con.	Exp.	Con.	Exp.	Con.	Exp.
Left Rear	21.9#	23.3	21.4	22.0	20.5	19.1
Center Rear	18.2	17.3	15.8	15.2	13.3	16.8
Right Rear	13.3	17.1*	18.0	21.4	18.8	20.1
Left Front	24.1	13.5	17.9	17.3	20.4	18.4
Center Front	13.9	11.8	14.7	10.1*	13.8	11.1
Right Front	8.6	17.1*	11.9	13.9	12.8	13.4
Front Bars	0.0	0.0	0.3	0.1	0.5	1.0
Contacts	60.4	63.9	62.7	55.7	65.9	60.6
Observations	1112	1088	1120	1176	1152	1160

Percent of total observations.
* Experimental and Control groups differ, P<.05.

Table XIV.3

Scan Data on Posture: Within Group Comparisons Across Periods for Control and Experimental Subjects

Category	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Control Group						
Walk	1.3#	1.3	1.9			
Sit	74.4	73.8	77.3			
Lie	17.8	18.5	14.0		*	*
Quadruhang	0.0	0.1	0.5		*	
Quadrustand	3.1	2.5	3.5			
Bipedal Stand	1.0	1.4	0.4			*
Run	0.0	0.0	0.0			
Crouch	2.5	2.3	2.4			
Experimental Group						
Walk	1.9	3.2	1.7			*
Sit	70.7	74.8	70.4			
Lie	21.4	17.6	22.2	*		*
Quadruhang	0.0	0.1	1.0		*	*
Quadrustand	3.3	1.8	2.6	*		
Bipedal Stand	0.6	0.4	1.2			*
Run	0.5	0.0	0.1	*		
Crouch	1.6	2.0	0.8			*

Percent of total observations.
* Periods differ, P<.05.

(Table XIV.4), and the Control group showed six changes among Periods. The relatively large number of changes occurring in the Control group suggests that the animals' use of space varied due to reasons other than electric field exposure, further suggesting that the changes observed for the Experimental group also were due to causes other than electric field exposure. Thus, in summary, it would appear that electric field exposure had little or no effect on the animals' use of their cage space.

B. Experiment IA (30 kV/m)

1. Between Groups Analyses

Posture.-- In Experiment IA, the East animals were exposed to a 30-kV/m electric field for 12 hours a day for three weeks. During Baseline, the Experimental and Control groups differed ($\chi^2 = 14.17$, df = 5, P<.02) due to the differential use of Lie ($\chi^2 = 8.09$, df = 1, P<.01). The χ^2 of 36.01 (df = 3) during exposure is highly significant (Table XIV.5), indicating that

Table XIV.4

Scan Data for Position: Within Group Comparisons for Control and Experimental Group Subjects

Category	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Control Group						
Left Rear	21.9#	21.4	20.5			
Center Rear	18.2	15.8	13.3		*	
Right Rear	13.3	18.0	18.8	*	*	
Left Front	24.1	17.9	20.4	*		
Center Front	13.9	14.7	13.8			
Right Front	8.6	11.9	12.8	*	*	
Front Bars	0.0	0.3	0.5			
Experimental Group						
Left Rear	23.3	22.0	19.1		*	
Center Rear	17.3	15.2	16.8			
Right Rear	17.1	21.4	20.1	*		
Left Front	13.5	17.3	18.4	*	*	
Center Front	11.8	10.1	11.1			
Right Front	17.1	13.9	13.4	*	*	
Front Bars	0.0	0.1	1.0		*	*

Percent of total observations.
* Periods differ, P<.05.

Table XIV.5

Posture Frequency Data from Experiment IA

Posture	West	East*	χ^2	P
Walk	3	6		
Sit	413	498	4.73	<.05
Lie	105	48	23.74	<.01
Quadruhang	5	0		
Quadrustand	6	19	6.22	<.02
Bipedal Stand	8	0		
Run	3	0		
Crouch	9	5	1.32	
Sum	552	576	36.01	
		df	3	
		P	<.001	

* Exposed to electric field.

electric field exposure did affect animal posture. Three behaviors had statistically significant χ^2 values (df = 1). The Exposed animals used Sit less frequently and Lie more frequently than predicted on the basis of marginal totals.

One of the "rules of thumb" for use of the χ^2 statistic is that the expected frequency for all cells should be at least five. In Experiment IA, where we had data from only three weeks, this condition is not true for the low frequency behaviors Quadruhang and Run. Thus, these behaviors were excluded from the analyses.

Position.-- Analysis of data on use of cage positions (Table XIV.6) did not detect a significant overall effect (χ^2 = 8.96, df = 5, NS). Data from Bars were not included because expected frequencies were less than 5.

Table XIV.6

Cage Position Frequency Data from Experiment IA

Location	West	East	χ^2	P
Left Rear	128	130	0.05	
Center Rear	82	78	0.34	
Right Rear	119	122	0.02	
Left Front	93	100	0.04	
Center Front	60	46	2.49	
Right Front	65	100	6.01	
Bars	5	0		
Sum	552	576	8.96	
		df	5	
		P	<NS	

The common thread running through the results from Experiments I and IA is the suggestion that electric field exposure made the animals more active This observation was not expected; we had assumed that we might detect behavioral changes related to efforts by the animals to produce shielding by interactions with other animals, the cage walls, or use of low elevation postures. However, the suggestion that electric field exposure increases activity could be regarded as significant with observations on the behavior of rats and pigs given the choice between shielded and unshielded areas. The animals seemed to avoid field exposure slightly during their normal "sleeping" period.

As in Experiment I, electric field exposure during Experiment IA did not affect the propensity of the animals to stay near the cage walls (Table XIV.7). The χ^2 value of 2.02, with df = 1, clearly is not significant.

Table XIV.7

Frequency of Apparent Cage Wall Contacts

Group	Yes	No	Sum
West	328	224	552
East*	366	210	576
Sum	694	434	1228

* Exposed to electric field.

2. Within Group Analyses

Posture.-- The distribution of frequency counts (Table XIV.8) for postures of the Control animals did not differ significantly in Pre-Exposure

Table XIV.8

Scan Data on Posture: Within Group Comparisons Across Periods for Control and Experimental Subjects

Category	Pre-Exposure	Exposure
Control Group		
Walk	6	3
Sit	418	413
Lie	98	105
Quadruhang	5	5
Quadrustand	18	6
Bipedal Stand	8	8
Run	0	3
Crouch	7	9
Experimental Group		
Walk	6	6
Sit	440	498
Lie	61	48
Quadruhang	4	0
Quadrustand	26	19
Bipedal Stand	3	0
Run	0	0
Crouch	12	5

and Exposure (χ^2 = 6.46, df = 4, Walk, Quadruhang, and Run excluded). The same general outcome occurred for the Experimental animals (χ^2 = 8.30, df = 5, Quadruhang and Run excluded). The sample size for these comparisons is rather limited, so statistical power is relatively low.

Position.-- The distribution of frequency counts (Table XIV.9) for use of cage positions also did not differ significantly when the Pre-Exposure and Exposure periods were compared for the Control groups (χ^2 = 5.69, df = 5, Bars excluded). The Experimental group (χ^2 = 12.73, df = 5, P<.05, Bars exluded). Pre-Exposure and Exposure periods differed significantly due to different use of the center and right front of the cage.

Table XIV.9

Scan Data for Position: Within Group Comparisons for Control and Experimental Group Subjects

Category	Pre-Exposure	Exposure
Control Group		
Left Rear	104	128
Center Rear	90	82
Right Rear	112	119
Left Front	108	93
Center Front	61	60
Right Front	80	65
Front Bars	5	5
Experimental Group		
Left Rear	119	130
Center Rear	70	78
Right Rear	104	122
Left Front	113	100
Center Front*	71	46
Right Front	71	100
Front Bars	4	0

* Periods differ, P<.05.

C. Experiment II (60 kV/m)

1. Between Group Comparisons

Position.-- The two groups (Table XIV.10) differed significantly during Pre-Exposure (χ^2 = 24.00, df = 5, P<.001, Bars excluded) because the two groups differed in the frequency of use for the Center Front (χ^2 = 7.72, df = 1, P<.01) and Right Front (χ^2 = 9.62, df = 1, P<.005) of the cage. Both locations were used relatively less by the Experimental group.

Table XIV.10

Frequency Data on Position During Experiment II

Behavior	Pre-Exposure		Exposure		Post-Exposure	
	Expt1	Cont1	Expt1	Cont1	Expt1	Cont1
Left Rear	276	236	286*	225	241	206
Center Rear	205	175	135	170	194*	156
Right Rear	211	180	243	233	204	219
Left Front	258	241	230	198	223	225
Center Front	114*	158	87*	131	138	151
Right Front	143*	198	147	183	136*	208
Bars	1	4	0	4	0	3
	1208	1192	1128	1144	1136	1168

* Groups differ, P<.05.

During Exposure, the two groups differed (χ^2 = 26.65, df = 5, P<.001, Bars excluded). The Experimental animals used the Center Front (χ^2 = 8.27, P<.005) proportionately less and the Left Rear (χ^2 = 8.17, P<.005) more than did the Control animals.

During Post-Exposure, the groups again differed (χ^2 = 22.70, df = 5, P<.001, Bars excluded). The Experimental animals used the Center Rear (χ^2 = 5.25, P<.025) more and the Right Front (χ^2 = 13.14, P<.001) less than the Control animals.

Contact.-- The frequency of apparent contact with the cage walls (Table XIV.11) differed significantly (χ^2 = 18.83, df = 2, P<.001) between

Table XIV.11

Frequency Data on Cage Wall Contacts

Condition	Experimental		Control	
Pre-Exposure*	614	(37%)	494	(30%)
Exposure*	470	(28%)	551	(34%)
Post-Exposure	587	(35%)	580	(36%)
	1671		1625	

* Groups differ, P<.01.

Experimental and Control groups. The frequencies differed significantly P<.005) for both Pre-Exposure (χ^2 = 9.86) and Exposure (χ^2 = 8.89) periods. During Pre-Exposure the Experimental animals were in contact with the cage walls more than the Controls, but the situation was the opposite during Exposure.

2. Within Group Comparisons

Posture.-- χ^2 analyses of means for the three experimental conditions for the Control group and the Experimental group also were computed. For the Exposed animals, the overall χ^2 for the three sets of frequencies was statistically significant (χ^2 = 37.77, df = 8, P<.001), so the three pair-wise comparisons were completed. Each of these also was statistically significant: Exposed vs Post (χ^2 = 12.51, df = 4, P<.025); Base vs Post (χ^2 = 13.82, df = 4, P<.01); and Base vs Expo (χ^2 = 30.51, df = 4, P<.001). In each set of comparisons, there were insufficient data to test Quadruhang, Bipedal Stand, or Run.

For the Control group, the situation was very similar. The overall χ^2 was significant (48.71, df = 12, P<.001). The three pair-wise comparisons also were significant: Expo vs Post (χ^2 = 15.85, df = 6, P<.025); Base vs Post (χ^2 = 21.52, df = 6, P<.005); and Base vs Expo (χ^2 = 32.13, df = 5, P<.001). In the first two comparisons the data on Run was insufficient to give expected values of 5, and for the third comparison, the sample size for both Run and Quadruhang was too small.

The data set and an indication of the specific behaviors showing significant differences in frequencies are given in Table XIV.12. The Control group displayed four statistically significant differences between the Baseline and Exposure conditions, but the Exposed group only showed one. There was one difference between Baseline and Post-Exposure for the Control animals and two for the Experimental animals. Likewise, the comparison of Exposure and Post-Exposure frequencies indicated two effects for the Experimental group and one for the Control group.

The equivalent number of statistically significant effects among the Control and Experimental groups suggests that the observations merely describe random variation among the means of relatively small behavioral samples. Electric field exposure does not seem to exert effects which are much greater than random variation among samples.

Position.-- The within group comparisons (Table XIV.13) of the data on positions used in the cage present a picture a little different than that just described for posture. For the Control group, the overall χ^2 (17.95, df = 10) was not statistically significant, so the "post-tests" among the three sets of period means are not required. For the Experimental group, the overall χ^2 is significant (36.17, df = 10, P<.001) as are two of the three pair-wise comparisons: Base vs Expo (χ^2 = 19.48, df = 5, P<.005); Base vs Post (χ^2 = 5.65, NS); and Expo vs Post (χ^2 = 29.89, df = 5, P<.001). In all cases, the frequency of use of the front cage bars was so low that that data was not included in the analyses reported here. The data are summarized in Table XIV.13.

Table XIV.12

Within Group Comparisons of Posture Data

	Percent of Total			Comparison P<.05		
Control	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Walk	2.9	5.1	2.7	*		*
Sit	65.2	72.2	71.7	*		
Lie	23.7	16.6	20.0	*		
Qhang	0.3	0.3	0.8			
Qstand	4.4	2.5	2.0	*	*	
Bipedal Stand	0.9	1.3	1.0			
Run	0.4	0.0	0.3			
Crouch	2.2	2.0	1.5			
	100.0	100.0	100.0			
Expt'l	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Walk	2.2	3.4	4.0		*	
Sit	69.7	76.0	73.3			
Lie	21.2	13.1	17.1	*	*	*
Qhang	0.1	0.0	0.1			
Qstand	3.5	4.3	3.3			
Bipedal Stand	0.2	0.0	0.4			
Run	0.7	0.0	0.0			
Crouch	2.4	3.2	1.8			*
	100.0	100.0	100.0			

* Periods differ, P<.05.

D. Experiment IIA (60 kV/m)

1. Between Group Comparisons

Introduction.-- To provide a "Pre-Exposure" data set for Experiment IIA, the data from the last 2 weeks of Post-Exposure were used. During this period, 48 scans were conducted. During the nine days period of electric field exposure during Experiment IIA, 105 scans were collected.

Posture.-- The two groups differed significantly (χ^2 = 10.29, df = 4, P<.05, Quadruhang, Bipedal Stand and Run excluded) during Pre-Exposure (Table XIV.14), but Walk (χ^2 = 5.76, P<.025) was the only behavior which differed significantly. The two groups also differed significantly during Exposure (χ^2 = 16.94, df = 5, P<.01, Quadruhang and Run excluded). The two behaviors where the groups differed were Walk (χ^2 = 4.96, P<.05) and Bipedal Stand (χ^2 = 10.29, df = 1, P<.005). The Experimental group did Walk and Bipedal Stand less than the Control group.

Table XIV.13

Within Group Comparisons of Position Data

	Percent of Total			Comparison P<.05		
Control	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Left Rear	19.8	19.7	17.6			
Center Rear	14.7	14.9	13.3			
Right Rear	15.1	20.3	18.8			
Left Front	20.2	17.3	19.4			
Center Front	13.3	11.5	12.9			
Right Front	16.6	16.0	17.8			
Bars	0.3	0.3	0.2			
	100.0	100.0	100.0			
Expt'l	Base.	Expo.	Post.	BvsE	BvsP	EvsP
Left Rear	22.8	3.4	4.0			*
Center Rear	17.0.	76.0	73.3	*		*
Right Rear	17.5	13.1	17.1	*		
Left Front	21.4	0.0	0.1			
Center Front	9.4	4.3	3.3		*	
Right Front	11.8	0.0	0.4			*
Bars	0.1	0.0	0.0			
	100.0	100.0	100.0			

* Periods differ, P<.05.

Table XIV.14

Posture Data From Experiment IIA

	Pre-Exposure		Exposure	
Behavior	Expt1	Cont1	Expt1	Cont1
Walk	16*	5	34*	55
Sit	271	273	533	521
Lie	75	86	231	211
Quadhang	1	1	0	3
Quadstand	10	10	24	20
Bipedal Stand	1	4	1*	13
Run	0	2	0	3
Crouch	10	3	17	14
	384	384	840	840

* Groups differ, P<.05.

Position.-- The two groups differed during Baseline (χ^2 = 12.34, df = 5, P<.05, Bars excluded), primarily because of a reduction in the use of the Right Front (Table XIV.15) of the cage by the Experimental group (χ^2 = 7.58, P<.01). During Exposure the two groups' use of the cage locations also differed significantly (χ^2 = 22.94, df = 5, P<.001, Bars excluded). The Exposed animals used the Center Rear (χ^2 = 7.15, P<.01) and the Right Front (χ^2 = 8.29, P<.01) less than did the Control animals, and they used the Left Rear (χ^2 = 4.00, P<.05) more than the Control animals.

Table XIV.15

Position Data for Experiment IIA

	Pre-Exposure		Exposure	
Behavior	Expt1	Cont1	Expt1	Cont1
Left Rear	79	69	180*	144
Center Rear	66	46	82*	120
Right Rear	71	72	142	126
Left Front	71	76	175	148
Center Front	56	50	145	136
Right Front	41*	70	115*	163
Bars	0	1	1	3
	384	384	840	840

* Groups differ, P<.05.

Contact.-- The distribution of scores for frequency of cage wall contact (Table XIV.16) differed significantly (χ^2 = 6.76, df = 1, P<.01) overall. The groups did not differ during Pre-Exposure, but they differed significantly (χ^2 = 37.31, df = 1, P<.001) during Exposure.

Table XIV.16

Experiment IIA Data on Cage Wall Contacts

Condition	Experimental		Control	
Pre-Exposure	205	(38%)	205	(31%)
Exposure*	335	(62%)	460	(69%)
	540		665	

* Groups differ, P<.01.

2. Within Group Comparisons

Posture.-- The Experimental group's frequency matrix did not differ significantly (χ^2 = 9.20, df = 4, NS) between Baseline and Exposure. However, the Control group did show statistically significant (χ^2 = 20.97, df = 5, P<.001) differences. The only behavior to change by itself was Walk (χ^2 = 14.79, P<.001). Table XIV.14 gives the frequencies involved in these comparisons.

Position.-- The Control group frequency matrix did not differ (χ^2 = 6.04, df = 5, NS) when Baseline and Exposure were compared. However, the Experimental group did show significant (χ^2 = 16.24, df = 5, P<.01) differences between Baseline and Exposure due to a significant (χ^2 = 12.02, P<.001) change in the use of the Center Rear. Table XIV.15 gives the frequencies involved in these comparisons.

E. Experiment IIB (60 kV/m)

1. Between Group Comparisons

Introduction.-- To provide a "Pre-Exposure" data set for Experiment IIB, the data from a six-day "Baseline" period between Experiments IIA and IIB were used. During this period, just under 72 scans were conducted. During the nine days period of electric field exposure of Experiment IIB, slightly fewer than 108 scans were collected.

Posture.-- The two groups differed significantly (χ^2 = 17.37, df = 4, P<.005, Quadruhang, Bipedal Stand, and Run excluded) during Pre-Exposure (Table XIV.17). Two behaviors, Walk (χ^2 = 5.21, P<.025) and Lie (χ^2 = 9.38,

Table XIV.17

Posture Data From Experiment IIB

	Pre-Exposure		Exposure	
Behavior	Expt1	Cont1	Expt1	Cont1
Walk	30*	15	25*	56
Sit	389	368	696*	529
Lie	108*	160	63*	184
Quadhang	1	0	0	0
Quadstand	19	23	32	34
Bipedal Stand	6	2	2	8
Run	4	2	0	1
Crouch	11	6	22	20
	568	576	840	832

* Groups differ, P<.05.

P<.005), differed significantly. The two groups also differed significantly, and to a very large degree, during Exposure (χ^2 = 97.62, df = 5, P<.001, Quadruhang and Run excluded). Walk (χ^2 = 12.16, P<.001), Sit (χ^2 = 21.20, P<.001), and Lie (χ^2 = 60.44, P<.001) all differed significantly. The Exposed animals did Walk and Lie less and Sit more than did the Control animals. This might reflect the "huddling" behavior seen in the videotapes and described by the proximity index. In a longer experiment, this effect on the first few days would be "washed out" by the data from the later days when the animals had adapted. With the previous data, the frequency of scan observations was so low that the data from only a few days do not provide an adequate sample size for meaningful statistical analysis.

Position.-- The two groups did not differ during Baseline (χ^2 = 5.50, df = 5, Bars excluded) in their use of the various cage regions. However, during Exposure the two groups' use of the cage locations differed significantly and dramatically (χ^2 = 227.42, df = 5, P<.001, Bars excluded). The Exposed animals (Table XIV.18) differed from the Control animals on every behavior category: Left Rear (χ^2 = 3.90, P<.05), Center Rear (χ^2 = 61.32, P<.001), Right Rear (χ^2 = 32.76, P<.01), Left Front (χ^2 = 60.02, P<.001), Center Front (χ^2 = 51.06, P<.001), and Right Front (χ^2 = 18.36, P<.001). The Cage Bar data were not analyzed.

Table XIV.18

Position Data for Experiment IIB

	Pre-Exposure		Exposure	
Behavior	Exptl	Contl	Exptl	Contl
Left Rear	114	121	198*	159
Center Rear	87	87	23*	114
Right Rear	89	108	82*	172
Left Front	112	89	288*	128
Center Front	91	102	37*	128
Right Front	74	68	212*	131
Bars	1	1	0	0
	568	576	840	832

* Groups differ, P<.05.

Contact.-- The distribution of scores for frequency of cage wall contact (Table XIV.19) differed significantly (χ^2 = 8.02, df = 1, P<.01) overall. The groups did not differ during Pre-Exposure (χ^2 = .29), but they differed significantly (χ^2 = 40.23, df = 1, P<.001) during Exposure.

Table XIV.19

Experiment IIB Data on Cage Wall Contacts

Condition	Experimental		Control	
Pre-Exposure	274	(50%)	287	(42%)
Exposure*	275	(50%)	399	(58%)
	549		686	

* Groups differ, P<.001.

2. Within Group Comparisons

Posture.-- Both the Control and Experimental group's frequency matrices differed when Baseline and Exposure periods were compared. For the Controls (χ^2 = 19.39, df = 4, P<.001), both Walk (χ^2 = 11.49, P<.001) and Lie (χ^2 = 4.47, P<.05) differed significantly. For the Experimental group (χ^2 = 51.56, df = 4, P<.001) based on differences in Walk (χ^2 = 4.61, P<.05), Sit (χ^2 = 9.08, P<.005), and Lie (χ^2 = 36.99, P<.001), the frequency counts comparisons are given previously in Table XIV.17.

Position.-- The Control group did not differ (χ^2 = 6.58, df = 5, NS) when the frequency arrays from Baseline and Exposure were compared. However, the Experimental group showed a very large change (χ^2 = 180.72, df = 5, P<.001). Six cage locations differed significantly: Center Rear (χ^2 = 68.63, P<.001), Right Rear (χ^2 = 9.74, P<.005), Left Front (χ^2 = 25.31, P<.001), Center Front (χ^2 = 50.30, P<.001), and Right Front (χ^2 = 24.87, P<.001). The frequency counts for these comparisons are given previously in Table XIV.18.

F. Summary

Tables XIV.20 and XIV.21 summarize all the position and posture data from Experiments I and II. The tables indicate significant differences between Experimental and Control groups. The "D"'s indicate a decrease by the Experimental group relative to the Control group in its frequency of occurrences of the posture or position, and the "I"'s indicate an increase. Some general conclusions can be drawn: (1) Field exposed baboons do alter postures and positions, (2) Exposed baboons show some effort at field reduction, (3) Effects are similar at 30 KV/m and 60 KV/m, and (4) Effects are not consistent across experiments.

In general, two posture effects tended to replicate across the experiments: Lie and Bipedal Stand decrease during field exposure. The decrease in Bipedal Stand might be expected because standing tall in the field increases the field strength around the upper quadrant of the baboon. Other posture effects were detected in some experiments. An increase in Quadrustand showed up once during Experiment I and twice during Experiment II. Sit increased only during the crossover phases of Experiments I and II. Walk showed a mixed result, increasing during Experiment I and decreasing during Experiment II.

Table XIV.20

Summary of Posture Data from Experiments I and II

Posture	I	I(3)	IA	II	II(3)	IIA	IIB
Walk	I	I		D		D	D
Sit			I				I
Lie			D	D	D		D
Quadruhang	-	-	-	-	-	-	-
Quadrustand			I	I	I		
Bipedal Stand	D	-	-	D	D	D	
Run	-	-	-	-	-	-	-
Crouch							

I = P<.05 increase by Experimental Group.
D = P<.05 decrease by Experimental Group.
- = Insufficient data

Table XIV.21

Summary of Position Data from Experiments I and II

Position	I	I(3)	IA	II	II(3)	IIA	IIB
Left Rear				I		I	I
Center Rear						D	D
Right Rear		I					D
Left Front							I
Center Front	D	D		D	D		D
Right Front		I				D	I
Contact		D		D	D	D	D

I = P<.05 increase by Experimental Group.
D = P<.05 decrease by Experimental Group.

An attempt to draw an overall picture of the results of the position analyses is even less successful. Table XIV.21 shows no dominant trend that is applicable for both Experiments I and II. Only during Experiment II do clear trends emerge; there was a decrease in Contact and in baboons occupying the Center Front position. During Experiment II, the baboons tended to use the Left Rear position more during Exposure than during Baseline. Frequency of Contact with cage walls was diminished. In summary, baboons exposed to strong electric fields move away from the cage walls and avoid the Center Front, but no other cage region is affected consistently. The animals do not appear to attempt to use the cage walls for shielding.