THE DEVELOPMENT OF PROBLEM-SOLVING BEHAVIOR IN BLIND RATS

A Thesis

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by

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INTRODUCTION

The persistance or transience of early treatment effects can be heightened or assuaged by factors other than their own potency. The works of Harris and Levine (1962) and Hess (1959) and many others who search for critical periods in an organism's life are clear in this regard as well as the research of Denenberg (1968), even though he does not agree with many of the concepts concerning critical periods. Publications by Christie (1951), King (1954; 1968) and Denenberg (1966) have attempted to illustrate some of these other factors and, in the first two studies, simultaneously push for some universality in what information researchers should report in their findings, e.g., strain, type of caging used, methods for testing effects of the independent variable, etc. The mentioning of such static processes is routine in contemporary research literature but yet, in many experiments using the paradigm of early experience as the independent variable and assessment of subsequent behavior as the dependent variable, the role of ongoing maturation, growth and, at times, environmental processes, has many times been neglected in its relation to the subject organism.

The classical experimental design has not readily lent itself to collating the dynamic character of these factors, for this approach has been to apply treatment, terminate at some point and then test for immediate and/or late effects. This is the common search for a residual of treatment effects and when one considers that the interval between experience "X" and test "Y"

has ranged from none at all in some experiments to a year or more in others (Denenberg, Woodcock and Rosenberg, 1968; Hunt and Otis, 1963), linking results to early "X" cannot but tenuously take into account the continuous and highly complex processes that impinge upon the organism from the moment of birth, perhaps even conception.

This is not meant to demean the value of such techniques. Any design which shows the presence of treatment effects a year after treatment was applied is certainly valuable for in this case one would assume that the effects persisted in spite of ontological processes.

Consider the relationship of Hebb's hypothesized "structural trace" (1949) to the interval between treatment and test. The question arises: What changes, if any, does the structural trace undergo during this interval and, more importantly for the behaviorist, in what observable way is the organism's behavior, due to an established trace, modified, also during this interval? Obviously, the organism's environment, both internal and external, are in a constant state of alteration. With age comes variations in body fluids, hormones and enzymes (Carubelli, 1968; Levine and Broadhurst, 1963), growth of the genitals, central nervous system, lymphatic system and general body structure (King, 1954; Bolles, 1964) all commencing and ending at different periods in the organism's life. Different behavior patterns also vary with age, peaking at one point, waning at another; for example, rats sleep more at day one of age than at weaning, climb more in the third week of life than

in the first or second, and explore more at 22 days than at 15 (Bolles, 1964; Anderson and Patrick, 1934). As sterile as life in a laboratory cage must be for an animal there still is no lack of variety in the external environment; the sounds of other animals, humans and machines all provide a background of variable stimuli at any given moment. With all these processes occurring it is remarkable that the effects of early stimulation are as robust as they sometimes are (Ganz, 1968).

Somewhere along the ontological trail, an organism acquires the ability to solve a series of problems such as discrimination tasks (Lavellee, 1970) and maze problems (Brown, 1968). Such problem-solving development as there is in the rat would to Hebb (1949) depend heavily upon the development of sensory modalities in early life. Experiments designed to restrict sensory organs early in life have shown deleterious behavioral effects, sometimes permanent (Myers and Fox, 1963), and other times temporary (Riesen, Ramsey and Wilson, 1964). On the other hand, experiments designed to restrict stimulation later in life have shown not so drastic results (Forgus, 1956; Hymovitch, 1952). The problem may be one of intellectual impairment; that is, the less enriching situations or the less sensory stimulation the organism encounters in its early environment, the more handicapped it may be in attempting to solve certain tasks. According to Denenberg (1969) this problem-solving ability does not develop until after the organism's sensory processes are functioning fully, thereby bringing it in

contact with "patterned physical stimulation".

Recently, Harlow, Harlow, Schiltz, and Mohr (1971) have taken issue with this concept in a study involving social isolation versus 'enrichment' with monkeys. Generally, the enriched group was superior to the isolation group on all tasks except a discrimination task, in which they were inferior. Instead of adhering to tradition, however, Harlow et al. interpreted their results not as a decrement due to intellectual functioning but as due to an emotional disturbance sufficient enough to impair performance. In other words, they have strongly suggested, presumably to the chagrin of many, that most research on early environmental experiences has just been interpreted incorrectly.

A rat that loses its vision will explore a maze more than a sighted rat (Glickman, 1958) but will still learn the maze (Hebb, 1949). The visual information that the animal is able to acquire before being blinded might be integrated in a manner useful to that animal in a situation where only auditory, kinesthetic and olfactory feedback information is possible. With reference to Tolman's 'sign-learning' hypothesis (Hilgard and Bower, 1966) and Hebb's 'varied sensory background' concepts (1963) the more experience an animal has with a maze and with visual cues in general, the better able it should be to solve a series of tasks, such as the Hebb-Williams maze, while blind, provided of course, the previous visual information is still useful in a non-visual situation. Even though the Hebb-Williams maze is heavily loaded visually (Pollard,

1961) and thus performance decrements are expected between blind and non-blind rats, the important findings would be how groups differed from each other as a function of earlier visual experience and also how performance differed as a function of growth, maturation, and experience--in short, time. Presumably, experience with the maze would result in better performance as time progresses, a sort of 'learning-to-learn' phenomenon (Harlow, 1949). One could also presume that the initial points on a learning curve would be heavily weighted emotionally due to the shock of being blinded and that a decline in mistakes running the maze would represent in part some habituation on the part of the organism.

The following experiment was designed to explore the phenomenon alluded to above, and, simultaneously, to provide a methodology by which behavior in intervals between treatment and testing may be measured.

METHOD

Subjects

Eleven Long-Evans hooded female rats were mated with 3 males to produce 24 male and 12 female experimental subjects from eight litters. One male rat died during experimentation.

Apparatus

Housing. Identical stainless steel solid-walled cages (10"X6"X6") were used for preweaning and postweaning housing. Each cage was provided with a layer of San-i-cel for the bottom. Prior to weaning (day 20) each litter had ad lib water and Purina Lab Chow; after weaning the experimental animals had ad lib chow only in wire mesh cages ($9\frac{1}{2}$"X8"X7") three hours per day and were food deprived in their stainless steel cages. They were provided with ad lib water in both situations. One group (G-W), the weight control group, was continuously housed and fed ad lib chow and water in the stainless steel cages during postweaning and was not removed except for weighing.

Hebb-Williams Maze. With few exceptions the Hebb-Williams maze was constructed according to the specifications of Rabinovitch and Rosvold (1951). These exceptions were that the floor was painted with white enamel paint and black grid lines, the walls were six in. high, painted with white enamel paint, and the barriers were plywood, six in. high and unpainted. The maze was in a corner of the laboratory beside a speaker that emitted white noise to mask extraneous sounds. Illumination was provided by overhead fluorescent lights. A Standard Electric Timer was used to measure time from start to

finish of each trial in .01 sec. Reinforcement was moist ground Purina Lab Chow mixed with an ounce of pure granulated white sugar.

Design

The Ss were assigned to six groups. Each group had six Ss consisting of 4 males and 2 females except one group of five Ss (G-70) which had 3 males and 2 females due to the death of one male. One group (G-W) served as a weight control and did not participate in the experiment otherwise. Enucleation occurred at various ages for the groups; G-10 was blinded at 10 days of age, G-20, at 20 days, G-40, at 40 days, G-70, at 70 days, and G-NB was not blinded.

Beginning at age 14 days, all rats were weighed once per week until they were 98 days old. Except for Group G-W and the age-at-blinding variable all Ss were treated the same.

Procedure

Breeding. Eleven female rats were mated with 3 male rats to produce eight litters. For a period of 15 days 3 to 4 females were placed in a group wire mesh cage with one male. At days 5 and 10 the females were rotated to another male. On day 15 the females were removed from the males and placed in individual stainless steel solid-walled cages (10"X6"X6"). All litters were born within 20 days of each other.

At day 5 all litters were trimmed to seven pups each.

Blinding. On day 10, using the split-litter technique, pups were randomly assigned to one of six groups after being sexed and earpunched. Also at this time pups in Group G-10 were enucleated.

In order to enucleate these rats it was necessary to prematurely open their eyelids. All pups were returned to their mother as soon as possible.

Blinding consisted of etherizing the rat and then removing the entire eyeball. Removal was done by working scissors in behind the eye so that tissue, muscles and nerve could be easily cut. Although Group G-NB was not blinded, it was etherized at age 10 days.

Adaptation and Testing. Ss were weaned at 20 days of age and placed on a 21-hour food deprivation that lasted until the completion of the experiment (105 days). At 21 days of age Ss were placed in the open field of the Hebb-Williams without barriers and allowed to find their way to the goal box where they were fed and allowed to remain for their first regular three-hour feeding period. Beginning on the 22nd day of age Ss were adapted to the test problems of the Hebb-Williams maze by using the Rabinovitch and Rosvold (1951) procedure. Some modifications were made, however. The last two problems of the Rabinovitch-Rosvold adaptation series were eliminated since Ss had adapted well and it was important to begin testing as early as possible. Ss were given one adaptation problem per day and no problems needed to be repeated. Criterion for successfully completing an adaptation problem was a run of two successive trials in less than 60 sec. total. Beginning on day 26 all Ss were tested on the first of randomly assigned test problems of the Rabinovitch-Rosvold series, one through twelve. Ss were then randomly assigned to one of the first four days of the week and then tested weekly on

randomly assigned non-repeating test problems. Each S received each of the 12 problems but the order of the problems was counterbalanced across Ss.

When all Ss had experienced one session with each test problem, the experiment was terminated (105 days). A typical session consisted of eight trials in which the number of errors and time taken to run the maze were recorded. The S was always placed in the start box oriented toward the passageway and the trial was completed when S's nose touched the wet mash reward located at the far corner of the goal box. The S was allowed 20 sec. in the goal box after which it was placed for one min. in its cage before beginning the next trial. During this inter-trial-interval and between each session, the floor of the maze was wiped with a vinegar-water solution to clean it of odor trails and debris. The regular three hour feeding period commenced for all rats after the sessions were over. If a subject took longer than 10 min. to complete a trial that session was terminated and begun the next day on the same problem and at the aborted trial.

RESULTS

For the weight data an analysis of variance for unequal sample sizes was performed on the last points in Figure 1 (Winer, 1962). On Group G-NB a single factor (Weeks) ANOVA for repeated measures was performed on the error and time scores over all twelve weeks (Winer, 1962). Error and latency data of the early-blinded groups, Groups G-10 and G-20, were subjected to a mixed ANOVA (Groups X Weeks X Subjects). Errors and time data for all groups were divided into three blocks of weeks (Weeks 1-3, Weeks 4-7, and Weeks 8-12) and each block subjected to a mixed ANOVA (Groups X Weeks X Subjects) for unequal sample sizes (Winer, 1962). If treatment significance was found in any of the blocks then the blind group cluster and the non-blind group cluster in that block were further subjected to an orthogonal comparison between clusters and the Newman-Keuls test for within cluster differences (Winer, 1962).

Frequency of repetitions on the same test problem as well as within problem error and time scores over the last five weeks of testing, were noted and presented in table and figure form, respectively. They were not, however, subjected to any statistical analysis.

Weight

Figure 1 shows the weights of the five experimental groups as a percentage of the weight-control group, Group G-W. Although the experimental groups steadily gained weight from week to week (as absolute weights show) Figure 1 implies that the weight-control

animals gained proportionally more and at a faster rate. At days 91 and 98 the experimental groups were ordered according to their age at blinding with the earliest blinded rats weighing the least and the non-blind rats the most. There was no overall significance between the experimental groups when tested at 98 days ($F(4,24)=0.71$, $p>.25$).

Group-NB

The error and time scores of Group NB were subjected to an ANOVA for repeated measures. The change in error scores over the 12-week testing period was significant ($F(11,55)=2.11, p<.05$) with the greater number of errors occurring during the initial weeks. The time scores over the same period were not significant ($F(11,55)=1.01, p>.25$). As Figure 2 shows, however, error scores appear to be fairly stable for Group G-NB, thereby providing a baseline for comparison to other groups. Figure 3 shows similar stability for time scores.

Early-Blinded Groups (G-10 and G-20) Mixed ANOVA

Time and error scores of Groups G-10 and G-20 were subjected to a mixed ANOVA (Groups X Weeks X Subjects). The analyses of both error and time scores indicate that the changes (Subject X Weeks) illustrated in the respective figures (2 and 4) are significant shifts toward worsening performances in the Hebb-Williams maze (Errors: $F(11,110)=2.18, p<.05$, Time: $F(11,110)=17.33, p<.01$). For errors and time scores the treatment and interaction effects were not significant (See Appendix 1).

Errors: All Groups Mixed ANOVA, Orthogonal Comparison, and Newman-Keuls Test

The twelve weeks of testing were divided into three blocks, weeks 1-3, weeks 4-7, and weeks 8-12, the delineating points being the ages at which Group G-40 and Group G-70 were enucleated (Groups G-10 and G-20 were enucleated before testing began). Figures 2 and 3 show the distribution of errors across weeks. Figure 2 is the per group error scores while Figure 3 is the combined scores of the blind versus non-blind groups. A mixed ANOVA revealed that error scores between groups were significant in all three blocks of weeks, 1-3, 4-7, and 8-12 ($F(2,24)=13.25, p<.01$, $F(3,24)=4.33, p<.01$, and $F(4,24)=2.99$, $p<.05$, respectively). Neither the effect of weeks in any of the three blocks ($F(2,60)=1.35$, $F(3,90)=1.76$, and $F(4,120)=0.43$) nor the Groups X Weeks interaction ($F(8,60)=0.34$, $F(12,90)=0.94$, and $F(16,120)=1.51$) were significant. An orthogonal comparison between the blind versus non-blind treatment means indicated that the greater number of errors committed by the blind groups as compared to the non-blind groups was significant at the .01 level in all three blocks of weeks ($F(1,24)=51.67$, $F(1,24)=13.42$, and $F(1,24)=7.96$, respectively). A Newman-Keuls test within blind and non-blind clusters revealed no significance (See Appendix 1).

Time: All Groups Mixed ANOVA, Orthogonal Comparison, and Newman-Keuls Test

The time scores were analyzed in the same manner as the error scores, in three blocks of weeks, weeks 1-3, weeks 4-7, and weeks 8-12. Figures 4 and 5 show the distribution of time scores across

weeks. Figure 4 is the per group time scores while Figure 5 is the combined scores of the blind versus non-blind groups. A mixed ANOVA on the first block of weeks, 1-3, revealed significance at the .01 level between groups ($F(4,24)=7.39$) and at the .10 level for the within subjects effect of weeks ($F(2,60)=3.01$). There were no weeks by groups interaction significance ($F(8,60)=0.45$). In the second block of weeks, 4-7, the mixed ANOVA revealed significance at the .05 level for the within subjects effect of weeks ($F(3,90)=3.96$) but no significant treatment effects ($F(4,24)=2.09$) or weeks by groups interaction ($F(12,90)=1.49$). In the last block of weeks, 8-12, the mixed ANOVA revealed significance treatment effects at the .10 level ($F(4,24)=2.41$). There were no significant effect of weeks ($F(4,120)=0.52$) or groups by weeks interaction ($F(16,120)=1.30$). An orthogonal comparison between the blind versus non-blind treatment means indicated that the greater time scores of the blind animals in blocks 1-3 and 8-12 were significant at the .01 and .10 level, respectively ($F(1,24)=20.97$ and $F(1,24)=3.08$). The 4-7 block was not tested in this manner due to the lack of treatment significance revealed by the mixed ANOVA. The Newman-Keuls test revealed no significance within blind and non-blind clusters except in the 1-3 block where Group G-10 took longer to reach the goal-box than the other blind group, G-20. This difference was significant at the .01 level.

Repetitions and Within Problem Error/Time Scores

Only subjects in Groups G-10, G-20, and G-40 had to be re-run on the same test problems with Group G-20 having the greatest number of repetitions. Table 1 shows the distribution per group across

weeks. All rats, however, eventually completed the mandatory eight trials within three successive days.

Figures 6 and 7 show the overall within problem performance of the blind and non-blind groups during the last five weeks of testing. As the curves clearly illustrate, all the subjects' performance generally improved from trial to trial. The inferior performance of the blind rats is also clear.

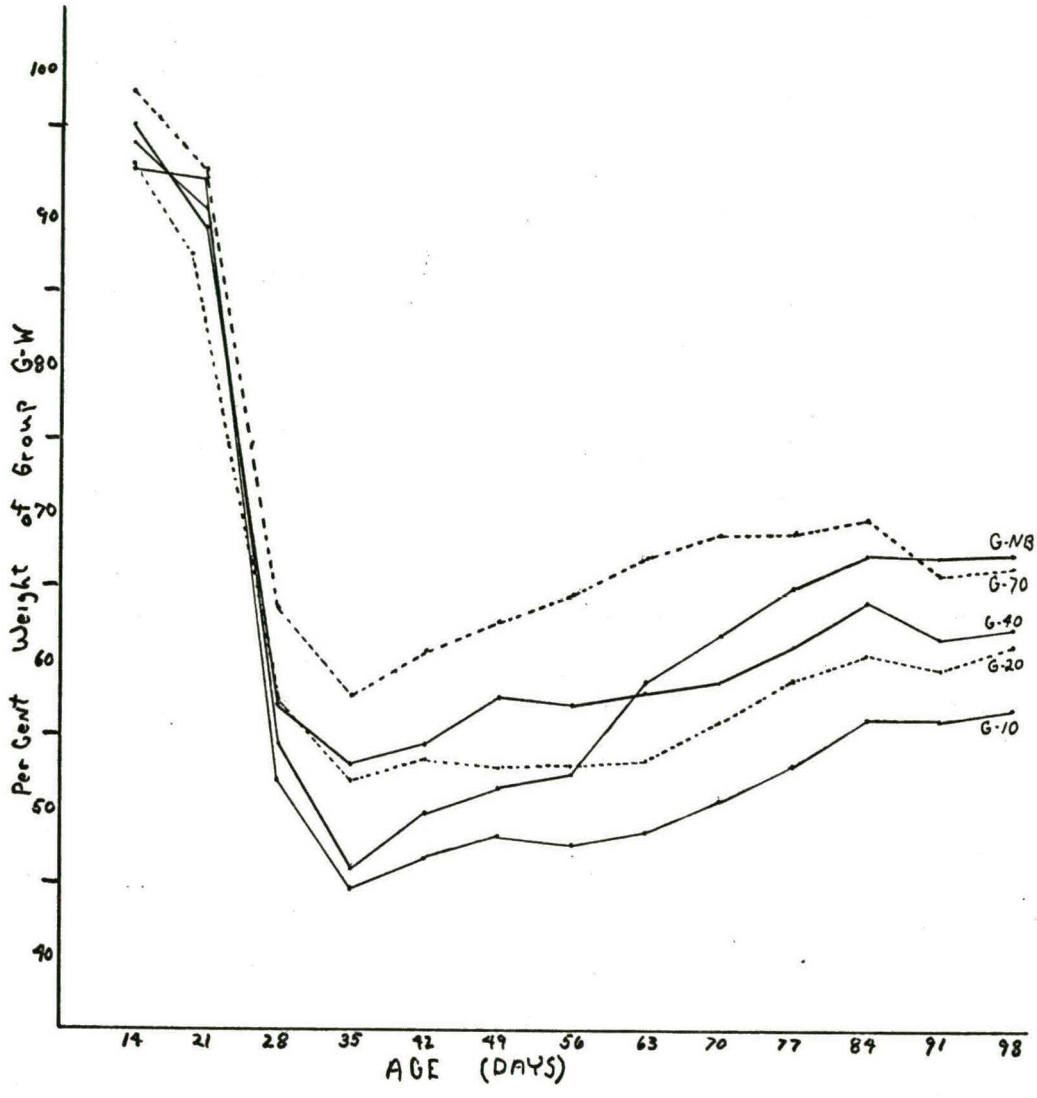

Fig. 1 Mean weight per experimental group as percentage of Group G-W across weeks

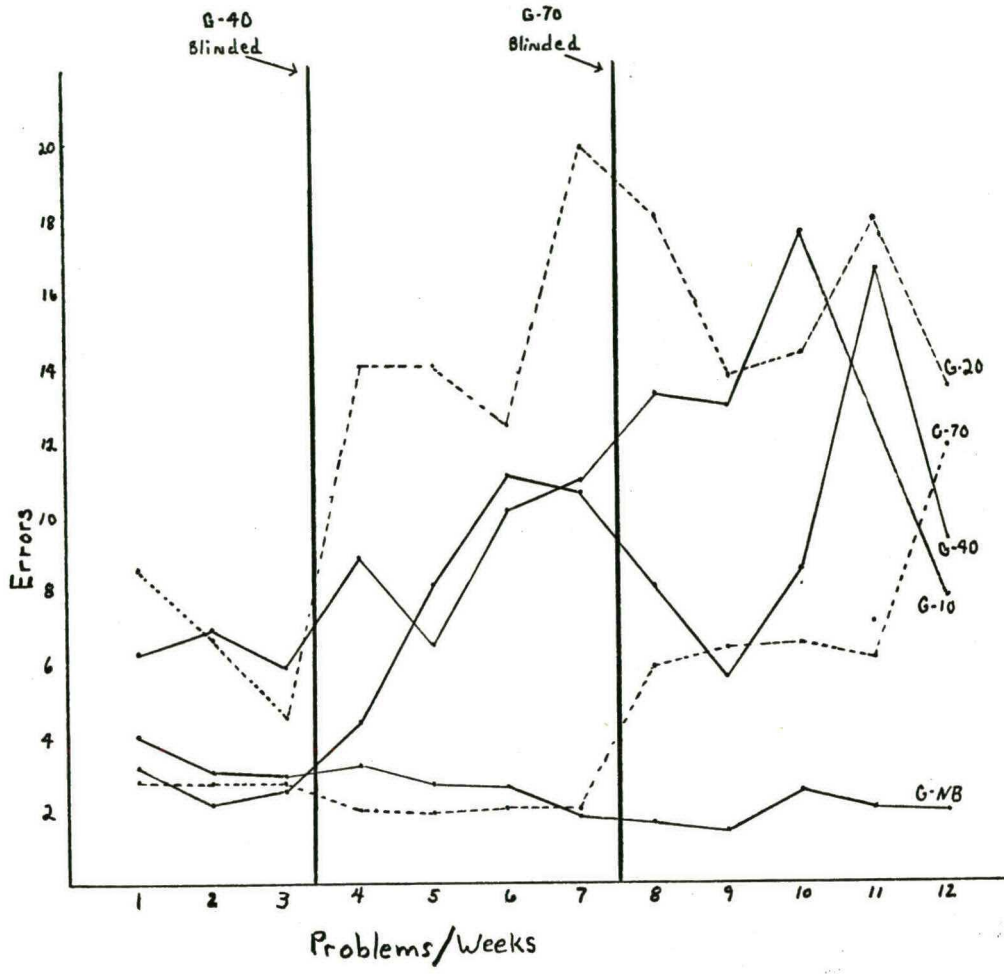

Fig. 2 Mean error scores per group across weeks

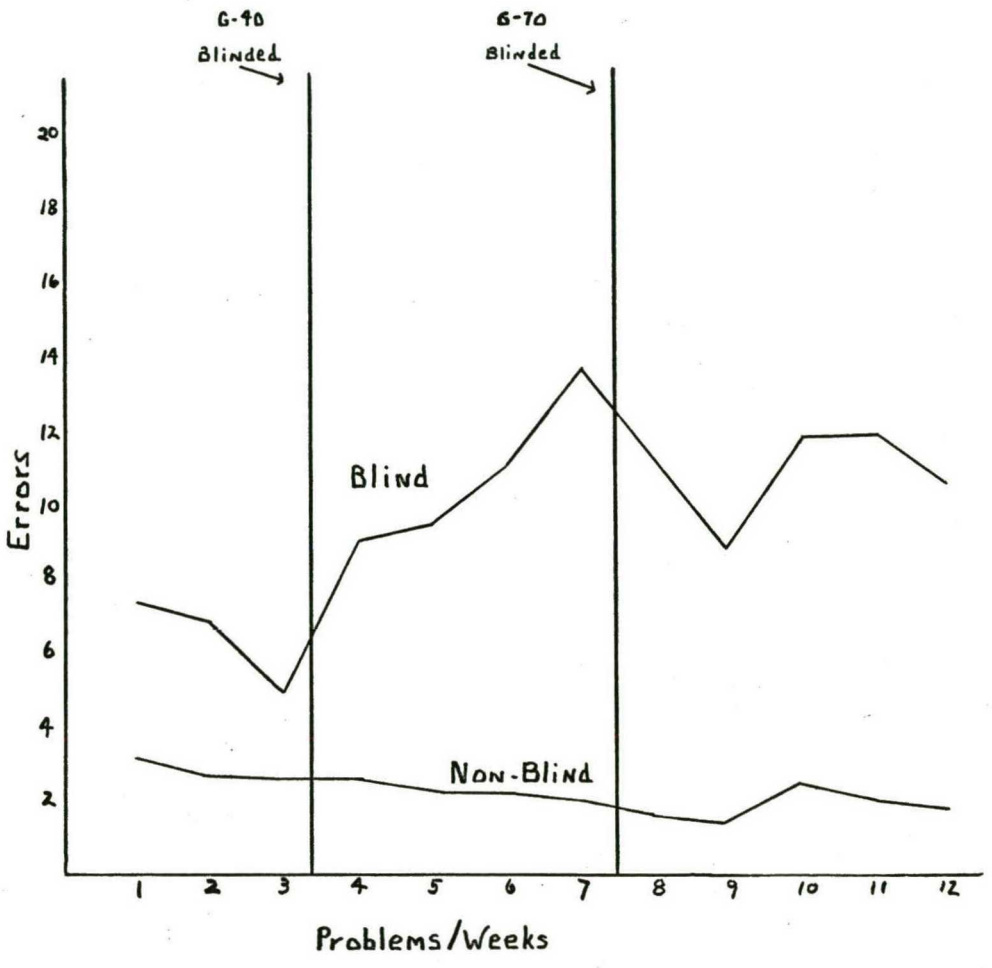

Fig. 3 Mean error scores per combined blind groups versus combined non-blind groups across weeks

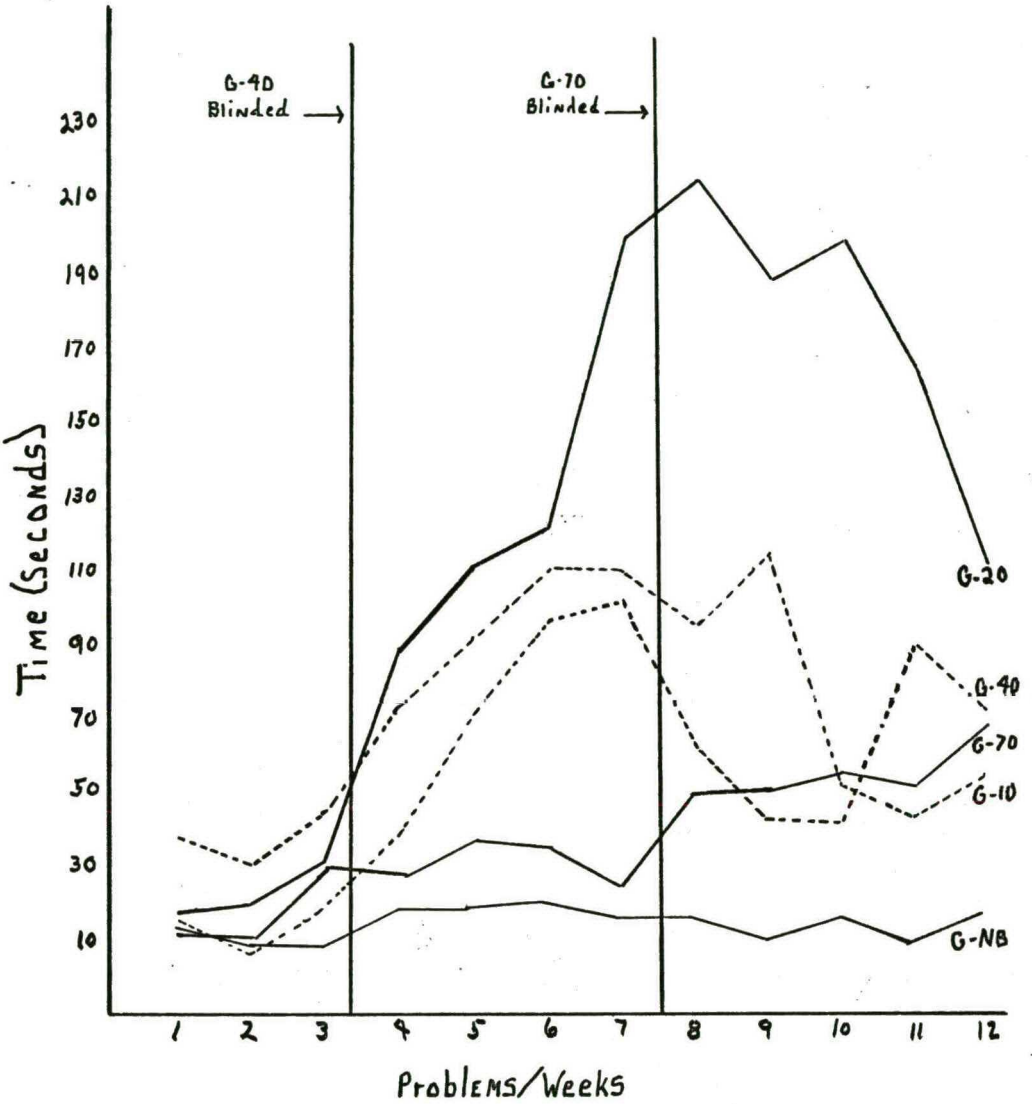

Fig. 4 Mean time scores per group across weeks

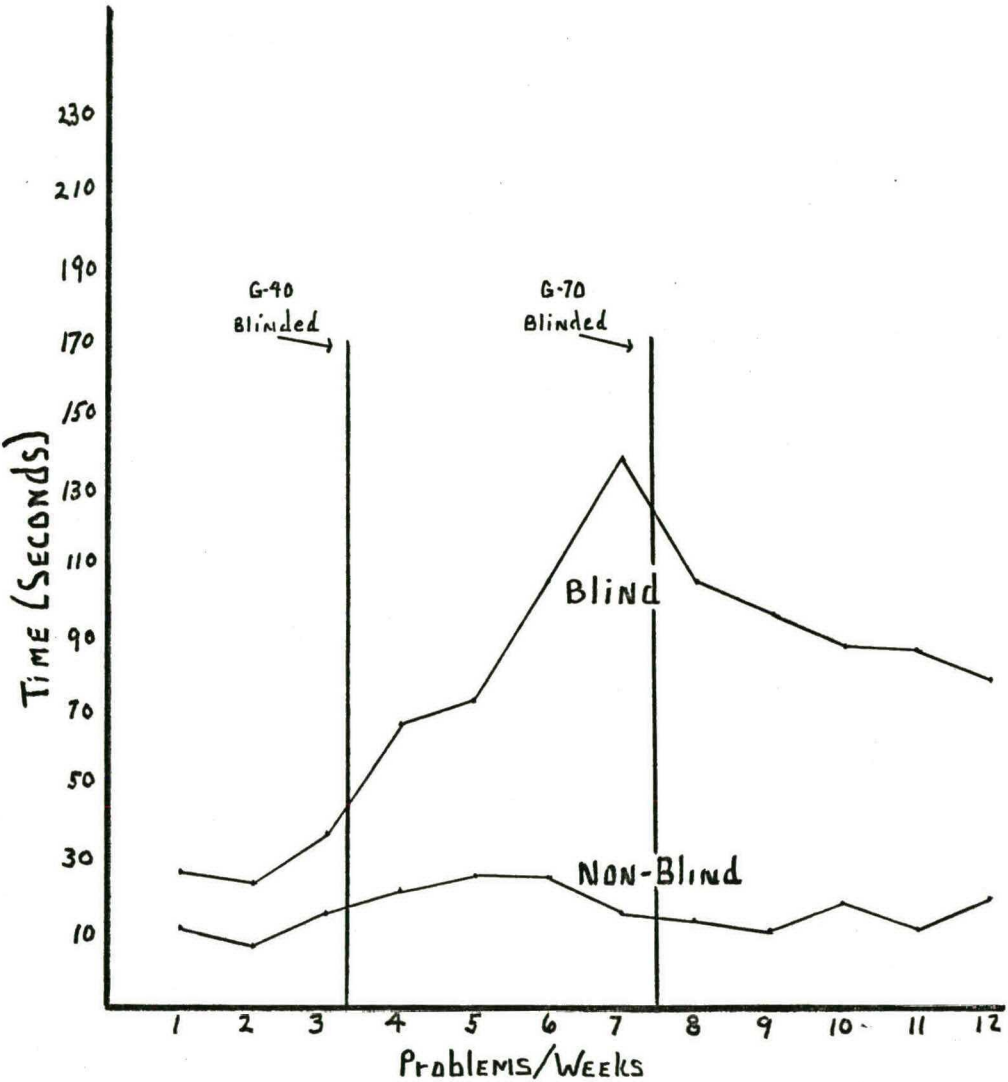

Fig. 5 Mean time scores per combined blind groups versus combined non-blind groups across weeks

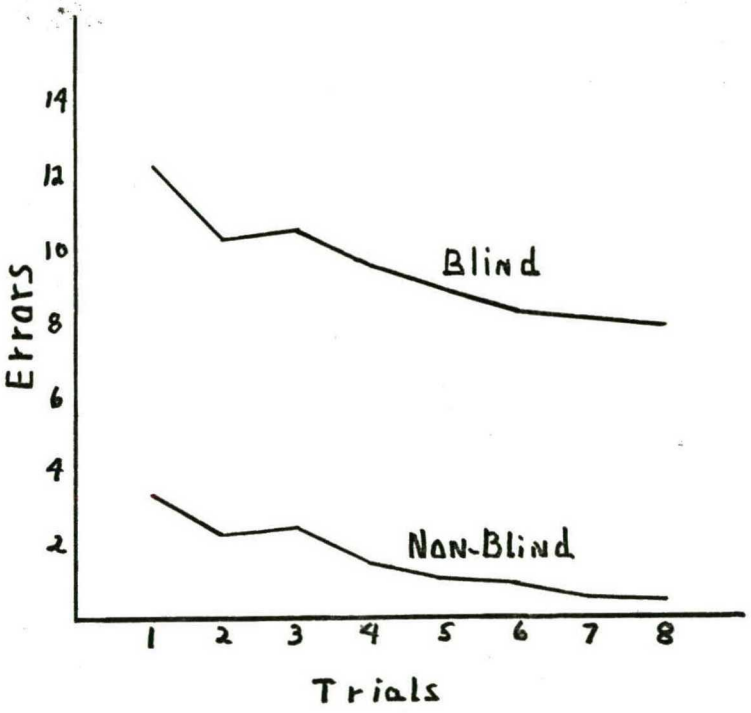

Fig. 6 Within-problem error scores per combined blind groups versus combined non-blind groups for last five weeks of testing

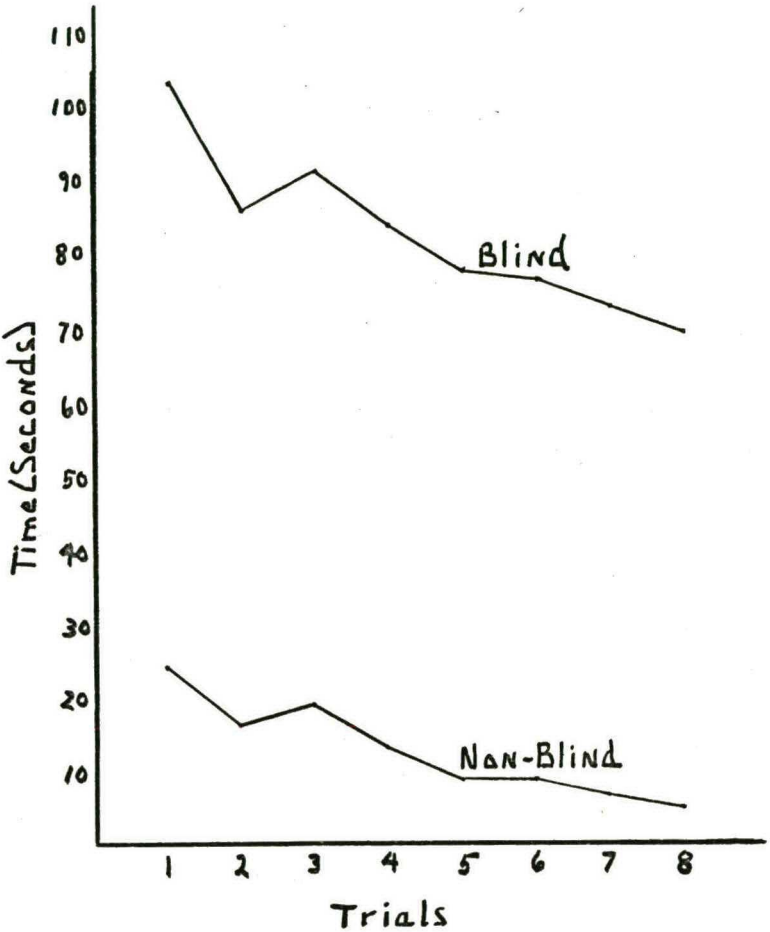

Fig. 7 Within-problem time scores per combined blind groups versus combined non-blind groups for last five weeks of testing

TABLE 1

NUMBER OF REPETITIONS PER GROUP

Problems/ weeks	G-10	G-20	G-40	G-70	G-NB
1 -	0	0	0	0	0
2 -	0	0	0	0	0
3 -	0	1	0	0	0
4 -	1	2	0	0	0
5 -	1	1	0	0	0
6 -	2	2	0	0	0
7 -	1	4	0	0	0
8 -	1	4	0	0	0
9 -	3	3	0	0	0
10 -	1	4	0	0	0
11 -	0	3	2	0	0
12 -	0	1	1	0	0
Total -	10	25	3	0	0

DISCUSSION

It seems that as far as errors and time scores in the Hebb-Williams maze are concerned the benefit of early integrated visual cues are minimal. In this experiment, information acquired via one modality, vision in this case, did not appear to transfer to another, namely, kinesthetic. Spigelman and Bryden (1967), however, have shown that rats blinded at 90 days of age were significantly better at a spatial auditory learning task than early-blinded rats on the same problem. Apparently, some transfer did occur.

Sighted rats performed consistently low throughout testing but the blind animals varied greatly from problem to problem in both errors and time. Even with this variability, however, the blind rats seemed to perform progressively worse (Figures 2 and 4). This is particularly evident in the scores of the two early-blinded groups, G-10 and G-20, up to about the seventh week of testing (about 75 days of age) where they peak out and begin a slight decline. Also, such variability of the blind groups was generally not enough to make the difference between them and the sighted rats nonsignificant.

In attempting to understand the absence of improvement over weeks, Schneirla's definition of "experience" (as Lehrman (1970) described it) may be useful: "the contribution to development of the effects of stimulation from all available sources (external and internal), including their functional trace effects surviving from earlier development". Presumably, the "functional trace"

effects are pretty much like Hebb's (1949) "structural trace". It appears then that there is little in the way of visual "functional trace" effects contributing to the blind animals' behavior in the maze. But, in addition, it seems that the lack of a functional trace, or its use, is not particularly disruptive at first, especially in the adaptive trials where all animals met criterion usually within three trials. Insofar as vision is concerned it seems that the functional trace must be triggered by the activity of the modality from which it was formed in order for it to begin to be beneficial.

The rat is a curious animal (Brown, 1968) and at the same time fearful of novel situations (Bolles, 1963). In the preceding experiment both processes seemed to be at work. The increased time and error scores of the blind animals indicate their heightened exploratory activity. Glickman (1958) found similar results and interpreted them in terms of the "optimal level of stimulation" concept; that is, with the loss of a sense organ comes activity meant to achieve the same level of arousal present under normal conditions.

In this experiment, the exploratory behavior of the blind animals seemed to be consequential to a fear response, that is, it was preceded by the state of fear. Also, it appears that the fear state was strong enough to suppress the strength of the deprivation state such that exploratory behavior increased. Generally, it is held that a state of deprivation in itself will decrease exploratory time (Young, 1961).

As to the nature of the fear response, it was exhibited only

by the blind animals and only at the entrance to the goal box. This manifested itself in the manner of slowly creeping through the passageway to a sort of vicarious-trial-and-error response of rocking the body back and forth while half in and out of the goal box. Many times it seemed as if the blind animal could locate the goal box within a reasonable amount of time and a minimum of errors but was fearful of entering. This was the greatest reason for the repetitions--fear of entering the goal box rather than inability to find it. Logically then, these rats would take longer to reach the food and commit more errors since they kept returning to the field to explore. This obvious fear of entering the goal box could be due to the rats' being aware somehow of the restricted nature of the box relative to the open field. The goal box is considerably smaller and, of course, lacks the barriers the animal encounters in the open field. The opportunity to be 'excited' then is diminished, so perhaps the only alternative to open field activity is to have an 'emotional' response. Curiously enough, once some of these animals were inside the goal box and the sliding door closed behind them, they would often ignore the food, freezing instead, or attempting an escape or some other avoiding behavior. This sometimes led to a repetition.

Blindness, as with fear, does not in itself prevent the occurrence of problem-solving behavior, at least with regard to the Hebb-Williams maze. Offhand, this fact seems to contradict, somewhat, Denenberg's contention (1969) that problem-solving behavior develops

only after the sensory modalities have matured and are fully functioning because rats having a limited amount of visual experience (Groups G-10, G-20, and G-40) were all able to solve the Hebb-Williams problems, just as the groups that had extensive visual experience were (Groups G-70 and G-NB). On the other hand, the simple fact that blind rats were able to learn (Figures 6 and 7) merely indicates the reliance of the organism on other sensory organs, presumably mature and fully functioning. The groups that were blinded early (G-10 and G-20) generally showed a significant trend toward worse performances from week to week. It may be then, as Denenberg claims, that the ability to solve certain problems is closely tied to the limits placed upon the organism by the nature of its sense organs, that is, mature sensory modalities lead to optimal problem-solving behavior.

Denenberg's idea might further be substantiated by comparing the non-blind group (Group G-NB) to the early-blind groups (Groups G-10 and G-20). By themselves, the curves of the non-blind group appear to be typical 'learning-to-learn' curves. However, the two early-blinded groups obviously performed progressively worse over the same period of time that the non-blind group was performing significantly better (errors).

In summary, this experiment has shown that the benefit of visual experience, whether of short or long duration, in aiding the problem-solving ability of a rat confronted with certain tasks, is minimal. There is, however, evidence suggesting that the improve-

ment in performance shown by sighted rats is a function of developmental processes. In addition, the data indicates that blinding an animal early in its life results in a heightened emotional response when confronted with novel stimuli.

APPENDIX 1

Analyses of Variance

Source		Item df	MS	F
Weight ANOVA for Last Two Points of Figure 1:				
	Treatment	4	1216.37	0.71
	Error	24	1718.69	
	Total	28		
Group G-NB ANOVA Across 12 Weeks Testing:				
Errors.....	Between Ss	5		
	Within Ss	66		
	Weeks	11	2.79	2.11**
	Residual	55	1.32	
	Total	71		
Time.....	Between Ss	5		
	Within Ss	66		
	Weeks	11	135.38	1.01
	Residual	55	133.64	
	Total	71		
Groups G-10 and G-20 Mixed ANOVA Across 12 Weeks Testing:				
Errors.....	Between Ss:			
	Treatment (A)	1	458.85	0.94
	Ss within groups	10	488.09	
	Within Ss:			
	Problems/Weeks (B)	11	150.74	2.18**
	AxB	11	55.26	0.80
	BxSs within groups	110	68.95	
Time.....	Between Ss:			
	Treatment (A)	1	30021.33	0.28
	Ss within groups	10	108106.94	
	Within Ss:			
	Problems/Weeks (B)	11	59298.33	17.33*
	AxB	11	1767.88	0.52
	BxSs within groups	110	3420.77	

*p < .01
**p < .05
***p < .10

APPENDIX 1
(continuation)

Analyses of Variance

Source		Item df	Item MS	Item F
All Groups Mixed ANOVA:				
Errors:				
Block 1-3:	Between Ss:			
	Treatment (A)	4	192.84	13.25*
	Ss within groups	24	14.55	
	Within Ss:			
	Problems/Weeks (B)	2	14.71	1.35
	AxB	8	3.71	0.34
	BxSs within groups	60	10.90	
Block 4-7:	Between Ss:			
	Treatment (A)	4	2498.29	4.33*
	Ss within groups	24	577.35	
	Within Ss:			
	Problems/Weeks (B)	3	48.19	1.76
	AxB	12	25.71	0.94
	BxSs within groups	90	27.32	
Block 8-12:	Between Ss:			
	Treatment (A)	4	3766.66	2.99**
	Ss within groups	24	1260.06	
	Within Ss:			
	Problems/Weeks (B)	4	17.51	0.43
	AxB	16	62.08	1.51
	BxSs within groups	120	41.01	

*p < .01
**p < .05
***p < .10

APPENDIX 1
(continuation)

Analyses of Variance

Source		Item df	MS	F
All Groups Mixed ANOVA:				
Time:				
Block 1-3:	Between Ss:			
	Treatment (A)	4	6382.50	7.39*
	Ss within groups	24	863.09	
	Within Ss:			
	Problems/Weeks (B)	2	930.14	3.01***
	AxB	8	138.58	0.45
	BxSs within groups	60	309.23	
Block 4-7:	Between Ss:			
	Treatment (A)	4	189426.07	2.09
	Ss within groups	24	90759.59	
	Within Ss:			
	Problems/Weeks (B)	3	10547.42	3.96**
	AxB	12	3961.26	1.49
	BxSs within groups	90	2664.83	
Block 8-12:	Between Ss:			
	Treatment (A)	4	543833.68	2.41***
	Ss within groups	24	225850.04	
	Within Ss:			
	Problems/Weeks (B)	4	1706.93	0.52
	AxB	16	4245.83	1.30
	BxSs within groups	120	3272.36	

*p < .01
**p < .05
***p < .10

APPENDIX 1
(Continuation)

Analyses of Variance

Source		Item		
		df	MS	F
Orthogonal Comparison of Blind and Non-blind Clusters:				
Errors:				
Block 1-3:	Method	1	751.65	51.67*
	Ss within groups	24	14.55	
Block 4-7:	Method	1	7750.57	13.42*
	Ss within groups	24	577.35	
Block 8-12:	Method	1	10030.79	7.96*
	Ss within groups	24	1260.06	
Time:				
Block 1-3:	Method	1	18098.12	20.97*
	Ss within groups	24	863.09	
Block 8-12:	Method	1	696331.52	3.08***
	Ss within groups	24	225850.04	

*p < .01
**p < .05
***p < .10

APPENDIX 1
(continuation)

Analyses of Variance

Source		Item			
Neuman-Keuls Within Cluster Test:					
Errors:			G-40	G-70	G-NB
Block 1-3:	Non-blind:	G-40		0.50	1.46
		G-70			0.96
			G-10	G-20	
	Blind:	G-10		0.89	
			G-NB	G-70	
Block 4-7:	Non-blind:	G-NB		0.36	
			G-40	G-10	G-20
	Blind:	G-40		1.65	24.94
		G-10			23.29
			G-70	G-40	G-10	G-20
Block 8-12:	Blind:	G-70		8.08	18.66	37.30
		G-40			10.58	29.22
		G-10				18.64

*p < .01
**p < .05
***p < .10

APPENDIX 1
(continuation)

Analyses of Variance

Source		Item				
Neuman-Keuls Within Cluster Test:						
Time:			G-NB	G-40	G-70	
Block 1-3:	Non-blind:	G-NB		10.54	20.85	
		G-40			10.31	
			G-20	G-10		
	Blind:	G-20		42.87**		
			G-NB	G-70		
Block 4-7:	Non-blind:	G-NB		44.17		
			G-40	G-10	G-20	
	Blind:	G-40		15.51	211.55	
		G-10			196.04	
			G-70	G-40	G-10	G-20
Block 8-12:	Blind:	G-70		8.08	18.66	37.30
		G-40			10.58	29.22
		G-10				18.64

*p < .01
**p < .05
***p < .10

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