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The effects of sequential fluid concentration shifts upon short term ingestive behavior in the rat.

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THE EFFECTS OF SEQUENTIAL FLUID CONCENTRATION SHIFTS UPON SHORT TERM INGESTIVE BEHAVIOR IN THE RAT

A Dissertation Presented

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ABSTRACT

The effects of double fluid concentration shifts were observed in four experiments using lick rate or intake as the dependent measure and either sucrose or saccharin as the incentive solution. The hypothesis to be tested was whether or not variation in response rate, either up or down, following the first shift would be sufficient to produce contrast effects upon return to the original concentration. To the extent that this hypothesis would be accepted, an analogy between such an incentive shift design and behavioral contrast would appear plausable. The results unanimously failed to support the hypothesis and an alternative hypothesis based on acquisition of stimulus control was suggested. Single incentive shift data were consistent with earlier data supporting a suggestion that deprivation conditions may affect contrast phenomena through an interaction with baseline performance levels.

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The question to which we should now address ourselves is whether a p value of less than .01 is socially significant.

Contrast effects, both positive (PCE) and negative (NCE), have been observed using electrical stimulation of the brain (ESB) as a reward (Panksepp & Trowill, 1969). It was suggested that the usually evasive positive component was obtained because of two factors related to ESB as a reward but not generally found in contrast studies using conventional reinforcers. First, it was suggested that shifts of current intensity with ESB involve a shift in quality rather than in quantity of reward. Since the original findings of Crespi (1942), many investigations have shifted the quantity of reward (eg. number of pellets) and few have observed PCE (see Black, 1968; and Dunham, 1968, for reviews). Variations of sucrose concentration, on the other hand, are typically thought to involve a manipulation of reinforcer quality and the few studies which have produced results suggestive of positive contrast have utilized shifts of sucrose concentration (Collier & Marx, 1959; Panksepp & Trowill, in press; Premack & Hillix, 1962). Secondly, and perhaps more importantly, through the use of ESB it is possible to establish reliable operant response patterns without obvious and often times severe deprivation conditions (Trowill, Panksepp, & Gandelman, 1969). The importance of deprivation conditions in contrast experiments is documented (Ehrenfreund & Badia, 1962; Gragg & Black, 1967; Premack & Hillix, 1962) and the suggestion

was made by Panksepp and Trowill (in press) that the time course and magnitude of contrast effects (positive vs negative) should be different under different levels of drive, low drive being most conducive for PCE and high drive for NCE.

Since it is possible that the reaction to incentive shifts using ESB might differ from the same type reactions for natural rewards in more subtle ways than simply through differences in drive levels, replications using natural rewards and ad libitum animals are desirable. One experiment (Panksepp & Trowill, in press) utilized a paradigm very similar to the experiment which used ESB as the reward. Rats under high (21 hrs.) or low (1 hr.) food deprivation were shifted from either 12% to 32% or from 32% to 12% sucrose solutions within single sessions. Both PCE and NCE were observed in the licking response, with the positive effect being considerably larger under the low deprivation condition. The effect was, however, more transient using sucrose as a reward. Unlike ESB it lasted only about one minute.

In a second experiment (Gandelman & Trowill, 1969) saccharin was used as the reward and fluid consumption was the dependent measure. All Ss were on ad libitum food and water throughout the experiment. Saccharin was given to each S daily for one hour until intake stabilized. At that time tap water was substituted for the

saccharin solution during three consecutive sessions. When the Ss were again given the palatable saccharin solution, their intake was considerably higher than before the water sessions. This "elated" responding persisted over several sessions and, in fact, did not completely return to preshift levels after seven days. Although these data were also used to support the admonition that high drive states tend to preclude the appearance of PCE, it was somewhat less than convincing since it did not include the proper deprived controls. Further, it would seem that although the paradigm included some characteristics of more traditional contrast designs, it was sufficiently different to caution its inclusion under the general rubric of contrast effects.

Later work using the latter paradigm has attempted to clarify relevant variables and has also tried to fit the data into the existing scheme for contrast designs. In one experiment using saccharin intake (Ashton, Gandelman, & Trowill, (a) in press) it was shown that deprivation conditions do interact with the behavioral effect in such a way as to mask or suppress postshift "elated" responding. It was interesting, however, that throughout testing, intake and intake variability were lower in the deprived conditions. A "ceiling effect" based upon variation of fluid need was suggested to explain the absence of the PCE under deprivation. Also in that experiment,

it was found that three days of no solution or three days of an empty tube did not produce PCE. Hence, an actual comparison solution, like water, may be a necessary condition for the effect.

Similarities between this between days design and behavioral contrast paradigms (see Dunham, 1968) were suggested and it was proposed that since responding was under the control of the taste stimulus the procedure of shifting to water could be considered to be most analogous to a time out (TO) from reinforcement. Shifting to no solution or to an empty bottle, on the other hand, simply served to remove the animal from the situation and so no PCE was observed.

It should be noted here that the results concerning deprivation conditions may provide a conflict between these data and those concerning more typical behavioral contrast designs. Although deprivation has not been systematically manipulated, investigations involving the latter paradigm usually employ animals at some fraction of normal body weight (e.g. pigeon at 80% b.w. key-pecking for food) and still PCE is observed. This observation, however, suggests that deprivation may obscure PCE only when it contributes to near maximal control response rates. This would be more probable when the experimenter was observing a consummatory response (i.e. lick rate) or an operant such as running (see Bower, 1961) than when the dependent

measure was rate of bar pressing or rate of key pecking where responding was under the control of a partial reward schedule.

Reduction of rate of responding in one component of a multiple schedule is a sufficient condition for positive behavioral contrast. Such reductions in responding may be produced by alterations of the schedule of reinforcement (Reynolds, 1961; Reynolds & Catania, 1961; Terrace, 1966) by punishment (Brethower & Reynolds, 1962; Terrace, 1968) or by providing the animal with additional cues (Reynolds & Limpo, 1968). Conversely, negative contrast occurs in the constant component of a multiple schedule when response rate increases in the variable component (Nevin & Shettleworth, 1966; Reynolds, 1961), although there is some question as to the symmetry of the two phenomena (Reynolds, 1961; Terrace, reported by Dunham, 1968, p. 308).

One study examining palatability shifts (Ashton, Gandelman, & Trowill, 1969) attempted to produce NCE. Two groups of 60 day old female albino rats on ad libitum food and water were given 1/2 hr. exposure to .25% saccharin solution twice daily until intake stabilized. Then one group received 8% sucrose for three sessions while the other group was given a local brand of chocolate milk. In a second test, the solutions were reversed for both groups.

It was assumed, and later shown, that both sucrose

and chocolate milk were more palatable than was the saccharin solution, and that an upward shift in palatability should produce negative contrast when the Ss were returned to the standard saccharin solution. Surprisingly, an increase in responding was observed after the first shift (see fig. 1). However, a more careful consideration of the data revealed that responding was not markedly increased during either sucrose or chocolate milk, and, in fact, was even lower to chocolate milk relative to preshift saccharin. This was, perhaps, a neophobic response.

The data allowed for at least two possible conclusions: 1) that a shift in palatability, either up or down, is sufficient for the increment in postshift responding--at least after a single exposure, or 2) that the postshift effect is really symmetrical, but that the experiment failed to provide an adequate increase in response to the comparison solutions (i.e. sucrose and chocolate milk). The latter was felt to be the more plausible explanation.

To summarize, deprivation has been shown to affect contrast. Further, a paradigm has been described which is similar to that of behavioral contrast but in which responding is under the control of a taste stimulus. It was suggested that a temporary shift to water was analogous to a "time out" from reinforcement in producing positive behavioral contrast and it is now proposed that further work is needed to provide a situation in which responding

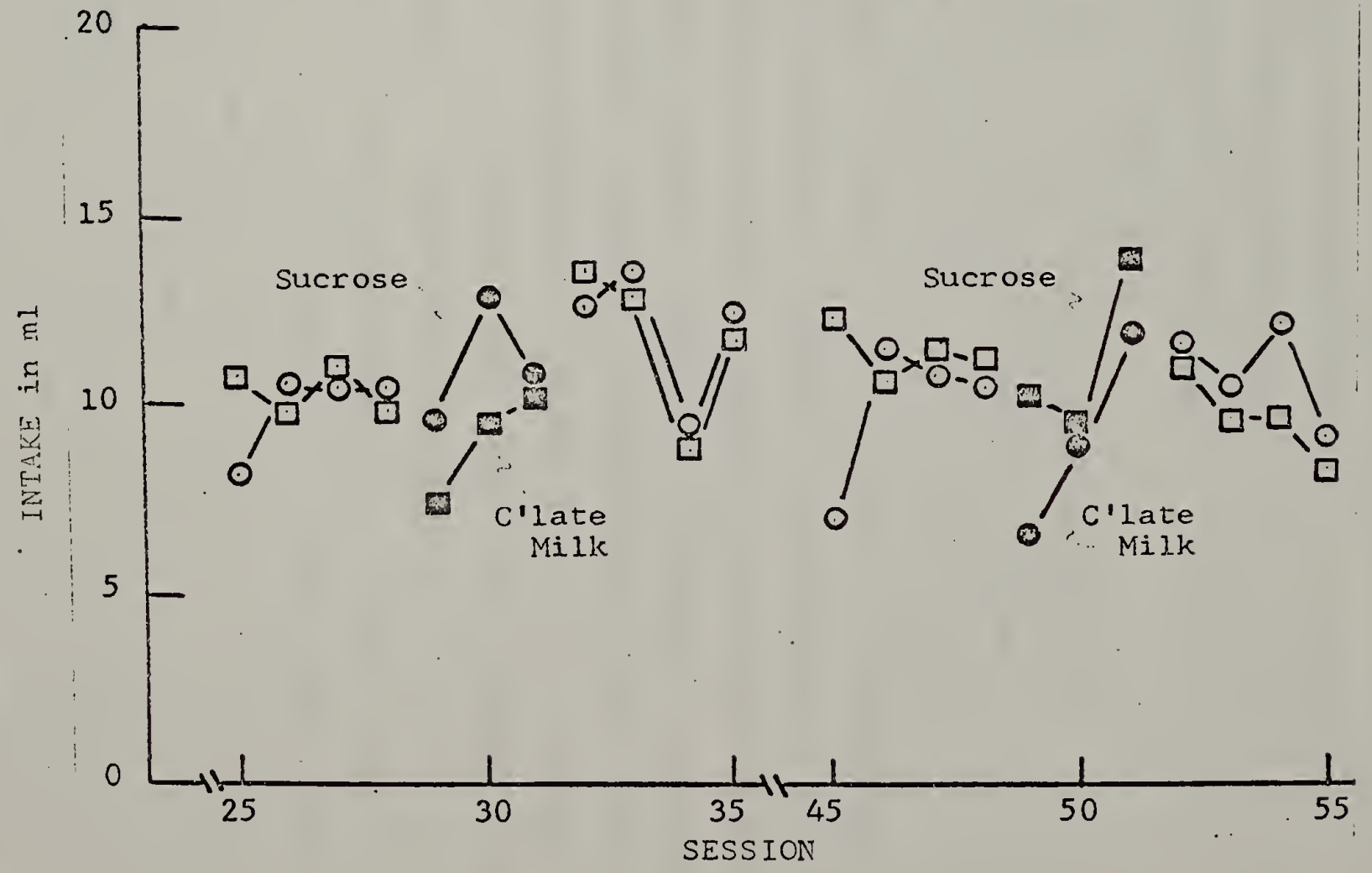

Fig. 1. Mean intake per session for groups shifted from .25Sacc to either 8CHO or chocolate milk. Shift solutions were reversed for the two groups during the second shift. Adapted from Ashton, Gandelman, and Trowill (1969).

is reduced or increased but not to near maximal (physiological) or minimal (motivational) limits. This may be accomplished by shifts within the taste quality involved: Shifts in concentration from high to low and back to high should produce PCE and shifts from low to high and back to low should, if the analogy to behavioral contrast is correct, produce NCE.

Other work employing palatability shifts has indicated differences between incentive solutions of saccharin and sucrose when intake is the dependent measure (Ashton, Gandelman, & Trowill, (b) in press). That experiment indicated that sucrose (8% w/w) would not provide PCE. However, another experiment using lick rate (Ashton & Trowill, in press) did obtain PCE with both saccharin and sucrose. Interestingly, PCE using saccharin was present under deprived and non-deprived conditions but, using sucrose, was present in all animals only under the ad libitum feeding conditions. A statistical description of the data was omitted from the study because of the small N and a re-examination might be suggested. Discrepancies between these data and those involving intake, it was suggested, were due to differences in time courses (e.g. persistence of drinking in the longer intake studies) and differences between saccharin and sucrose within the study due to differences in baseline. Differences in baseline were also noted between deprived and nondeprived conditions in

the sucrose experiment which would account for the lack of PCE in the deprived group.

The experiments reported herein were designed to examine the analogy between the studies of palatability shifts and the phenomenon of behavioral contrast by providing the conditions necessary for PCE and NCE thus testing for the symmetry of effect as seen with behavioral contrast. In addition, deprived and nondeprived subjects were used to examine the possible effects of altered baselines due to differences in motivational level. Finally, since differences between saccharin and sucrose have been observed in terms of baseline responding and in the interaction of deprivation conditions, both were used in these investigations.

Experiment 1

Method.

Subjects. All Ss in Experiment 1 were naive, female, albino rats (Charles-River Breeding Laboratories, Wilmington, Massachusetts). Ages at the beginning of testing ranged from 80 to 150 days with Ss of like ages being distributed proportionally throughout the groups. All Ss were housed individually in a ventilated room and were allowed ad libitum tap water.

All Ss in nondeprived conditions were allowed continuous access to Purina Lab Chow pellets. Ss in deprived conditions were allowed Purina Lab Chow only in amounts sufficient to maintain a certain percentage of their free feeding body weight. Free feeding body weight was established for each individual animal prior to testing but mean group weights were monitored throughout the experiment and were compared to those groups on ad libitum feeding as a control for normal weight gain. Each animal's weight was adjusted accordingly over days in order to maintain individual and group weight loss at or near the a priori level of 80%.

A 12 hr. light-dark cycle was in effect which allowed for experimentation to take place during the dark period. It was felt that this procedure would lead to a higher percentage of "drinkers" since general activity and feeding-

drinking cycles are elevated in rats during the nighttime hours. Thus, room lights were automatically turned off at 3:00 AM and turned on again at 3:00 PM. Testing began regularly at 8:00 AM and typically lasted until 12:00 noon (see procedures below). Daily weighing and feeding took place at 3:00 PM.

Apparatus. Testing was done in two similarly modified Wahmann small animal cages (Wahmann LC-126, Wahmann Manufacturing Corp., Baltimore, Maryland). The dimensions of these galvanized cages measured 9 in. wide (22.86 cm), by 15 in. deep (38.10 cm), by 9 in. high (22.86 cm). Modification consisted of a rectangular hole measuring 3/4 in. high (1.91 cm) by 1-1/4 in. wide (3.18 cm) cut 1-1/2 in. (3.81 cm) above the floor. Fluids were presented through the hole described above. The tip of the metal drinking spout [5/16 in. o.d. (8 mm); 1/4 in. i.d. (6 mm); 1/8 in. (3 mm) at orifice] was flush with the outside wall of the test chamber (which was made of 1/32 in. stock). This arrangement prevented most Ss from mouthing or grasping the drinking spout.

Individual tongue contacts were monitored with commercial drinkometers (Grason-Stadler E4690-A, West Concord, Massachusetts) the sensing contacts of which were attached to the metal drinking spout and to the cage floor. The short-circuit current of the drinkometer, according to the manufacturer, was less than 1μA dc. Output from the

drinkometers was channelled through electromechanical pulseformers and stepping switches to a bank of digital counters which recorded tongue contacts from each chamber, separately, in one min. blocks.

The test chambers were located in the same room in which the animals were housed. Both chambers were illuminated by a single 15 watt red bulb located centrally above the boxes. White noise and an air conditioner masked extraneous sounds. The two chambers, though close together, were insulated from each other by two 1/8 in. pieces of Masonite, and 1 in. of styrofoam. Recording equipment was located in an adjoining room.

Solutions. All solutions, in this experiment and in those to be subsequently described, were mixed as weight percent solutions (i.e., w/w) employing the ratio of the weight of solute to the total weight of solution, multiplied by a factor of 100. Tap water was used as the solvent in all cases.

Sucrose ($C_{12}H_{22}O_{11}$; mol. wt. 342.30) was obtained in the form of commercial cane sugar (granulated). Sucrose is abbreviated herein after as CHO, symbolizing the constituents of a carbohydrate but without specifying proportions. The percent sign and mixture specifications (i.e., w/w) are deleted so that 32CHO should be read as a 32 percent solution of sucrose mixed in a weight solute to weight solution ratio.

Sodium saccharin ($C_7H_4NNaO_3S \cdot 2H_2O$; mol. wt. 241.20) was obtained from Merck & Co., Rahway, New Jersey. Sodium saccharin is abbreviated Sacc. As with CHO, .3Sacc is to be read as a .3 percent solution of sodium saccharin mixed in a weight to weight ratio.

Prescreening. Prior to the outset of the experiment each S was given two, 4 hr. exposures to the solution that it would encounter first during training. A criterion of 10 ml consumption was established; an S drinking less than 10 ml during the second prescreening session was classified as a "non-drinker" and was discarded. Only one S was discarded on the basis of prescreening (see appendix E). The prescreening sessions occurred on two consecutive days and took place during the last 4 hrs. of the dark cycle.

Procedure. The 96 animals used in this experiment were divided equally and randomly into 16 groups of 6 animals each, with the only restriction that there must be roughly equal age representation within each group (age differences corresponded to different shipments of experimental animals).

Half of the groups experienced CHO as the incentive solution while the other half drank Sacc. The paradigm involved two concentration shifts: High-low-high (HLH), or low-high-low (LHL). Additional groups maintained on a single solution, either high or low, served as between subject controls. Deprivation level, ad libitum feeding

TABLE 1. Summary of experimental design; Experiment 1.

Saccharin	Nondeprived	High	High	High	N=24	(6/group)
		High	Low	High		
		Low	High	Low		
		Low	Low	Low		
	Deprived	High	High	High	N=24	(6/group)
		High	Low	High		
		Low	High	Low		
		Low	Low	Low		
Sucrose	Nondeprived	High	High	High	N=24	(6/group)
		High	Low	High		
		Low	High	Low		
		Low	Low	Low		
	Deprived	High	High	High	N=24	(6/group)
		High	Low	High		
		Low	High	Low		
		Low	Low	Low		

or 80% body weight, was a crossed independent variable. A summarizing outline of procedures may be seen in Table 1.

High concentration for CHO was 24%; low was 8%. Sacc high was 0.3%; low was 0.1%. High concentrations were chosen such that satiation effects (with CHO) and aversive taste qualities (with saccharin) would be avoided. The low concentrations were chosen such that responding would simply be maintained.

Two animals were tested simultaneously. Recording began with the first tube contact and counted licks in one minute blocks for five consecutive minutes. The recording equipment was independent for each chamber so that the data reflect drinking time from the first tube contact in all instances.

Ten day's experience with the apparatus and procedures was allowed prior to the initiation of the first concentration shift. Solution concentrations were shifted appropriately during session 11 and were returned to preshift concentration during session 12.

Results.

Sucrose. No animals in the CHO groups were dropped from the experiment either on the basis of prescreening or because of a lack of responding during the test sessions.

Figures 2 and 3 show mean total licks for each test session for nondeprived and deprived groups respectively.

Figure 4 describes an analysis of mean body weights of all nondeprived animals compared to a mean of all deprived animals.

Figure 2 reveals that, although the preshift baselines of the shifted groups were not accurately matched by the appropriate nonshifted controls, there was a change in overall responding in a direction appropriate to the concentration in both groups during session 11. With the return of the preshift solution concentration during session 12, overall rates returned to nominal preshift levels without evidence of under- or overshooting. Figure 3 shows a similar shift in rate during session 11 for deprived groups. An analysis of variance comparing sessions 10 and 12 for all CHO groups indicated a slight increase in responding postshift (Pre-Post main effect, $\underline{F}=4.46$, df=1/32, $\underline{p}<.05$) although the difference could not be differentiated by groups (Pre-Post x groups, $\underline{F}=1.33$, df=3/32, $\underline{p}>.20$) or by deprivation level (Pre-Post x deprivation, $\underline{F}=1.10$, df=1/32, $\underline{p}>.20$). Similarly, there was also an insignificant main effect for groups (Group main effect, $\underline{F}=1.57$, df=3/32, $p>.20$).

Figs. 5 and 6 give a more detailed picture of the shift sessions. Nondeprived groups are shown in Fig. 5 and deprived groups in Fig. 6. Again, an analysis of variance comparing sessions 10 and 12 for all CHO groups showed a significant main effect for minutes (Minute main

effect, F=42.74, df=4/128, p<.001) but with no significant interactions by pre-post (F=0.45, df=12/128, p>.20), by groups (F=1.11, df=12/128, p>.20), or by deprivation (F=0.56, df=4/128, p>.20). In addition, no three-way interactions involving minutes were significant.

Turning to an analysis of session 11, Dunnett's test (see Myers, 1966, page 337) was used to contrast the shifted groups with their appropriate controls, following a significant group effect (Group main effect, F=9.18, df=3/32, p<.001) in the overall analysis of variance. Comparing groups shifted from 24CHO to 8CHO (HLH) with groups maintained at 8CHO (LLL) it was found that the former groups were significantly below their LLL controls (d=2.62, df for MS_{error}=32, p<.025). Similarly, groups shifted upwards from 8CHO to 24CHO (LHL) responded significantly higher during session 11 than groups maintained at 24CHO (HHH) (d=2.16, df for MS_{error}=32, p<.05). In the overall analysis of variance, however, these differences were not differentiated by deprivation (groups x deprivation, F=1.59, df=3/32, p>.20).

Since it had been anticipated on the basis of work by Panksepp and Trowill (1970) that PCE would be in evidence following the first shift in nondeprived Group LHL but not in deprived Group LHL a further analysis of session 11 was performed. It was felt that perhaps the analysis of variance was not a proper tool in view of the relatively

small N in each group and the usually large between-subject variability characteristic of the licking response. Consecutive Mann-Whitney U tests (Siegel, 1956, pp. 116-127) were performed on minute-by-minute blocks comparing non-deprived Groups HHH and LHL in session 11. The results are shown in Table 2.

As can be seen graphically in Fig. 5, responding during the first 2 min. was significantly higher in group LHL; during the second 2 min. the response rate remained marginally higher. Since response rates in Group LHL were somewhat higher than those of Group HHH during pre-shift sessions, consecutive sign tests (Siegel, 1956, pp. 68-75) were performed for each S in Group LHL for each minute comparing session 10 to session 11. The results are shown in Table 2. Only minute 1 was statistically significant. A similar analysis of deprived Groups HHH and LHL showed a complete lack of PCE (see Table 2).

The results of the nonparametric analysis of deprived Groups HLH and LLL are also given in Table 2. NCE was indicated by significant U tests in the last 4 min. of session 11. Sign tests comparing sessions 10 and 11 also indicated significant decreases in responding for Group HLH during the last 4 min. The effect may be seen graphically in Fig. 6. A complimentary analysis of non-deprived Groups HLH and LLL failed to show NCE (see Table 2).

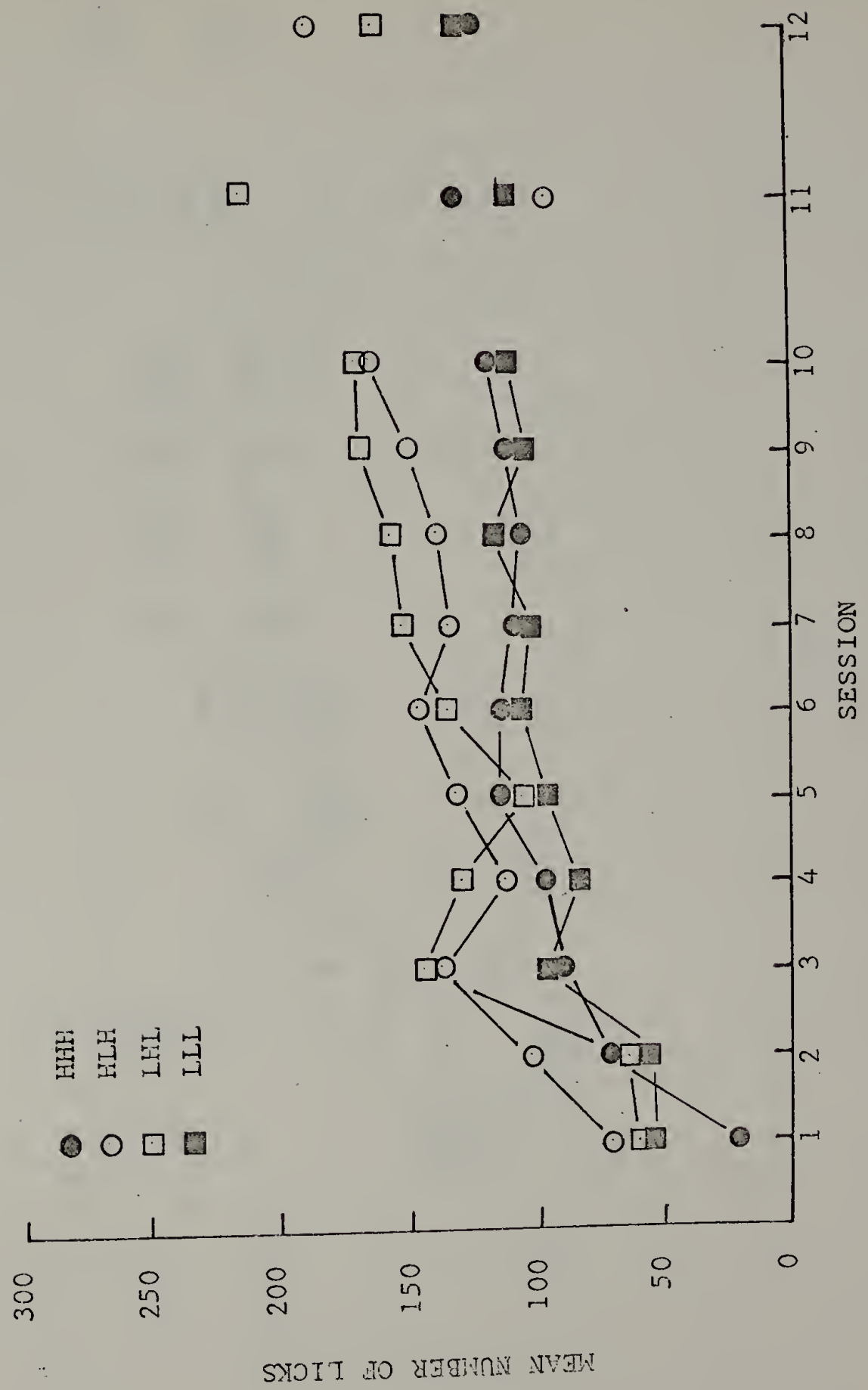

Fig. 2 Mean total licks per session for nondeprived CHO groups.

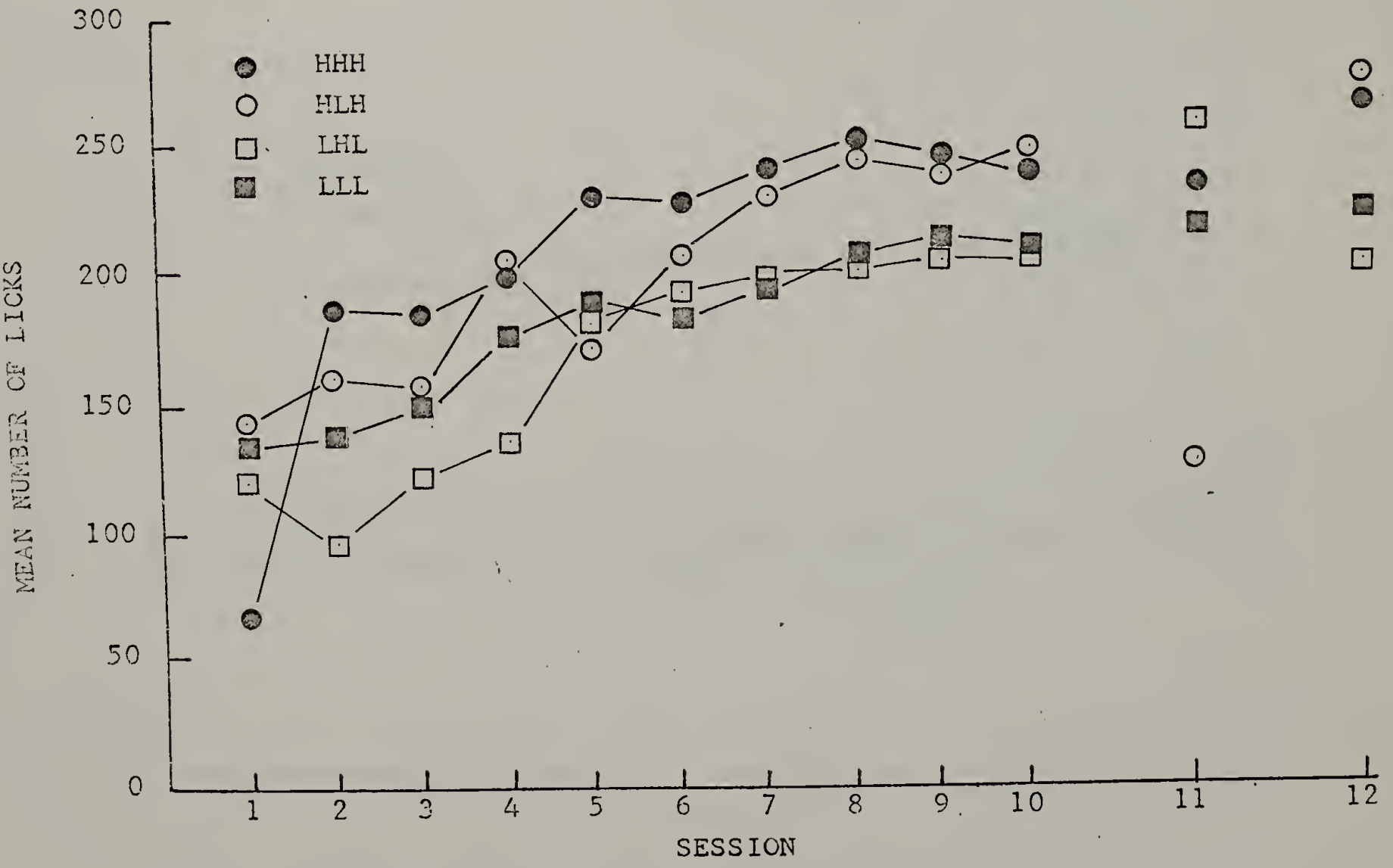

Fig. 3 Mean total licks per session for deprived CHO groups.

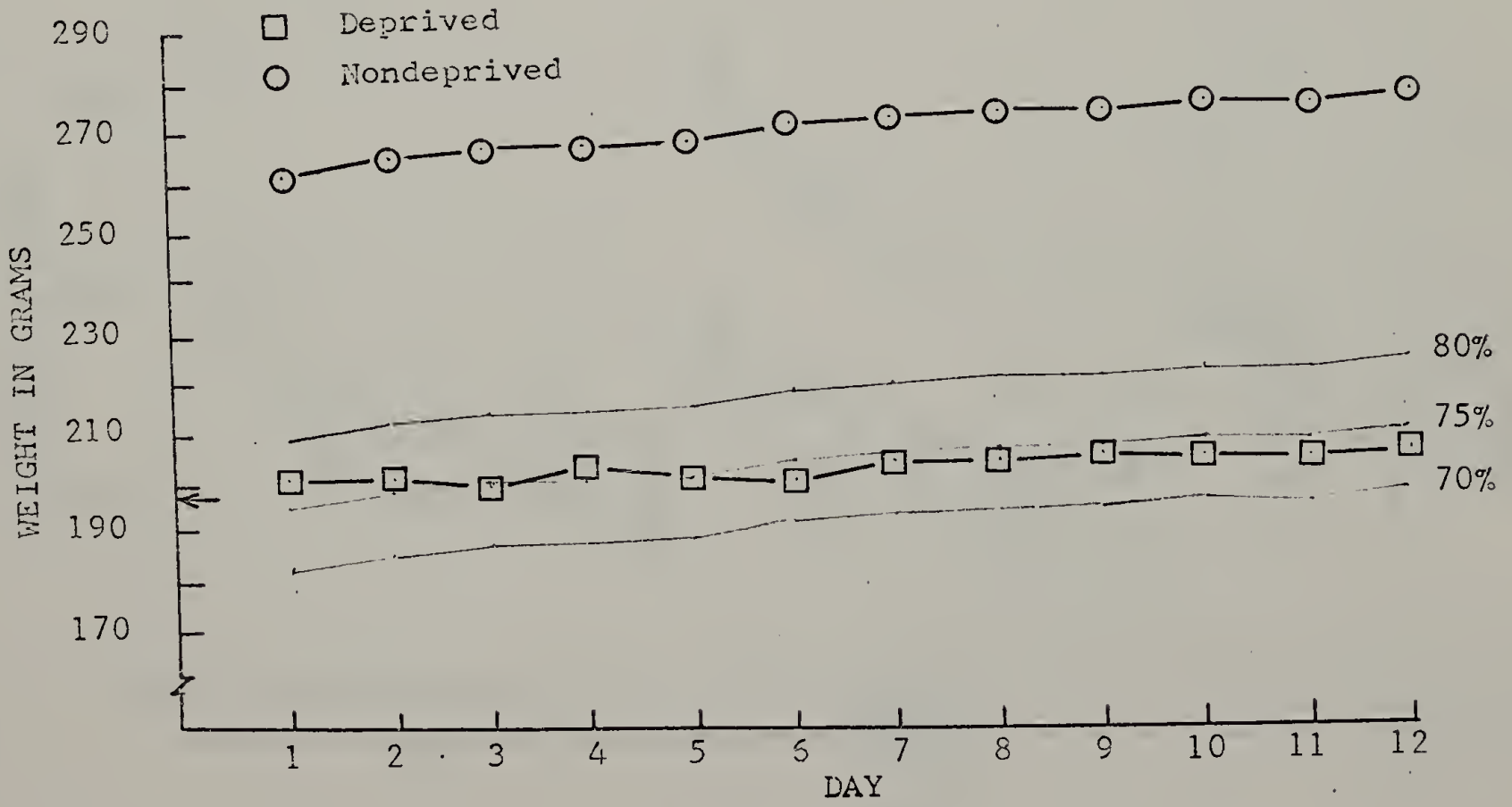

Fig. 4. Mean body weight for all CHO animals divided on the basis of deprivation for each test day. Arrow indicates mean 80% body weight for deprived groups based on their own free-feeding weight. Also indicated are 80, 75, and 70 percent body weight lines based on a direct percent of mean weight of ad libitum groups.

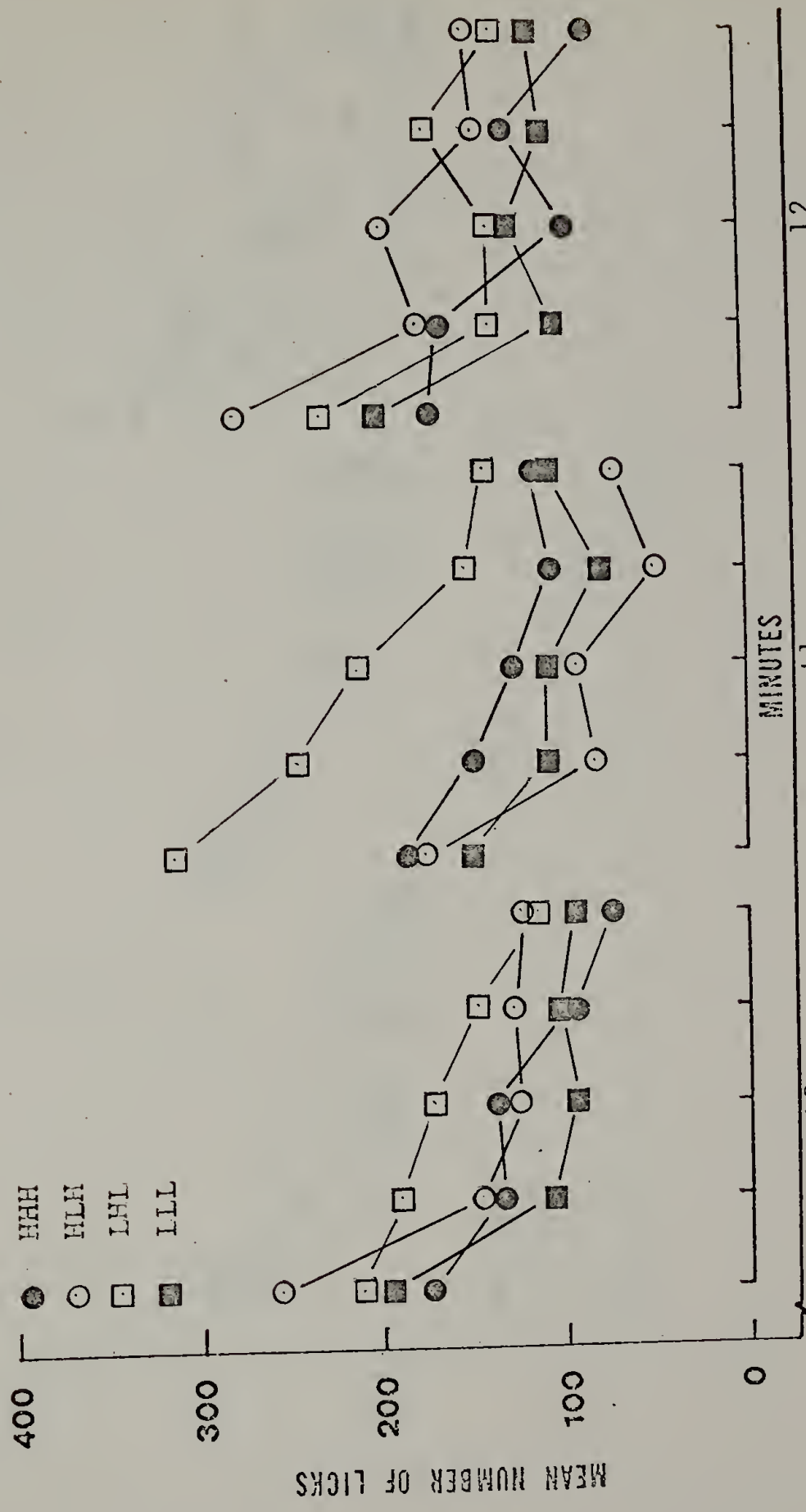

Fig. 5. Mean number of licks per minute for session 10 (preshift), session 11 (shift), and session 12 (postshift) for nondeprived CHO groups.

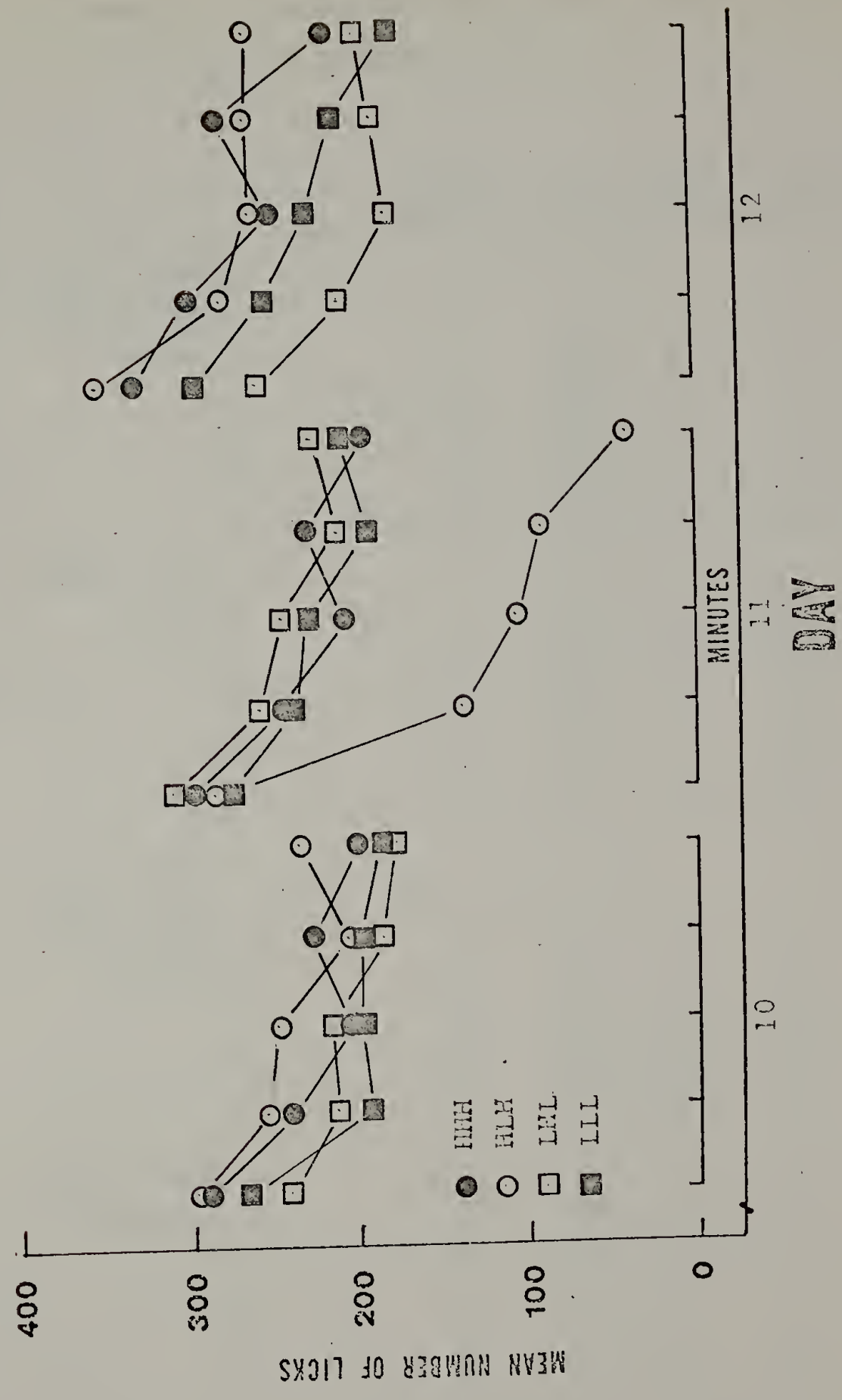

Fig. 6. Mean number of licks per minute for session 10 (preshift), session 11(shift), and session 12 (postshift) for deprived CHO groups.

TABLE 2

Results of nonparametric analysis of CHO groups during session 11.

	U Value*	p<	Sign	n	p<
Nondeprived Groups:					
HHH vs LHL					
minute 1	4	.013	0-	6	.016
2	6	.032	2-	6	.344
3	8	.066	2-	6	.344
4	8	.066	2-	6	.344
5	17	.469	3-	6	.656
HLH vs LLL					
minute 1	10	.120	1+	6	.109
2	16	.409	0+	6	.016
3	13	.242	1+	6	.109
4	10	.120	2+	6	.344
5	8	.066	1+	6	.109
Deprived Groups:					
HHH vs LHL					
minute 1	16	.409	1-	6	.109
2	16	.409	1-	6	.109
3	13	.242	0-	6	.016
4	17	.469	2-	6	.344
5	15	.350	1-	6	.109
HLH vs LLL					
minute 1	12	.197	1+	6	.109
2	4	.013	0+	6	.016
3	3	.008	0+	6	.016
4	6	.032	0+	6	.016
5	1	.002	0+	6	.016

* $n_1=6$, $n_2=6$ in all cases

Saccharin. One S in the Sacc group was dismissed from the experiment on the basis of the prescreening data. A second S was dropped because no responses were emitted through test day 5. Since both of these Ss were in the first replication, additional Ss were added in the second replication to assure equal representation in each group.

Figs. 7 and 8 show mean total licks for each test session for nondeprived and deprived groups respectively. Fig. 9 shows mean body weights for all animals in the Sacc groups divided on the basis of deprivation.

It is apparent from Figs. 7 and 8 that preshift response rates could not be differentiated on the basis of solution concentration. In addition, with the exception of a slight increase in response rate in nondeprived Group LHL, shifts in solution concentration had a negligible effect on the rats' licking behavior when expressed in session totals.

An analysis of variance involving sessions 10 and 12 for all Sacc groups confirmed the lack of effect (Pre-Post main effect, $F=0.71$, $df=1/32$, $p>.20$; Pre-Post x groups, $F=2.90$, $df=3/32$, $p>.05$). The deprivation condition imposed on the animals was without effect (Deprivation main effect, $F=2.65$, $df=1/32$, $p>.10$).

Figs. 10 and 11 show minute by minute responding over the last three test sessions. A preshift-postshift by

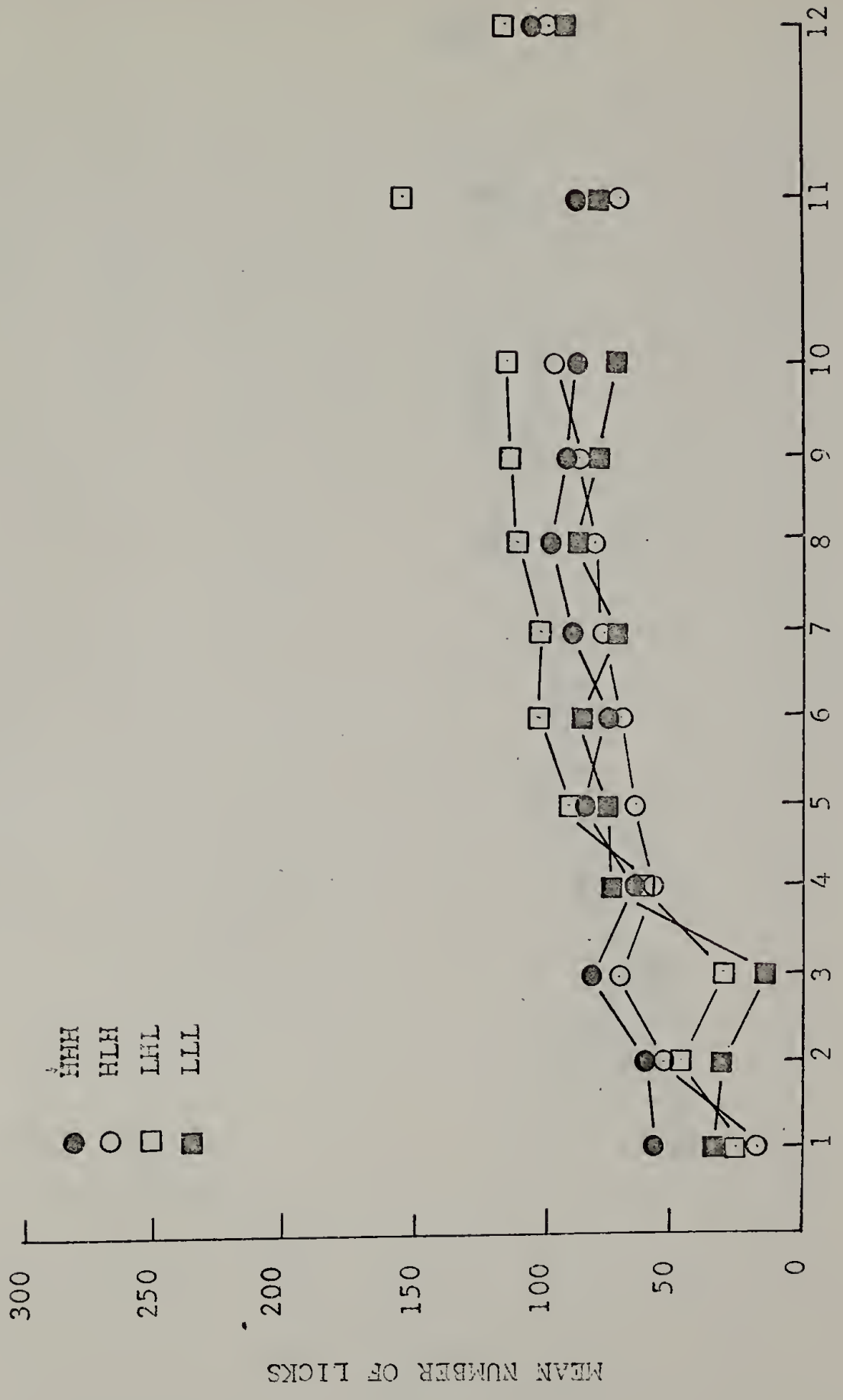

Fig. 7 Mean total licks per session for nondeprived Sacc groups.

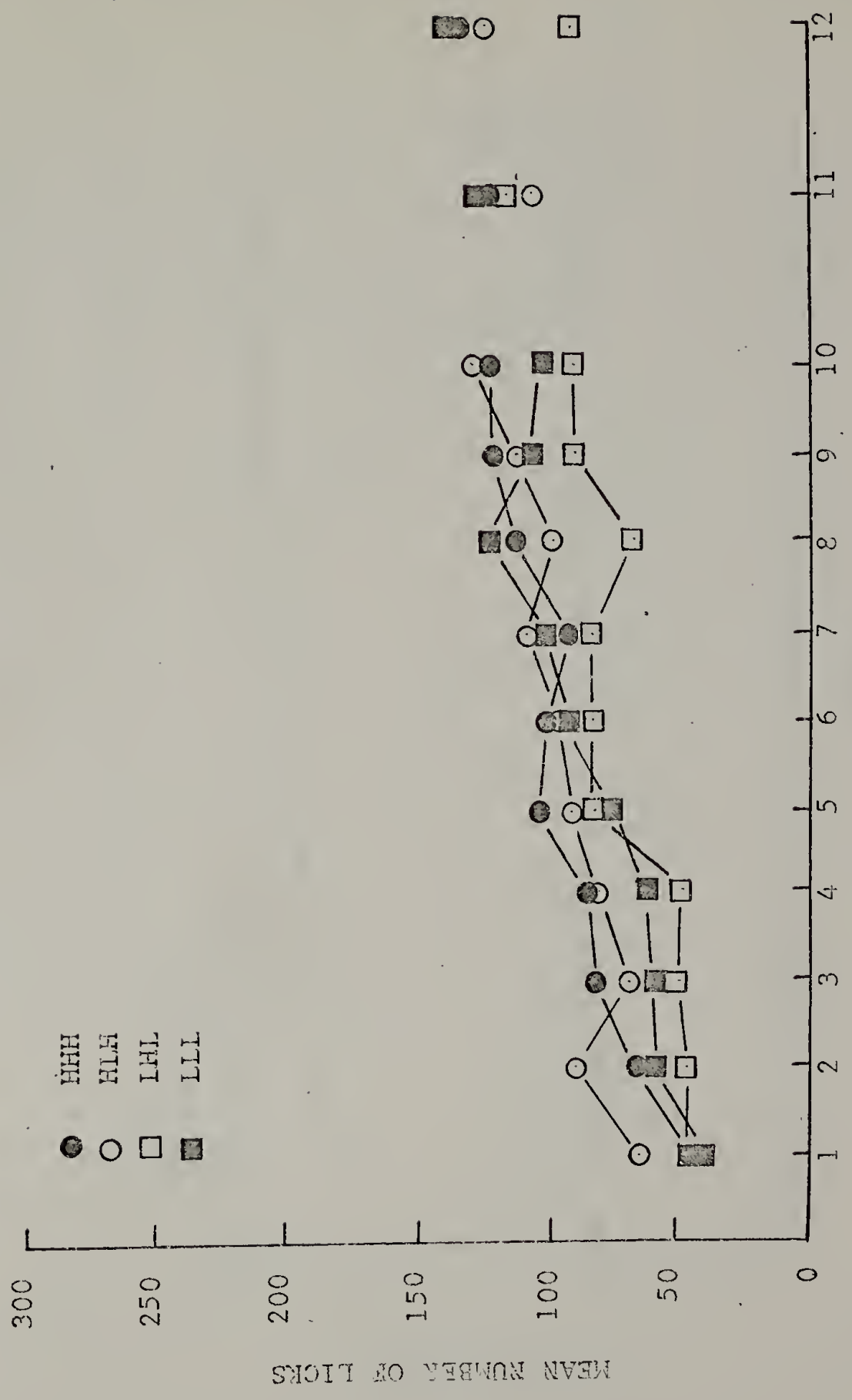

Fig. 8 Mean total licks per session for deprived Sacc groups.

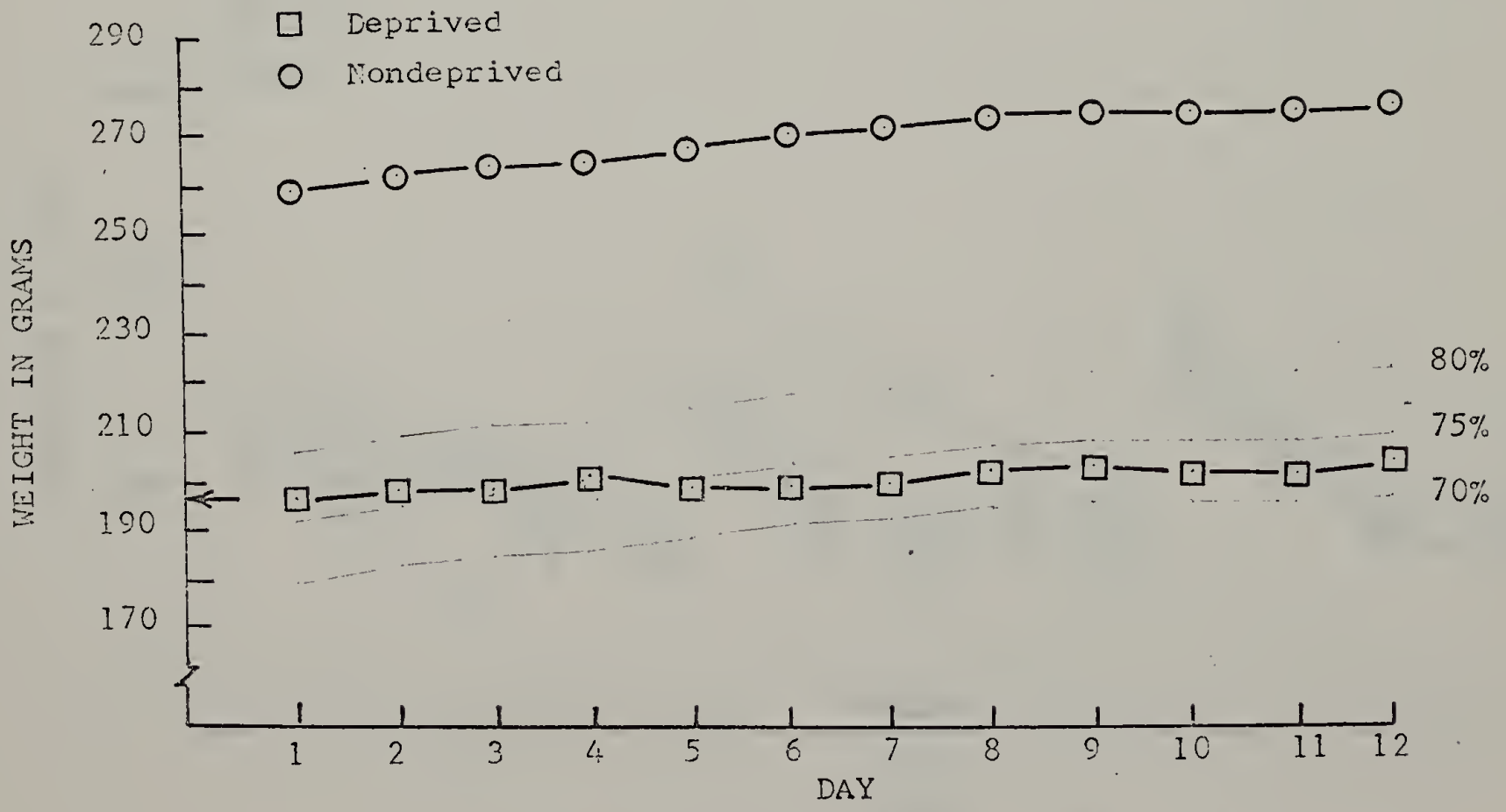

Fig. 9. Mean body weight for all Sacc animals divided on the basis of deprivation for each test day. Arrow indicates mean 80% body weight for deprived groups based on their own free-feeding weight. Also indicated are 80, 75, and 70 percent body weight lines based on a direct percent of mean weight of ad libitum groups.

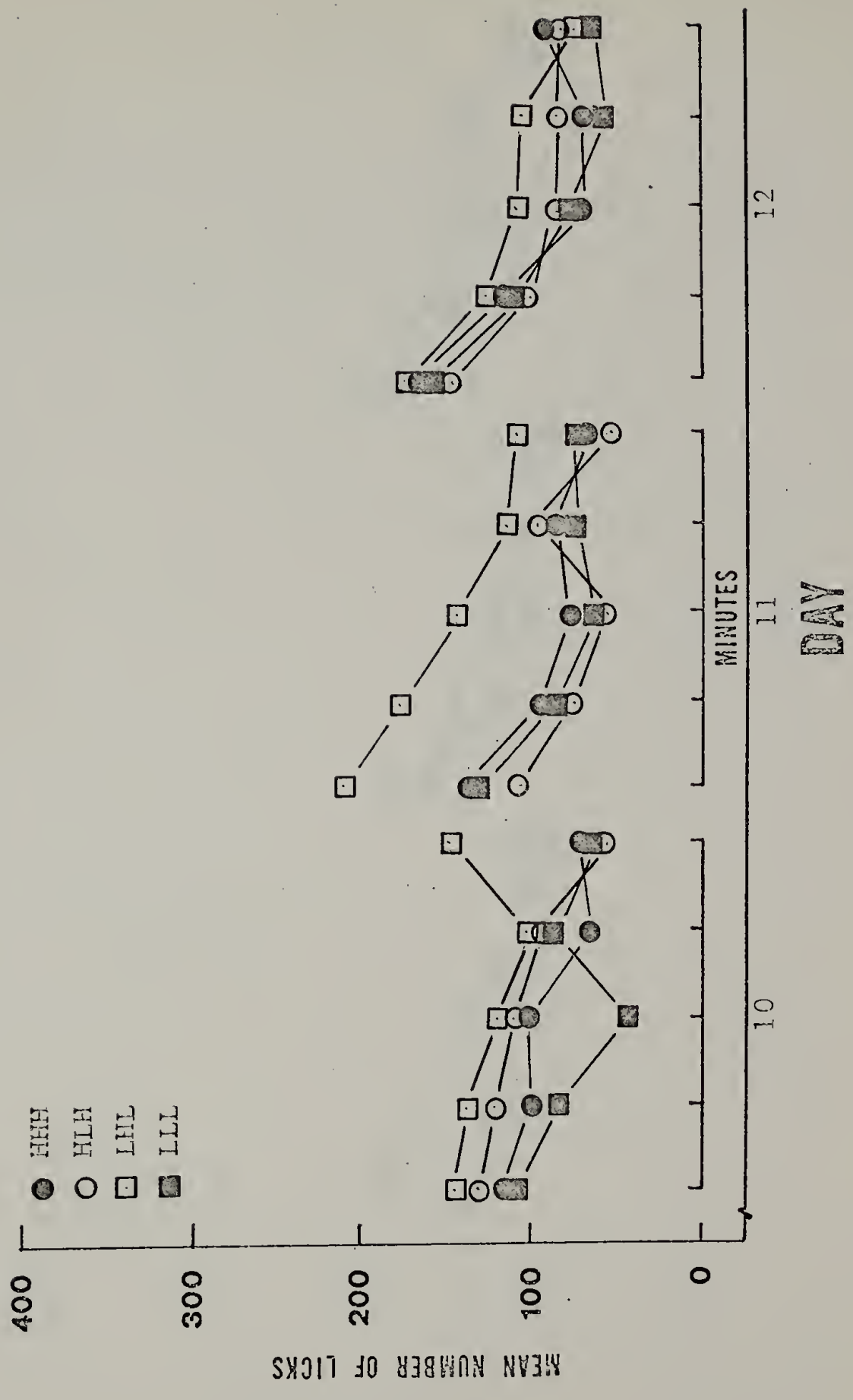

Fig. 10. Mean number of licks per minute for session 10 (preshift), session 11 (shift), and session 12 (postshift) for nondeprived Sacc groups.

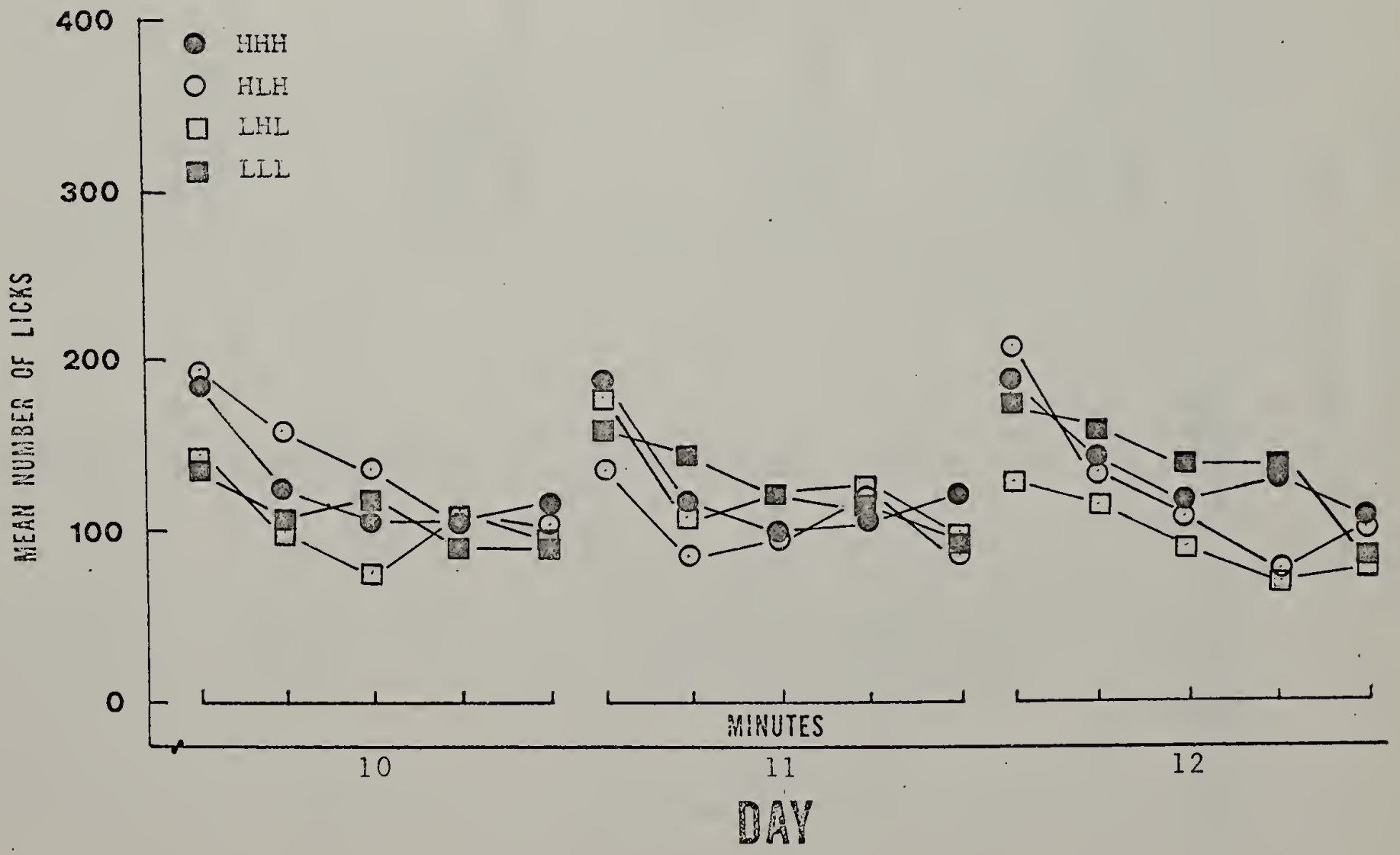

Fig. 11. Mean number of licks per minute for session 10 (preshift), session 11 (shift), and session 12 (postshift) for deprived Sacc groups.

TABLE 3

Results of nonparametric analysis of Sacc groups during session 11.

	U Value*	p<	Sign	n	p<
Nondeprived Groups:					
HHH vs LHL					
minute 1	12	.197	1-	6	.109
2	7	.047	1-	6	.109
3	10	.120	1-	6	.109
4	14	.294	2-	6	.344
5	10	.102	1+	6	.109
LLL vs HLH					
minute 1	15	.350	1+	6	.109
2	13	.242	1+	6	.109
3	15	.350	1+	6	.109
4	12	.197	2+	6	.344
5	15	.350	2+	6	.344
Deprived Groups:					
HHH vs LHL					
minute 1	17	.469	1-	6	.109
2	17	.469	3-	6	.656
3	13	.242	0-	6	.016
4	12	.197	3-	6	.656
5	14	.294	3-	6	.656
LLL vs HLH					
minute 1	12	.197	2+	6	.344
2	4	.013	0+	6	.016
3	11	.155	2+	5	.500
4	17	.469	2+	6	.344
5	16	.409	2+	6	.344

* $n_1=6$, $n_2=6$ in all cases

minute interaction (sessions 10 and 12) was marginally significant (F=2.68, df=4/128, p<.05) and an inspection of the contributing means showed response rates to be higher at the beginning of the postshift session and lower at the end. This tendency could not be differentiated further by any other terms in the overall analysis.

Fig. 10 shows Group LHL to be clearly higher than all other groups during session 11. An inspection of the overlap between Group LHL and Group HHH in the form of a Mann-Whitney U test, however, found an excessive amount of between subject variability. The results of these tests are found in Table 3. Analyses of other groups met similar difficulty. Sign tests failed to show unanimous within subject directional response rate shifts. These data are also found in Table 3.

Discussion.

The results of Experiment 1 indicate a need for caution regarding an analogy of the double incentive shift employed here to behavioral contrast paradigms. A consideration of the data leads to a conclusion that, using lick rate as the dependent measure, shifts in incentive solution concentration either up or down do not produce NCE or PCE relative to standard (preshift) or control (nonshift) responding.

Although acceptance of the Null Hypothesis regarding an analysis of session 12 could be taken as evidence for a relatively insensitive behavioral measure, the response to the first concentration shift in session 11 would argue against such a conclusion. The CHO data are very much in agreement with earlier work (Panksepp & Trowill, 1970) which demonstrated a significant but transient PCE in licking following a within session concentration shift (12CHO to 32CHO) in animals under low deprivation conditions and strong and durable NCE in deprived animals following a similar downward shift (32CHO to 12CHO). In that experiment, however, PCE and NCE were in evidence under the complimentary deprivation conditions, high and low respectively, although each was attenuated presumably due to alterations in baseline responding. The same was not true in the present experiment (see Figs. 5 and 6) which utilized a between session shift. A within session shift would undoubtedly be a more sensitive test of alterations of incentive quality although it would be reasonable to suspect a confounding due to adaptation in the sensory system or other physiological changes. It is worthwhile to note that the present data are also consistent with those data which show NCE to be positively correlated with deprivation (Ehrenfreund & Badia, 1962; Gragg & Black, 1967).

The Sacc data were not orderly although there was an

indication of PCE during session 11 in the ad libitum group (see Fig. 10). The absence of NCE during session 11 is in agreement with other data in the literature (Hulse, 1962; Vogel, Mikulka, & Spear, 1968). There were no indications of contrast effects during session 12 for any group.

Since contrast effects were obtained in session 11 but not in session 12 an analysis in terms of adaptation level (Helson, 1964) is potentially useful. Clearly one day's experience with a particular solution concentration is not equivalent to 10 day's experience and it remains an empirical question as to how long it takes to establish or reestablish a particular level of adaptation. If an adaptation level explanation is to be pursued, however, given that PCE would be observed following a water shift to a lower solution concentration even though both result in a lowereing of response rate, one must argue either that a water shift causes a shift in adaptation level more readily than a concentration shift or that a different mechanism is involved for each. It may be that the concentration shift simply does not involve a response change of sufficient magnitude to be reflected by the relatively insensitive between-session procedure.

Since Experiment 1 did not provide any evidence for contrast effects following the second concentration shift, Experiment 2 was added to test for the effects of a water shift holding other parameters constant. This, in effect,

was a replication of earlier work (Ashton & Trowill, in press).

Experiment 2

Several parameters in Experiment 1 differed from those of earlier studies involving lick rate (Ashton & Trowill, in press). Among the more important were: 1) the animals were tested during the darkened cycle (in the earlier study the animals were actually housed in a room which was constantly illuminated), 2) the shift period lasted for only one session, and 3) the test session lasted for 5 min. rather than 10 as in the previous experiment.

The reasons for nocturnal test sessions have been stated. The logic which called for a one session shift stemmed from an experiment (Dube, Ashton, & Trowill, in press) which showed that the PCE observed in saccharin drinking following a water shift was most apparent in Ss shifted for very brief periods of time. Finally, 5 min. test sessions were used because elation effects in the earlier lick rate study were evidenced only during the first 3 min. of the test sessions with rates rapildy returning to nominal levels for the remainder of the session.

Because these parameters in Experiment 1 had been altered from the previous work and because neither NCE nor PCE had been strongly in evidence following the second shift, Experiment 2 attempted to replicate the earlier

work by utilizing a water shift and the aforementioned parameters of Experiment 1.

Method.

Subjects. All animals in Experiment 2 had been previously used as control Ss in Experiment 1, excepting 6 noted below, and had thus been given a particular solution for 12 sessions. All Ss were maintained as in Experiment 1.

Apparatus and Procedure. The apparatus was that used in Experiment 1.

The procedure of Experiment 2 was basically a direct extension of Experiment 1. All Ss from Experiment 1 had had 12 5 min. exposures to the appropriate solution. In addition, 6 Ss had been added, and these were given experience equivalent to that of the nondeprived .3Sacc group. During session 13 all Ss were shifted to tap water and during session 14 all, excepting the 6 additional .3Sacc Ss, were returned to the appropriate preshift solutions. The 6 Ss mentioned above were given two days of tap water and were returned to .3Sacc on session 15.

Results.

The results of the water shift are shown in Figs. 12 through 15. Separate analyses of variance were performed on the prewater-postwater days for each solution and for

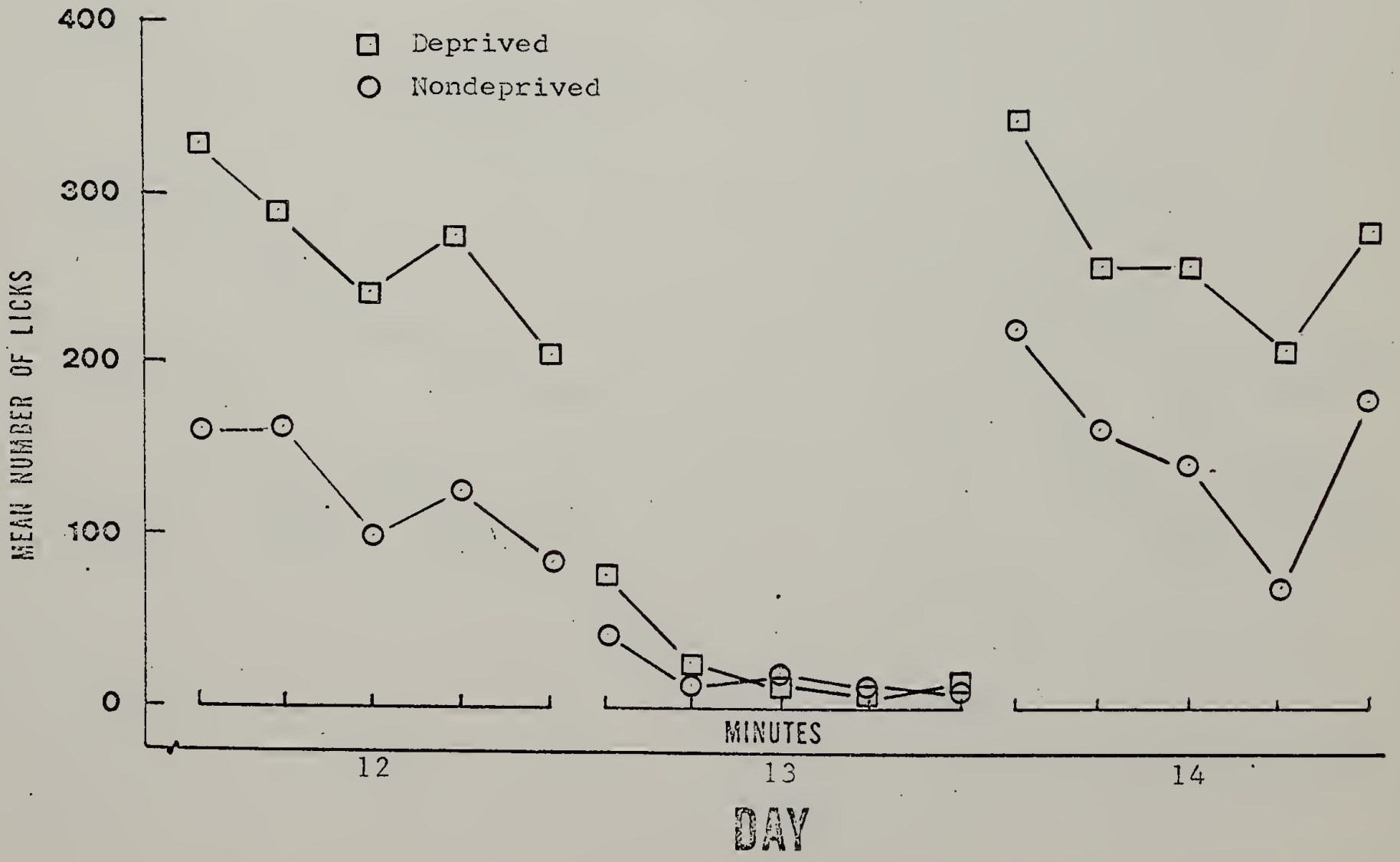

Fig. 12. Mean number of licks per minute for session 12 (preshift), session 13 (water shift), and session 14 (postshift) for deprived and nondeprived 24CHO groups.

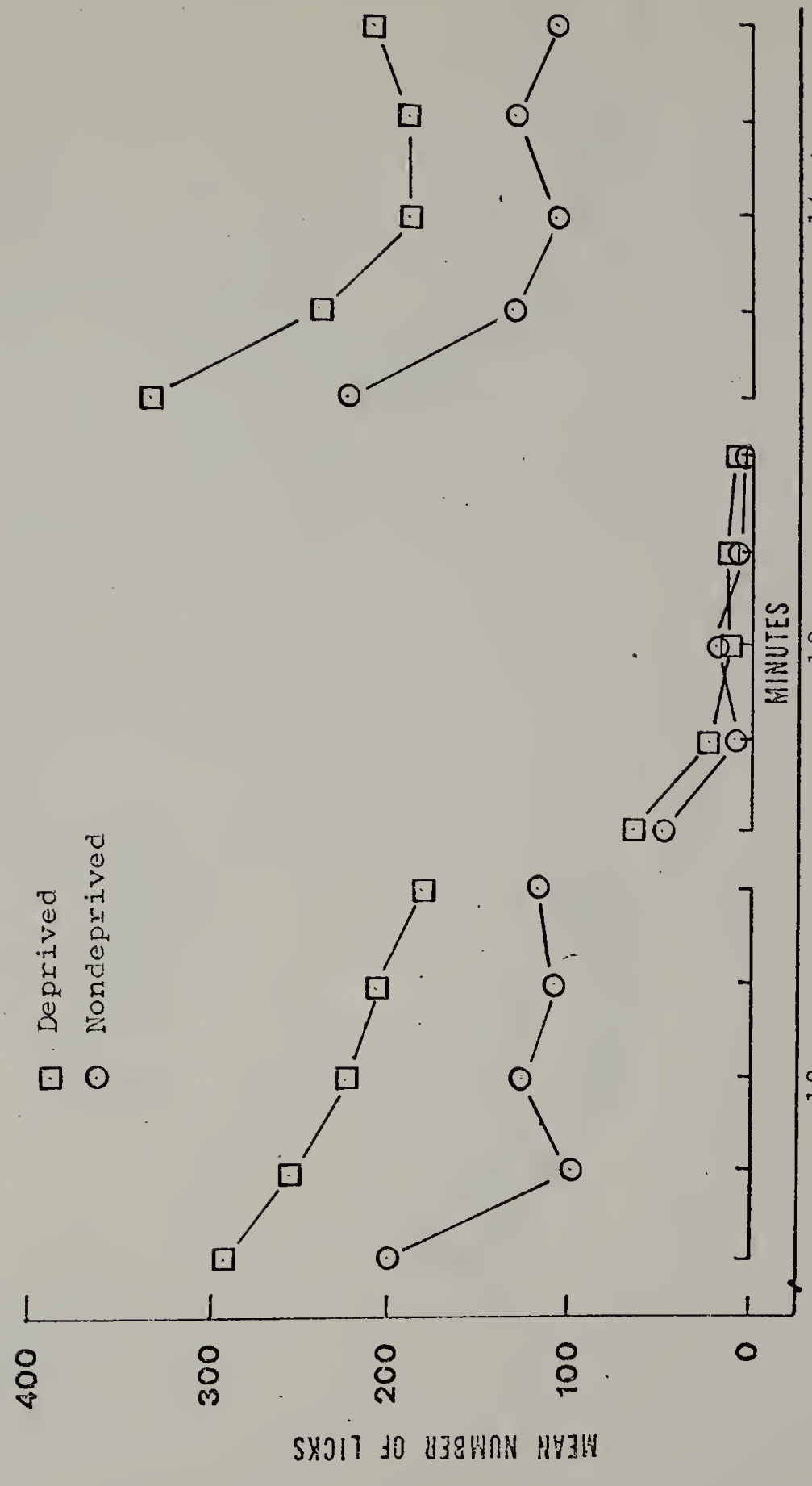

Fig. 13. Mean number of licks per minute for session 12 (preshift), session 13 (water shift), and session 14 (postshift) for nondeprived and deprived 8CHO groups.

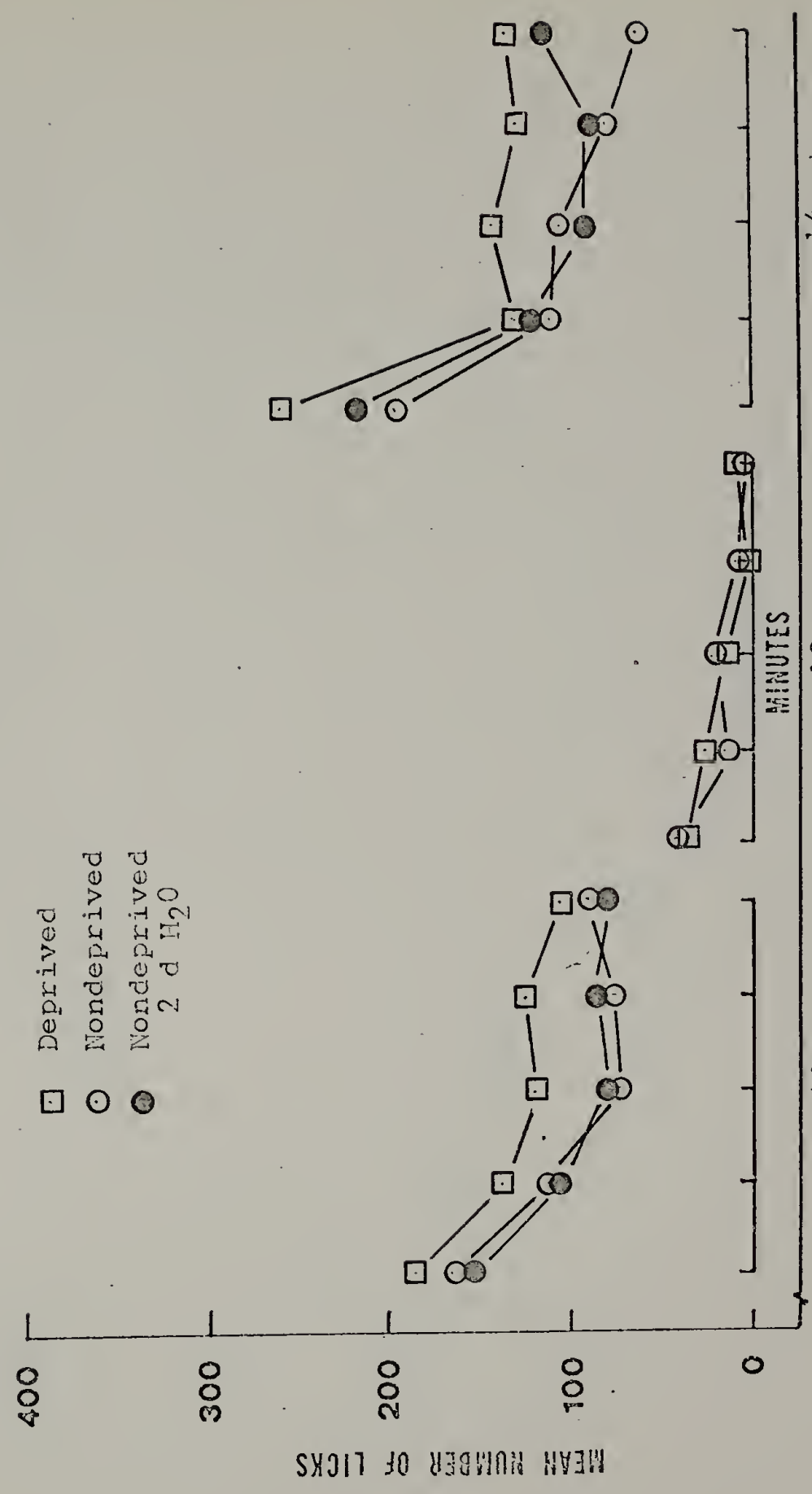

Fig. 14. Mean number of licks per minute for session 12 (preshift), session 13 (water shift), and session 14 (postshift) for nondeprived and deprived •3Sacc groups. Also shown are preshift and postshift data from animals shifted to water for two days.

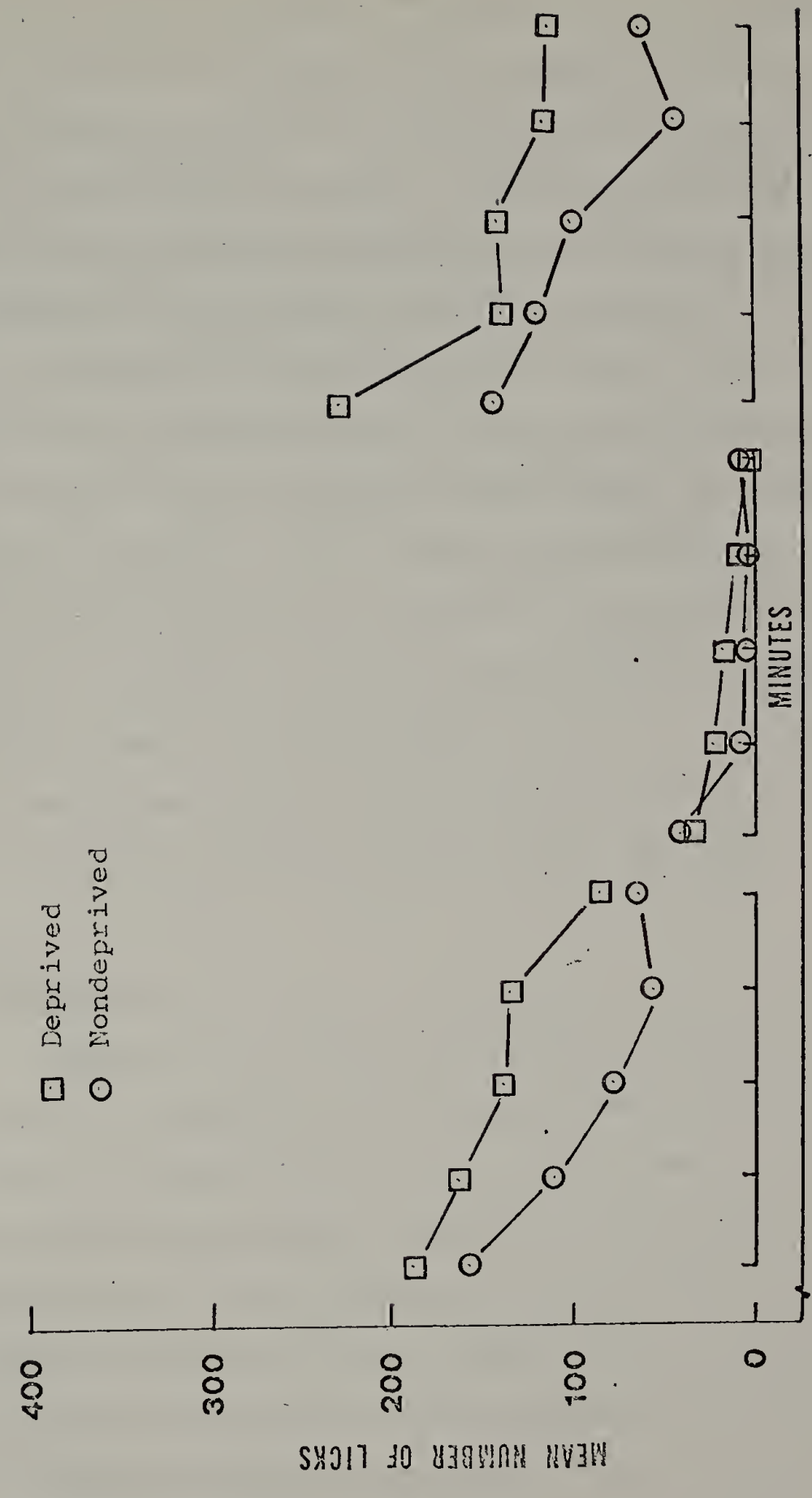

Fig. 15. Mean number of licks per minute for session 12 (preshift), session 13 (water shift), and session 14 (postshift) for nondeprived and deprived .1Sacc groups.

the Ss in the two water day group. Only one significant term appeared and that was the preshift-postshift by minute interaction (F=7.88, df=4/32, p<.001) among the Ss given 24CHO (see Fig. 12). This term reflected a sharp increase in lick rate across both deprivation conditions during the last minute of testing postshift.

Although no terms were significant in the anlaysis for the two groups receiving .3Sacc there was an increase in response rate during the first minute of postshift testing (see Fig. 14). A sign test evaluating minute one preshift and minute one postshift in the group which received two days of water indicated that all individual response rates increased (N=6, p<.16). A t test performed on these same data indicated that the difference was statistically reliable (t=3.71, df=5, p<.025).

Discussion.

The results of this experiment indicate that at least one of the parameters altered from earlier work (Ashton & Trowill, in press) had acted in such a way as to attenuate the contrast phenomenon. Neither of the sucrose concentrations used in the present investigations matched the 16CHO solution used in the earlier study. Although it is not pleasing to suggest that concentration effects would be so overwhelming, the possiblity that such is the case cannot be ruled out at this time.

The data from the .3Sacc groups, although not as prominent as in the earlier study, suggest a postwater PCE; the data from the Ss which received two days of water were, in fact, equivalent to earlier data. This may indicate that total exposure time, including number of preshift sessions, length of sessions, and number of shift sessions, is an important variable to be considered. That NCE is a direct function of the number of preshift exposures in incentive contrast paradigms has been suggested by other authors (Vogel, Mikulka, & Spear, 1966; 1968).

Nocturnal test sessions are unprecedented in the contrast literature. Although there was an exceptionally high percent of "drinkers" in home cage prescreening sessions (only one S was discarded) dark cycle testing may have had an adverse effect upon the brief test sessions. First, since the rat is more active during the dark cycle it may take longer for Ss to attend to the fluid spout, particularly for nondeprived animals. Second, since feeding and drinking cycles are elevated during the nighttime hours and since testing occurred during the second six hours of darkness the animals may have concluded a large portion of their meal taking and may have thus been satiated. This obviously would apply only to the nondeprived animals.

The second point forces a distinction between "nondeprived" and "satiated" since one of the original hypotheses

involved alterations of baseline with variations of deprivation conditions. Such post hoc distinctions make the theoretical position less appealing but it is apparent that response levels were, overall, lower in the present experiments than in the earlier study using similar, albeit not identical, solution concentrations.

Experiment 3

Experiment 3 attempted to see if NCE could be shown in a situation where nondeprived Ss were drinking saccharin in their home cages. Previous attempts to demonstrate NCE in this situation (Ashton, Gandelman, & Trowill, 1969) failed to produce a substantial increase in intake during the shift sessions. Using the parametric data of Hammer (1967) it was predicted that Ss shifted from .03Sacc to .3Sacc and then back to .03Sacc would show a substantial increase in fluid drinking during the shift sessions which, if the analogy to behavioral contrast were correct, should provide sufficient conditions for NCE.

Method.

Subjects. Twenty-four 90 day old, female, albino rats, bred in the University of Massachusetts, Psychology Department colony, were divided equally and randomly into two groups. All Ss were individually housed and maintained on ad libitum food (Purina Lab Chow pellets) and tap water in a ventilated room under conditions of continuous illumination. All testing was done in Ss' home cages.

Procedure. A graduated water bottle (Wahmann LC-274) containing .03Sacc was attached to each cage for 1/2 hr. twice daily for 28 sessions. During sessions 29 and 30 .3Sacc was given to half of the Ss (Group LHL) and .03Sacc

was given to the remainder (Group LLL). During the remaining four sessions all Ss again received .03Sacc. Intake was measured to an accuracy of 1 ml.

Results.

Mean intake per session for Group LHL and LLL is shown in Fig. 16. An analysis of variance for preshift data indicated a nonsignificant Group main effect (F=0.51, df=1.22, p>.10) but a significant effect due to time of testing (AM-PM Test main effect, F=4.98, df=1/22, p<.05) indicating higher consumption during the morning session.

Differences between the two groups during the two shift sessions were analyzed by One-tailed Mann-Whitney U tests. The first shift session showed no differences between the two groups (U=68, p>.10) although the second session showed Group LHL intake to be significantly higher than that of Group LLL (U=26, p<.01).

An analysis of variance comparing two sessions preshift to two sessions postshift indicated that intake was higher postshift (Pre-Post main effect, F=8.34, df=1/22, p<.01) although no differentiation could be made according to groups (Group x Pre-Post, F=1.41, df=1/22, p>.20). Intake was higher during the second daily session (AM-PM Test main effect, F=4.68, df=1/22, p<.05). Sign tests comparing a mean of the two preshift sessions to the first postshift session for

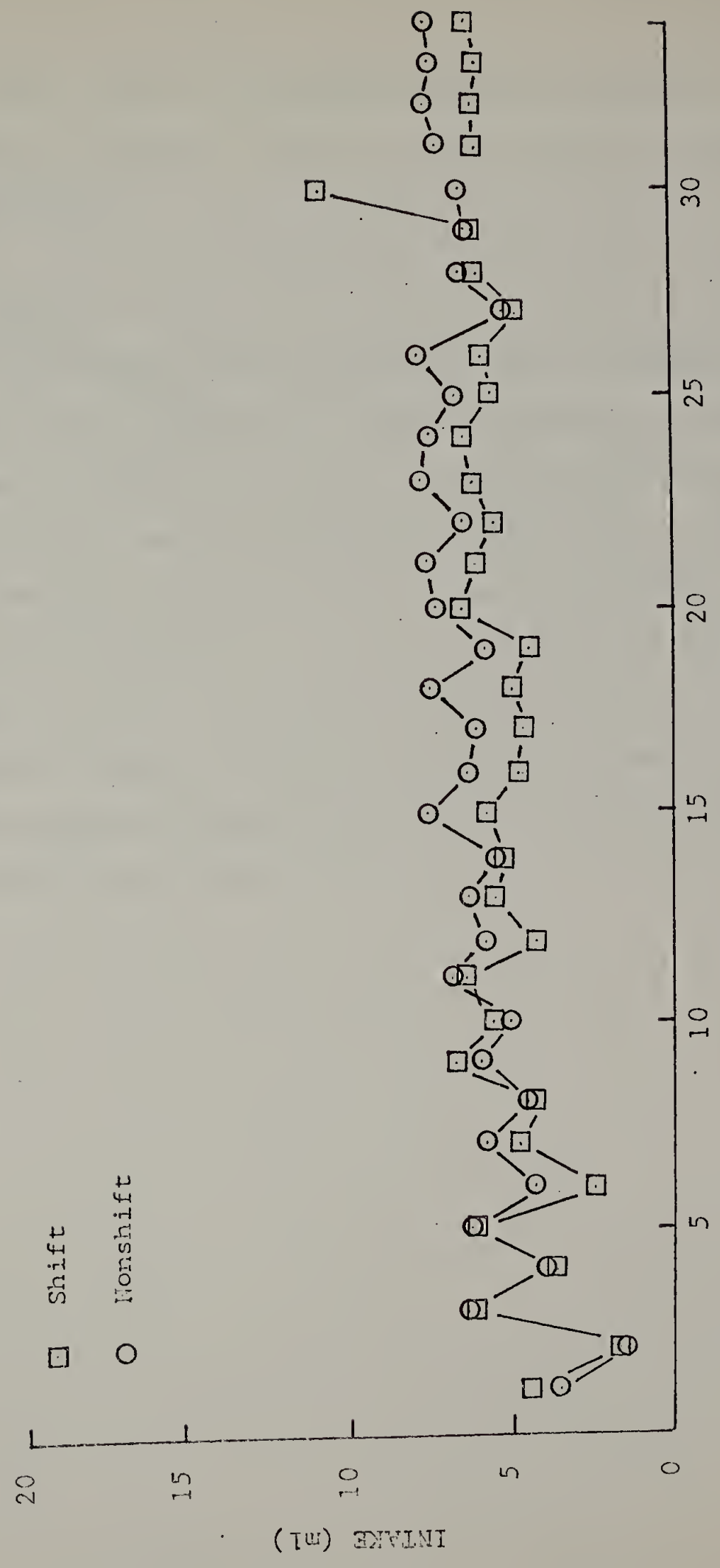

Fig. 16. Mean Sacc intake per session.

each group failed to show any unanimous directional change (Group LHL, Sign=4(-), N=11, $p<.274$; Group LLL, Sign=3(-), N=11, $p<.113$).

Discussion.

The results of this experiment lend no support to an analogy between behavioral contrast paradigms and the present design. In spite of a significant increase in response rate during the shift sessions for Group LHL there was absolutely no tendency toward NCE with a return to the preshift solution. In fact, intake was slightly higher postshift than preshift over all subjects, and the sign test analysis, which uses the smaller number of signs to assign probabilities, found fewer decreases than increases in each case.

Experiment 4

The use of sucrose as a reward in an experiment where intake is the dependent measure offers a situation which is unique in that, with a single bottle, maximum intake during a half hour test is in the 4CHO stimulus concentration range (Hammer, 1967) even though preference testing with two or more bottles will show that rats will consistently chose the higher (or highest) CHO concentration available (Young, 1967; Young & Greene, 1954). Differences between one bottle and multiple bottle test situations can undoubtably be traced to some form of a "Gestalt" effect where there is truly a choice available (multiple stimulus) and also to physiological postingestional factors (e.g., osmotic effects) which would apply to both test conditions.

The importance of these considerations for the present paradigm is that, using intake as the dependent measure in a situation where only one bottle is available at a time, a shift from 32CHO to 4CHO and then back to 32CHO should provide an <u>increase</u> in responding while at the same time offering the <u>S</u>s a <u>less</u> preferred reward. If the analogy to behavioral contrast is to hold there should be, following the second concentration shift, a decrease in responding beyond that of a suitable control condition (NCE). If, on the other hand, the <u>S</u> is responding to a palatability

dimension it might be predicted that a positive contrast effect would occur.

Subjects. Thirty-six 90 day old, female, albino rats, bred in the University of Massachusetts, Psychology Department colony, were divided equally and randomly into four groups. All Ss were individually housed in a ventilated room under conditions of continuous illumination. Half of the Ss were maintained on ad libitum food (Purina Lab Chow pellets) and tap water while the other half were allowed only 7 g. of Purina pellets daily; feeding occured 1/2 hr. after the second test session (see below). All testing was done in Ss home cages.

Procedure. A graduated water bottle (Wahmann LC-274) containing 32CHO was attached to each cage for 1/2 hr. twice daily for 28 sessions. During sessions 29 and 30 4CHO was given to 1/2 of the Ss under the deprived condition and to 1/2 of the Ss under the nondeprived condition. The remaining Ss received 32CHO. During sessions 30-34 all Ss were given 32CHO. Intake was measured to an accuracy of 1 ml.

Results.

Mean intake per session for nondeprived Groups 32-4-32 and 32-32-32 is shown in Fig. 17. A similar data plot for deprived groups is shown in Fig. 18. An analysis of variance including all preshift data indicated a strong tendency

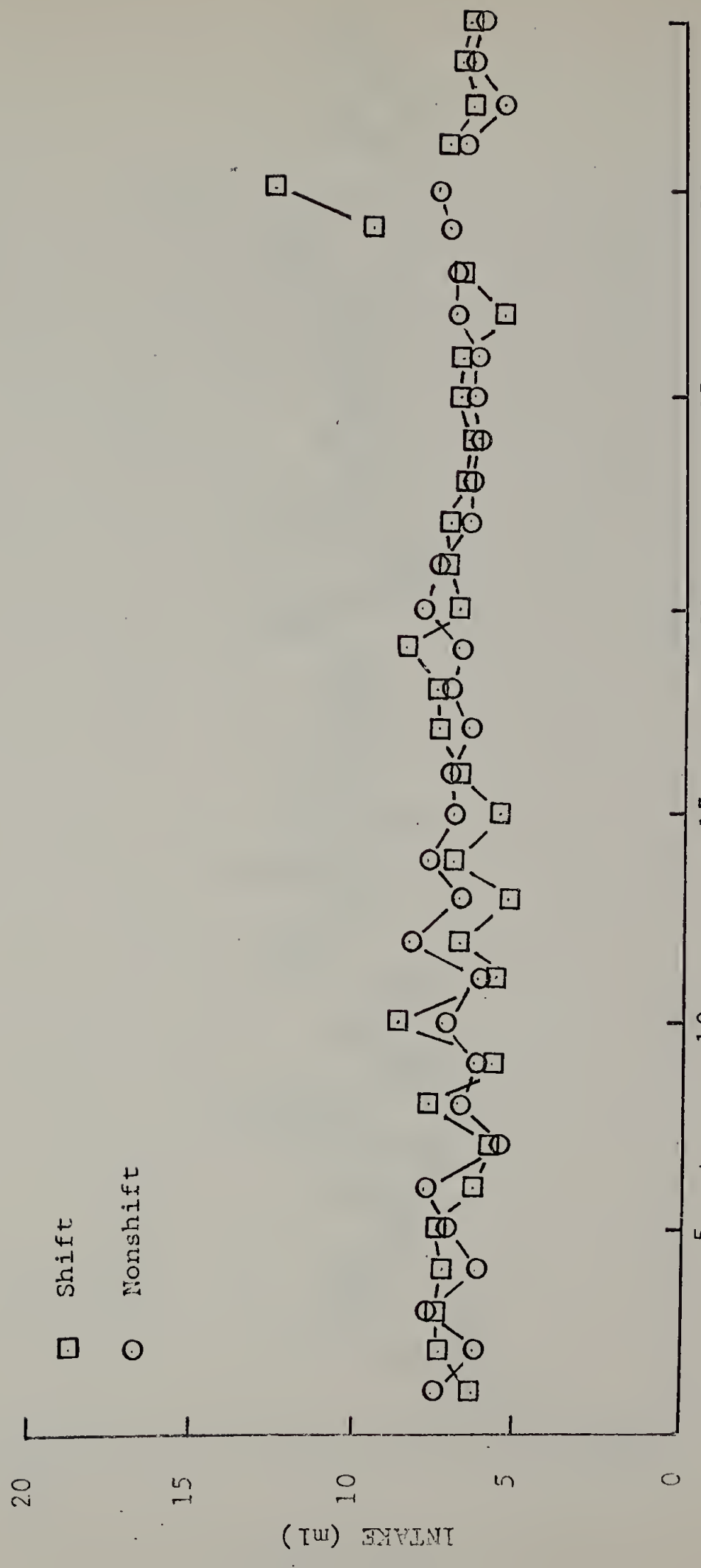

Fig. 17. Mean CHO intake per session for nondeprived groups.

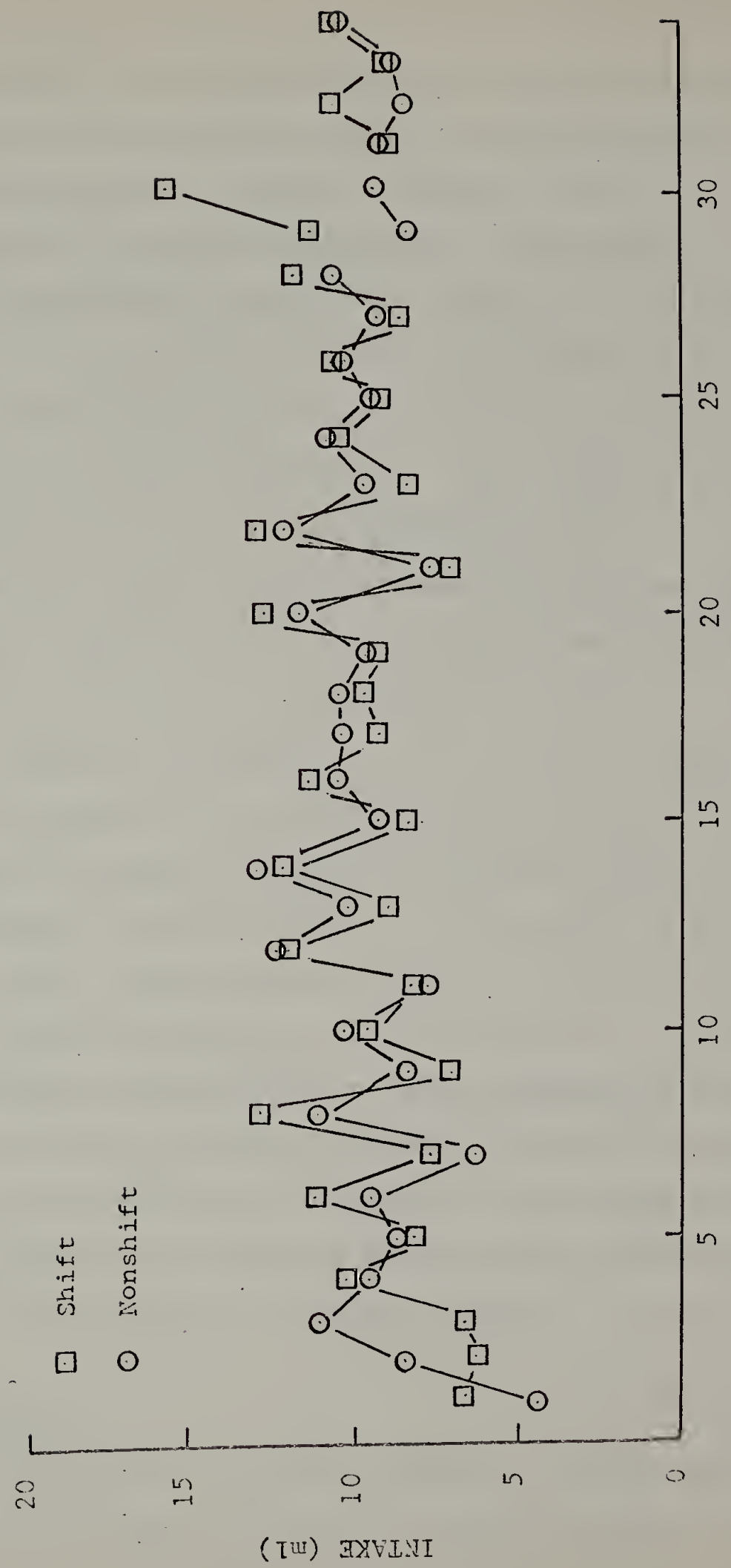

Fig. 18. Mean CHO intake per session for deprived groups.

for intake to be higher during the afternoon test session (AM-PM Test main effect, F=68.67, df=1/32, p<.001; AM-PM Test x Deprivation, F=34.34, df=1/32, p<.001). No terms suggesting group differences were significant.

Differences between groups during the two shift sessions were analyzed by One-tailed Mann-Whitney U tests. The first shift session showed no differences between shifted and nonshifted groups under either deprivation condition (nondeprived, U=21, p<.10; deprived, U=24, p>.10); intake in shifted groups during the second session was significantly higher than that of the nonshifted controls (nondeprived, U=7, p<.001; deprived, U=9, p<.01).

Sign tests comparing a mean of the two immediate preshift sessions to the first postshift session for each group failed to indicate unanimous directional changes (nondeprived Groups: 32-4-32, Sign=1(-), N=7, p<.062; 32-32-32, Sign=2(+), N=9, p<.090; deprived Groups: 32-4-32, Sign=3(+), N=8, p<.363; 32-32-32, Sign=2(+), N=9, p<.090). An analysis of variance comparing two sessions immediately preshift to two sessions immediately postshift yielded no significant terms regarding shift performance and/or group differences. The deprivation procedured were effective (Deprivation main effect, F=31.96, df=1/32, p <.001).

Discussion.

The absence of contrast effects, positive or negative, following a shift from 32CHO to 4CHO is perhaps surprising

in view of the significant increase in response rate (which should produce NCE according to prefalent theories of behavioral contrast) and the marked decrease in incentive quality (which might produce PCE if the logic of incentive shift paradigms were to be extended).

General Discussion.

The preceeding four experiments have failed to support the hypothesis which suggested that variations in response rate were responsible for contrast effects in drinking behavior following a double incentive shift. Experiment 1, which employed lick rate, and Experiments 3 and 4, which used intake as the dependent measure, were consistent in their results. It appears that the use of behavioral contrast as a theoretical model is inappropriate, at least so far as the present between-session design is concerned. Experiment 2 replicated, in part, earlier work (Ashton & Trowill, in press).

Double incentive shift vs. behavioral contrast. Although lines of similarity can be drawn between the experimental procedures here in discussion in an attempt to generalize theoretical predictions, obvious differences must be recognized. Behavioral contrast paradigms typically use manipulations of reinforcement schedules to obtain variations of response rate with differences in responding under the constant schedule component (i.e., positive or

negative behavioral contrast) usually being seen within a single session. The design employed in the experiments described herein involved between session shifts which are undoubtedly less sensitive to contrast effects. Furthermore, behavioral contrast paradigms allow for multiple exposures to the schedule changes and the contrast effects develop over time. The present design allows for only a single exposure to the comparison solution.[1] These factors may well act in concert to obscure an animal's response to fluid concentration shifts.

Effects of reinforcement schedule. Further distinctions may be made concerning reinforcement schedules. Hulse (1962) has shown that animals who are continuously reinforced in their licking behavior (by a sweet taste) are conditioned to respond in such a way as to be less responsive to the reinforcer, per se, but also to shifts in reward quality or quantity. In fact, his data showed that animals in groups which had received continuous reinforcement, either under high or under low saccharin concentrations, would react with a decrement in responding following shifts downward or upward, respectively.[2] This, he hypothesized, was due to stimulus generalization. Groups which had had partial reward training (dry tube on some trials) showed response shifts in directions appropriate to the concentration shifts. In the words of the author, ". . .behavior comes under critical and orderly control of the stimulus

properties of the reinforcer through discrimination training."

Response decrements were not seen in Experiment 1 for groups shifted from low solution concentrations to high solution concentrations even though they recieved continuous reinforcement for licking and it is not clear how that experiment differed from that of Hulse. But it is probable that animals receiving tap water for the first time in an experimental environment which has before contained only a sweetened solution would be undergoing a discrimination process through partial reward and/or extinction. To be sure, a shift to water for any length of time in the double shift paradigm involves massed nonreward trials and manifpulation of that variable has been shown to be of importance in an experiment utilizing intake as the response measure and a shift to tap water (Dube, Ashton, & Trowill, in press).

It is suggested that one initial response to discrimination training of the sort developed by partial reinforcement is an increase in responding following a number of nonrewarded trials. Shifts in concentration (to nonzero values as judged behaviorally) do not constitute nonreward and would cause stimulus control to develop more slowly if even in in a similar fashion. Multiple shifts in concentration may be more appropriately fit by an adaptation level approach (see Helson, 1964). It must also be recognized, however, that negative results from an earlier

experiment which used an empty tube for three sessions (Ashton, Gandelman, & Trowill, in press) may be detrimental to this post hoc hypothesis.

Effects of fluid concentration. Although fluid concentration effects may prove to be of importance in the double shift paradigm it should be reiterated that such an assumption must remain tentative in the absense of parametric data. Weinstein (1970), however, reportedly demonstrated convincing NCE using an operant response (bar pressing) in a single incentive shift. That experiment used concentrations of 16% and 4% sucrose which, according to the work of Guttman (1953) showing maximum and minimum bar press rates to 16% and 4% sucrose, respectively, should have provided maximum incentive separation. Although those solution concentrations are not unique in their ability to produce contrast effects, the results of Weinstein's experiment are suggestive of the importance of concentration factors in contrast paradigms. In addition, Guttman's work cautions against the assumption, often casually made, of a direct linear relationship between incentive, as measured by an operant response rate, and preference, as measured by choice (see also Young, 1967).

Sucrose vs. saccharin. Although it has been suggested that the reinforcing effect of sugars (and other sweet evoking compounds such as sodium saccharin) lies in the sensory stimulation they provide and that probably all of the effects

that have been obtained with sucrose can be replicated with saccharin (Bolles, 1967, Pp. 348-349), differences between sucrose and saccharin have been noted in double incentive shift paradigms (Ashton, Gandelman, & Trowill, in press; Experiment 2 above) and in single shift paradigms (Vogel, Mikulka, & Spear, 1968; also following the first concentration shift in Experiment 1 above). Other work examining intake (Collier & Novell, 1967) and preference (Young & Madsen, 1963) would also indicate a need for caution in accepting such an equation. The former points to differences in nutritional value, osmolarity, and other colligative properties while the latter seems to indicate that the equality is, at best, one way with saccharin being replicable with properly selected sucrose concentrations, but not the converse. Thus, there are data to suggest that sucrose and saccharin are, qualitatively and quantitatively, quite different and that the two will produce quite different results in terms of behavioral responses.

Summary. The effects of double fluid concentration shifts were observed in four experiments using lick rate or intake as the dependent measure and either sucrose or saccharin as the incentive sulution. The hypothesis to be tested was whether or not variation in response rate, either up or down, following the first shift, would be sufficient to produce contrast effects upon return to the original concentration. To the extent that this hypothesis would be

accepted, an analogy between such an incentive shift design and behavioral contrast would appear plausable. The results unanimously failed to support the hypothesis and an alternative hypothesis based on acquisition of stimulus control was suggested. Single incentive shift data were consistent with earlier data supporting a suggestion that deprivation conditions may affect contrast phenomena through an interaction with baseline performance levels.

REFERENCES

Ashton, A.B., & Trowill, J.A. Effects of reinforcement shifts upon lick rate. Psychonomic Science, in press.

Ashton, A.B., Gandelman, R., & Trowill, J.A. The effects of palatability shifts upon subsequent saccharin and sucrose intake. Paper read at meeting of Psychonomic Society, St. Louis, Mo., November, 1969.

Ashton, A.B., Gandelman, R., & Trowill, J.A. Effect of food deprivation upon elation of saccharin drinking following a temporary shift to water. Psychonomic Science, (a), in press.

Ashton, A.B., Gandelman, R., & Trowill, J.A. Effects of reinforcement shifts upon subsequent sucrose consumption. Psychonomic Science, (b), in press.

Black, R.W. Shifts in magnitude of reward and contrast effects in instrumental and selective learning: A reinterpretation. Psychological Review, 1968, 75, 114-126.

Bower, G.H. A contrast effect in differential conditioning. Journal of Experimental Psychology, 1961, 62, 196-199.

Brethower, D.M., & Reynolds, G.S. A facilitative effect of punishment upon unpunished behavior. Journal of the Experimental Analysis of Behavior, 1962, 5, 191-199.

Collier, G., & Marx, M.H. Changes in performance as a function of shifts in magnitude of reinforcement. Journal of Experimental Psychology, 1959, 57, 305-309.

Collier, G., & Novell, K. Saccharin as a sugar surrogate. Journal of Comparative and Physiological Psychology, 1967, 64, 404-408.

Crespi, L. Quantitative variation of incentive and performance in the white rat. American Journal of Psychology, 1942, 15, 467-517.

DiLollo, V., & Meyer, P.N. Variation in fluid intake following shifts between water and saccharin solution. Psychonomic Science, 1970, 18, 55-56.

Dube, R.P., Ashton, A.B., & Trowill, J.A. Responses to palatability shifts: Effects of varying the retention interval. Psychonomic Science, in press.

Dunham, P.J. Contrasted conditions of reinforcement: A selective critique. Psychological Bulletin, 1968, 69, 295-315.

Ehrenfreund, D. & Badia, P. Response strength as a function of drive level and pre- and post-shift incentive magnitude. Journal of Experimental Psychology, 1962, 52, 85-89.

Gandelman, R., & Trowill, J. Effects of reinforcement shifts upon subsequent saccharin consumption. Psychonomic Science, 1969, 15, 25.

Gragg, L., & Black, R.W. Runway performance following shifts in drive and reward magnitude. Psychonomic Science, 1967, 8, 177-178.

Guttman, N. Operant conditioning, extinction, and periodic reinforcement in relation to concentration of reinforcing agent. Journal of Experimental Psychology, 1953, 46, 213-222.

Hammer, L.R. Saccharin and sucrose intake in rats: long- and short-term tests. Psychonomic Science, 1967, 8, 367-368.

Helson, H. Adaptation Level Theory. New York: Harper and Row. 1964.

Hulse, S.H. Partial reinforcement, continuous reinforcement, and reinforcement shift effects. Journal of Experimental Psychology, 1962, 64, 451-459.

Nevin, J.A., & Shettleworth, S.J. An analysis of contrast effects in multiple schedules. Journal of the Experimental Analysis of Behavior, 1966, 9, 305-315.

Myers, J.L. Fundamentals of Experimental Design. Boston: Allyn and Bacon. 1966.

Panksepp, J., & Trowill, J. Positive and negative contrast effects with hypothalamic reward. Physiology and Behavior, 1969, 4, 173-175.

Panksepp, J., & Trowill, J. Positive incentive contrast with electrical stimulation of the brain.

Journal of Comparative and Physiological Psychology, 1970, 70, 358-363.

Panksepp, J. & Trowill, J. Positive and negative contrast in licking with shifts in sucrose concentration as a function of food deprivation. Learning and Motivation, in press.

Premack, D., & Hillix, W.A. Evidence for shift effects in the consummatory response. Journal of Experimental Psychology, 1962, 63, 284-288.

Reynolds, G.S. Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71.

Reynolds, G.S., & Catania, A.C. Behavioral contrast with fixed-interval and low rate reinforcement. Journal of the Experimental Analysis of Behavior, 1961, 4, 387-391.

Reynolds, G.S., & Limpo, A.J. On some causes of behavioral contrast. Journal of the Experimental Analysis of Behavior, 1968, 11, 543-547.

Siegel, S. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill. 1956.

Terrace, H.S. Stimulus control. In W.K. Honig (Ed.), Operant Behavior: Areas of Research and Application. New York: Appleton-Century-Crofts. 1966.

Terrace, H.S. Discrimination learning, the peak shift, and behavioral contrast. Journal of the Experimental Analysis of Behavior, 1968, 11, 727-741.

Trowill, J.A., Panksepp, J., & Gandelman, R. An incentive model of rewarding brain stimulation. Psychological Review, 1969, 76, 264-281.

Vogel, J.R., Mikulka, P.J., & Spear, N.E. Effect of interpolated extinction and level of training on the "depression effect". Journal of Experimental Psychology, 1966, 72, 51-60.

Vogel, J.R., Mikulka, P.J., & Spear, N.E. Effects of shifts in sucrose and saccharine concentrations on licking behavior in the rat. Journal of Comparative and Physiological Psychology, 1968, 66, 661-666.

Weinstein, L. Negative incentive contrast with sucrose. Psychonomic Science, 1970, 19, 13-14.

Young, P.T. Taste preference. In Handbook of Physiology, Section 6: Alimentary Canal. Charles F. Code, ed. New York: American Physiological Society. 1967.

Young, P.T., & Greene, J.T. Quantity of food ingested as a measure of relative acceptability. Journal of Comparative and Physiological Psychology, 1953, 46, 288-294.

Young, P.T., & Madsen, C.H., Jr. Individual isohedons in sucrose-sodium chloride and sucrose-saccharin gustatory areas. Journal of Comparative and Physiological Psychology, 1963, 56, 903-909.

[1] It is worth noting, in this regard, that an experiment carried out as an undergraduate research problem at the University of Massachusetts laboratory by Phillip Carrigan (1970, unpublished) failed to demonstrate contrast effects in fluid consumption using 10 consecutive between session sucrose concentration shifts.

[2] None of the groups in Hulse's (1962) experiment showed statistically reliable contrast effects including double shift groups. There was a trend toward NCE following a single shift in the continuously reinforced group, however.

APPENDIX A

Summary of Analyses of Variance for Experiment 1

Analysis of Variance

CHO groups: Sessions 10 and 12

Source of Variance	MS	df	F	
Between S				
Groups (G)	45562.62	3	1.57	
Deprivation (H)	915253.33	1	31.44	p<.001
Chamber (B)	5824.13	1	0.20	
GxH	41323.54	3	1.42	
S/GHB	29107.31	32	-	
Within S				
Pre-Post (D)	20488.53	1	4.46	p<.05
GxD	6127.64	3	1.33	
HxD	5044.03	1	1.10	
GxHxD	1699.44	3	0.37	
SD/GHB	4593.44	32	-	
Minutes (M)	124276.50	4	42.74	p<.001
GxM	3215.13	12	1.11	
SM/GHB	2907.48	128	-	
DxM	973.11	4	0.45	
SDM/GHB	2164.78	128	-	

Analysis of Variance

CHO groups: Session 11

Source of Variance	MS	df	F	
Between S				
Groups (G)	163067.20	3	9.18	p<.001
Deprivation (H)	313276.00	1	17.64	p<.001
GxH	28147.70	3	1.59	
S/GHB	17756.73	32	-	
Within S				
Minutes (M)	88932.08	4	52.72	p<.001
GxM	3969.08	12	2.35	p<.01
GxHxM	2336.41	12	1.38	
SM/GHB	1687.03	128	-	

Analysis of Variance

Sacc groups: Sessions 10 and 12

Source of Variance	MS	df	F	
Between S				
Groups (G)	2703.65	3	0.13	
Deprivation (H)	55083.68	1	2.65	
Chamber (B)	2025.41	1	0.10	
GxH	27838.36	3	1.34	
S/GHB	20808	32	-	
Within S				
Pre-Post (D)	1809.63	1	0.71	
GxD	7444.99	3	2.90	
HxD	28.03	1	0.02	
GxHxD	794.77	3	0.31	
SD/GHB	2559.09	32	-	
Minutes (M)	73223.04	4	37.78	$p<.001$
GxM	1249.56	12	0.64	
SM/GHB	1938.09	128	-	
DxM	3993.57	4	2.69	$p<.05$
SDM/GHB	1482.65	128	-	

Analysis of Variance

Sacc groups: Session 11

Source of Variance	MS	df	F	
Between S				
Groups (G)	21472.34	3	1.71	
Deprivation (H)	17819.97	1	1.42	
GxH	14310.70	3	1.14	
S/GHB	12563.04	32	-	
Within S				
Minutes (M)	33594.86	4	30.19	$p<.001$
GxM	1527.12	12	1.37	
GxHxM	967.13	12	0.87	
SM/GHB	1112.90	128	-	

APPENDIX B

Summary of Analyses of Variance for Experiment 2

Analysis of Variance

24CHO groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Deprivation (H)	486286.01	1	14.96	p<.005
Chamber (B)	3864.68	1	0.12	
S/HB	32502.10	8	-	
Within S				
Pre-Post (P)	4928.01	1	1.26	
HxP	7857.01	1	2.01	
SP/HB	3910.60	8	-	
Minutes (M)	35095.66	4	9.85	p<.001
HxM	1488.01	4	0.42	
SM/HB	3563.21	32	-	
PxM	19099.63	4	7.88	p<.001
HxPxM	451.63	4	0.19	
SPM/HB	2423.34	32	-	

Analysis of Variance

8CHO groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Deprivation (H)	286163.33	1	9.14	p<.025
Chamber (B)	50.70	1	0.01	
S/HB	31315.97	8	-	
Within S				
Pre-Post (P)	554.70	1	0.11	
HxP	229.63	1	0.05	
SP/HB	5053.95	8	-	
Minutes (M)	46677.68	4	19.29	p<.001
HxM	2605.40	4	1.08	
SM/HB	2420.08	32	-	
PxM	2198.97	4	1.20	
HxPxM	2009.74	4	1.10	
SPM/HB	1834.13	32	-	

Analysis of Variance

.3Sacc groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Deprivation (H)	51294.68	1	6.94	p<.05
Chamber (B)	1992.68	1	0.27	
S/HB	7390.74	8	-	
Within S				
Pre-Post (P)	7473.41	1	3.16	
HxP	1896.08	1	0.80	
SP/HB	2367.08	8	-	
Minutes (M)	41140.40	4	20.38	p<.001
HxM	807.69	4	0.40	
SM/HB	2018.22	32	-	
PxM	2464.89	4	1.31	
HxPxM	1719.01	4	0.92	
SPM/HB	1875.26	32	-	

Analysis of Variance

.1Sacc groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Deprivation (H)	68688.68	1	1.87	
Chamber (B)	261.08	1	0.01	
S/HB	36649.98	8	-	
Within S				
Pre-Post (P)	785.41	1	0.93	
HxP	88.41	1	0.11	
SP/HB	841.60	8	-	
Minutes (M)	35893.34	4	11.24	$p<.001$
HxM	2072.47	4	0.65	
SM/HB	3193.40	32	-	
PxM	1427.49	4	1.11	
HxPxM	2135.20	4	1.66	
SPM/HB	1283.89	32	-	

APPENDIX C

Summary of Analyses of Variance for Experiment 3

Analysis of Variance

Sacc groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Groups (G)	12.76	1	0.34	
S/G	37.07	22	-	
Within S				
Pre-Post (P)	27.09	1	8.34	$p<.01$
GxP	4.59	1	1.41	
SP/G	3.25	22	-	
AM-PM (T)	10.01	1	4.68	$p<.05$
PxT	5.51	1	1.58	
SPT/G	3.48	22	-	

APPENDIX D

Summary of Analyses of Variance for Experiment 4

Analysis of Variance

CHO groups: Preshift-Postshift

Source of Variance	MS	df	F	
Between S				
Groups (G)	2.25	1	0.21	
Deprivation (H)	342.25	1	31.96	p<.001
HxG	3.36	1	0.31	
S/HG	10.71	32	-	
Within S				
Pre-Post (P)	7.11	1	1.58	
HxP	5.44	1	1.21	
GxP	13.44	1	2.99	
HxGxP	1.00	1	0.22	
SP/HG	4.50	32	-	
AM-PM (T)	17.36	1	3.34	
GxT	26.69	1	5.13	p<.05
HxT	20.25	1	3.89	
ST/HG	5.20	32	-	
PxT	28.44	1	5.62	p<.025
SPT/HG	5.06	32	-	

APPENDIX E

Subject Losses

Subject Losses

	N	
Experiment 1		
loss due to:		
prescreening	1	(.1Sacc)
inadequate response rate	1	(.1Sacc)
death	0	
other	0	
total	2	
Experiment 2		
loss due to:		
inadequate response rates	0	
death	0	
other	0	
total	0	
Experiment 3		
loss due to:		
inadequate response rates	0	
death	0	
other	0	
total	0	
Experiment 4		
loss due to:		
inadequate response rates	0	
death	0	
other	0	
total	0	