AMBIENT ILLUMINATION AND THE RESPONSE OF CHICKS TO A FLICKERING LIGHT

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by

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Recent experimental and theoretical work in the areas of imprinting and approach to a flickering light have pointed to the importance of (1) the internal state of the organism and (2) the intensity of stimuli occurring in these situations. Most research in this area fails to mention the visual (light) stimulation present prior to imprinting or approach to light tests. This study was directed toward the influence of light intensity in the environment in which the organism was raised (raising-environment) on the approach-withdrawal response to a flickering light. Two specific responses were predicted. Chicks raised in a low light intensity environment will not approach a high intensity intermittent light stimulus as much as they will a low intensity intermittent light stimulus and chicks raised in a high light intensity environment will not approach a low intensity intermittent light stimulus as much as they will a high intensity intermittent light stimulus.

Forty white leghorn chicken eggs were incubated. Chicks were reared in isolation pens. Twenty chicks were raised in darkness while the other twenty were raised in 200 ft. C. illumination. Chicks were tested at 16 and 40 hours in a three foot runway with 10 and 200 ft. C. red flickering test lights. Two orders of test light presentation were used. Tests lasted five minutes with two tests at each time of testing. Random noise was present throughout the experiment.

Approach-withdrawal responses were measured by the time spent in each of five sections of the test runway. A four dimensional analysis of variance showed only the time of testing (16 and 40 hours) main effect to be significant. Order of test light presentation vs. time of testing, order of test light presentation vs. test light intensity, and raising condition (dark or 200 ft. C.) vs. time of testing were the significant interactions.

The results were discussed in terms of two tenable interpretations. Chicks may have approached the test light at 40 hours after hatch more than at 16 hours because of experience and familiarity with the test lights gained during the 16 hour test. It is also possible that the group reared in darkness did not mature at the same rate as the chicks raised under high illumination. After exposure to the test lights at 16 hours the group raised in darkness may have "caught up" to the group raised in under high illumination and at 40 hours both groups approached the test lights to the same degree.

Several conclusions were drawn from this study. The two specific responses predicted were not observed, however the ambient illumination in the chicks raising-environment was an important variable. Time of testing chicks was also an important parameter of the approach response. Intensity of the test light and order of presenting the test light had a negligible effect of approach responses.

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INTRODUCTION

Recently Moltz (1963) developed a theory of imprinting drawing heavily from the work of Schneirla (1959). The theory uses the principle that in early ontogeny the magnitude of stimulation impinging on the organism controls approach (A-type) and withdrawal (W-type) behavior.

Low magnitude stimulation elicits A-type behavior through the parasympathetic nervous system; through the concurrence of parasympathetic arousal with low intensity stimulation an "organic set" is developed. In terms of this set an animal can readjust his position in an attempt to maintain external stimulation within an intensity range optimal for the set.

Imprinting, according to Moltz, is a precocial bird's attempt to maintain stimulation within the optimal intensity range of the A-type organic set. When an object moves away from the organism stimulus intensity falls and the organism follows (approaches) in an attempt to maintain optimum intensity of stimulation. As an object approaches stimulus intensity increases and the organism will not approach or may withdraw to bring stimulus intensity within the optimum range of the A-type organic set.

Experimentally Moltz (1963) found that an insignificant number of birds imprinted an object which was only seen when moving toward the bird. Strength of imprinting was significantly weaker than in a group of birds imprinted on an object seen only when retreating from the bird. Of the subjects seeing only the object moving away, a highly significant percent imprinted on the retreating object.

The importance of an organism's internal state and of stimulus intensity has been stated by Kovack and Hess (1963) using a different approach than Moltz. These investigators gave various intensities of shock to chicks of different ages while the chicks were in the presence of a moving object. The results indicated that "there is an optimal intensity of excitation at which following is maximal."

Sudden auditory stimulation given chicks while in the presence of a moving object resulted in stronger imprinting than in a control group not receiving the sudden stimulus. Pitz and Ross (1960) suggest the importance of "a certain level of arousal or CNS activation."

Smith and Hoyes (1961) used a blinking light as a stimulus. They compared a dull (.002 ft. C.) and bright (.36 ft. C.) light. A significantly greater number of chicks approached the brighter light. These authors conclude that intensity is a crucial variable in a chick's response to an intermittent light stimulus.

The above works point to the importance of (1) the internal state of the organism and (2) the intensity of stimuli occurring in the test situation. The general trend of imprinting and approach to light research and theory appears to be towards the precise identification of the relationship between the above two factors. In previous research the conditions of raising before imprinting or approach to light are described in terms of temperature, isolation, and time, however, the intensity of illumination in the raising environment is rarely stated. Several investigators have raised chicks in darkness, e.g., Hess, Smith and Hoyes; however, many other studies have not indicated the illumination conditions of the test animals prior to testing or imprinting.

Since the majority of imprinting and approach to flickering light studies use visual stimuli it is apparent that the intensity of visual stimulation in the raising and testing situations may be related and may be an important parameter to be studied and controlled. The research reported below is directed toward this problem. In general, it is expected that the intensity of the ambient illumination in the raising environment will influence the approach to a flickering light. It is further expected that this influence will be apparent in two specific ways. First, chickens raised in a low light intensity environment should not approach a high intensity intermittent light stimulus as much as they would a low intensity intermittent light stimulus. Second, chickens raised in a high light intensity environment should not approach a low intensity intermittent light stimulus as much as they would a high intensity intermittent light stimulus.

METHOD

Subjects: Fertile White Leghorn eggs were procured from the MSU poultry farm. They were incubated in two Brower 36 egg incubators. Within two hours after hatching each chick was placed in an isolation pen. Chicks were randomly assigned to pens and treatment groups. A total of forty chicks were raised in isolation. Twenty were raised in darkness and twenty in 200 ft. C. illumination.

Apparatus: After hatching the chicks were transferred to raising pens. Each chick occupied a 11.5" x 11.5" cubicle with 12" walls constructed of white 1/2" celotex. The cubicles rested on 1/4" chicken wire raised one inch off the ground. Cubicle floors were covered with newspapers. Low intensity (darkness) raising pens were covered with white bed sheet. High intensity raising pens were covered with several layers of waxed paper which had high transmittance but eliminated any "light spots." Light was provided by 300 watt bulbs, one hung above every two pens. The illumination was 200 ft. C. fairly evenly distributed in each pen. All light readings were made with a Grossen industrial light meter.

Each chick was tested in a runway three feet long, one foot wide, and one foot high constructed of 1/2" white celotex. The runway rested on 1/4" chicken wire elevated one inch off the ground with newspapers covering the floor. The runway was unobtrusively marked off into five sections of equal size. At one end of the runway a 3" diameter hole was cut 1-1/2" from the runway floor. A piece of red heat resistant gelatin paper was used as a filter to cover the hole. A TDC slide projector was placed 10" from the red filter. Light intensity from the projector was controlled by a General Radio Variac. The chicks were tested at 10 and 200 ft. C. A Marrietta variable speed motor with 1/8" shaft was placed one inch from the red gelatin filter. A piece of cardboard in the shape of a half circle was mounted on the shaft. The cardboard was rotated so that the light from the projector was on in the runway .5 sec. and off .5 sec. The test and raising apparatus were maintained at the same temperature, 88-92 degrees F. Ambient illumination around the test runway was about 5 ft. C.

A General Radio noise generator (noise spectrum 20-20,000 cps) was run at 4-1/2 volts to provide a masking noise. The noise was fed through a 10 watt Bell amplifier. The amplifier output went to two Quam 4" speakers, one for the low intensity and one for the high intensity raising groups. Random noise was present in the test situation also.

Procedure: Each chick was carried by hand from his pen to the test runway by the experimenter. He was placed at right angles to the light in the middle section of the runway. After a half minute adaptation the blinking light was turned on and time spent in each of the five sections of the runway was recorded by stop watch. Observations of the chick's behavior were also recorded. After a five minute test the chick was picked up and replaced in the middle of the runway at right angles to the test light. After thirty seconds the light was presented again; however, the intensity was different from the previously used light intensity. After the second five minute test the chick was carried back to his pen. The same procedure was followed at two separate times, once at 16 hours after hatch and again at 40 hours after hatch.

There were, then, four conditions varied in the experiment. Chicks were raised under high or low intensity illumination. They were tested at 16 and 40 hours after hatch. All chicks were tested with two light intensities, 10 and 200 ft. C., at both test times. Two orders of test light presentation were used. Twenty chicks, ten from each raising condition, received order 1, which was high intensity test light first and low intensity light second. The remaining twenty chicks received order 2, which was low intensity test light first and high intensity light second. This experimental design is summarized in Table 1.

Table 1. Summary of experimental design.

			16 Hours		40 Hours	
		Subject				
High Intensity Environment	Order 1	1 10	High Test Light	Low Test Light	High Test Light	Low Test Light
	Order 2	11 20	Low Test Light	High Test Light	Low Test Light	High Test Light
Low Intensity Environment	Order 1	21 30	High Test Light	Low Test Light	High Test Light	Low Test Light
	Order 2	31 40	Low Test Light	High Test Light	Low Test Light	High Test Light

RESULTS

Raw data for each chick consisted of the amount of time spent in each section of the runway during each five minute test. A chick's data for each five minute test was converted into a weighted mean score. The weights used were the distances from the far end of each section to the red filter paper. This distance was multiplied by the time spent in the corresponding section. Theoretically weighted mean scores could range from 360 (maximum approach) to 1800 (maximum withdrawal) with 880 being the score if the chick did not leave the starting section. A four dimensional (2 x 2 x 2 x 2) analysis of variance was performed on the weighted means. Table 2 presents the results of the analysis.

From the recorded observations of the chick's behavior it was noted that each group of chicks displayed similar variability and types of behavior.

One main effect, time of testing, was significant at the .001 level of confidence. The chicks spent more time closer to the light (approached more) when tested at 40 hours than when tested at 16 hours. The difference exhibited in this main effect appears to be an outcome of the raising condition vs. time of testing interaction which will be discussed below.

Table 2. Summary of analysis of variance.

Source	SS	df	MS	F
Order (a)	30,803	1	30,803	--
Raising light (b)	267,978	1	267,978	1.556
a b	53,362	1	53,362	--
Between Subjects	6,198,637	36	172,184	
Total Between Ss	6,550,780	39		
Time of test (c)	436,393	1	436,393	15.297***
Test light (d)	3,784	1	3,784	--
a c	153,635	1	153,635	5.3856*
a d	236,542	1	236,542	8.29**
b c	521,893	1	521,893	18.29***
b d	41,601	1	41,601	--
c d	36,119	1	36,119	--
a b c	9,242	1	9,242	--
a b d	111,411	1	111,411	3.905
a c d	47,268	1	47,268	1.656
b c d	24,849	1	24,849	--
a b c d	63,033	1	63,033	2.21
Error	3,080,958	108	28,527	
Total Within	4,766,728	120		
Total SS	11,317,508	159		

Note: * = .05
** = .01
*** = .001

Of the interactions four were significant beyond at least the .05 level of confidence. First, order of test light presentation vs. time of testing was significant at the .05 level. The weighted means for this interaction are given in Table 3. It is evident that the chicks tested with order 2 increased in approach responses at 40 hours more than the order 1 chicks. A t-test for correlated means failed to find significance between any of the cells. The nature of the interaction (see Figure 1) was the change in mean approach between 16 and 40 hours for the order 2 group.

Secondly, the order of test light presentation vs. test light intensity interaction was significant at the .01 level. The weighted means are given in Table 4. There is no significant difference between any of the cells as tested by critical difference or t-test. The interaction is the result of the balanced design used. Any parallel trend in the order 1 and 2 data appear as an interaction in the analysis of variance. It is apparent that whichever light was presented second was approached more than the light presented first.

Third is the raising condition vs. time of testing interaction which is significant at the .001 level. From Table 5 of means it is evident that the interaction results from the large score of the chicks raised in the low illumination environment and tested at 16 hours, regardless of test light intensity. Critical difference and t-test show the mean in cell c to be significantly larger (.01 level) than the other means in the table.

Table 3. Interaction: order of test light presentation and time of testing--in weighted mean scores.

	16 Hours	40 Hours
Order 1 (Hi-Lo)	827	784
Order 2 (Lo-Hi)	861	695

Table 4. Interaction: order of test light presentation and test light intensity--in weighted mean scores.

	High	Low
Order 1 (Hi-Lo)	849	762
Order 2 (Lo-Hi)	744	811

Table 5. Interaction: raising condition and time of testing-in weighted mean scores.

	16 Hours	40 Hours
High Raise (200 ft. C.)	746	756
Low Raise (Darkness)	942	723

Figure 1. Order of test light presentation vs. time of test intensity interaction.

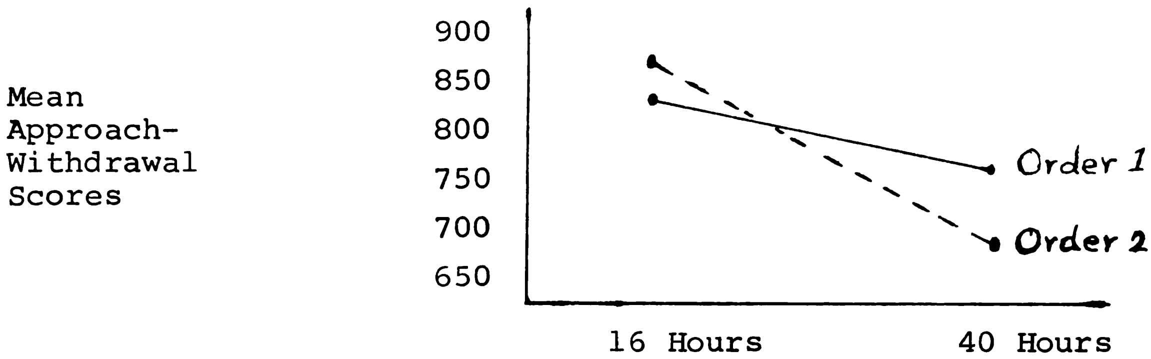


Figure 2. Order of test light presentation vs. test light intensity interaction

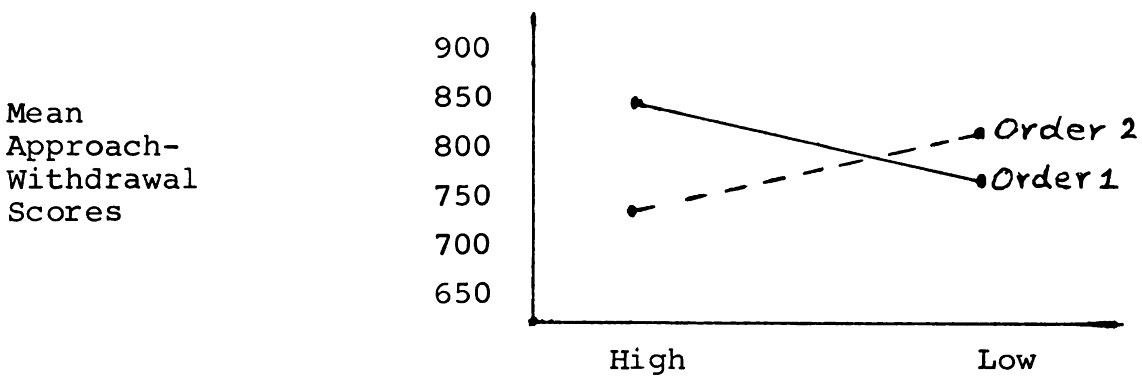
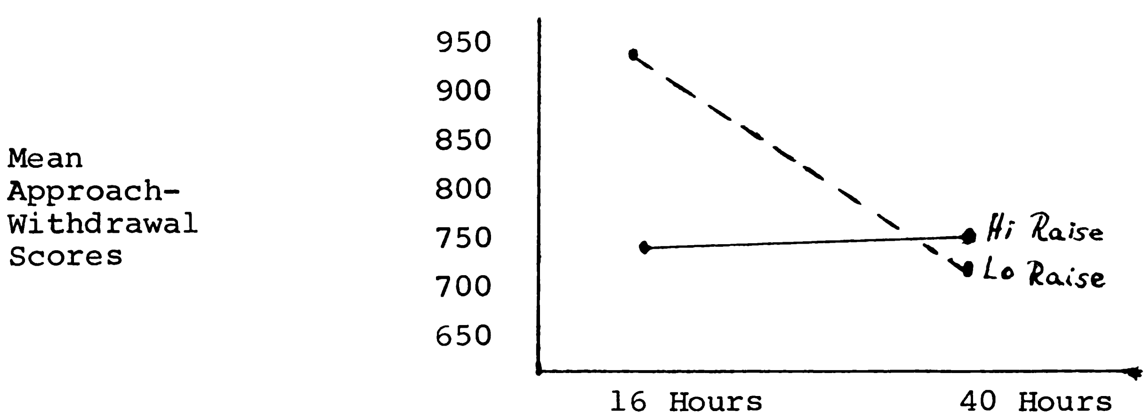


Figure 3. Raising condition test light vs. time of testing interaction.



DISCUSSION

It is evident that the results do not support the two specifically predicted responses. More importantly the general expectation being tested (raising light intensities affect approach-withdrawal responses) did have support. First, chicks raised in darkness and subjected to light at 16 hours stayed farther from the flickering light than the chicks raised under high illumination (refer to Table 5). At 40 hours the chicks raised in darkness approached the flickering light significantly more than at 16 hours. One way of looking at the above behavior is that it is a reaction to avoid an unfamiliar stimulus or at least not to approach it. The chick's reared in darkness experienced light for 10 minutes at 16 hours. It is possible that this experience familiarized the chicks with light. Then, when tested at 40 hours, these same chicks approached the light to the same degree as chicks reared in 200 ft. C. illumination. Further support for this interpretation can be found in the order of test light presentation vs. test light intensity (Table 4) interaction. Chicks approached the light more during the second five minute test than during the first five minute test, regardless of test light intensity first experienced.

In other words, after an experience with a test light the chicks would more quickly approach more closely either light intensity.

The order of test light presentation vs. time of testing interaction (Table 3) supports the idea of increased approach to the light with increasing experience. Regardless of the order of test light presentation the chicks approached more at 40 hours than at 16 hours.

A second interpretation is also supported by the results. The chicks reared in darkness may mature at a different rate from the chicks raised in high intensity illumination. This explanation might be particularly appropriate in regard to the raising condition vs. time of testing interaction. There was little change in the approach response of chicks raised in high illumination at 16 and 40 hours. Chicks reared in darkness, however, approached significantly more at 40 than at 16 hours. These chicks approached significantly less than the chicks reared in 200 ft. C. illumination at 16 hours only. It is possible that darkness retarded development of the approach response. After exposure to light at 16 hours plus twenty-four hours additional development time that dark reared animals "caught up" or developed to a level similar to that of the chicks reared in 200 ft. C.

Imprinting experimenters and theorists have been very much interested in the critical period. The critical period has been thought to be the period of time when imprinting or following was most likely to occur. Studies dealing with approach to light have not examined the critical period. While imprinting and approach to light responses have not been equated many similarities have been noted and discussed. The results of this study appear to show a dissimilarity between imprinting and approach to light. There was no evidence of a critical period or "time limit" on the chicks approach to lights response. Actually the opposite occurred. The chicks approached the test light significantly more as they increased in age. It should be noted that this result can be taken as a contraindication to interpreting the results of this study in terms of fear responses. Hess (1959) hypothesized the development of fear as the major variable terminating imprintability, e.g., ending the critical period. In this study there was no evidence of the end of a critical period and fear may not have appeared.

The above discussion cannot be taken to mean that there is not a critical period for the approach to light response. The study only tested two points on the time continuum and it is possible that both points were in the early or later part of the critical period. It is also possible that the response measures used were not sensitive to a critical period. A much more thorough study of the relation between time and response to light is necessary before any conclusive statement can be made.

While the effect of arousal on the approach response was not directly studied in this experiment two questions are implied by the results. First, does the stimulation resulting in increased arousal and consequently greater imprinting need to be different from the light which is to be approached or the object to be followed? The present study found no difference in response to high vs. low test light. If a substantial increase in light intensity, i.e., 10 to 200 ft. C. is considered a stimulus which might increase arousal a difference in response would have been expected. It is possible that the present study used two light intensities which were both on the upper end of a scale of intensities for a chicken. Secondly, perhaps another distinguishing feature between imprinting and approach to light behavior is the effect of arousal. Several studies mentioned earlier have indicated that increased arousal strengthens imprinting. It is possible that the operations used in these studies to increase arousal will result in no effect on approach to light responses.

The results of this study are somewhat similar to those of Polt and Hess (1964).[1] They gave chicks a two hour presentation of a 100 watt bulb before testing in Hess's imprinting apparatus. Two experimental and two control groups were used. Controls were kept in darkness until tested. Experimental groups were exposed to light at

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[1]The experiment reported in this thesis was conceived and executed between October, 1964, and March, 1964, prior to publication of the Polt and Hess work.

either 16 or 48 hours after hatch and then tested. The only significant ($p < .05$) difference in following was between chicks exposed to light and tested at 48 hours and the control chicks tested at 48 hours.

Although analysis of variance was not used by Polt and Hess it appears that there was an interaction between time of testing and light intensity of the environment prior to testing. This is essentially the same result found in this study. But, this comparison only holds in a very general way. When more closely examined it is seen that the significant behavioral differences do not occur at the same testing time, e.g., Polt and Hess found a difference at 48 hours while this study found the difference at 16 hours after hatch. Since very different methodologies and analyses were used in the two experiments an explanation for this discrepancy does not appear self-evident.

By way of summary several conclusions can be stated. The time of testing chick approach to a flickering light is an important and significant parameter to be controlled and studied. Intensity of the ambient illumination in the raising-environment of chicks appears to influence subsequent approach to a flickering light as a function of the time of testing. Further experimentation in this area should control and report pre-test visual (light) environment. Otherwise experiments will not be comparable.

The results imply that test light intensity and order of test light presentation have a negligible influence on chick's approach to light. Two interpretations of the results were discussed. Familiarity with light and differing maturation rates are both tenable and supported by the results. Further experimentation is obviously necessary. This study also leads to several other experimental possibilities. These are: (1) is arousal influential on approach to light behavior? (2) Is it necessary for arousal to be in another sense modality or from a source other than the flickering light? (3) What is the detailed relation between raising-environment light intensity and time of testing, e.g., many points on the time continuum should be studied. (4) Does a critical period appear in the response to flickering light as it does in imprinting?

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APPENDIX I

T-test Values

Interaction: Order of Test Light Presentation and Time of Testing

order 1 --	16 hours	vs.	40 hours	t = 1.2
order 2 --	16 hours	vs.	40 hours	t = 3.11
40 hours --	order 1	vs.	order 2	t = 3.28

Interaction: Order of Test Light Presentation and Test Light Intensity

order 1 --	high	vs.	low	t = 3.27
order 2 --	high	vs.	low	t = 2.366
high test light --	order 1	vs.	order 2	t = 1.895

Interaction: Raising Condition and Time of Testing

Raise Low --	16 vs. 40 hours	t = 5.185
16 hours --	high raise vs. low raise	t = 3.86

APPENDIX II

Weighted Mean Scores

	Subject	16 hours		40 hours	
		Hi	Lo	Hi	Lo
	1	654	438	1034.4	591.6
	2	914.4	537.6	1080	1252.8
order 1	3	616.8	482.8	880.8	520.8
	4	592.8	464.4	608.4	410.4
	5	940.8	852	1236	1080
	6	780	542.4	672	428.4
	7	762	507.6	490.8	446.4
	8	806.4	464.4	717.6	1104
	9	1080	1080	1080	816
	10	936	610.8	765.6	585.6
High Raise					
		Lo	Hi	Lo	Hi
	11	841.2	1056	626.4	507.6
	12	644.4	690	681.6	540
	13	656.4	454.8	732	396
	14	591.6	572.4	628.8	577.2
	15	746.4	471.6	660	436.8
	16	1059.6	1056	848.4	540
	17	948	1080	1080	640.8
order 2	18	705.6	608.4	798	783.6
	19	760.8	732	574.8	532.8
	20	1018.8	1088.4	1382.4	1466.4
		Hi	Lo	Hi	Lo
	21	1080	1183.2	639.6	640.8
order 1	22	667.2	498	620.4	498
	23	1080	1080	1080	1080
	24	714	1080	794.4	570
	25	1080	1080	1080	837.6
	26	676.8	484.8	448.8	400.8
	27	856.8	548.4	543.6	400.8
	28	1080	1526.4	807.6	1573.2
	29	966	846	939.6	740.4
	30	1080	1412.4	1080	804
Low Raise					

	Subject	16 hours		40 hours	
		Lo	Hi	Lo	Hi
	31	1080	1080	1016.4	808.8
	32	871.2	997.2	484.8	452.4
	33	1016.4	1051.2	1101.6	942
	34	1080	730.8	944.4	531.6
	35	1080	1056	747.6	1126.8
	36	846	1080	452.4	376.8
	37	1080	1009.2	538.8	408.8
	38	792	879.6	862.8	498
order 2	39	535.2	424.8	486	493.2
	40	900	1080	566.4	519.6