Wagner College Forum for Undergraduate Research

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EDITOR'S INTRODUCTION

This issue of the journal is of special significance. It is the first. The Wagner Forum for Undergraduate Research was formed to fill a void. It was felt by the editors that it is important to have an arena where students can publish their research and have a wider audience that can see what types of areas of academic intellect and expertise are being explored at Wagner College. The journal is devoted to publishing empirical and theoretical papers by undergraduate students in all disciplines. Papers are reviewed with respect to their scholarly merit. Length and type of articles have been determined by the paper's objectives and scope of contribution to its respective field.

To enhance readability, the Wagner Forum For Undergraduate Research has been subdivided into three sections entitled *The Natural Sciences*, *The Social Sciences* and *Critical Essays* respectively. The first two sections are limited to papers and abstracts dealing with scientific investigations (experimental and theoretical). The third section is reserved for speculative papers based on the scholarly review and critical examination of previous works.

From the natural sciences, a paper by Shanfeld and Falabella describes winning lotto numbers and to what extent winning the lotto is a matter of luck or chance. Those of you interested in striking it rich and becoming wealthy quickly might be interested in this article. A technical note by Alauddin and Alauddin addresses the serious problem of arsenic contaminated groundwater in Bangladesh. The research focuses on the speciation of metabolites as a means of gaining a better understanding of how arsenic is assimilated by the body after ingestion and how individuals exposed can be detoxified. Another paper by Christina Owens and Donald Stearns describes the photosensitivity of early stage nauplii of brine shrimp. Many other articles encompassing the disciplines of physics, chemistry, biology, mathematics and computer science await the curious reader.

Additionally, from the social sciences, there is a report by Jessica Morin on the impact of a thin-ideal depiction in media and its impact on disordered eating among college students. A critical essay by Michael O'Connor, in his Senior Honors Project, gives us an interesting perspective on heroin abuse as a product of the urban environment as depicted in the literary works of Burroughs, Selby, Algren and Baldwin.

This issue would not have been possible without the dedication of faculty and students who have contributed to its publication. Special thanks go to the students who conducted the research showcased in this multidisciplinary publication. It is our hope that this forum will serve as a springboard for discussions amongst students and faculty and provide motivation for future endeavors.

Gregory Falabella and Richard Brower, Editors

Section I: The Natural Sciences

Full Length Papers

Technical Notes

Abstracts/Extended Abstracts

Winning Lotto Numbers: Pure Chance or Hidden Bias

Randye Joy Shanfeld and Dr. Gregory J. Falabella
Senior Honors Thesis[1]

This project is an investigation into whether or not picking certain numbers or combinations of numbers can increase the odds of winning a lotto jackpot. Data from recent New York State lotto drawings is collected and processed by a series of computer programs developed specifically for this task. Through careful scrutiny and a variety of statistical tests, interesting short and long-term trends are revealed. This information is then exploited in an attempt to increase the probability of selecting a winning ticket.

I. Introduction

Ever dreamed of winning the lottery? Thought if you only had a feasible system you could actually win? Well, it turns out that greed is wonderful motivation for mathematical research. In order to begin this research, one must know a little background information. To play the New York State lottery, a person first chooses six numbers from one through fifty-nine. After choosing numbers, this person buys a ticket for a dollar, in which they will be given two chances. Then all this person has to do is watch the drawing of the winning numbers on television, which occurs twice a week.

But what are the odds of actually winning the lottery? This can be found by performing a few simple mathematical calculations. The number of ways n objects taken r at a time can be chosen or arranged, are called permutations and denoted $_nP_r$ where

$$_nP_r = \binom{n}{r} = \frac{n!}{(n-r)!}$$

In a permutation the order of arrangement of the objects is important. For example, 123 is a different permutation than 132. If order is not important (e.g. lotto drawings) then combinations, $_nC_r$, rather then permutations are computed.

$$_nC_r = \binom{n}{r} = \frac{n!}{r!(n-r)!}$$

The number of ways six numbers can be selected from a possible fifty-nine is

$$_{59}C_6 = \binom{59}{6} = \frac{59!}{6!(59-6)!} = 45,057,474$$

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[1] Presented at the 56th Eastern Colleges Science Conference in Niagara, NY

Since each lotto game calls for two sets of six numbers, the odds of winning a lotto jackpot are 1 in 22,528,737. Another way of looking at this is that there are six chances of selecting any one correct number out of a choice of 59. There are only five chances of selecting a second number out of the remaining 58 choices and so on:

$$\left(\frac{6}{59}\right) \times \left(\frac{5}{58}\right) \times \left(\frac{4}{57}\right) \times \left(\frac{3}{56}\right) \times \left(\frac{2}{55}\right) \times \left(\frac{1}{54}\right) = \frac{6!(59-6)!}{59!} = \frac{1}{45,057,474}$$

In the past, it has been proven that the lottery, over any great length of time, is indeed fair. However, the existence of recent short-term patterns, or trends, is largely unknown. The discovery of short-term patterns could possibly help one make future number predictions, and create better odds of winning the lottery. Hence, making greed one of the objectives for the following research.

II. Governing Equations

When a population is numerically ordered according to size, the value that occupies the middle position is known as the median. To locate the median one must calculate its depth using the formula

$$d(\tilde{x}) = \frac{n+1}{2}$$

If d(x) is a decimal, the next consecutive integer is used as the depth. When this population is ordered it is beneficial to take its range, by subtracting the lowest value from the highest value.

When discussing probability of a population, the mean, or average, is usually calculated using the formula

$$\mu = \sum_{i=1}^{n} xP(x)$$

where each element, x, is multiplied by its own probability, P(x). The mean is also known as the expectation, and can be expressed as

$$E(x) = \sum_{i=1}^{n} x_i f(x_i) = \frac{1}{n}\sum_{i=1}^{n} x_i$$

The spread, or dispersion of data around the mean, is known as the variance, σ^2. The variance can be found using

$$\sigma^2 = E[(x-\mu)^2] = \sum_{i=1}^{n}(x_i-\mu)^2 f(x_i) = \frac{1}{n}\sum_{i=1}^{n}(x_i-\mu)^2$$

The nonnegative square root of the variance is the standard deviation, σ.

Expectation and variance apply to one variable. However, it is often useful to examine if there is a relationship between two parameters. Covariance is a measure of linear dependency, found by using the formula

$$Cov(x,y) = E[(x-\mu_x)(y-\mu_y)]$$

Another way of understanding the relationship between two parameters is by finding the linear correlation coefficient of the population. The linear correlation coefficient, ρ, is defined as

$$\rho(x,y) = \frac{Cov(x,y)}{\sigma_x\sigma_y} \qquad\qquad 0 \le \rho \le 1$$

When ρ equals zero, it is said that the parameters are linearly unrelated.

The probability that an event will occur, is defined as the relative frequency with which that event can be expected to occur. More simply put,

$$P(A) = \frac{X_A}{n}$$

where X_A is the number of times that event A occurs, and n is the total number of events. However, many conditions can effect the probability of more than one event, such as whether the events are independent. A and B are independent events, if the occurrence of one event does not influence the probability of the other event. In the case of independent events, the following formula can be used to calculate the probability of the events occurring.

$$P(A\ and\ B) = P(A)P(B)$$

III. Results

Initially, winning lottery numbers were collected for two years, from September 1999 to September 2001. The winning numbers were examined individually, with no regard to the specific ticket they came from or the other numbers involved in the jackpot. A FORTRAN program was then written to calculate the frequency of each number, and

the results were graphed. The resulting bar graph is known as a frequency distribution.
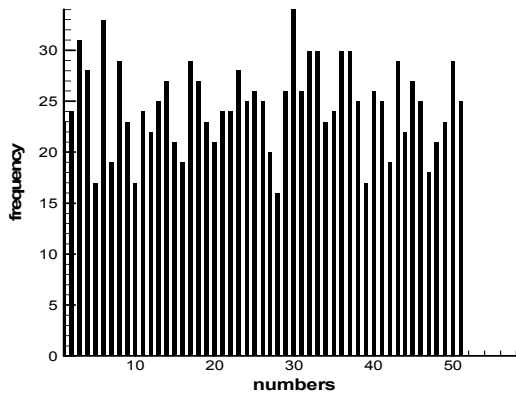

Figure 1: Winning New York State Lotto Numbers from 9/01/99 to 9/01/01

It can be seen in figure 1 that almost every lotto number has appeared between 15 and 34 times in lottery drawings between 9/01/99 and 9/01/01. Interestingly, the numbers 52 through 59 never once appeared during the time in question. Overall, the distribution of winning lottery numbers was found to be fairly even as expected.

Following the frequency, other preliminary statistics were calculated. The mean of the winning lottery numbers, μ, was found to be 24.88. Once the mean was computed, the variance and standard deviation was found. However, other than the obvious implications of the frequency distribution, the preliminary statistics did not reveal any significant results.

- Due to the inadequacy of the preliminary statistics, the winning lottery numbers needed to be examined more closely, looking at each individual ticket. With the examination of the tickets, the following questions were raised:
- With good confidence, can one state that the average of the six winning numbers fall within a specific range?
- Is there a high probability that the difference between the highest and lowest entries will have an upper and a lower bound?
- Is there a larger probability that the standard deviation will fall within a certain range?

A series of FORTRAN programs were then written to answer these questions. First, the mean was computed for each winning ticket, and it can be seen from figure 2 that all means fell between eleven and forty, with the majority between twenty and thirty.

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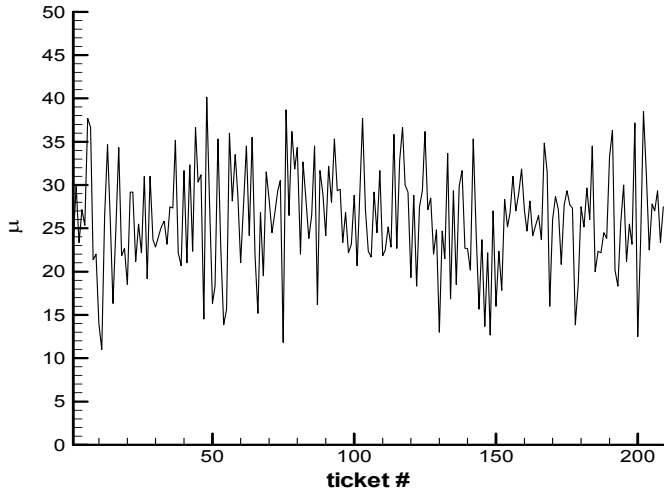
Figure 2: Mean of each winning ticket

The probability that the mean fell within a certain region was calculated, and it can be seen from figure 3 that the probability was the greatest between twenty and thirty. It also showed that it is largely improbable for the mean to fall within the regions zero to ten and fifty to sixty.
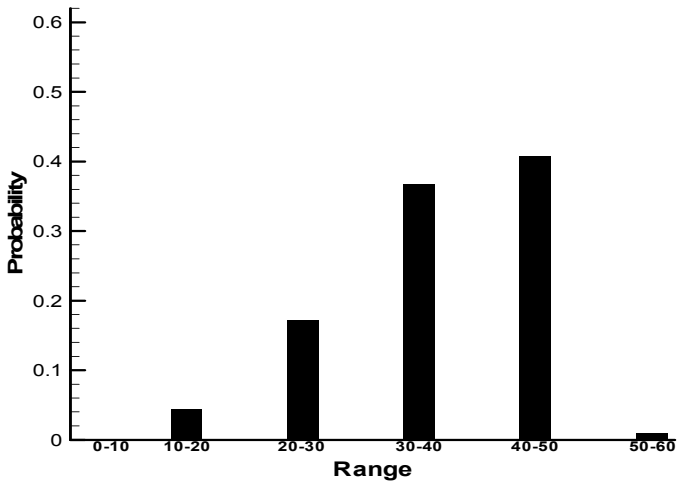
Figure 3: Probability of mean within a certain range

Following the mean, the range was calculated for each winning ticket, and through figure 4, it can be seen that all ranges fell between fourteen and fifty, with the majority between twenty-five and forty-five.
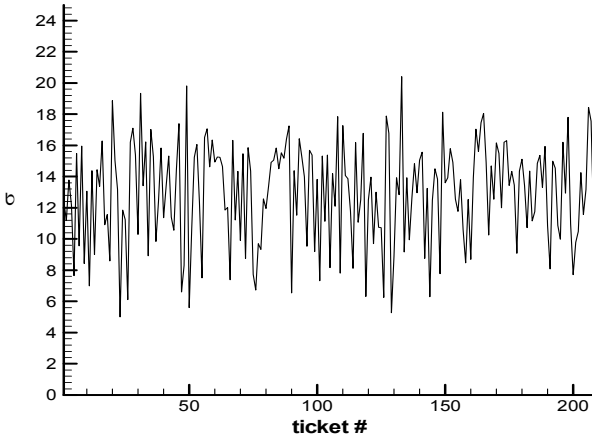
Figure 4: Range of each winning ticket

The probability that each ticket's range would fall within a certain region was then examined, and Figure 5 shows that the probability was the greatest with the range between thirty and fifty, having a probability between .36 and .40. It can also be seen that of all the winning tickets, no range fell between zero and ten.
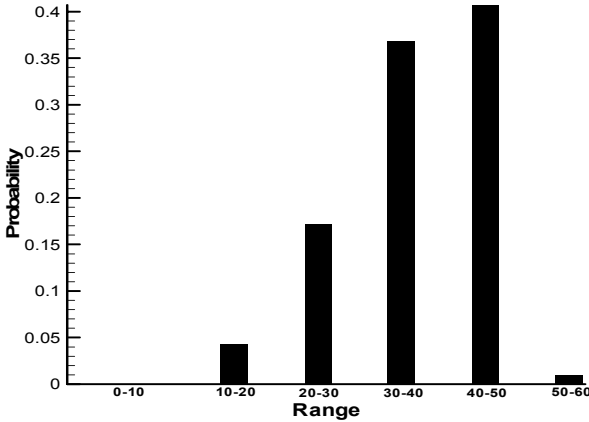
Figure 5: Range within a certain region

Next, the standard deviation of each ticket was investigated. The standard deviations, as shown in figure 6, all fell between 4.5 and 20.8, with the majority between ten and sixteen.
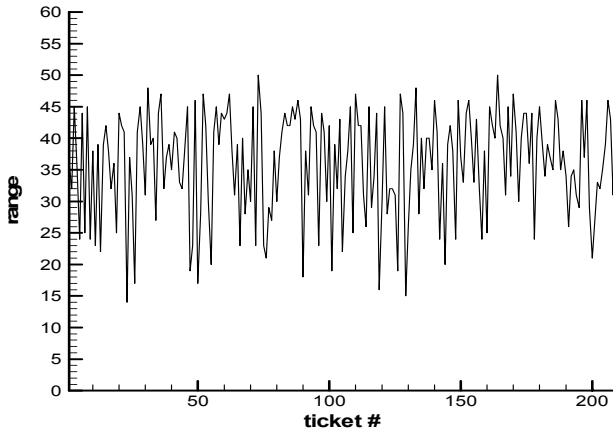
Figure 6: Standard Deviation of each ticket

The probability that the standard deviation fell in a certain range was also explored. It can be seen from figure 7 that the probability was greatest between ten and fifteen. Figure 7 also shows that it is improbable for the standard deviation to fall below five or above twenty-five.
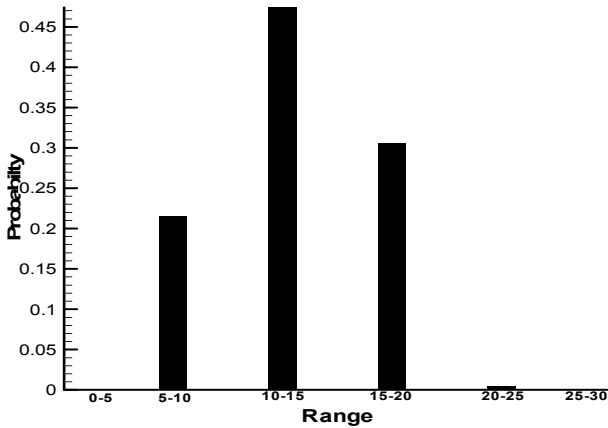
Figure 7: Standard Deviation within a certain range

After doing these basic statistical tests on the tickets themselves, it was necessary to look for other patterns. Searching for more interesting patterns involved analyzing the tickets to find:

- the maximum amount of consecutive numbers
- the range in which the lowest number falls
- the range in which the second lowest number falls
- the range in which the second highest number falls
- the range in which the highest number falls

First, the winning tickets were examined for consecutive numbers. As seen in figure 8, the probability of having a pair of consecutive numbers on a winning lottery ticket is almost fifty percent. Obtaining three consecutive numbers on a winning ticket is rare, having a probability of one percent. Moreover, the occurrence of two pairs of consecutive numbers has a probability of ten percent. More than three consecutive numbers never occurred.
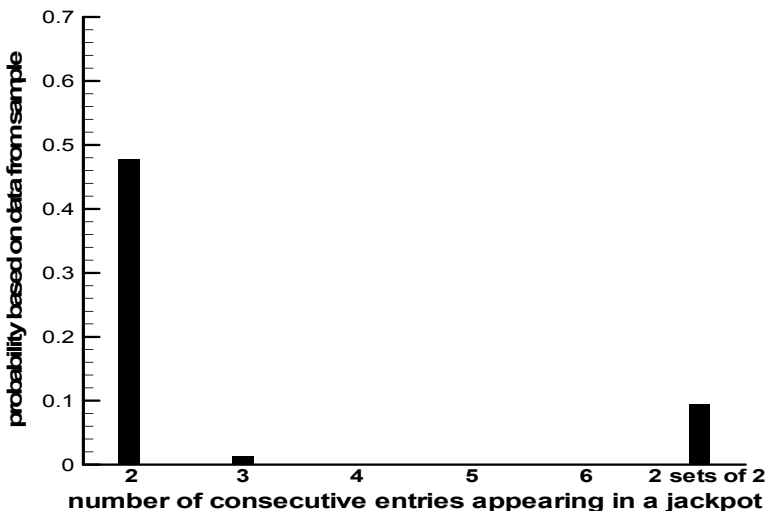
Figure 8: Probability of consecutive entries

Next, the range in which the lowest number falls was found, and it can be seen from figure 9 that the probability was greatest for the lowest number being between one and nine. The lowest number never fell within a range greater than twenty to twenty-nine.
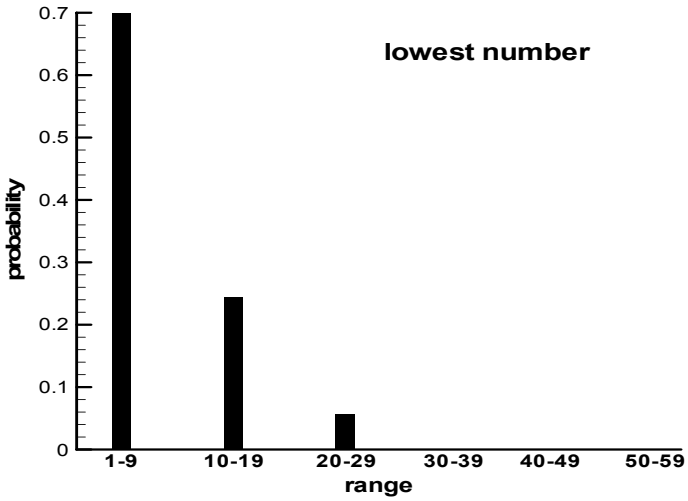
Figure 9: Probability of the lowest number within a certain range

Following this, the range in which the second lowest number falls was explored. Figure 10 shows that it is most probable for the second lowest number to be between ten and nineteen. The second lowest number never fell in a range above thirty to thirty-nine.
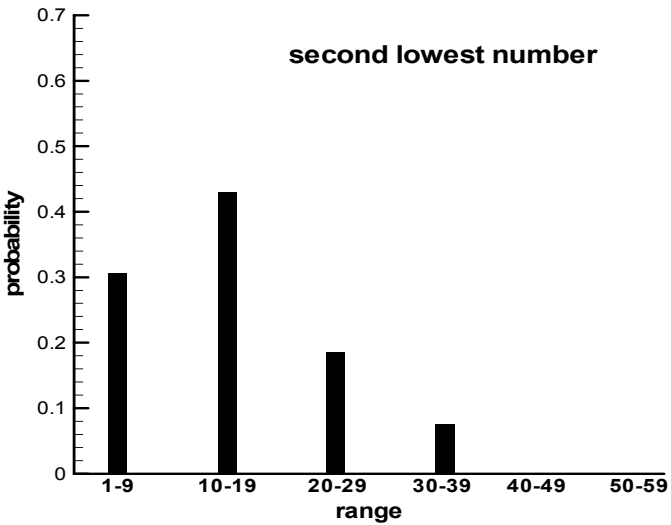
Figure 10: Probability of the second lowest number within a certain range

Next, the range was found in which the second highest number falls, and it can be seen from figure 11 that the probability was the greatest for second highest number to fall between thirty and forty-nine. It was interesting that there was some probability for the number to be between ten and nineteen, which is quite low.
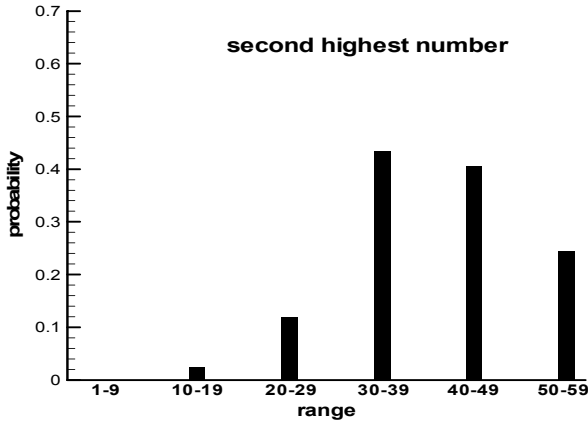
Figure 11: Probability of the second highest number within a certain range

The final examination was to look at the range in which the highest number falls, and figure 12 shows that the probability was highest for the highest number to be between forty and forty-nine. The figure also shows that the highest number was never below twenty.
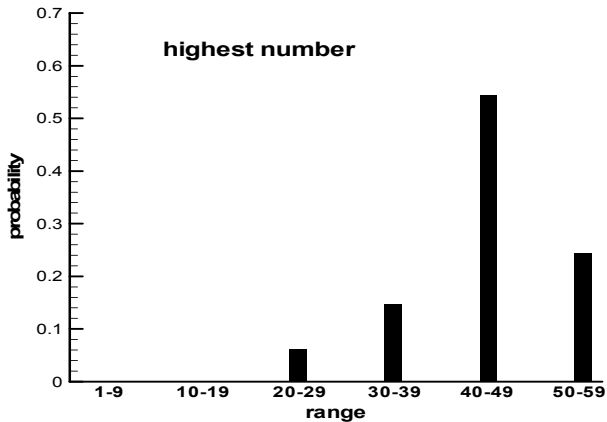
Figure 12: Probability of the highest number within a certain range

Based on the sample data collected from the preceding tests, it was concluded that there is a:

- 93.3% probability that there will be at least two, but not more than three, numbers in any one of the following six categories: 1-9, 10-19, 20-29, 30-39, 40-49, 50-59
- 99.5% chance that the mean of the winning tickets will be greater than ten but less than forty
- 94.74% probability that the range associated with the winning tickets will be greater than twenty but less than fifty
- 98.56% chance that no more than two consecutive numbers will appear on any winning ticket
- 90.43% probability that multiple sets of two consecutive numbers will not occur
- 94.36% chance that the lowest number will be less than twenty
- 92.33% chance that the second lowest number will be less than thirty
- 97.51% probability that the second highest number will be greater than nineteen
- 93.78% probability that the highest number will be greater than twenty-nine

These rules were applied to all the possible tickets, eliminating 31.1% of the tickets. In other words, it reduced the odds of winning the lottery from one in 45 million to one in 31 million. However, when these rules were applied to the winning tickets, they excluded 30.1% of the winning tickets.

In order to test these rules further, winning lottery numbers were collected from 9/6/01 through 12/31/01. These numbers were then analyzed by the same tests, to see if they paralleled the previous results. When first examining the new numbers, the most obvious difference can be seen in the frequency distribution. This shows (see figure 13) an even distribution of the numbers fifty-two through fifty-nine, whereas previously the frequency of these numbers was zero. The graph also shows that the frequency of the numbers four, twelve, sixteen, and thirty-seven was zero.

For the second set of numbers, the region in which the mean, range, and standard deviation fell followed that of the first set of numbers. However, the number of consecutive entries on a ticket was slightly lower than the first set of numbers, as seen in figure 14.

The rest of the results followed the patterns set forth previously. The numbers were then tested by the rules created earlier, and 32.4% of the winning tickets were excluded. The results associated with this set of numbers did not achieve any advantage, whereas the first set achieved a small advantage. This indicates that the rules developed from the data need to be refined and focused on achieving a small advantage.
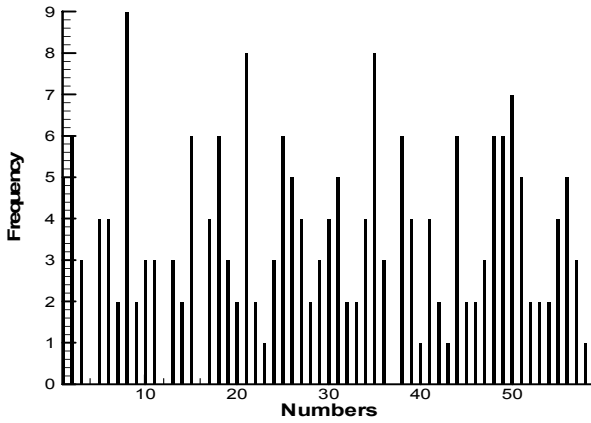
Figure 13: Winning New York State Lotto numbers from 9/06/01 to 12/31/01
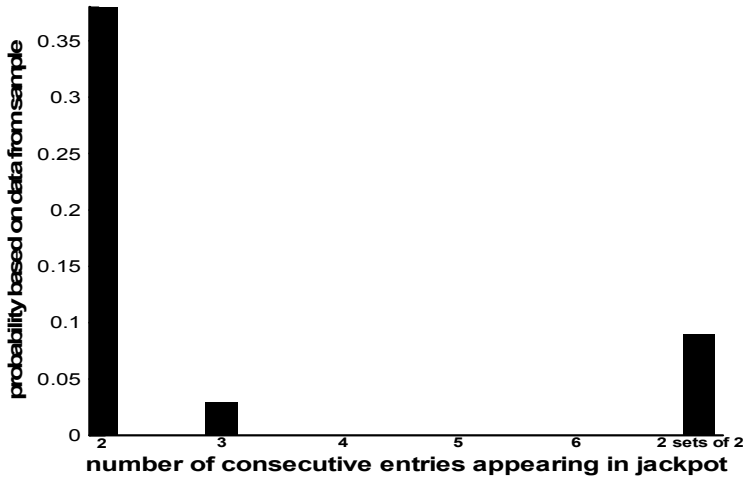
Figure 14: Probability of consecutive entries of second set of numbers

IV. Conclusion

This research study indicates that the lottery is indeed quite fair and that it is extremely difficult, if possible at all, to formulate a system to improve one's odds of winning. Despite this some interesting trends were found. These trends can be useful in one's approach to picking lottery numbers. The first pattern one should be aware of is choosing six numbers that have a mean between ten and forty. The probability of a winning ticket having a mean less than fifteen or greater than forty, is extremely small. Most people stray from choosing consecutive numbers, however, there is a fifty percent chance of the winning ticket containing two consecutive numbers. Other important trends include in which category the numbers fall. For the purpose of this study, the categories were defined using a range of ten, producing the categories 1-9, 10-19, 20-29, 30-39, 40-49, and 50-59. Overall, there is nearly a one hundred percent chance of the winning ticket containing any two numbers in one category. The odds drop considerably to less than forty percent, when examining the winning tickets for three numbers in one category. Moreover, the probability of obtaining four tickets in one category is almost zero.

Future research will focus on obtaining a slight (1-5%) advantage, rather than eliminating a sizable fraction of the total number of lottery tickets. More conservative rules, a larger sample, and the discovery of additional trends, will be part of such an investigation.

Appendix A: Lotto Jackpots from 09/01/99 to 09/01/01

8	13	17	26	34	44	5	8	13	17	20	24
18	20	22	34	35	50	28	31	41	42	48	51
5	16	18	25	26	50	5	9	10	45	46	51
8	19	24	28	41	43	9	13	14	15	21	26
14	21	22	26	31	38	2	7	17	25	29	30
6	31	44	46	49	50	3	35	38	41	45	5
26	28	30	38	47	51	1	3	22	29	38	43
4	6	11	28	30	49	2	4	6	9	30	32
10	15	18	25	30	34	5	8	14	18	24	25
2	4	6	12	20	40	10	16	44	46	49	51
1	7	9	12	13	24	6	9	22	37	44	51
7	14	18	33	41	46	9	18	39	43	44	48
23	25	30	41	44	45	6	12	24	37	45	50
10	13	14	29	38	49	1	10	12	24	35	44
1	8	11	14	21	43	6	12	27	30	41	50
6	7	14	35	43	44	4	33	34	37	48	51
16	27	31	40	44	48	2	9	21	36	37	40
3	15	20	22	32	39	19	23	31	44	46	50
8	17	20	28	30	33	1	17	18	27	28	40
1	2	5	14	44	45	1	13	14	18	21	24
5	13	33	37	40	47	22	34	36	40	43	50
2	27	30	36	37	43	9	23	25	27	37	38
13	17	20	24	26	27	22	30	31	40	45	49
3	19	28	30	33	40	12	22	31	33	43	50
6	10	20	29	31	37	20	23	26	39	48	50
25	26	27	30	36	42	8	10	13	23	33	45
3	4	6	22	36	44	10	16	36	37	46	51
6	11	33	37	48	51	2	15	33	36	38	46
6	12	14	21	44	45	3	6	22	26	41	45
12	14	18	24	26	43	8	9	29	30	33	50
1	3	16	27	48	49	6	28	29	46	47	51
3	14	25	29	38	42	3	4	6	14	24	46
2	5	30	37	39	42	4	15	38	41	42	50
11	16	20	24	30	38	6	12	19	41	47	49
3	7	27	40	41	47	17	19	21	22	31	35
2	16	26	32	39	49	13	14	32	39	44	51
17	31	35	38	41	49	18	19	21	23	38	49
6	11	17	26	30	43	6	21	41	43	50	51
3	4	9	30	36	42	8	12	27	39	40	50
8	30	33	37	39	43	5	23	26	32	45	46
4	12	16	18	31	45	12	13	17	31	32	35
9	15	35	38	48	49	5	18	20	23	46	49
14	15	17	18	23	47	2	10	17	19	42	43
18	30	36	40	46	50	11	18	20	24	25	41
8	19	23	41	45	46	3	23	26	36	40	45
6	10	32	42	46	51	12	13	16	25	27	31

8	13	24	42	43	47		2	4	27	32	34	35
19	32	33	41	50	51		2	6	9	12	32	46
6	11	25	30	42	49		1	20	28	34	40	47
11	14	20	25	31	33		4	18	23	28	34	44
6	8	9	33	34	40		15	18	20	23	37	48
11	21	25	32	37	49		3	29	30	38	40	46
1	8	13	35	44	46		15	17	25	26	32	47
18	29	30	32	38	43		13	23	32	33	36	37
1	2	15	32	33	48		9	23	35	36	41	47
3	8	21	28	30	45		15	17	28	29	33	40
9	15	19	23	34	51		1	18	21	29	33	46
4	11	22	31	34	35		1	8	35	40	42	43
22	31	35	38	41	48		3	4	25	32	38	43
4	6	16	24	37	49		1	6	26	29	39	51
19	22	26	38	44	48		6	9	11	40	45	48
16	25	36	45	48	50		5	11	12	34	35	45
1	13	38	40	43	45		17	30	32	37	45	48
20	21	31	33	34	36		6	21	31	38	42	51
4	8	9	29	32	34		2	3	10	17	28	36
5	22	25	34	37	50		3	9	24	33	37	50
4	8	19	21	26	32		8	13	23	33	46	49
13	16	18	29	44	45		12	14	21	35	39	42
17	19	25	32	34	49		3	6	11	20	42	43
19	29	33	38	48	50		7	8	24	36	40	51
17	23	26	28	33	36		6	22	29	33	36	50
3	9	29	31	49	50		11	12	22	29	45	47
1	3	15	31	37	45		3	23	24	33	34	47
18	20	23	25	30	33		2	7	8	15	25	26
1	3	13	16	18	27		1	8	10	17	34	41
13	14	16	17	40	48		4	17	25	27	43	49
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3	7	45	46	50	51		9	26	29	34	37	43
1	11	16	19	25	29		7	14	17	31	41	46
7	15	32	36	39	47		14	30	35	38	39	51
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11	22	25	32	38	51		1	9	20	28	29	47
6	17	38	40	43	46		3	8	17	21	38	46
2	11	20	30	36	37		7	8	24	29	37	42
3	12	17	21	34	49		4	5	17	34	41	42
2	4	10	30	32	43		11	32	35	36	41	45
26	27	30	36	43	50		25	30	36	37	39	51
7	13	19	25	40	43		3	4	9	33	35	37
4	13	15	18	20	24		1	4	7	30	32	36
8	13	22	23	29	47		11	17	19	30	35	42
3	4	6	10	14	45		19	22	23	32	36	48
6	8	14	29	32	44		2	7	13	21	36	48
2	8	10	11	19	2		7	12	23	32	35	44
5	7	22	28	49	51		1	3	18	27	43	47
3	4	6	16	27	40							

7	14	25	30	31	34
17	37	39	43	45	50
15	17	19	44	45	47
2	14	23	29	30	37
3	21	27	35	39	42
2	11	24	31	46	51

2	5	24	36	47	48
7	10	21	39	49	50
22	23	40	41	46	51
2	4	11	15	20	23
10	11	21	24	33	41

Appendix B: Lotto Jackpots from 09/06/01 to 12/31/01

2	11	24	31	46	51
18	27	38	48	49	51
10	15	28	29	35	42
8	13	26	35	45	51
1	15	24	31	34	44
3	8	29	30	31	49
21	25	39	50	54	59
15	19	32	38	47	50
21	25	27	39	44	56
3	8	13	21	33	41
8	14	19	35	42	50
1	6	23	30	40	51
5	17	30	35	41	49
5	8	21	24	50	56
8	18	34	44	50	54
3	8	25	31	38	44
1	17	25	27	28	50
1	2	32	33	36	39
8	18	21	22	26	49
9	10	20	34	55	56
6	8	11	17	22	41
21	27	29	34	41	48
5	7	13	38	44	48
5	22	35	47	52	58
10	25	35	45	48	49
2	14	15	21	48	51
7	43	46	49	52	57
1	11	35	50	55	56
6	15	18	31	48	53
2	9	18	26	36	57
6	15	26	30	55	56
19	20	25	36	38	53
2	18	21	38	39	44
17	26	35	47	55	57

Appendix C: List of FORTRAN Programs Created and Used in the Analysis

Copies of the programs created and used in the analysis can be obtained from Professor Gregory J. Falabella at:

    Address: Dr. Gregory J. Falabella
                  Wagner College
                  Department of Chemistry and Physics
                  1 Campus Road
                  Staten Island, NY 10301

    Phone: (718) 390-3403

    Email: gfalabel@wagner.edu

Appendix D: List of FORTRAN Programs Developed and Used to Test Hypothesis

```
      PROGRAM RFTX1
C
C     This program confirms numerically that the odds of winning
C     a lotto jackpot should be 2:45,057,474.
C
      INTEGER I,J,K,L,M,N,X
C
      X=0
      DO 10 I=1,59
        WRITE(*,*) I
        DO 20 J=I+1,59
          DO 30 K=J+1,59
            DO 40 L=K+1,59
              DO 50 M=L+1,59
                DO 60 N=M+1,59
                  X=X+1
 60             CONTINUE
 50           CONTINUE
 40         CONTINUE
 30       CONTINUE
 20     CONTINUE
 10   CONTINUE
      WRITE(*,*) X
      END




      PROGRAM RFTX2
C
C     This program determines the odds of winning a lotto jackpot
C     if the trends found in this study exclude certain combinations
C     of numbers.
C
      INTEGER I,J,K,L,M,N,X,FLAG
```

19

```
      REAL AVG
C
      X=0
      DO 10 I=1,19
        WRITE(*,*) I
        DO 20 J=I+1,29
          DO 30 K=J+1,59
            DO 40 L=K+1,59
              DO 50 M=L+1,59
                DO 60 N=M+1,59
                  AVG=(1.0*I+1.0*J+1.0*K+1.0*L+1.0*M+1.0*N)/6.0
                  IF ((AVG .LT. 10.0) .OR. (AVG .GT. 40.0)) FLAG=1
                  IF (M .LT. 20) FLAG=1
                  IF (N .LT. 30) FLAG=1
                  IF ((M-I .LT. 20) .OR. (M-I .GT. 50)) FLAG=1
                  IF ((J .EQ. I+1) .AND. (K .EQ. I+2)) FLAG=1
                  IF ((K .EQ. J+1) .AND. (L .EQ. J+2)) FLAG=1
                  IF ((L .EQ. K+1) .AND. (M .EQ. K+2)) FLAG=1
                  IF ((M .EQ. L+1) .AND. (N .EQ. L+2)) FLAG=1
                  CALL CAT1(I,J,K,L,M,N,FLAG)
                  CALL CAT2(I,J,K,L,M,N,FLAG)
                  IF (FLAG .EQ. 0) X=X+1
                  FLAG=0
 60             CONTINUE
 50           CONTINUE
 40         CONTINUE
 30       CONTINUE
 20     CONTINUE
 10   CONTINUE
      WRITE(*,*) X
      END
C     ********************************************************************
      SUBROUTINE CAT1(I,J,K,L,M,N,FLAG)
C
C     This subroutine determines if more than one number falls into any
C     one category.
C
      INTEGER I,J,K,L,M,N,FLAG
      INTEGER FLAG1,FLAG2,FLAG3,FLAG4,FLAG5,FLAG6,FLAG7
C
C     Find out how many fall in a certain range
C
      FLAG1=0
      FLAG2=0
      FLAG3=0
      FLAG4=0
      FLAG5=0
      FLAG6=0
C
      IF ((I .GE. 0) .AND. (I .LT. 10)) FLAG1=FLAG1+1
      IF ((I .GE. 10) .AND. (I .LT. 20)) FLAG2=FLAG2+1
      IF ((I .GE. 20) .AND. (I .LT. 30)) FLAG3=FLAG3+1
      IF ((I .GE. 30) .AND. (I .LT. 40)) FLAG4=FLAG4+1
      IF ((I .GE. 40) .AND. (I .LT. 50)) FLAG5=FLAG5+1
      IF ((I .GE. 50) .AND. (I .LT. 60)) FLAG6=FLAG6+1
C
      IF ((J .GE. 0) .AND. (J .LT. 10)) FLAG1=FLAG1+1
      IF ((J .GE. 10) .AND. (J .LT. 20)) FLAG2=FLAG2+1
      IF ((J .GE. 20) .AND. (J .LT. 30)) FLAG3=FLAG3+1
```

```
       IF ((J .GE. 30) .AND. (J .LT. 40)) FLAG4=FLAG4+1
       IF ((J .GE. 40) .AND. (J .LT. 50)) FLAG5=FLAG5+1
       IF ((J .GE. 50) .AND. (J .LT. 60)) FLAG6=FLAG6+1
C
       IF ((K .GE. 0) .AND. (K .LT. 10)) FLAG1=FLAG1+1
       IF ((K .GE. 10) .AND. (K .LT. 20)) FLAG2=FLAG2+1
       IF ((K .GE. 20) .AND. (K .LT. 30)) FLAG3=FLAG3+1
       IF ((K .GE. 30) .AND. (K .LT. 40)) FLAG4=FLAG4+1
       IF ((K .GE. 40) .AND. (K .LT. 50)) FLAG5=FLAG5+1
       IF ((K .GE. 50) .AND. (K .LT. 60)) FLAG6=FLAG6+1
C
       IF ((L .GE. 0) .AND. (L .LT. 10)) FLAG1=FLAG1+1
       IF ((L .GE. 10) .AND. (L .LT. 20)) FLAG2=FLAG2+1
       IF ((L .GE. 20) .AND. (L .LT. 30)) FLAG3=FLAG3+1
       IF ((L .GE. 30) .AND. (L .LT. 40)) FLAG4=FLAG4+1
       IF ((L .GE. 40) .AND. (L .LT. 50)) FLAG5=FLAG5+1
       IF ((L .GE. 50) .AND. (L .LT. 60)) FLAG6=FLAG6+1
C
       IF ((M .GE. 0) .AND. (M .LT. 10)) FLAG1=FLAG1+1
       IF ((M .GE. 10) .AND. (M .LT. 20)) FLAG2=FLAG2+1
       IF ((M .GE. 20) .AND. (M .LT. 30)) FLAG3=FLAG3+1
       IF ((M .GE. 30) .AND. (M .LT. 40)) FLAG4=FLAG4+1
       IF ((M .GE. 40) .AND. (M .LT. 50)) FLAG5=FLAG5+1
       IF ((M .GE. 50) .AND. (M .LT. 60)) FLAG6=FLAG6+1
C
       IF ((N .GE. 0) .AND. (N .LT. 10)) FLAG1=FLAG1+1
       IF ((N .GE. 10) .AND. (N .LT. 20)) FLAG2=FLAG2+1
       IF ((N .GE. 20) .AND. (N .LT. 30)) FLAG3=FLAG3+1
       IF ((N .GE. 30) .AND. (N .LT. 40)) FLAG4=FLAG4+1
       IF ((N .GE. 40) .AND. (N .LT. 50)) FLAG5=FLAG5+1
       IF ((N .GE. 50) .AND. (N .LT. 60)) FLAG6=FLAG6+1
C
       FLAG7=0
       IF (FLAG1 .GT. 1) FLAG7=1
       IF (FLAG2 .GT. 1) FLAG7=1
       IF (FLAG3 .GT. 1) FLAG7=1
       IF (FLAG4 .GT. 1) FLAG7=1
       IF (FLAG5 .GT. 1) FLAG7=1
       IF (FLAG6 .GT. 1) FLAG7=1
       IF (FLAG7 .EQ. 0) FLAG=1
C
       IF (FLAG1 .GT. 3) FLAG=1
       IF (FLAG2 .GT. 3) FLAG=1
       IF (FLAG3 .GT. 3) FLAG=1
       IF (FLAG4 .GT. 3) FLAG=1
       IF (FLAG5 .GT. 3) FLAG=1
       IF (FLAG6 .GT. 3) FLAG=1
       END
C      ****************************************************************
       SUBROUTINE CAT2(I,J,K,L,M,N,FLAG)
C
C      This subroutine determines if a ticket contain two sets of
C      two consecutive numbers.
C
       INTEGER I,J,K,L,M,N,FLAGX,FLAG
C
       FLAGX=0
       IF (J .EQ. I+1) FLAGX=FLAGX+1
       IF (K .EQ. J+1) FLAGX=FLAGX+1
```

```
      IF (L .EQ. K+1) FLAGX=FLAGX+1
      IF (M .EQ. L+1) FLAGX=FLAGX+1
      IF (N .EQ. M+1) FLAGX=FLAGX+1
      IF (FLAGX .GE. 2) FLAG=1
      END



      PROGRAM RFTX3
C
C     This program reads in the jackpot numbers from a sequential file
C     and determines how many winning tickets are excluded by the
C     general rules developed in this study.
C
      INTEGER TICKET(209,6),COUNT
      INTEGER I,J,K,L,M,N,X,FLAG
      REAL AVG
C
      OPEN(1,FILE='num.dat')
      OPEN(2,FILE='outx.dat')
C
      IMAX=209
      JMAX=6
      DO 10 I=1,IMAX
        DO 20 J=1,JMAX
          READ(1,*) TICKET(I,J)
 20     CONTINUE
 10   CONTINUE
C
      X=0
      DO 30 COUNT=1,IMAX
        I=TICKET(COUNT,1)
        J=TICKET(COUNT,2)
        K=TICKET(COUNT,3)
        L=TICKET(COUNT,4)
        M=TICKET(COUNT,5)
        N=TICKET(COUNT,6)
        AVG=(1.0*I+1.0*J+1.0*K+1.0*L+1.0*M+1.0*N)/6.0
        IF ((AVG .LT. 10.0) .OR. (AVG .GT. 40.0)) FLAG=1
        IF (M .LT. 20) FLAG=1
        IF (N .LT. 30) FLAG=1
        IF ((M-I .LT. 20) .OR. (M-I .GT. 50)) FLAG=1
        IF ((J .EQ. I+1) .AND. (K .EQ. I+2)) FLAG=1
        IF ((K .EQ. J+1) .AND. (L .EQ. J+2)) FLAG=1
        IF ((L .EQ. K+1) .AND. (M .EQ. K+2)) FLAG=1
        IF ((M .EQ. L+1) .AND. (N .EQ. L+2)) FLAG=1
        CALL CAT1(I,J,K,L,M,N,FLAG)
        CALL CAT2(I,J,K,L,M,N,FLAG)
        IF (FLAG .EQ. 0) X=X+1
        IF (FLAG .EQ. 1) WRITE(2,100) I,J,K,L,M,N
        FLAG=0
 30   CONTINUE
      WRITE(*,*) X
 100  FORMAT(6I6)
      END
C     ****************************************************************
      SUBROUTINE CAT1(I,J,K,L,M,N,FLAG)
C
C     This subroutine determines if more than one number falls into any
```

```
C     one category.
C
      INTEGER I,J,K,L,M,N,FLAG
      INTEGER FLAG1,FLAG2,FLAG3,FLAG4,FLAG5,FLAG6,FLAG7
C
C     Find out how many fall in a certain range
C
      FLAG1=0
      FLAG2=0
      FLAG3=0
      FLAG4=0
      FLAG5=0
      FLAG6=0
C
      IF ((I .GE. 0) .AND. (I .LT. 10)) FLAG1=FLAG1+1
      IF ((I .GE. 10) .AND. (I .LT. 20)) FLAG2=FLAG2+1
      IF ((I .GE. 20) .AND. (I .LT. 30)) FLAG3=FLAG3+1
      IF ((I .GE. 30) .AND. (I .LT. 40)) FLAG4=FLAG4+1
      IF ((I .GE. 40) .AND. (I .LT. 50)) FLAG5=FLAG5+1
      IF ((I .GE. 50) .AND. (I .LT. 60)) FLAG6=FLAG6+1
C
      IF ((J .GE. 0) .AND. (J .LT. 10)) FLAG1=FLAG1+1
      IF ((J .GE. 10) .AND. (J .LT. 20)) FLAG2=FLAG2+1
      IF ((J .GE. 20) .AND. (J .LT. 30)) FLAG3=FLAG3+1
      IF ((J .GE. 30) .AND. (J .LT. 40)) FLAG4=FLAG4+1
      IF ((J .GE. 40) .AND. (J .LT. 50)) FLAG5=FLAG5+1
      IF ((J .GE. 50) .AND. (J .LT. 60)) FLAG6=FLAG6+1
C
      IF ((K .GE. 0) .AND. (K .LT. 10)) FLAG1=FLAG1+1
      IF ((K .GE. 10) .AND. (K .LT. 20)) FLAG2=FLAG2+1
      IF ((K .GE. 20) .AND. (K .LT. 30)) FLAG3=FLAG3+1
      IF ((K .GE. 30) .AND. (K .LT. 40)) FLAG4=FLAG4+1
      IF ((K .GE. 40) .AND. (K .LT. 50)) FLAG5=FLAG5+1
      IF ((K .GE. 50) .AND. (K .LT. 60)) FLAG6=FLAG6+1
C
      IF ((L .GE. 0) .AND. (L .LT. 10)) FLAG1=FLAG1+1
      IF ((L .GE. 10) .AND. (L .LT. 20)) FLAG2=FLAG2+1
      IF ((L .GE. 20) .AND. (L .LT. 30)) FLAG3=FLAG3+1
      IF ((L .GE. 30) .AND. (L .LT. 40)) FLAG4=FLAG4+1
      IF ((L .GE. 40) .AND. (L .LT. 50)) FLAG5=FLAG5+1
      IF ((L .GE. 50) .AND. (L .LT. 60)) FLAG6=FLAG6+1
C
      IF ((M .GE. 0) .AND. (M .LT. 10)) FLAG1=FLAG1+1
      IF ((M .GE. 10) .AND. (M .LT. 20)) FLAG2=FLAG2+1
      IF ((M .GE. 20) .AND. (M .LT. 30)) FLAG3=FLAG3+1
      IF ((M .GE. 30) .AND. (M .LT. 40)) FLAG4=FLAG4+1
      IF ((M .GE. 40) .AND. (M .LT. 50)) FLAG5=FLAG5+1
      IF ((M .GE. 50) .AND. (M .LT. 60)) FLAG6=FLAG6+1
C
      IF ((N .GE. 0) .AND. (N .LT. 10)) FLAG1=FLAG1+1
      IF ((N .GE. 10) .AND. (N .LT. 20)) FLAG2=FLAG2+1
      IF ((N .GE. 20) .AND. (N .LT. 30)) FLAG3=FLAG3+1
      IF ((N .GE. 30) .AND. (N .LT. 40)) FLAG4=FLAG4+1
      IF ((N .GE. 40) .AND. (N .LT. 50)) FLAG5=FLAG5+1
      IF ((N .GE. 50) .AND. (N .LT. 60)) FLAG6=FLAG6+1
C
      FLAG7=0
      IF (FLAG1 .GT. 1) FLAG7=1
      IF (FLAG2 .GT. 1) FLAG7=1
```

```
       IF (FLAG3 .GT. 1) FLAG7=1
       IF (FLAG4 .GT. 1) FLAG7=1
       IF (FLAG5 .GT. 1) FLAG7=1
       IF (FLAG6 .GT. 1) FLAG7=1
       IF (FLAG7 .EQ. 0) FLAG=1
C
       IF (FLAG1 .GT. 3) FLAG=1
       IF (FLAG2 .GT. 3) FLAG=1
       IF (FLAG3 .GT. 3) FLAG=1
       IF (FLAG4 .GT. 3) FLAG=1
       IF (FLAG5 .GT. 3) FLAG=1
       IF (FLAG6 .GT. 3) FLAG=1
       END
C      ******************************************************************
       SUBROUTINE CAT2(I,J,K,L,M,N,FLAG)
C
C      This subroutine determines if a ticket contain two sets of
C      two consecutive numbers.
C
       INTEGER I,J,K,L,M,N,FLAGX,FLAG
C
       FLAGX=0
       IF (J .EQ. I+1) FLAGX=FLAGX+1
       IF (K .EQ. J+1) FLAGX=FLAGX+1
       IF (L .EQ. K+1) FLAGX=FLAGX+1
       IF (M .EQ. L+1) FLAGX=FLAGX+1
       IF (N .EQ. M+1) FLAGX=FLAGX+1
       IF (FLAGX .GE. 2) FLAG=1
       END
```

Behavioral Assay to Determine Photosensitivity of Early-Stage Nauplii of the Brine Shrimp *Artemia Franciscana*

Ms. Christina M. Owens and Dr. Donald E. Stearns

Thesis research[1] in partial fulfillment of requirements for *Reflective Tutorial in Biology* [2]

Dark-adapted nauplii ($\leq$ 55h posthatch) of the brine shrimp *Artemia franciscana* were tested for sensitivity to different light intensities and wavelengths by measuring phototactic responses. Positive, negative and total phototaxis, regardless of sign, were used as behavioral measures to assay the sensitivity of nauplii to 16 different wavelengths (range = 410 to 710nm at 20-nm intervals) using two stimulus intensities: 1.0×10^{-4} $\mu Em^{-2}s^{-1}$ and 1.0×10^{-5} $\mu Em^{-2}s^{-1}$. The experimental organisms showed photosensitivity to a broad range of wavelengths, with greatest sensitivity in the blue-green portion of the visible spectrum (450-550nm range). Maximal photosensitivity of this naupliar-eyed organism was estimated to be 5.0×10^{-7} $\mu Em^{-2}s^{-1}$ (= 3.0×10^{11} photons $m^{-2}s^{-1}$), found at λ = 530nm. This photosensitivity was as great as or greater than similarly determined photosensitivities of crustaceans with compound eyes, indicating that photosensitivity is not heightened by complex, compound eye structures. Phototactic sign and degree of response depended on the particular combination of wavelength and intensity of the stimulus light. There was evidence of individual variation in phototactic sign, as well as phototactic sign switching. A comparison of photoresponses to different stimulus intensities (6.0 $\mu Em^{-2}s^{-1}$, 1.0×10^{-4} $\mu Em^{-2}s^{-1}$, 1.0×10^{-5} $\mu Em^{-2}s^{-1}$) indicated that, instead of a direct correlation between intensity and response, there is an optimal intermediate light intensity that elicits a greater response than higher or lower intensities.

I. Introduction

Light is a major factor in many aquatic environments and serves as a selective feature for the evolution of ecologically meaningful behaviors, here referred to as photobehaviors. Light conditions vary from place to place and time to time. Organisms have evolved different abilities to perceive light in different photoenvironments. Plankton are "organisms that drift or float passively with the current in a sea or lake" (Martin 1990). The term *zooplankton* refers to "the animal component of plankton. All major animal phyla are represented in zooplankton, as adults, larvae, or eggs" (Martin 1990). Many zooplankters have evolved behavioral mechanisms to avoid visual

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[1] 2nd Prize, Best Student Research Paper in Biology, 56th Annual Eastern Colleges Science Conference in Niagara University, New York

[2] This manuscript is included here for the purpose of displaying Wagner College undergraduate research, not as an official publication. It is being submitted to the *Bulletin of the New Jersey Academy of Science* for publication consideration.

predation by fish. Many use light as a timing cue for nocturnal vertical migration (Stearns and Forward 1984b, reviews by Forward 1988 and Haney 1988), which places them in deeper, darker waters during the day when visual predation is highest, then in surface waters at night, when visual predation is minimized. Many zooplankters also exhibit nocturnal grazing on phytoplankton ("the plant component of plankton, consisting chiefly of microscopic algae, such as diatoms and dinoflagellates" [Martin 1990]). These zooplankters fill their otherwise transparent guts with green chlorophyll primarily at night, again when visual predation is low (e.g. Arfi *et al.* 1992, Stearns 1986, review by Haney 1988, Bollens and Stearns 1992). Zooplankton also show light-mediated responses to the chemicals given off by visual predatory fishes and exhibit nocturnal vertical migration and nocturnal grazing only in the presence of fish chemicals (Loose *et al.* 1993, Cieri and Stearns 1999, Forward and Rittschof 1999).

Photobehaviors have commonly been used to determine the spectral and intensity sensitivities to light shown by aquatic organisms (review by Forward 1988). If an organism is particularly sensitive to a color or intensity, then it will behaviorally respond more readily to that light stimulus compared to other colors or intensities. Thus, sensitivity to light can be determined using a photobehavioral assay. Other methods for determining which colors and light intensities are perceived by an organism include electrophysiological measurements involving measurements of neural activity via implanted electrodes, and absorption spectra using extracted visual pigments and spectrophotometry (Forward 1976). However, the photobehavioral assay is a more appropriate method to measure light perception by zooplankton for ecological discussion, because photobehaviors of these animals are directly linked to ecologically meaningful behaviors such as nocturnal vertical migration and nocturnal feeding.

Phototaxis is a behavioral response to a light stimulus that results in a directional movement either towards (positive) or away from (negative) the light source (Schneider and Stearns 1998). To understand natural photobehaviors of zooplankton, one must first know the organism's ability to perceive light at various light intensities and wavelengths--in other words, the organism's photosensitivity. This research is essentially a behavioral assay designed to determine the photosensitivity of early-stage, brine shrimp (*Artemia franciscana*) nauplii at several different wavelengths and intensities.

Study Organism

Artemia franciscana has the following taxonomic classification (Pechenik 1991, Fox 2001 July 26):

> Kingdom Animalia
> Phylum Arthropoda
> Subphylum Crustacea

Class Branchiopoda
Superorder Sarsostraca
Order Anostraca
Family Artemiidae
Genus *Artemia*
Species *Artemia franciscana*

This crustacean is commonly called brine shrimp, although it is not, strictly speaking, a true shrimp (Browne 1993). The life cycle (Fox 2001 July 26) usually includes a dormant cyst (approximately 200 µm in diameter [U.S. Geological Survey 2001]) that can be kept for many years if dry. Once hydrated, the cyst hatches into the first naupliar stage (Figure 1). The nauplius is free swimming. It feeds on its own yolk sac while developing through a series of instars. When the yolk sac is consumed, the nauplius feeds on small algal cells and detritus, using hair-like structures, known as setae, on antennae (U.S. Geological Survey 2001). After several molts, the postlarval (zoeal) stage is reached, in which the organism resembles a small adult. The adult stage (Figure 2), which is the sexually mature stage, is reached after a total of approximately 15 molts (U.S. Geological Survey 2001). Adult brine shrimp are about 1.0 cm in length (U.S. Geological Survey 2001). The newly hatched larvae have only one, unstalked, median naupliar eye consisting of three pigment cups, while the adults develop two additional, stalked, compound eyes (Fox 2001 July 26).

  Artemia franciscana was the experimental species used in these experiments for several reasons. It is relatively easy, fast, inexpensive, and space-efficient to raise this species in the laboratory. Raising the organisms to the experimental age does not require feeding (Fox 2001 July 26). The experimental animals are hardy and tolerate handling and sorting well. The nauplii respond phototactically to appropriate light stimuli and are large enough to be seen with the unaided eye. While the experimental procedure involved movements in relation to highly directional lighting conditions and therefore cannot be considered ecologically meaningful photobehaviors, the purpose of this research--to determine spectral and intensity photosensitvities of *A. franciscana* early-stage nauplii--was accomplished using a photobehavioral assay.

II. Materials and Methods

Culturing and Collection of Experimental *Artemia franciscana*

  All *Artemia* culturing, sorting and testing were done at room temperature (~23° C). A 3-L plastic cake container was used to store the seawater supply used for hatching *Artemia franciscana* cysts (30 ‰ S, made from distilled water and commercially available synthetic sea salts [Instant Ocean® and Reef Crystals ™], using a refractometer

for salinity measurement). The bottom of a 2-L, plastic, soda bottle was removed. The remaining portion was placed upside down on a metal ring stand, filled with approximately 1 L of the prepared seawater and vigorously aerated using an air stone, with the bottom used as a cover. Approximately ½ to 1 teaspoonful of Great Salt Lake *A. franciscana* cysts (90% viability, Sanders Brine Shrimp Company Inc., Ogden, Utah) was added to the soda bottle, then covered with the remaining part of the bottle to keep out foreign particles. After approximately 48 h, a mixture of hatched nauplii, unhatched cysts and cyst debris was collected using a standard turkey baster. The collection procedure involved removing the air stone, thoroughly mixing the contents and collecting a sample using the turkey baster while the organisms were still being carried by the mixed water. The remaining contents of the soda bottle were discarded and the bottle and air stone were rinsed and cleaned in preparation for another batch of *Artemia* cysts. Three soda-bottle setups were in the laboratory and used on a staggered basis to guarantee a sample of hatched *Artemia* nauplii every day.

Each collection was transferred to a large finger bowl (ID = 17.78 cm, height = 6.35 cm) partially filled with the prepared seawater. The collection was released into a strainer (mesh size = 158 μm) placed in the center of the finger bowl. A haphazard subset from this strainer was transferred to a smaller finger bowl (ID = 10.16 cm, height = 3.81cm) by first swirling the strainer contents, then collecting and transferring using a 3-ml pipet. Once in the small finger bowl, the experimental nauplii were haphazardly collected using the same procedure and transferred to small weighing canoes (length = 3.49 cm, width = 4.76 cm, height = 1.27 cm, Cynmar® Corp.), with contoured sides ideal for pouring. The nauplii were sorted into 10 groups with 9-13 individuals per group. In this fashion, the experimental nauplii were separated from the unhatched cysts and cyst debris. Of a total of 400 groups, 15 groups contained 9 individuals, 362 contained 10 individuals, 21 contained 11 individuals and two contained 13 individuals. Although there was some variation in group size, the size range was adequate for estimating percent response. No group smaller than nine individuals was used. All collections were completed well after sunrise between 0800 and 1200h Eastern Standard Time. All experiments were completed well before sunset, to minimize possible variation due to circadian rhythmicity in photosensitivity. All experimental groups collected in a day were placed on a laboratory cart and transported to the experimental setup for testing. All nauplii were no older than 55h (post hatch) at the time of testing; most were no older than 50h.

<center>Experimental Setup and Procedure</center>

The phototaxis experiments took place in a light-tight dark room. In this room the experimental groups for the day were placed in the light-tight drawer with the darkroom lights off for at least 1h to allow time for the test organisms to reach their level of

<center>28</center>

maximal photosensitivity. After dark adaptation, the experimental organisms were tested for phototactic responses to selected light intensities and wavelengths using a specially designed apparatus (Figure 3).

The light source was an 83V, 300W, FHS lamp fitted inside a Kodak Carousel 4200 slide projector. Light intensity was controlled by the use of neutral density filters (Oriel Corporation) placed in the path of the light beam using a filter holder attached to the lens of the slide projector. These neutral density filters altered the light intensity without changing the wavelengths. Wavelength was controlled by the use of interference filters (λ range = 410 to 710nm at 20-nm intervals, 1/2 bandwidth = 5nm, Omega Optical) similarly placed in the filter holder. To prevent light leaks, the slide projector was placed inside a cardboard box with an opening only for the selected light stimulus. The box was covered with black felt to absorb stray light; black felt was also placed under the box, on the inside doorknob of the dark room, and over the entire work area for the same purpose. Black electrical tape was used to frame each filter and to surround the opening in the cardboard, to further ensure that there was no stray light leakage.

The test chamber was a plexiglass trough (inside dimensions: length = 15 cm, width = 3.4 cm, height = 3.9 cm) divided into five equally-sized sections by removable plexiglass partitions. The chamber was positioned so that the light stimulus passed along its long axis (Figure 3). A laboratory jack was used to position the test chamber. The jack was lined with black felt to absorb any scattered light that might pass through the bottom of the test chamber. The inside of the distal wall of the test chamber was painted with licorice colored acrylic paint (Plaid #938), to minimize internal reflection of light.

Other precautions were taken to minimize artifactual responses. The projector was connected to a Sola constant voltage transformer designed to maintain constant output even in the presence of fluctuations in power from the wall outlet, thus ensuring constancy of the stimulus light intensity throughout the experiment. Possible problems due to vibrations from the constant voltage transformer were minimized by wrapping it in foam rubber and placing it in a plastic container (Tucker tote, Tucker Housewares) in a darkroom cabinet on the opposite side of the experimental station. Results using the dark control samples, with the slide projector fan on only, showed no evidence of skewed distribution of individuals that would otherwise indicate a directional response to vibrations (see Results). All testing was done at approximately the same temperature (23° C) and salinity (30 ‰ S) to avoid possible effects of changes in these environmental factors on phototactic behavior reported by Seifert (1932) for *Artemia*.

The selected light intensity was measured by placing the quantum light sensor (Model LI-190SA, LI-COR®) in the center of the test chamber's outer wall closest to the light source, with the sensor facing the light source (Figure 3). The sensor was connected to a Model LI-1400 dataLOGGER (LI-COR®) used to record the quantal light intensity. For light readings, one person positioned the light sensor while an assistant read the

digital intensity measurements from a meter located in a sink on the other side of a vertical dark curtain, using a dim light that did not reach the experimental setup.

A weighing canoe containing the dark-adapted nauplii was removed from the light-tight drawer in complete darkness. The nauplii were gently poured into the center section of the test chamber, which had been previously filled with 70ml seawater with the partitions already inserted. The canoe was then gently rinsed with seawater to ensure successful transfer of all nauplii to the test chamber. This transfer was performed in complete darkness. By placing the experimental organisms in the center chamber, each individual would have an equal probability of moving toward or away from the light source.

The nauplii were left in the center section of the test chamber for 1 min to allow sufficient time to recover from the transfer process. All timing was done using a stopwatch placed in a deep sink behind a vertical dark curtain. After 1 min, the stimulus light was turned on and the partitions were simultaneously lifted from the test chamber. The light stimulus remained on for 90s to allow the nauplii sufficient time to swim to either end of the test chamber. Schneider and Stearns (1998), using a similar setup and the same development stage of *Artemia franciscana*, found that 90s was sufficient exposure time for each experiment. After the 90-s stimulus period, the partitions were reinserted in the test chamber, the stimulus light was turned off, the overhead light was turned on and the number of nauplii in each section was counted visually. Those individuals found in the section closest to the light source were considered positively phototactic, while those found in the section furthest from the light source were considered negatively phototactic. Those nauplii found in the three remaining sections were not considered to be phototactic. Percent positive and percent negative phototaxis was determined for each experimental group. After the counts were made, the contents of the test chamber were emptied into the darkroom sink and the test chamber was rinsed with clean seawater. The test chamber was then repositioned on the laboratory jack, realigned with the stimulus light beam, filled with 70ml fresh sea water and the partitions were reinserted in preparation for the next run.

Using this procedure, *Artemia franciscana* nauplii were tested for phototactic sensitivity to 16 different wavelengths *(λ* range = 410 to 710nm at 20-nm intervals, ½ bandwidth = 5nm, Omega Optical), all tested at both 1×10^{-4} and 1×10^{-5} $\mu Em^{-2}s^{-1}$. Dark controls were tested in the same manner except that the stimulus light was not turned on. The data collected were used to estimate response spectra for positive phototaxis and negative phototaxis. By combining positive and negative phototaxis, total phototactic responsiveness was used to describe a response spectrum for phototaxis independent of sign.

Using the wavelength 530nm, the nauplii were similarly tested for phototactic responses to seven different light intensities (1×10^{-4}, 1×10^{-5}, 1×10^{-6}, 5×10^{-7}, 2.3×10^{-7},

1.6 x 10^{-7}, and 1 x 10^{-7} $\mu Em^{-2}s^{-1}$). Intensity threshold for light perception was estimated using this behavioral assay. For each wavelength/light intensity treatment, at least 10 replicates were tested, and at least nine nauplii were tested in each group. No organism was used more than once.

Statistical Analysis

Before performing parametric statistical analyses, all percentage data were arcsine-transformed and tested for homoscedasticity using the F_{max}-test for homogeneity of variances (Sokal and Rohlf 1995). The transformed data were then tested using Model I, one-way analysis of variance with equal sample sizes (Sokal and Rohlf 1995) followed by the T-method for multiple comparisons among pairs of means based on equal sample sizes (Sokal and Rohlf 1995), with α set to 0.05. To achieve equal sample sizes (n = 10 replicates), 10 data points were randomly eliminated from the dark controls, and five data points were randomly eliminated from λ = 510nm at light intensity = 1 x 10^{-4} $\mu Em^{-2}s^{-1}$ and λ = 530nm at light intensity = 1.6 x 10^{-7} $\mu Em^{-2}s^{-1}$.

III. Results

Results of Spectral Sensitivity Experiments

Photoresponsiveness of dark-adapted *Artemia franciscana* nauplii to each wavelength of the two stimulus intensities (1.0 x 10^{-4} $\mu Em^{-2}s^{-1}$, 1.0 x 10^{-5} $\mu Em^{-2}s^{-1}$) was estimated by percent positive phototaxis, percent negative phototaxis and percent total phototaxis regardless of sign. For the dark controls, the percent found in the section closest to the slide projector averaged 8.0% $\pm$ 13.17% SD (n = 10 replicates), the percent found in the section furthest from the projector averaged 8.0% $\pm$ 7.89% SD (n = 10 replicates), and the percent found in both end sections combined averaged 16.0% $\pm$ 12.65% SD (n = 10 replicates).

When testing for positive phototaxis at a stimulus intensity of 1.0 x 10^{-4} $\mu Em^{-2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together (F_s = 11.58; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the 16 tested wavelengths, only 410, 690, and 710nm significantly differed from the dark control when tested with α set to 0.05.   The response spectrum for positive phototaxis at 1.0 x 10^{-4} $\mu Em^{-2}s^{-1}$ is shown in Figure 4.

When testing for positive phototaxis at a stimulus intensity of 1.0 x 10^{-5} $\mu Em^{-2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together (F_s = 5.44; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the 16 tested

wavelengths, only 510 and 530nm significantly differed from the dark control when tested with α set to 0.05. The response spectrum for positive phototaxis at 1.0×10^{-5} $\mu Em^{-2}s^{-1}$ is shown in Figure 5.

A comparison of these two figures reveals a light intensity effect on the response at selected wavelengths. For example, at 510nm, the nauplii showed a nonsignificant 0% positive response when tested at 1.0×10^{-4} $\mu Em^{-2}s^{-1}$, compared with a highly significant 35.7% positive response when tested at 1.0×10^{-5} $\mu Em^{-2}s^{-1}$ (T-method for multiple comparisons among pairs of means with α set at 0.01). The wavelengths showing significant positive responses at the higher intensity did not overlap with those showing significant response at the lower tested intensity (compare Figures 4 and 5).

A comparison of Figures 4 and 6 also reveals a wavelength effect on the type of response at 1.0×10^{-4} $\mu Em^{-2}s^{-1}$. For example, at 690 and 710nm, the nauplii show positive phototaxis, whereas they show negative phototaxis at many other wavelengths. One interesting finding occurred at a wavelength of 410nm, where significant positive and negative phototaxis were found. Since no significant negative phototaxis was found at 1.0×10^{-5} $\mu Em^{-2}s^{-1}$, phototactic sign switching at different wavelengths was not found at this intensity.

When testing for negative phototaxis at a stimulus intensity of 1.0×10^{-4} $\mu Em^{-2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together ($F_s = 53.53$; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the 16 tested wavelengths, the following 11 significantly differed from the dark control when tested with α set to 0.05: 410, 430, 450, 470, 490, 510, 530, 550, 570, 590, 630nm. The response spectrum for negative phototaxis at 1.0×10^{-4} $\mu Em^{-2}s^{-1}$ is shown in Figure 6.

When testing for negative phototaxis at a stimulus intensity of 1.0×10^{-5} $\mu Em^{-2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together ($F_s = 4.05$; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed, however, that none of the 16 tested wavelengths significantly differed from the dark control when tested with α set to 0.05. The response spectrum for negative phototaxis at 1.0×10^{-5} $\mu Em^{-2}s^{-1}$ is shown in Figure 7.

Using negative phototaxis as the measure of response, the intensity effect is even more dramatic than that found earlier for positive phototaxis. While no significant negative response was found for any tested wavelength at 1.0×10^{-5} $\mu Em^{-2}s^{-1}$, significant responses at 1.0×10^{-4} $\mu Em^{-2}s^{-1}$ ranged from 31.4% to 97%. At the stimulus intensity 1.0×10^{-4} $\mu Em^{-2}s^{-1}$, negative phototaxis was much more evident than positive phototaxis (compare Figures 4 and 6), whereas at the lower stimulus intensity of 1.0×10^{-5} $\mu Em^{-2}s^{-1}$, the reverse was found (compare Figures 5 and 7). At 510 and 530nm, phototactic sign

switching is evident, with significant positive phototaxis at $1.0 \times 10^{-5}\ \mu Em^{-2}s^{-1}$ and significant negative phototaxis at $1.0 \times 10^{-4}\ \mu Em^{-2}s^{-1}$.

Since phototactic sign switching can occur, and since degree of response varies with wavelength and intensity, total phototactic response regardless of sign may be a more sensitive measure of photosensitivity than using positive or negative phototaxis alone. When testing for total phototaxis, regardless of sign, at a stimulus intensity of 1.0×10^{-4} $\mu Em^{-2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together ($F_s = 37.62$; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the 16 tested wavelengths, the following nine significantly differed from the dark control when tested with α set to 0.05: 410, 430, 450, 470, 490, 510, 530, 550, 570nm. The response spectrum for total phototaxis at $1.0 \times 10^{-4}\ \mu Em^{-2}s^{-1}$ is shown in Figure 8.

When testing for total phototaxis, regardless of sign, at a stimulus intensity of $1.0 \times 10^{-5}\ \mu Em^{2}s^{-1}$, the Model I, one-way ANOVA showed significance when all wavelengths and the dark control were tested together ($F_s = 6.41$; df = 16, 153; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the 16 tested wavelengths, only 510nm significantly differed from the dark control when tested with α set to 0.05. The response spectrum for total phototaxis at $1.0 \times 10^{-5}\ \mu Em^{-2}s^{-1}$ is shown in Figure 9.

Results of Light Intensity Sensitivity Experiment Using 530-nm Light

Photoresponsiveness of dark-adapted *Artemia franciscana* nauplii to various intensities at the same wavelength (530nm light) was also estimated by percent positive phototaxis, percent negative phototaxis and percent total phototaxis regardless of sign. The same dark controls used in the spectral experiments were used here. When testing for positive phototaxis at $\lambda = 530$nm, the Model I, one-way ANOVA showed significance when all intensities and the dark control were tested together ($F_s = 8.65$; df = 7, 72; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the seven tested intensities, only one ($1.0 \times 10^{-5}\ \mu Em^{-2}s^{-1}$) significantly differed from the dark control when tested with α set to 0.05 (Figure 10).

When testing for negative phototaxis at $\lambda = 530$nm, the Model I, one-way ANOVA showed significance when all intensities and the dark control were tested together ($F_s = 48.74$; df = 7, 72; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the seven tested intensities, the following three significantly differed from the dark control when tested with α set to 0.05 (Figure 11): 5.0×10^{-7}, 1.0×10^{-6}, $1.0 \times 10^{-4} \mu Em^{-2}s^{-1}$.

When testing for total phototaxis, regardless of sign, at $\lambda = 530$nm, the Model I, one-way ANOVA showed significance when all intensities and the dark control were tested

together ($F_s = 35.85$; df = 7, 72; p << 0.001). The subsequent T-method for multiple comparisons among pairs of means showed that, of the seven tested intensities, the following two significantly differed from the dark control when tested with α set to 0.05 (Figure 12): 5.0 x 10^{-7} and 1.0 x$10^{-4}\mu Em^{-2}s^{-1}$. Since phototactic response indicates light perception, regardless of the phototactic sign, Figure 12 was used to estimate the threshold light intensity for visual detection by dark-adapted nauplii. This behavioral assay estimated the threshold for visual perception to be approximately 5.0 x 10^{-7} $\mu Em^{-2}s^{-1}$.

IV. Discussion

The dark-adapted, naupliar-eyed *Artemia franciscana* nauplii showed phototaxis to light intensities as low as 5.0 x 10^{-7} $\mu Em^{-2}s^{-1}$ (= 3.0 x 10^{11} photons m^{-2}s^{-1}). This photosensitivity is similar (within an order of magnitude) to that estimated for the naupliar-eyed nauplii of the barnacles *Balanus improvisus* (1.5 x 10^{12} photons m^{-2}s^{-1}, Lang *et al.* 1979), *Balanus balanoides* (5.23 x 10^{10} photons m^{-2}s^{-1}, Barnes and Klepal 1972) and *Elminius modestus* (3.78 x 10^{11} photons m^{-2}s^{-1}, Barnes and Klepal 1972), the compound-eyed zoeae of the mud crab *Rhithropanopeus harrisii* (2.8 x 10^{11}photons m^{-2}s^{-1}, Forward *et al.* 1984), as well as the adult, naupliar-eyed copepods *Acartia tonsa* (2.8 x 10^{11} photons m^{-2}s^{-1}, Stearns and Forward 1984a) and *Mesocyclops edax* (1.4 x 10^{11} photons m^{-2}s^{-1}, Swift and Forward 1983), the adult, naupliar-eyed and compound-eyed *Artemia salina* (2.0 x 10^{12} photons m^{-2}s^{-1}, Bradley and Forward 1984) and the adult, compound-eyed coastal mysid *Praunus neglectus* (7.0 x 10^{11} photons m^{-2}s^{-1}, Nicol 1959). Other tested crustaceans appear to be much less photosensitive, such as the compound-eyed zoeae of the crabs *Cancer gracilis* (2.0 x 10^{13} photons m^{-2}s^{-1}), *Hemigrapsus oregonensis* (7.5 x 10^{14} photons m^{-2}s^{-1}), *Lophopanopeus bellus bellus* (2.0 x 10^{13} photons m^{-2}s^{-1}), *Pagurus beringanus* (2.0 x 10^{13} photons m^{-2}s^{-1}) and *Pagurus granosimanus* (2.0 x 10^{13} photons m^{-2}s^{-1}) (Forward 1987). These results suggest that structurally complex compound eyes do not enhance photosensitivity over that achieved using naupliar eyes alone.

The species of naupliar *Artemia* used in this research was the same species used in a similar experiment by Schneider and Stearns (1998), having been obtained from the same Great Salt Lake location through the same Sanders Brine Shrimp Company Inc., Ogden, Utah, then delivered to Connecticut Valley Biological Supply Co., Inc., where it was sold as *Artemia salina* instead of *Artemia franciscana*. Schneider and Stearns (1998) found a threshold perception of light intensity of 8.6 x 10^{-6} $\mu Em^{-2}s^{-1}$, compared with the present research's somewhat lower threshold of 5.0 x 10^{-7} $\mu Em^{-2}s^{-1}$. Schneider and Stearns (1998) used 450-nm light to estimate the threshold intensity, whereas the present research used 530-nm light. In both cases, the wavelength used for intensity perception was obtained by examining the peaks in the response spectrum for total phototaxis, then using the wavelength that appeared to show the greatest response at the tested intensity. Schneider

and Stearns (1998) used a much higher stimulus intensity (6.0 μEm^{-2}s^{-1}) for their response spectrum than was used in the present research (1.0 x 10^{-4} μEm^{-2}s^{-1}). At 6.0 μEm^{-2}s^{-1}, average total phototactic responses were no higher than 65% at the peaks of the response spectrum, even at λ = 450nm (Figures 2 and 3 of Schneider and Stearns 1998). In this research, however, the total phototactic responses at 1.0 x 10^{-4} μEm^{-2}s^{-1} exceeded 65% for seven of 16 wavelengths and averaged 97% at λ = 530nm (Figure 8). These results indicate that these nauplii can perceive light at intensities below those indicated by Schneider and Stearns (1998). These results also show that degree of response is not always directly correlated with the degree of stimulus. In this comparison, the same developmental stage of the same species under similar conditions showed, for a number of tested wavelengths, a much higher total phototactic response to a much lower stimulus intensity.

At 1.0 x 10^{-4} μEm^{-2}s^{-1}, the nauplii were photosensitive to a broad range of wavelengths, as measured by positive, negative or total phototaxis. The only tested wavelengths showing no significant response were 610, 650, and 670nm. These results indicate that the nauplii have several photopigments that collectively absorb light across a broad spectrum. Schneider and Stearns (1998) also provided evidence of more than one photopigment in their nauplii. Given the frequent changes in optical conditions that characterize shallow waters and the concomitant changes in the light transmission spectrum, it appears adaptive for a zooplankter living under such conditions to have multiple photopigments for maintaining responsiveness in a changing optical environment.

Artemia nauplii showed significant negative phototaxis at 11 of 16 tested wavelengths when the intensity stimulus was 1.0 x 10^{-4} μEm^{-2}s^{-1}. When tested at 1.0 x 10^{-5} μEm^{-2}s^{-1}, however, the *Artemia* nauplii showed no significant negative phototaxis, regardless of wavelength. These results may be due to low, less perceptible stimulus intensity leading to decreased responsiveness. However, the experimental organisms can perceive light intensities as low as 5.0 x 10^{-7} μEm^{-2}s^{-1}. Comparing positive responses for the two tested stimulus intensities showed significant positive phototaxis at 410, 690, and 710nm at 1.0 x 10^{-4} μEm^{-2}s^{-1}; 510 and 530nm at 1.0 x 10^{-5} μEm^{-2}s^{-1}. However, at λ = 510nm, positive phototactic responsiveness was much greater (mean = 35.7%) at the lower stimulus intensity than at the higher intensity (mean = 0%). It is clear from these results that the naupliar phototactic response, in sign or degree, depends on the particular combination of wavelength and intensity of the stimulus light.

It is of particular interest to note that, when tested at λ = 410nm at a stimulus intensity of 1.0 x 10^{-4} μEm^{-2}s^{-1}, the nauplii responded with both significant positive (~20%) and negative (~37%) phototaxis. Clearly, the nauplii were moving but not in a single particular direction. Individual variation in phototactic sign may explain this

result, or it may be the result of phototactic sign switching during the stimulus period. For each of two stimulus intensities at $\lambda = 450$nm (2.4 x 10^{-5} and 7.7 x 10^{-4} μEm^{-2}s^{-1}), Schneider and Stearns (1998) similarly reported both significant positive and negative phototaxis for the same developmental stage of this species. Seifert (1932) found that *Artemia* populations at some intensities split into photopositive and photonegative groups. These results support the possibility of individual variation in sign of phototactic response at least to some light stimuli. Additional research is needed to further understand the underlying cause(s) for such variation. Given the unnatural light setup in which these experiments were conducted, it is not appropriate to assume an adaptive value for individual variation in phototactic sign in nature or to attempt to apply ecological significance to it. Additional research using light stimuli that are found in the natural environment is needed to determine the possible occurrence of this behavior in nature.

For $\lambda = 510$nm and $\lambda = 530$nm, a comparison of Figures 5 and 6 shows that significant positive phototaxis at a stimulus intensity of 1.0 x 10^{-5} μEm^{-2}s^{-1} switches to significant negative phototaxis at a stimulus intensity of 1.0 x 10^{-4} μEm^{-2}s^{-1}--direct evidence of intensity-dependent, phototactic sign switching. Schneider and Stearns (1998) also found evidence of intensity-dependent, phototactic sign switching in nauplii of this species. For the same reasons stated in regard to individual variation in phototactic sign, it is not appropriate to assume an adaptive value for phototactic sign switching in nature or to attempt to apply ecological significance to it.

In summary, early-stage nauplii of *Artemia franciscana* showed photosensitivity to a broad range of wavelengths, with greatest sensitivity in the blue-green portion of the visible spectrum (450-550 nm range). Maximal photosensitivity was estimated to be 5.0 x 10^{-7} μEm^{-2}s^{-1} (= 3.0 x 10^{11} photons m^{-2}s^{-1}), found at $\lambda = 530$nm. Phototactic sign and degree of response depended on the particular combination of wavelength and intensity of the stimulus light. There was evidence of individual variation in phototactic sign, as well as phototactic sign switching. A review of the research literature revealed that *A. franciscana* nauplii show similar photosensitivity when compared with many other tested crustaceans, including larval stages, adults, those with naupliar eyes only, those with compound eyes only, and those with both naupliar and compound eyes. There was no evidence indicating enhanced photosensitivity of compound eyes compared with simple nauliar eyes. A comparison of photoresponses to different stimulus intensities (6.0 μEm^{-2}s^{-1}, 1.0 x 10^{-4} μEm^{-2}s^{-1}, 1.0 x 10^{-5} μEm^{-2}s^{-1}) indicated that, instead of a direct correlation between intensity and response, there is an optimal intermediate light intensity that elicits a greater response than higher or lower intensities.

V. Acknowledgements

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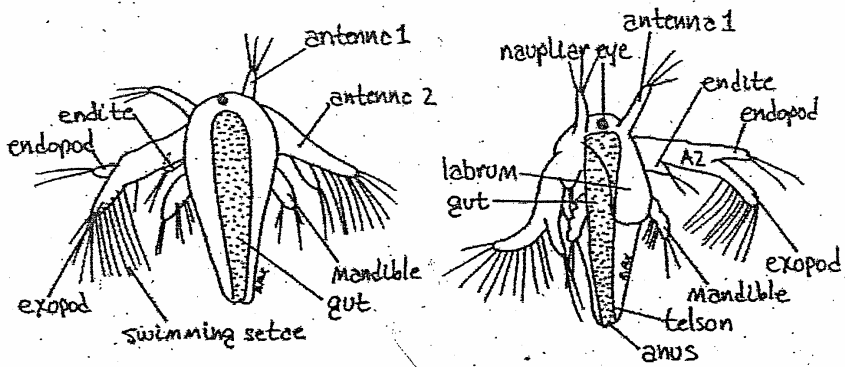
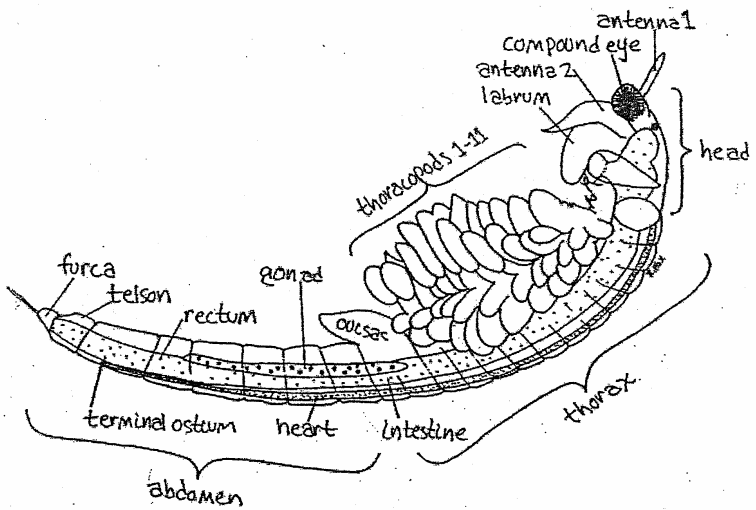**Figure 1. Dorsal (left) and ventral (right) views of *Artemia franciscana* nauplius (from Fox 2001 July 26)**

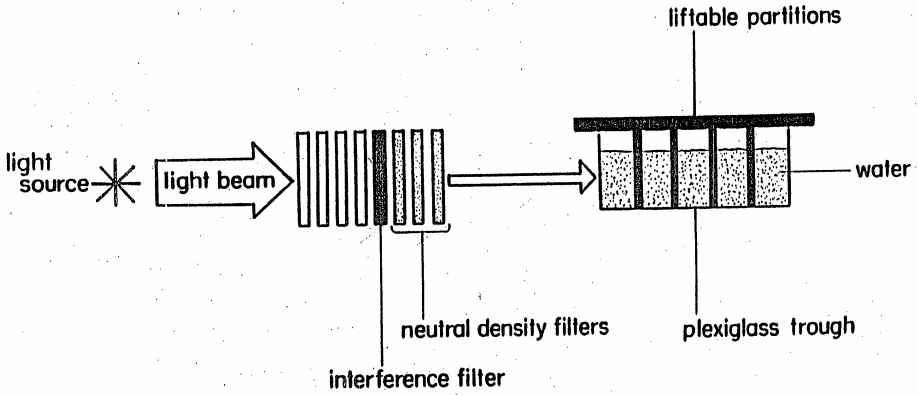**Figure 2. Adult, female *Artemia franciscana*, viewed from the left (from Fox 2001 July 26)**

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Figure 3. Diagram of laboratory setup for phototaxis experiments with *Artemia franciscana* nauplii (from Schneider and Stearns 1998)

Figure 4. Percent positive phototactic response (mean, standard deviation) of ≤ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-4} $\mu Em^{-2}s^{-1}$). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly ($p < 0.05$) different from DC
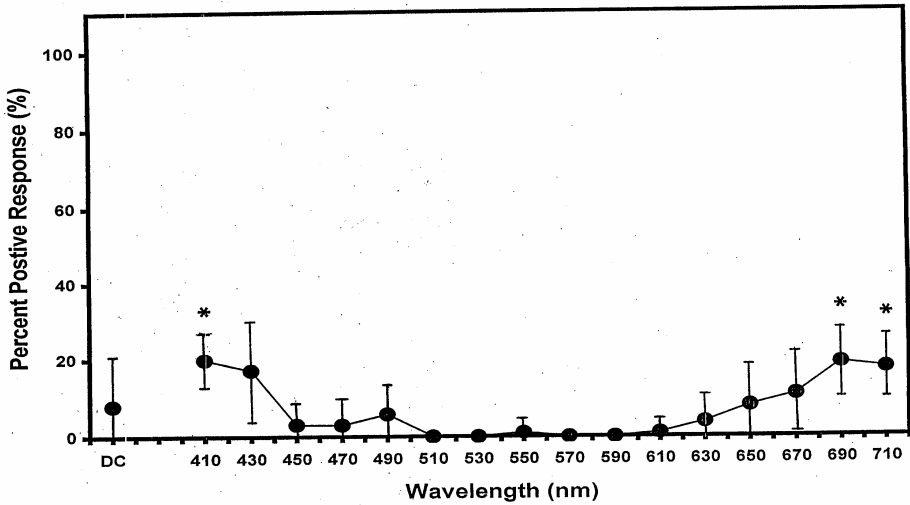
Figure 5. Percent positive phototactic response (mean, standard deviation) of ≤ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-5} $\mu Em^{-2}s^{-1}$). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly (p < 0.05) different from DC

Figure 6. Percent negative phototactic response (mean, standard deviation)of ≤ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-4} $\mu Em^{-2}s^{-1}$). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly (p < 0.05) different from DC
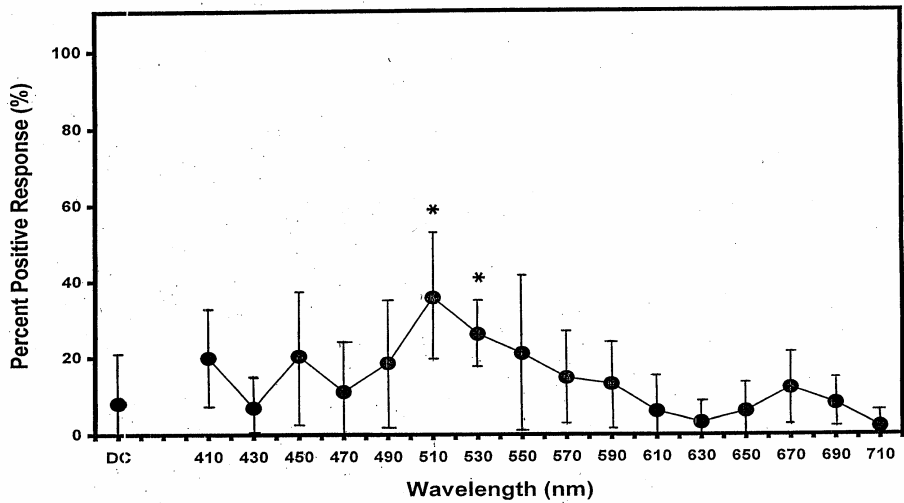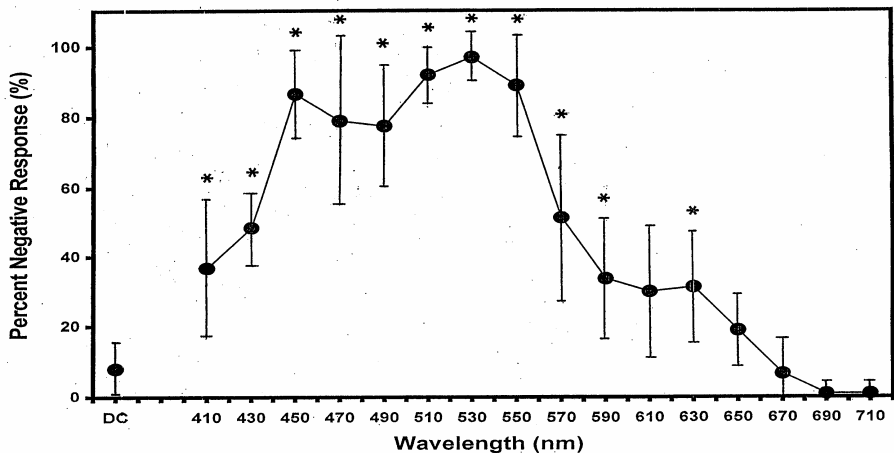
Figure 7. Percent negative phototactic response (mean, standard deviation)of $\leq$ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-5} $\mu Em^{-2}s^{-1}$). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly (p < 0.05) different from DC

Figure 8. Percent total phototactic response (positive + negative mean, standard deviation) of $\leq$ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-4} $\mu Em^{-2}s^{-1}$). n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly (p < 0.05) different from DC

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Figure 9. Percent total phototactic response (positive + negative mean, standard deviation) of ≤ 55 h posthatch *Artemia franciscana* nauplii when exposed to different wavelengths of light of the same intensity (1×10^{-5} $\mu Em^{-2}s^{-1}$). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly ($p < 0.05$) different from DC
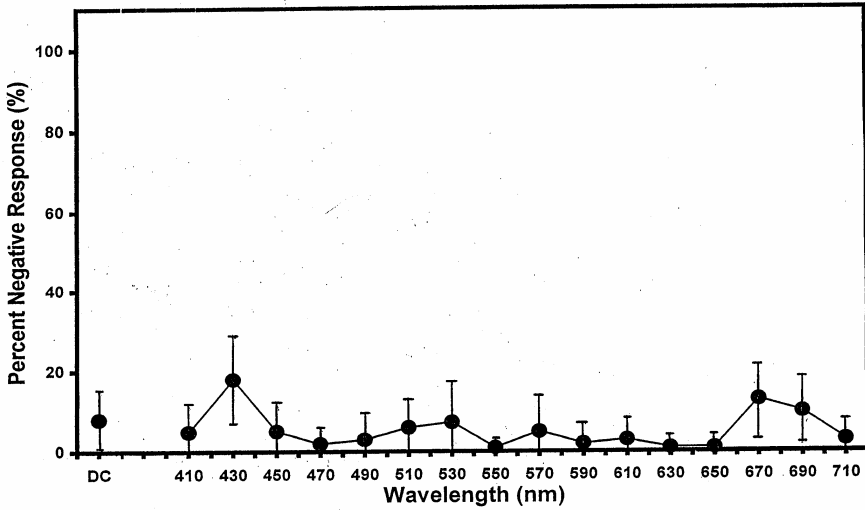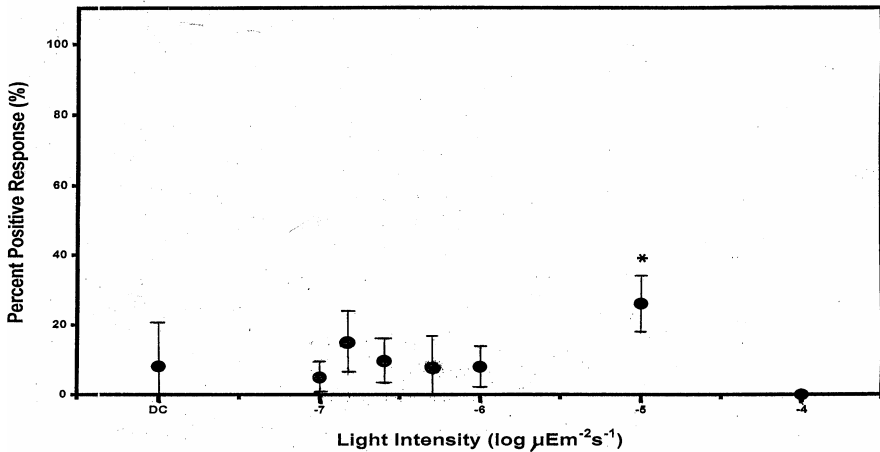

Figure 10. Percent positive phototactic response (mean, standard deviation) of ≤ 55h posthatch *Artemia franciscana* nauplii when exposed to different intensities of light of the same wavelength ($\lambda = 450$ nm). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly ($p < 0.05$) different from DC
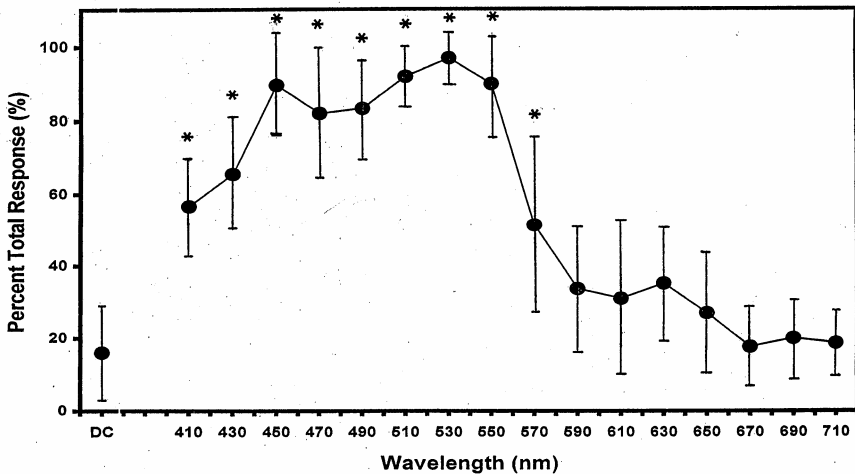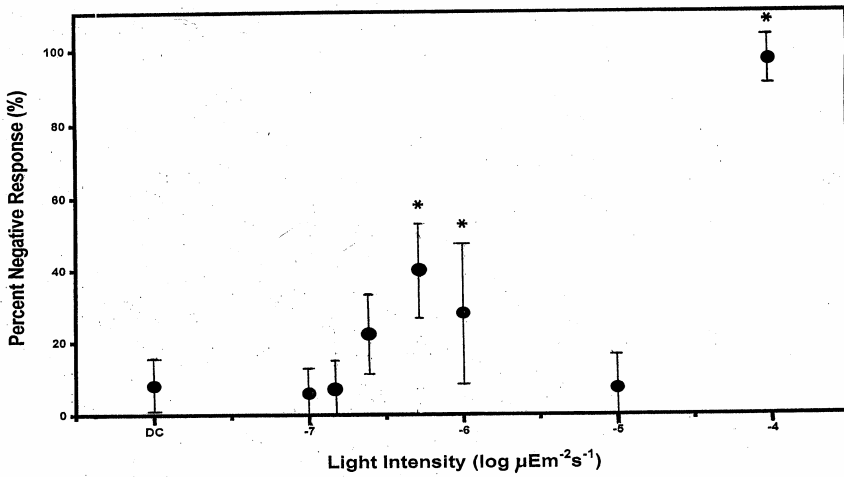
Figure 11. Percent negative phototactic response (mean, standard deviation) of ≤55h posthatch *Artemia franciscana* nauplii when exposed to different intensities of light of the same wavelength (λ = 450 nm). Standard deviation bars were not extended below the x-axis. n = 10 replicates of at least nine nauplii per replicate. DC = dark control group; * = response that is significantly (p < 0.05) different from DC
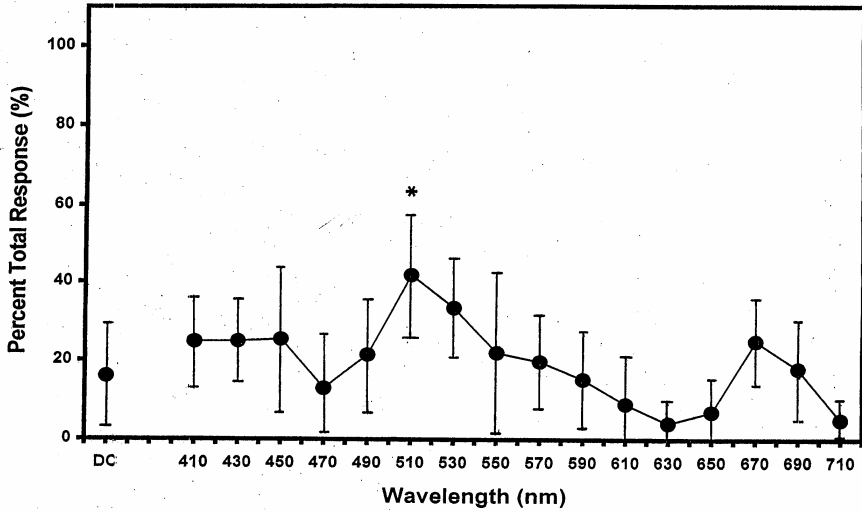

Figure 12. Percent total phototactic response (positive + negative mean, standard deviation) of ≤ 55 h posthatch *Artemia franciscana* nauplii when exposed to different intensities of light of the same wavelength (λ = 450 nm). n = 10 replicates of at least nine nauplii per replicate. DC =dark control group; * = response that is significantly (p < 0.05) different from DC
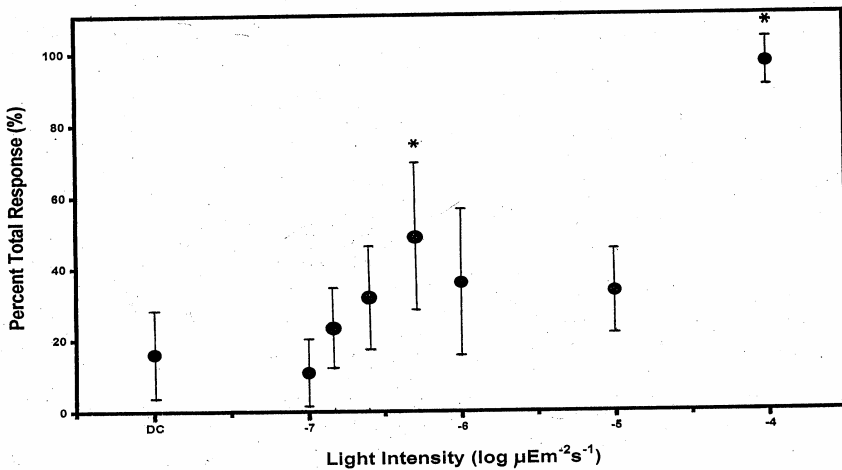
Increased Functionality and Copy Protection for Online Images: Dynamic Flash Images and the Web

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Streaming data driven applets and pages is what drives today's Internet. It is because of this that ways need to be made to create interfaces between today's technologies. Using formats such as Macromedia's SWF (shockwave) files, for its strength in streaming multimedia and animation, the PHP Group's PHP (Personal Home Page) files, for their easy access to databases, and either MySQL or Microsoft SQL Server 2000, one can create professional, dynamic presentations on the web that can be modified while unattended on the server side.

One may either store the binary information from the images in a database, or simply link to the location of the location, creating either a secure way to get to the data, or a network of resources, that can then be processed by the PHP to be used dynamically; changing the image that is linked to will change the image in the data-driven application immediately, cutting down on any publishing or compiling time for the programmer.

This was done to create a single location for data that is easily transported between servers. It may be expanded by creating more applications that use the same set of data, or through other tables, accessible through either a drop-down menu, or links, or in the case of flash, buttons. Different data sets may be chosen through time events, as well.

I. Introduction

Online copy protection is a gray area when considering jurisdiction and enforcement of laws. While the actions of many on the Internet are questionable at best, because copyright infringement is so rampant, they fail to be held accountable for their actions. An example of this is the relative ease with which one may copy an image from a web page, to be used either in another publication, or even another website. This prevents the original author of the work for getting credit for it.

Since it is hard to find violators of online copyright, and even harder to get the material removed, it is up to the website administrators to find ways to prevent copying of online materials. The main method in use to copy images is the right-click method. A visitor to a web site right-clicks on the image, and clicks "Save Picture As…" and can simply enter a folder location and the file is transferred to be used as they wish. To circumvent this, many websites have taken to disabling the right mouse button from their websites. Some example code of this, shown in JavaScript, is in Listing 1.

```
if (document.layers)
{document.captureEvents(Event.MOUSEDOWN);document.onmousedown=clickNS;}
else{document.onmouseup=clickNS;document.oncontextmenu=clickIE;}

document.oncontextmenu=new Function("return false")
```

Listing 1: JavaScript to Disable Right-Clicking

This works by intercepting the right clicks and calling a function instead of the original context menu. The line "new Function("return false")" just pops up a message window, completely circumventing the context menu. While this may succeed in diverting some web visitors, it is growing less effective as those who search for these images look for ways to circumvent this. In most cases, by going to the view menu, and clicking source, one may find the uniform resource locator (URL) of the original image. An example from Google.Com of an image URL follows:

<img src=images/res0.gif alt="Go to Google Home" border=0 width=110 height=58>

From this point, the user may enter the full URL (including the server) to get the image, in this example, http://www.google.com/images/res0.gif . In essence, this may be done very simply in a matter of about 30 seconds. A more complex way needed to be created for images that are particularly in danger of being copied.

From its inception, Macromedia's Flash did not provide an easy way to copy its online movies, in the form of SWF files. One may not simply right-click a file to save it, and browsers will not simply allow you to save it unless a link to just the file is created. The method to circumvent this is very similar to that for images, where one searches for the SWF reference within a page, but differs in that a new page must be created with a link to that SWF movie, the page must be loaded, and then the user may right-click and click "Save Target As…" in order to get the movie. However there is an added layer of protection for the images held within. The author of an SWF file may choose to make it protected, or read-only, thus putting a barrier between the person that copies the file, and the image itself. In fact, even if there is no protection on the Flash movie, images cannot be exported from the movie once they have been imported without additional programs.

Since SWF files do have this additional layer of protection, putting images into Flash movies is a sound way to protect them from copyright infringes. This can be extended to unprotected images via server-side processing using active server pages, such as either Microsoft's ASP or PHP Group's PHP format. As shown in listing 1, images may be stored in a central database, and transferred through server side COM+ DLLs to a form that can be dynamically transformed into a Flash Movie.
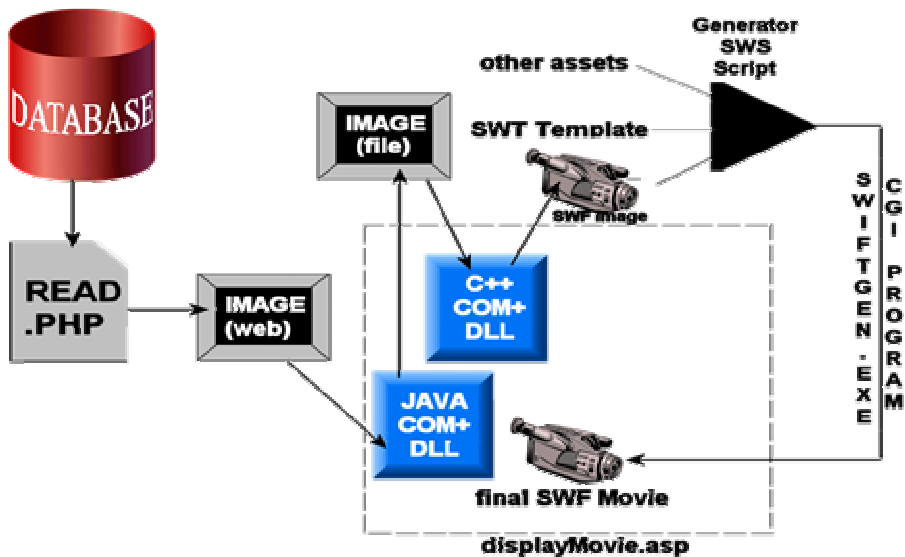
Figure 1: Online Images – From Database to SWF

II. Implementation Using PHP And MySQL

The first step in creating this solution was to create the database to store the images, as well as an easy way for the server administrator to upload images to this database. Any database server may be used, provided that a connection exists from the preferred active server page format. In this case, since PHP was used for the database access, MySQL was a natural choice. A table was created to store the long blob information, which was actually the binary content of the image. Also stored is the file size, a type descriptor for the row (in the case of an image, "file"), and a brief text description of the image. Listing 2 shows the SQL command to create the table.

```
CREATE TABLE testjpgs
          (
                    id INT(4) NOT NULL AUTO_INCREMENT PRIMARY KEY,
                    description CHAR(255),
                    bin_data LONGBLOB,
                    filename CHAR(255),
                    filesize CHAR(50),
```

```
                              filetype CHAR(50)
              );
```

Listing 2: SQL command for Image Data Table

At this point, the table needs to be filled with some initial images, requiring an
upload script to be made. To keep the project as concise as possible, a PHP script was
used to connect and upload the images, through a form on a web page. The code for this
is shown in Listing 3.

```php
<?php
// store.php - (C)2001, Jason W. Nadal
//                                      modified from original version from Florian Dittmer

//PHP Script to insert a binary jpg or other image into a database table with the
//following specification:

//table creation line:

//        CREATE TABLE testjpgs
//                (
//                        id INT(4) NOT NULL AUTO_INCREMENT PRIMARY KEY,
//                        description CHAR(255),
//                        bin_data LONGBLOB,
//                        filename CHAR(255),
//                        filesize CHAR(50),
//                        filetype CHAR(50)
//                );
?>

<HTML>
<HEAD><TITLE>Store binary data into SQL Database</TITLE></HEAD>
<BODY>

<?php
print "book = ".$book;
// code that will be executed if the form has been submitted:

if ($submit) {
   // connect to the database
   // (you may have to adjust the hostname,username or password)
```

```php
  MYSQL_CONNECT("localhost","root","");
  mysql_select_db("imageDB");

  $form_data_size = filesize($form_data);
        $form_data_name = $form_data;
        $data = addslashes(fread(fopen($form_data, "r"), filesize($form_data)));



  $result=MYSQL_QUERY("INSERT INTO
".$book."(description,bin_data,filename,filesize,filetype) ".
    "VALUES
('$form_description','$data','$form_data_name','$form_data_size','$form_data_type')");

  $id= mysql_insert_id();
  print "<p>This file has the following Database ID: <b>$id</b>";

        ?><img src="read.php?id=<?print"$id";?>"><?
  MYSQL_CLOSE();

} else {

  // else show the form to submit new data:
?>

  <form method="get" action="store.php?book=<?$book?>" enctype="multipart/form-data">
  File Description:<br>
  <input type="text" name="form_description"  size="40">
  <INPUT TYPE="hidden" name="MAX_FILE_SIZE" value="1000000">
        <INPUT TYPE="hidden" name="book" value="<?print $book;?>">
  <br>File to upload/store in database:<br>
  <input type="file" name="form_data"  size="40">
  <p><input type="submit" name="submit" value="submit">
  </form>

<?php

}

?>
</BODY>
</HTML>
```

Listing 3: Store.PHP Source

The MYSQL_CONNECT line needs to be modified to use the correct username and password. The final product is shown below, in Figure 2. All the administrator needs to do is to click the "Browse…" button and enter the description.

Figure 2: Store.PHP – The upload Script

From there, the image may be added from a disk or the server's hard drive to the database. To see the full contents of the database, an unprotected list with thumbnails was made, to be stored in a secure directory on the server. In this way, the admin may see the full quality, full sized image in order to add the images to pages. Listing 4 shows the code for the image gallery, and Figure 3 shows the final result of this.

```
<html>
<head>
<title>Image Database</title>
</head>



<body bgcolor=black text=white marginwidth="0" marginheight="0" topmargin="0"
leftmargin="0">
<table border=1 bgcolor=black width=75%>
<tr>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>ID</b></font></td>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>Name</b></font></td>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>Size</b></font></td>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>Type</b></font></td>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>Description</b></font></td>
<td><font face=Verdana, Arial, Helvetica, sans-serif size=2><b>Thumb</b></font></td>
```

```
</tr>
<?

// Lister.php - (C)2001, Jason W. Nadal
//                                    modified from alternatingColors2.php by J. Nadal

//PHP Script to display entries in the image database with the following fields:
//                         id INT(4) NOT NULL AUTO_INCREMENT PRIMARY KEY,
//                         description CHAR(255),
//                         bin_data LONGBLOB,
//                         filename CHAR(255),
//                         filesize CHAR(50),
//                         filetype CHAR(50)
        $connection=mysql_connect ('localhost', 'root', '');
        $db=mysql_select_db ('imageDB');
//      $theQuery = "SELECT filename,description FROM testJPGs";
        $theQuery = "SELECT filename,description FROM ".$book;
        $result = mysql_query ($theQuery);
        $colorNum=1;
        $count=1;

        //color alternator code:
        $colors[1]="B0C4DE";                    //dark
        $colors[0]="F0F8FF";                         //light
        $colorNum=0;
        $color=$colors[0];

        while ($row = mysql_fetch_array($result))
        {
                //color alternater code begin
                $colorNumOffset = $colorNum % 5;
                if($colorNum%5 == 0)
            {
                        if ($color == $colors[0]) {$color = $colors[1];}
                    else {$color=$colors[0];}
                        $colorNum=1;
            }
                else
                {
                        $colorNum++;
                }
                //end color alternator code
```

```
                $name=$row["filename"];
                $size=filesize($name)." b";
                $type=filetype($name);
                $desc=$row["description"];
                print("<tr>          <td bgcolor=$color><font face=Verdana, Arial,
Helvetica, sans-serif size=2 color=black>$count</font></td><td bgcolor=$color><font
face=Verdana, Arial, Helvetica, sans-serif size=2 color=black>$name</font></td><td
bgcolor=$color><font face=Verdana, Arial, Helvetica, sans-serif size=2
color=black>$size</font></td><td bgcolor=$color><font face=Verdana, Arial, Helvetica, sans-
serif size=2 color=black>$type</font></td><td bgcolor=$color><font face=Verdana, Arial,
Helvetica, sans-serif size=2 color=black>$desc</font></td><td bgcolor=$color><a
href=\"../read.php?id=$count&book=$book\"><img border=0
src=\"../read.php?id=$count&book=$book\" height=100 width=100></a></td></tr>");
                $count++;
        }
?>
</table>
</body>
</html>
```

Listing 4: Lister.PHP source

Figure 3: Lister.PHP – The administrative image gallery

This listing script utilizes another script to read a single image at a time from the database, and return the blob data, in this case the binary data of the image, as an image. This is done through the short Read.PHP file, in Listing 5.

```php
<?php

// read.php - (C)2001, Jason W. Nadal

//PHP Script to view a binary jpg or other image from a database table

if($id) {

  // you may have to modify login information for your database server:
  @MYSQL_CONNECT("localhost","root","");

  @mysql_select_db("imageDB");

  $query = "select bin_data,filetype from ".$book;
  $result = @MYSQL_QUERY($query);

  $data = @MYSQL_RESULT($result,$id-1,"bin_data");
  $type = @MYSQL_RESULT($result,$id-1,"filetype");

  Header( "Content-type: $type");
  echo $data;

};
?>
```

Listing 5: Store.PHP source code

Read.PHP is available only on the local network in order to only allow access to the full JPEG version of the image for trusted machines. In this way, security is still maintained. Read.PHP is only passed two variables: the row number of the image ($id), and the specific table in the database where the image is located ($book). The result, shown in Figure 4, is a URL that mimics an actual JPEG file.
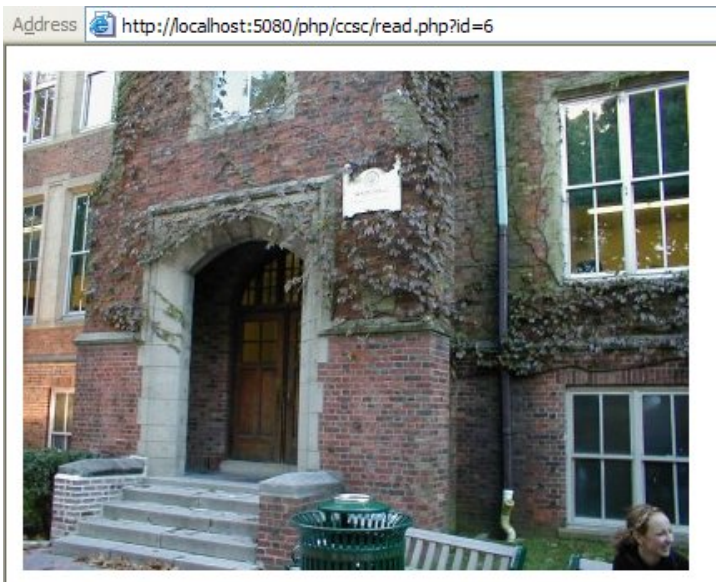
Figure 4: An example image from Read.PHP

At this point, the image needs to be taken and converted by the server to a Flash file. This will be a single frame looping movie that just displays the image. For distinction, a text field was added that displays "Protected Image." This may be changed through generator scripting, explained later.

Since there was not an existing prepackaged active template library (ATL) control that would let the final page take an image from a URL to convert it into a single frame SWF movie, one had to be created. ServerWriteJPEG.DLL is a COM+ ATL control written in Java (specifically Microsoft's Visual J++ 6.0) to do just that. The code for the control is shown in Listing 6.

```
//JASON W. NADAL
//January, 2002

//ServerWriteJPEG.dll
//JAVA (Visual J++) Com+ DLL
//Reads a file from a web address, and writes that file to the
//Server's hard drive to the location given.

import java.awt.*;
import java.awt.event.*;
import java.net.*;
import java.io.*;
```

```java
import java.applet.Applet;



/**
 * This class is designed to be packaged with a COM DLL output format.
 * The class has no standard entry points, other than the constructor.
 * Public methods will be exposed as methods on the default COM interface.
 * @com.register ( clsid=9AC16B8C-466F-44FF-8702-4DCA956D28A5,
typelib=05AFCB28-DA82-4846-84FA-695BD3345B4D )
 */
public class WriteJPEG
{
        //how to register a dll:
        //regsvr32 c:\xyz\abc.dll

        //how to unregister a dll:
        //regsvr32 /u c:\xyz\abc.dll


        public static void onCOMRegister(boolean register)
        {
                //No specific registration code is needed.
        }

        public String copyFileFromURL(String theURL, String outFile)
        {
                //takes the file at fileURL and copies it to a file
                //on the server's hard drive, destFile
                URL url;

                try
                {
                        url = new URL(theURL);
                        File outputFile = new File(outFile);
                        URLConnection conn = url.openConnection();
                        InputStream in = conn.getInputStream();
                        FileOutputStream out = new FileOutputStream(outputFile);
                        int c;
                        while ((c = in.read()) != -1)
                                out.write(c);
                        in.close();
                        out.close();
                }
```

```
                    catch (Exception exc) {}
                    return "Finished.";
            }

            public String copyFile(String inFile, String outFile)
            {
                    //copies a file from the server to another location on the server.
                    File inputFile = new File(inFile);
                    File outputFile = new File(outFile);
                    try
                    {
                            FileInputStream in = new FileInputStream(inputFile);
                            FileOutputStream out = new FileOutputStream(outputFile);
                            int c;
                            while ((c = in.read()) != -1)
                                    out.write(c);
                            in.close();
                            out.close();
                    }
                    catch (Exception exc) {}
                    return "Finished.";
            }
}
```

Listing 6: ServerWriteJPEG.JAVA source code

A temporary image file now exists on the server. This paves the way for the file to be converted into a single frame flash image. A prepackaged DLL, J2S.DLL already exists for the purposes of taking a file on a server and making a single frame movie. Now that the image is on the server's hard drive, the component J2S.Converter.1 has the method Convert, which takes two file arguments, input and output, and generates an SWF file on the backend when the client requests a page. In the Java ATL control, the copyFileFromURL() method provides the interface to move the file from the LAN onto the server.

Swift-Generator (swiftgen.exe), is a CGI program written in C/C++ that allows the programmer to add dynamic content to a Flash movie. It takes one argument, the location of the SWS scripting file (ie: "/CGI/SWIFTGEN.EXE?SWS= /ASSETS/SWS/MOVIE.SWS"). Swift-Generator then compiles the published SWT template file along with any assets mentioned in the SWS scripting file and creates the final compiled movie, at the time the page is requested. The scripting file used in the example is shown in Listing 7a.

```
% Jason Nadal
%       (c)2002
%       mainMovie.sws      Swift-Generator Scripting file
%       Script template from Template file mainMovie.swt
%       compiles the Template File (mainMovie.swt) with the assets into the final
%       result SWF movie when called with Swift-Generator CGI program.

INPUT "../php/ccsc/flashMovie/mainMovie.swt"

% Output for testing
%OUTPUT "export.swf"
% Output for CGI
OUTPUT -cgi "-"

% Font definitions
% FONT 4  is  Times New Roman  (224 glyphs)


SUBSTITUTE TEXT 5 {
        FONT 4 HEIGHT 24 KERNING 0.98 COLOR #ffff80
        STRING "Image Gallery - Protected Image"
}
```

<center>Listing 7a: MainMovie.SWS Generator Scripting File</center>

To get this scripting file, an initial Flash movie needs to be created with the placeholder for the image, as well as any text fields that are wanted. The main movie file, named MainMovie.FLA in the example, contains a separate movie instance from _ROOT which loads the generated single frame looping image movie using the command:
LOADMOVIE("IMAGE.SWF",_ROOT.SPOTFORMOVIE);
This will change dynamically without changing the flash source every time the client requests an image.

The movie is then exported to a template file, in the form of SWT. The file may be fed into SWIFTGEN.EXE and the resources dumped to a skeleton scripting file, which is modified to the final scripting file in Listing 6. The movie location is added to an object to be displayed via the final asp page, as shown in Listing 7b.

```
<BODY bgcolor=black text=white>
<OBJECT classid="clsid:D27CDB6E-AE6D-11cf-96B8-444553540000"
        codebase="http://download.macromedia.com/pub/shockwave/cabs/flash/s
wflash.cab#version=5,0,0,0"
        WIDTH=450 HEIGHT=350>
```

```
            <PARAM NAME=movie
                      VALUE="http://1.1.0.9:5080/cgi-
                 bin/swiftgen.exe?sws=../php/ccsc/flashMovie/mainMovie.sws">
            <PARAM NAME=quality VALUE=high>
            <PARAM NAME=bgcolor VALUE=#000000>
            <EMBED src="http://1.1.0.9:5080/cgi-
            bin/swiftgen.exe?sws=../php/ccsc/flashMovie/mainMovie.sws"
                           quality=high bgcolor=#000000  WIDTH=450 HEIGHT=350
                     TYPE="application/x-shockwave-flash"

            PLUGINSPAGE="http://www.macromedia.com/shockwave/download/index.cgi?
            P1_Prod_Version=ShockwaveFlash">
            </EMBED>
</OBJECT>
</BODY>
```

Listing 7b: HTML Markup for SWF Movie

Note that in this scenario, even if a user does look at the source code and recognize the
image as a Flash movie, they must discover that the results of the CGI program must be
an SWF file, and decide how to get that file, before even trying to recover the image from
within.

    ShowResult.ASP is the container that holds all of the elements of the protection
scheme. It contains the calls to all of the COM+ components to do all of the dirty work
of creating the copy of the LAN image, the single frame Flash movie, and the final result
window. The code for this is shown in Listing 8.

```
<%@ Language = "VBScript" %>
<% Response.Buffer = True %>

<html>
<head>
<%
        theImageName = Request("name")
        Response.Write("<title>Show Protected Image -")
        Response.Write(theImageName)
        Response.Write("</title>")
%>
<body topmargin="3" leftmargin="3" marginheight="0" marginwidth="0" bgcolor="#000000"
link="#000066" vlink="#000000" alink="#0000FF" text="#FFFFFF">

<%
```

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```
                Set myObject2 = Server.CreateObject("ServerWriteJPEG.WriteJPEG")
                theURL="http://1.1.0.9:5080/php/ccsc/read.php?id="
                theID = Request("id")
                theBook = Request("book")
                getBook = "&book="
                theURL=theUrl+theID+getBook+theBook
                result = myObject2.copyFileFromURL(theURL,
                                    "d:\xitami\webpages\php\ccsc\imageTemp\image.jpg")
                Set myObject = Server.CreateObject("J2S.Converter.1")
                myObject.FlashVersion = 5
                Response.write("theURL=")
                Response.write(theURL)
%>
<br>
<%
        result = myObject.Convert("d:\xitami\webpages\php\ccsc\imagetemp\image.jpg",
                            "d:\xitami\webpages\php\ccsc\flashMovie\image.swf")

%>
<br>
<iFrame src="http://1.1.0.9:5080/php/ccsc/flashMovie/showMovieSwiftGen.php" width="460"
height="360"
                    border="0" frameborder="0" scrolling=no>
</iFrame>
</body>
</html>
```

Listing 8: ShowResult.ASP source code

A form for the gallery was made to fully demonstrate the final result, since the original process from Figure 1 is complete at this point. This was done in PHP to allow the addition of other tables ($book). The code is shown in Listing 9, with the web view shown in Figure 5 below it.

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<HTML>
<HEAD>
<TITLE> Image Form </TITLE>
<META NAME="Generator" CONTENT="EditPlus">
<META NAME="Author" CONTENT="">
<META NAME="Keywords" CONTENT="">
<META NAME="Description" CONTENT="">
</HEAD>
```

```
<BODY bgcolor="#000000" text="#FFFFFF">
<form action="http://172.16.0.98/imageForm/showResult.asp?book=<?print $book?>"
method="GET" target="bottom" name="thisForm">
<?

// imageForm.php - (C)2002, Jason W. Nadal
//                                        modified from store.php by J. Nadal

//PHP Script to display entries in the image database with the following fields:
//                        id INT(4) NOT NULL AUTO_INCREMENT PRIMARY KEY,
//                        description CHAR(50),
//                        bin_data LONGBLOB,
//                        filename CHAR(50),
//                        filesize CHAR(50),
//                        filetype CHAR(50)
//format is display as radio buttons with the labels as the file descriptors

        $connection=mysql_connect ('localhost', 'root', ");
        $db=mysql_select_db ('imageDB');
//      $result = mysql_query ("SELECT description FROM testJPGs");
        $result = mysql_query ("SELECT description FROM ".$book);
        $count=1;

        while ($row = mysql_fetch_array($result))
        {
                $desc=$row["description"];
                $line = "<input type=\"radio\" name=\"id\" value=\"".$count."\"
                    onclick=\"document.thisForm.submit();\">".$desc."<br>";
                print($line);
                $count++;
        }
?>
<input type="hidden" name="book" value="<?print $book?>">
</FORM>

</BODY>
</HTML>
```

Listing 9: FormMain.PHP source code

Figure 5: The Completed ImageForm.PHP

The form shown in Figure 5 consists of radio boxes corresponding to all rows of the selected table ($book). For each radio box, the image descriptor taken from the description field in the database is used as the title of the image. The original file names are never shown, adding some additional security to the file. The conventional way of images is shown below in Figure 6, using the insecure Read.php (which should be put in a secure location of the server, since by itself it is insecure). Lastly, the final SWF movie is shown in Figure 7, with all security in place.
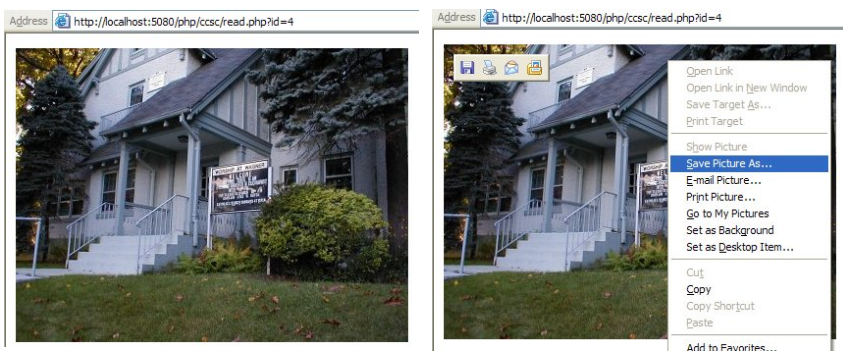

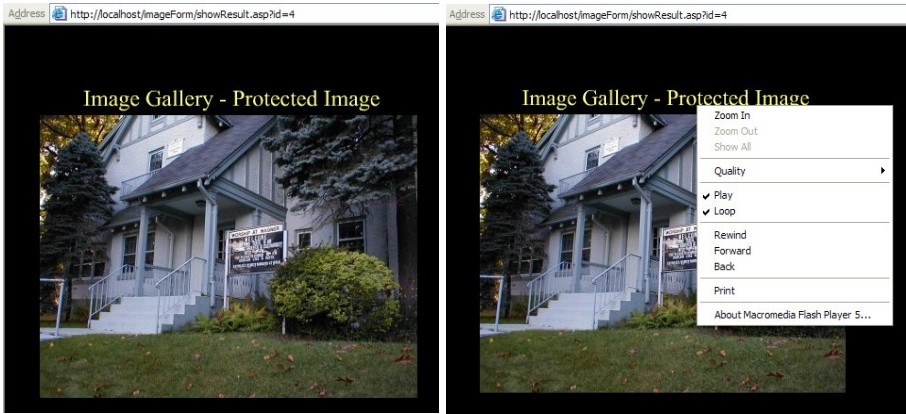Figure 6: The conventional method of saving images

Figure 7: The new protected SWF image

Speciation of Arsenic Metabolic Intermediates in Human Urine by Ion-Exchange Chromatography & Flow Injection Hydride Generation Atomic Absorption Spectrometry

Sarah Alauddin and Dr. Mohammad Alauddin
Presented[1] at the 56th Eastern Colleges Science Conference in Niagara, NY

Biomethylation is considered as the principal metabolic and detoxification pathway for inorganic arsenic in human. The end products of methylation are less toxic and more readily excreted through urine. Therefore, speciation of metabolites in urine is essential to a better understanding of arsenic metabolism, health effects and detoxification ability of individuals exposed to arsenic through drinking water, food and environmental materials. Speciation of inorganic and methylated arsenic in urine is an analytical challenge. We have developed a technique for separating and analysis of various arsenic species, such as, arsenite, arsenate, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) in urine. The technique is based on chromatographic separation followed by flow injection hydride generation atomic absorption spectrometry (FI-HG-AAS). Arsenite (As^{III}) was found to be the major component in urine. The detection limit varies from 1.0 – 2.0 μg/l for various species. The technique has been successfully applied to speciation of arsenic metabolite intermediates in urine samples collected from patients in Bangladesh. Results from our findings from an arsenic affected area in Bangladesh will be discussed. The technique will permit us to carry out routine arsenic speciation in biological tissues, essential for toxicological and epidemiological studies.

I. Introduction

Bangladesh is in the grip of worst mass poisoning the world has ever witnessed. This poisoning is taking place from drinking arsenic contaminated groundwater, typically pumped by a hand pump attached to tube well. Arsenic contamination in groundwater is nothing new to developed countries. Previously arsenic contamination of groundwater has occurred in Chile, Argentina, USA, inner Mongolia, Hungary, New Zealand, West Bengal, India. But the case of Bangladesh is the worst.

The maximum permissible level of arsenic in drinking water in Bangladesh is 50 microgram per liter. About 80 million people of Bangladesh are drinking water over this limit. About 35 million children are at risk of developing arsenicosis. The extent of arsenic contamination in Bangladesh groundwater has surpassed all previous incidences

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[1] Received award for Outstanding Presentation in Chemistry

recorded anywhere in the world. Currently the USA drinking water permissible level is 5 microgram per liter. In Bangladesh, arsenic levels in groundwater in some of the severely affected areas like Kushtia, Comilla, Chandpur, Noakhali and Barisal range from 600 to 3200 microgram per liter. The highest recorded arsenic level so far is 4720 microgram per liter of water (1).

Absorption of arsenic at levels of few hundred microgram per liter has led to cancers of bladder, skin, lung and some non-cancer effects such as melanosis and keratosis in different parts of the world including Bangladesh (2,3). Chronic arsenic poisoning cases result from the ingestion and absorption of inorganic arsenic from groundwater (2, 4). Once the arsenic is ingested, partly it is excreted through urine, hair and nail. The body then tries to detoxify arsenic. Inorganic arsenic, As(III) and As(V) undergo biomethylation in the human body through a series of reaction. The final products are less toxic metabolites, such as, monomethyl arsonic acid (MMA), dimethyl arsinic acid (DMA) and these are readily excreted through the urine (5). The toxicity decreases from inorganic arsenite and arsenate to MMA and DMA, the biomethylation of arsenic in the body is considered as a major detoxification pathway (6). The conversion of inorganic arsenic to organic arsenic in the biological system does not stop here. The organification of arsenic leads to the formation of trimethyl arsine oxide (TMAO), arsenobetaine and arsenocholine. In human, the biomethylation occurs mostly in the liver. The actual methylation process involves reduction of pentavalent arsenic to trivalent state followed by addition of a methyl group from the methyl donor S-adenosylmethyonine (SAM) (7). The metabolites MMA, DMA are commonly observed in the urine of people exposed to inorganic arsenic (7). The methyl donor after donating its methyl group, itself is converted to S-adenosylhomocysteine (SAH). The regeneration of SAM from SAH is possible by 5,10-methyltetrahydrofolate, vitamin B_6 and $B_{12.}$ So if we analyze urine sample from arsenic affected people and check the concentration of MMA and DMA we can tell who is methylating and detoxifying arsenic and who is not. It is believed that good nutrition and methionine rich food may help an individual in methylating arsenic.

II. Objectives of the study

1. Estimate recent exposure to arsenic by individuals in a seriously affected area in Bangladesh.
2. Determine key arsenic metabolites, such as arsenite, arsenate, monomethylarsonate (MMA),
   dimethylarsinate (DMA) in urine of patients from affected area.
3. Determine MMA/DMA ratio for male, female adults and children.
4. Estimate the extent of methylation by the individuals in the same area. Presence or absence of methylated arsenic (MMA, DMA) in urine will indicate relative detoxification ability and nutritional intervention can be recommended.

III. Methodology

The samples were collected from Hajiganj, Bangladesh in January 2002. Dr. Alauddin visits this area with his Bangladesh collaborating institution, International Center for Diarrhea and Disease Research. I visited Bangladesh in March 2002 and worked with Dr. Alauddin's research group in Dhaka, Bangladesh. The analytical technique for measuring inorganic and methylated arsenic species in human urine involves (a) separation of different chemical forms of arsenic and then (b) detection of arsenic species by hydride-generation atomic absorption spectroscopy (HG-AAS). The flow sheet for the methodology is given in Figure 1. The separation is based on ion-exchange chromatography. The arsenic species like, arsenite occurs as aneutral species, arsenate and MMA occur as anion and DMA occurs as cation in body pH. So anion and cation exchange columns retain these species, while arsenite is not retained by columns. The retained arsenic species are then washed out of columns with hydrochloric acid and acetic acid buffers (Figure 1) . The method development was presented by Dr. M. Alauddin previously in an overseas seminar(8).

We followed HG-AAS method for measuring arsenic. In this method, hydrogen gas is produced by the reaction of sodium borohydride and hydrochloric acid. Arsenic from sample, then reacts with hydrogen to form arsine vapor (AsH_3) which is then transported to a quartz tube placed in a burner. The arsine vapor breaks into arsenic atoms. The arsenic atoms then absorbs light (193.7 nm wavelength) from a arsenic lamp and the absorbance is proportional to concentration of arsenic in sample. The AAS is calibrated with known standard solutions of arsenic.

IV. Results

The detection limit for all the species ranged from 1 to 2 microgram per liter of sample. In almost all samples from male and female individuals it is observed that arsenite is the major species present in urine and the amount of both MMA and DMA are very low (Table I). Only the average values for male and female groups are indicated in the following table. The detailed data were presented in the Eastern Colleges Science Conference 2002 at Niagara University (9). In the first column, the parentheses show the number of samples analyzed. Arsenite (As^{3+}) is the most toxic form of arsenic in this group and most of the arsenic in urine is arsenite and least toxic DMA is rather low.

The methylated arsenic species in urine indicate the degree of individual detoxification ability. A low concentration of MMA and DMA in urine indicate a high degree of arsenic retention in the body and the person needs help in methylating arsenic from the body. Our current study is very important in Bangladesh, because, arsenic speciation in urine allows us to screen patients who are poor methylator and at risk of developing severe form of arsenicosis and cancer. In that case, vitamin and nutrition supplements may help biomethylation and detoxification. Of course, the individual must stop drinking arsenic contaminated water.

Dilute Urine Sample

0.45 micron filter $\longrightarrow$ Retains part. As $\rightarrow$ eluted 0.5 M HCl

C_{18} column

Resin based
Cation Exchange Column $\longrightarrow$ Retains DMA
(SCX)

$\qquad$ eluted with 1.0 M HCl

Silica based
Anion Exchange Column $\longrightarrow$ Retains $As^V \rightarrow$ eluted 1.0 M HCl
(SAX) $\qquad$ and MMA $\rightarrow$ eluted 0.1 M HOAc

As^{III}

Elution from $\qquad$ Gas liquid $\qquad$ AsH_3 vapor $\qquad$ Drying tube
Column $\longrightarrow$ separator

$\qquad$ HCl NaBH$_4$ Ar $\qquad$ AAS detector $\longleftarrow$ Heated quartz T-tube

Readout

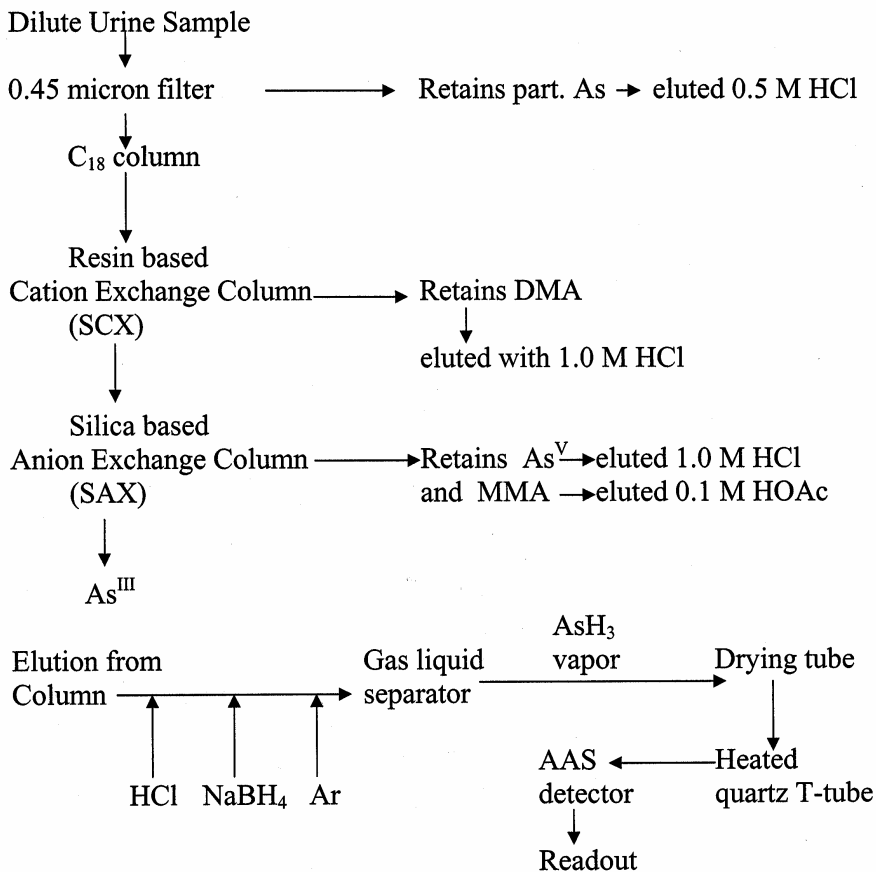Figure 1. Flow sheet of the separation of arsenic species in urine and detection by HG-AAS

Table I. Arsenic speciation in Male-Female urine samples (average values)
(unit: microgram per liter urine)

M/F	As(part.)	As(III)	As(V)	MMA	DMA	MMA/DMA
Male(8)	3.85	117	15.2	5.51	25.4	0.25
Female(12)	3.18	126	32.2	7.26	25.5	0.35

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V. Conclusions

1. Solid phase extraction (SPE) through ion exchange columns permits speciation of major arsenic metabolites in urine.
2. SPE is a slow separation process, only 2 to 3 samples could be separated and analyzed in a day. Routine speciation of large number of samples will require adoption of high performance liquid chromatography technique.
3. Arsenite was the major component in urine of all individuals tested, MMA/DMA ratio indicates poor methylation capacity by all patients, most likely due to poor nutrition status.
4. Purification of key enzymes and measurement of enzyme activities involved in arsenic methylation, need to be carried out, nutrition definitely plays a role in detoxification of arsenic.
5. The speciation technique can be extended to crops, vegetables grown in arsenic affected areas.

Safe drinking water and good nutrition, along with proper hygiene and sanitation practice are must for rural people in Bangladesh in combating what is shaping up as the worst mass poisoning in the world.

VI. Acknowledgements

VII. References

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Popcorn PVP Induced by Purified EVP

Dawn Pothier and Dr. Susan Tseng

Presented[1] at the 56th Eastern Colleges Science Conference in Niagara, NY

Without the addition of any free radical initiators, the crosslinking agent 1-vinyl-3-ethylidenepyrrolidone (EVP) facilitates the polymerization of vinylpyrrolidone (VP) to form popcorn polyvinylpyrrolidone (PVP). A pressure tube reactor was placed in a heated glycerin oil bath. A solution of a known concentration of VP and approximately 2% EVP (based on the weight of VP monomer) was added to the reactor. Using a data acquisition program, the temperature was recorded by a thermocouple probe connected to a computer. Pictures of the reaction were also taken approximately every two seconds with a digital camera and saved to the computer. In some reactions, other cross-linking agents were substituted for EVP.

Once a PVP nucleus has formed, the monomer diffuses into the nucleus and reacts with the active radical sites. The exothermic polymerization is observed as an expanding popcorn-like formation. Measuring the temperature, the rate of the reaction of the system at various monomer concentrations (60 – 80%) was analyzed. The results of the sStudy indicated that the pre-polymerized PVP, trially-1,3,5-triazine-2,4,6-(1H, 3H, 5H)-trione and N,N'methylenebisacrylamide did not react efficiently with the monomer. The EVP/VP systems in Figure 1, show that the induction period lengthened and the peak temperature dropped as the VP monomer concentration was decreased. Also, during the
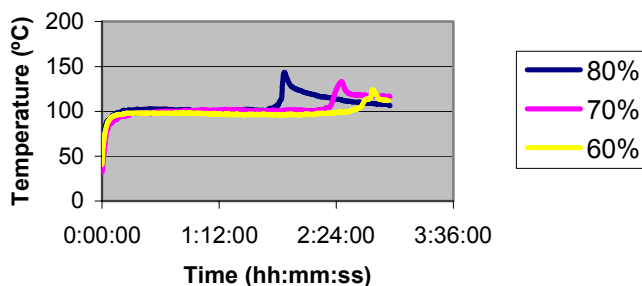

Figure 1: Temperature Profile for EVP Induced Popcorn PVP with Varying Monomer Concentrations

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[1] received outstanding presentation in Chemistry award

nucleation period of the reaction, the temperature of a single nucleus polymerization appeared to oscillate, while the ambient temperature remained relatively stable (shown in Figure 2). This phenomenon is interpreted as the process of monomer diffusion and propagation. More experimental evidence is needed before further conclusions are made.
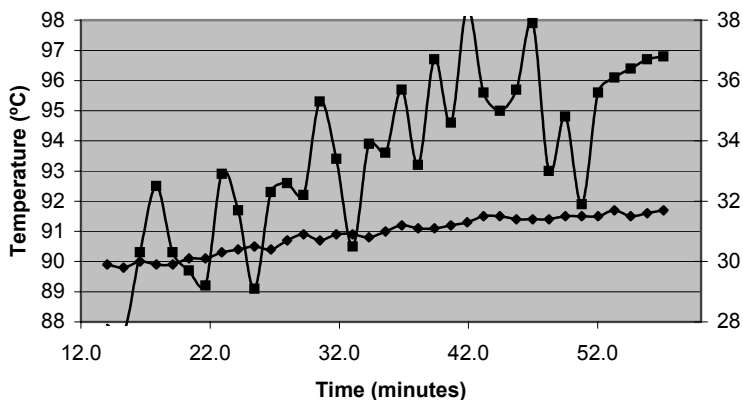
Figure 2. Temperature Oscillation in the nucleation Stage
(- ■ − 80% VP with one nucleus , − ♦ − Ambient)

Hydrothermal Growth of Iron Sulfide Crystals

Richard Moses and Dr. Maria Gelabert
Presented at the 56th Eastern Colleges Science Conference in Niagara, NY

The chemistry of deep-sea hydrothermal chimneys involves anions other than oxygen, most notably sulfur. In this anaerobic environment, minerals such as pyrite (FeS_2) grow readily on the inside of the chimneys and organisms metabolize hydrogen sulfide. In the effort to better understand the sulfide chemistry in hydrothermal vents, a laboratory investigation was conducted to determine optimum conditions for growth of sulfide crystals. Most literature in hydrothermal synthesis involves study of compound classes such as oxides and phosphates, not sulfides. Here, we report the crystal growth of iron sulfides under hydrothermal conditions in the presence of ammonia. Experimental conditions such as concentration and reactants were monitored. Optimum conditions for growth of iron sulfide crystals will be discussed.

Gases and Thermostatistics

Randye Joy Shanfeld, Steven R. Corn and Dr. Gregory J. Falabella
Presented at the 55th Eastern Colleges Science Conference in Wilkes Barre, PA

Physical systems are often analyzed from a large-scale or macroscopic point of view. The substances of which they are comprised are assumed to be continuous and governed by gross or average effects. This is done to keep problems tractable from a computational point of view. In reality, the behavior of the individual molecules determines the observed properties and the concept of a continuum has limitations. This research effort is an investigation into the actions of the individual molecules of a gas. Emphasis is on the validity of the kinetic molecular theory of gases and the associated Maxwell-Boltzmann distribution for a system containing a small number of molecules and relatively short mean free paths (figure 1).

Procedure

1. Using the Kinetic Molecular Theory of Gases as a guide develop a mathematical model which describes the motion of individual gas molecules confined to given region of space.
2. Create a computer program to simulate the interactions between a given number of molecules.
3. Use the code to determine if the velocities of each individual molecules fall into a general pattern. Also, investigate what effect the total amount of energy contained in the system has on the shape of this distribution.
4. Compare the results to accepted theory.

Maxwell-Boltzmann Distribution

The temperature of a gas is a measure of the net molecular motion but what about the velocities of the individual molecules?

Maxwell-Boltzmann distribution- a characteristic distribution of molecular speeds which depends on temperature (i.e. v^2_{rms}).

$$P(v) = 4\pi N \left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} v^2 e^{-\frac{mv^2}{2kT}} = 4\pi N \left(\frac{2}{3}\pi v^2_{rms}\right)^{-\frac{3}{2}} v^2 e^{-\frac{3v^2}{2v^2_{rms}}}$$

$$\Pr(v_a \leq v \leq v_b) = \frac{1}{N}\int_{v_a}^{v_b} P(v)dv$$

Pr is the probability that a molecule has a speed between v_a and v_b
N $\cong$ Pr is the number of molecules moving at speeds in the range v_a#v#v_b.
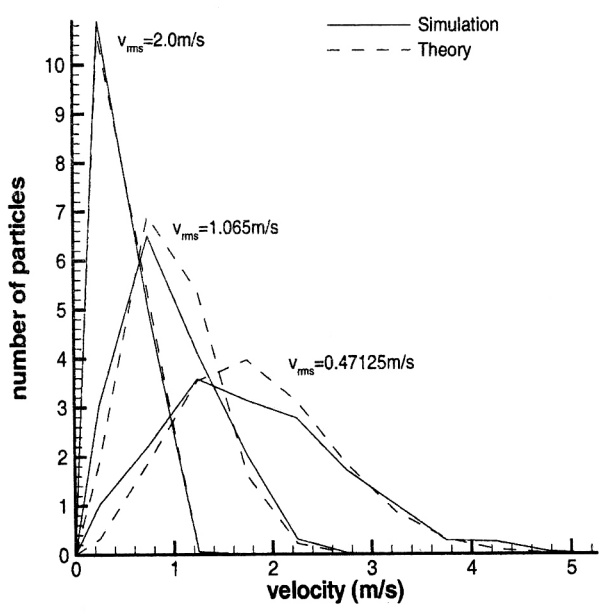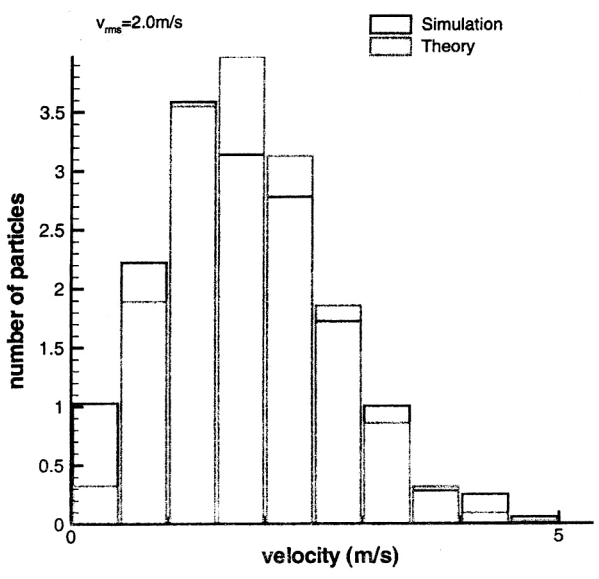
Figure 1: Results indicating that the kinetic molecular theory of gases is a good approximation for a system containing only a small number of molecules in relatively close proximity.

Experimental Analysis of the Hydrolysis
of Vinylpyrrolidone by Gas

Maryanne Gaul, Dr. Brian Palestis and Dr. Susan Tseng
Presented at the 56th Eastern Colleges Science Conference in Niagara, NY

The competing side reaction of the polymerization of polyvinylpyrrolidone is the hydrolysis of vinylpyrrolidone. The hydrolysis is acid catalyzed as shown:
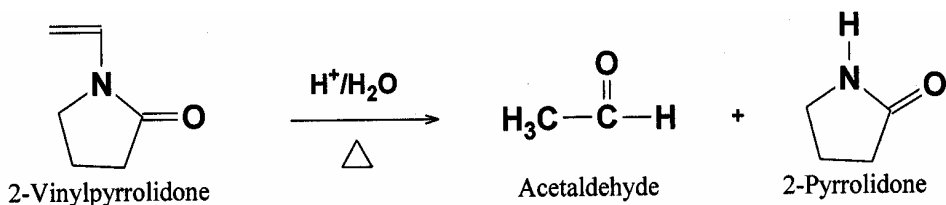
Therefore, the VP polymerization condition should be in relatively basic aqueous solution. The purpose of this research is to define the best polymerization condition such that the monomer solution is not hydrolyzed in the time frame of the polymerization reaction. In order to do this, a good analytical method must be used to determine the percentage of unhydrolyzed vinylpyrrolidone under each reaction condition. Gas chromatography (Varian 3300) was utilized with a relatively non-polar capillary column (DB5), and the technique of using an internal standard was applied. N.N'Dimethylacetamide was selected as an internal standard because of its similar molecular weight, polarity and of course retention time to VP. Response factors of these two compounds will be determined. The hydrolysis reaction conditions that we chose to investigate are the concentration of VP aqueous solution, the pH range form 4-8, third reaction temperature, and fourth reaction time. A statistical computer program (JPM/SAS Institute) will be used to establish a matrix, and all parameters will be able to be studied simultaneously. All the reactions after completion will be subjected to GC analysis to determine the % VP remaining intact, and the results from the GC analysis will be subjected to statistical analysis. From this we can find the best reaction condition to avoid vinylpyrrolidone hydrolysis. This paper reports the quantitative GC analytical method of unhydrolyzed VP.

Numerical Simulation of Free Convection

Peter Herbst and Dr. Gregory J. Falabella

Presented at the 55th Eastern Colleges Science Conference in Wilkes Barre, PA

Convection is the transfer of heat energy by the bulk motion of a fluid. If this flow is generated by thermally induced density variations it is known as natural or free convection. It is tempting to overlook such flows because the velocities and heat transfer rates associated with them are small. This, however, is a mistake. The design of many systems is often influenced by natural convection. More importantly, buoyant flows are the driving force behind many significant environmental processes and are especially of interest when considering the impact of thermal energy discharge by chimneys and cooling towers. The current research effort is a numerical investigation of the effect of immersing a heated vertical plate into a quiescent fluid (figure 1). The two-dimensional Navier-Stokes equations are solved using finite-differences. Boundary layer and Boussinesq approximations are made use of to maintain a reasonable computational effort.

Background

Convection is the transfer of heat energy by the bulk motion of a fluid. It is governed by Newton's Law of Cooling

$$q = hA\left(T - T_\infty\right)$$

where
  q is the rate of heat transfer to or from the fluid
  T is the temperature of the fluid
  A and T are the area and temperature of the surface in contact with the fluid

Forced Convection

-motion produced by some external means such as a fan, a pump or the wind
-relatively high velocities and heat transfer coefficients (h.25-250W/m$^2\cong$K for gases and
  h.50-20000W/m$^2\cong$K for liquids)

Free or Natural Convection

-flow induced by thermal density variations (buoyancy driven)
-sometimes mistakenly overlooked because associated velocities and heat transfer
 coefficients are small (h.5-25W/m$^2\cong$K)
-often the driving force behind many significant environmental processes
-especially of interest when considering the impact of thermal energy discharge by chimneys
  and cooling towers

Governing Equations and Assumptions

Navier-Stokes Equations

-five nonlinear partial differential equations (hyperbolic) which represent the conservation of
 mass, momentum and energy and an equation of state
-govern all fluid (liquid and gas) flow as long as fluid can be modeled as a continuum (i.e.
 matter distributed uniformly throughout space)
-extremely complex and can only be solved analytically for a handful of situations

Boundary Layer Equations

-simplification of the Navier-Stokes equations
-applicable when the boundary layer is thin and viscous effects are confined to extremely
 small regions close to solid surfaces (no separation)
-velocity and pressure gradients normal to and diffusion parallel to the primary flow
 direction neglected

Boussinesq Approximation

-allows boundary layer equations to be further simplified
-accounts for the effect of variable density with just one buoyancy force term permitting the
 density variation in the continuity equation to be neglected
-essentially assumes a linear dependence of the density on the temperature

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = g\beta\left(T - T_\infty\right) + \upsilon\frac{\partial^2 u}{\partial y^2}$$

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha\frac{\partial^2 T}{\partial y^2}$$
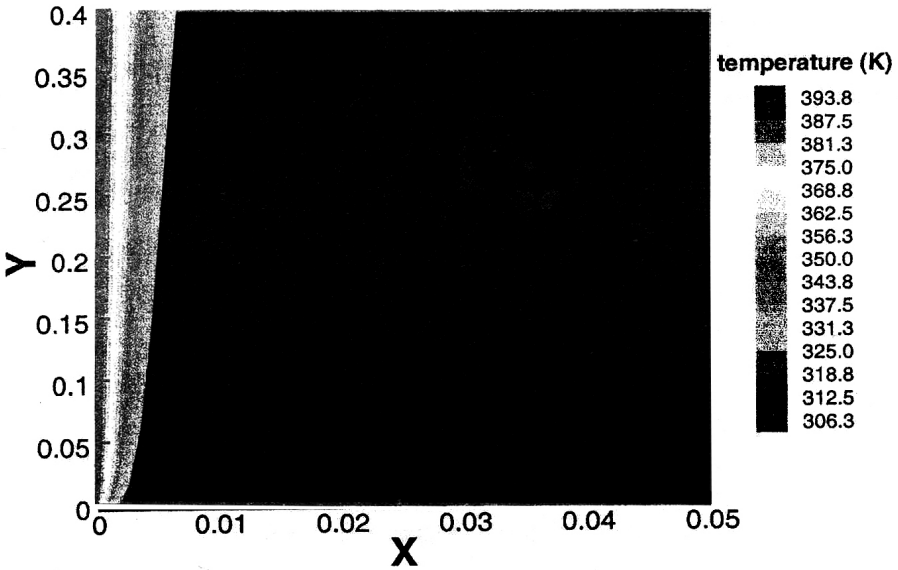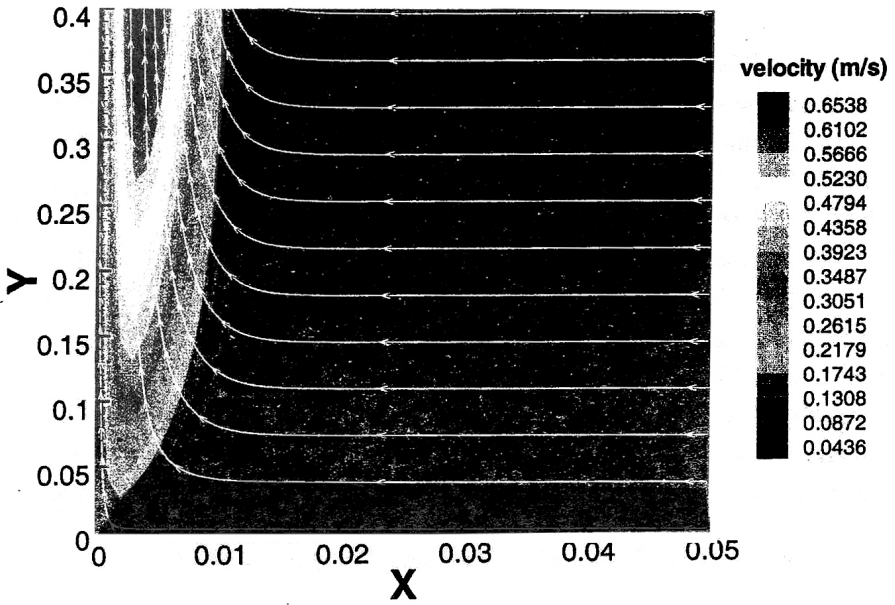
Figure 1: The motion and thermal diffusion that result when a heated (T=400K) vertical plate (left boundary) is placed in a quiescent fluid (air, T=300K)

Speciation of Arsenic Sediment Leachate by Solid Phase Extraction and Flow Injection Hydride Generation Atomic Absorption Spectrometry

Margaret Fiasconaro and Dr. Mohammad Alauddin.
Presented at the 56th Eastern Colleges Science Conference in Niagara, NY

Bangladesh is under the grip of worst ever mass poisoning the world has ever witnessed. The poisoning is taking place through arsenic laced underground water from tube-wells in the country. Analysis of a set of bore-hole sediments from Itchapur village in Comilla (located near the junction of River Jamuna and Meghna) in Bangladesh at depths ranging from 5 to 90 feet revealed presence of high levels of arsenic. The groundwater samples from the same village also contained elevated levels of arsenic. Bacteria and microorganisms in soil and sediment can transform inorganic arsenic to methylated species, namely, monomethylarsonate (MMA) and dimethylarsonate (DMA). The methylated arsenic species are relatively less toxic than inorganic arsenic. The speciation of methylated arsenic in sediments and groundwater is essential to assess arsenic exposure and health risks from consumption of well water and crops grown in surface soil.

We have developed a technique for separating and analyzing various arsenic species, such as arsenite, arsenate, monomethylarsonate (MMA), and dimethylarsonate (DMA) in sediment leachate and groundwater collected from the same area. The technique is based on ion-exchange chromatographic separation followed by flow injection hydride generation atomic absorption spectrometry (FI-HG-AAS). Arsenite was found to be a major component and lower levels of MMA (6 to 61 ppb) and DMA(5 to 19 ppb) were detected in these samples. The detection limit varies from 1.0- 2.0 ppb for various species. The findings of the research project has far reaching impact on the drinking water supply and crops grown in arsenic affected areas of Bangladesh. Results from our findings and future application of the methodologies will be discussed.

Growth Kinetics of NiSO$_4$.7H$_2$O Crystals

Luther Schaeffer and Dr. Maria Gelabert

Presented at the 56th Eastern Colleges Science Conference in Niagara, NY

Undergraduate laboratories involving thermodynamics of crystal growth are rare. Yet, the general area of crystal growth is critical to many materials-related technologies. Here, growth of nickel sulfate heptaahydrate crystals was studied by two different methods: slow cooling of a saturated solution, and constant-temperature growth from supersaturated solution. In both sets of experiments, concentration and time were monitored simultaneously to yield growth rate and time data. After obtaining data, graphical plots such as ln(rate) vs. time were done in order to obtain meaningful thermodynamics quantities. The special challenges posed by the experimental design will be discussed, as well as the mathematical relationships of the crystal growth variables.

Section II: The Social Sciences

Full Length Papers

Abstracts/Extended Abstracts

The Impact of Thin-Ideal Depicting Media
on Disordered Eating Among College Students

Jessica Morin

As the prevalence of eating disorders in America has increased over the past thirty years, the influence of sociocultural factors, such as the media, have been spotlighted as potentially causing this influx in the number of Americans suffering from these disorders. This study is interested in the relationship between eating disorders and thin-depicting media. Forty-two students from a private, Northeastern college participated in the study, which measured the amount of candy consumed after viewing thin-depicting media compared to viewing non-thin-depicting media. The study supported the hypothesis that female college students who viewed thin-depicting media ate less than did those who viewed non-thin-depicting media. The study supports a possible causal relationship between thin-depicting media and eating disorder symptomatology.

I. Introduction

Everyone will grapple, now and then, with feelings of dissatisfaction with their appearance. As a society, this has become a normal part of the development process among adolescents. In some cases, however, the evaluation of one's physical appearance becomes an obsession with changing it. This can lead to a variety of body-image disorders, eating disorders, and behavior disorders aimed at changing one's body composition in an attempt to achieve an irrational concept of perfection. A variety of factors have been proposed as influencing the development of eating disorders, including familial, psychological, biological, and sociocultural influences. As the prevalence of eating disorders in America has increased over the past thirty years (American Psychiatric Association, 1994), the influence of sociocultural factors, such as the media, have been spotlighted as potentially causing this influx in the numbers of Americans suffering from these disorders.

In modern media, thinness is equated with attractiveness, success, and happiness (Garfinkel and Garner, 1982). As actors and models have gotten thinner and thinner, the average American's weight has actually increased, causing a greater discrepancy between the media's images and ideals, and the realistic body-type of the average American viewer (Garner, Garfinkel, Schwartz, & Thompson, 1980). This may account for America's growing obsession with fitness and weight loss. As the struggle to be thin increases, the prevalence of eating disorders has followed as a way of achieving the desired thinness.

Cantor and Harrison (1997) studied the relationship between media exposure and eating disorder symptomatology. They proposed that "Television and magazine consumption, especially thinness-depicting and thinness promoting (TDP) television, will be positively associated with eating disorder symptomatology" (p. 46). Media exposure was measured as the quantity of media use, including television programming viewed and magazine genres read. TDP television was defined as programs with primarily thin main characters; TDP magazines emphasize thin models and dieting behaviors. The extent of disordered eating and related symptoms—body dissatisfaction, drive for thinness, perfectionism, and ineffectiveness—were measured using two previously validated scales, the Eating Attitudes Scale (EAT) and the Eating Disorders Inventory (EDI). The participants of the study were 232 female and 190 male undergraduate students from a large Midwestern university. Most were white and middle to upper-middle class.

Cantor and Harrison's (1997) hypothesis was supported: the amount of media consumption, especially TDP media, significantly predicted women's eating disorder symptomatology and men's attitudes in favor of their own personal thinness and dieting. This study supports the argument that the overabundance of ultra-thin fashion models and actresses in current media is an unhealthy promoter of personally destructive behaviors.

One weakness of this study was its inability to prove causation because of its correlational methodology. Consumption of TDP media may cause eating disorder symptomatology, yet eating disordered persons might chooses to consume TDP media. Alternatively, both behaviors could be caused by some other variable, such as familial influence. Therefore, this study failed to provide support for the hypothesis that consumption of TDP media causes eating disorders. A strength of this study was the use of multiple scales and variables to look at both media consumption and eating disorder symptomatology. By using more than one scale (EAT and EDI), as well as researcher-formulated questions, they were able to look at many dimensions of this issue.

Wegner, Hartmann, and Geist (2000) conducted another study that looked at the media's influence on body image. They proposed that "women who were exposed to the photographs of models would report greater general self-consciousness and specifically body self-consciousness than college women exposed to control photographs" (p. 1151). In this experiment, the independent variable was the type of photographs that were shown to the participants. The dependent variable was self-consciousness as measured by the Self-consciousness Scale and the Body Self-consciousness Questionnaire. Female undergraduate students were randomly assigned to view one of two notebooks filled with photographs. One book was filled with images of thin models from popular magazines, and the other was filled with images of other types of models (children, older adults, non-thin). After viewing the photographs, the participants completed both surveys.

Analysis of the data showed that the experimental group was more self-conscious on both measures of self-consciousness than was the control group. This implies that the women compared themselves to the thin models that they viewed. The results provide evidence that self-consciousness of college women may be attributed, in part, to the depiction of thin models in today's media.

One weakness of this study is that it does not show whether self-consciousness caused by viewing of thin media images is temporary or perpetual. Self-consciousness was measured only once, immediately after viewing. Another weakness of this study is that it does not show media viewing to be related to any sort of behavior. Although this study supports a link between media and body image concerns, it fails to provide evidence that body image concerns lead to disordered behavior.

The present study will explore the relationship between the viewing of popular thin-depicting television and eating habits. College students will eat less during and after viewing a thin-ideal depicting television program than during and after viewing a non-thin-ideal depicting television program.

II. Method

Participants

Participants were all undergraduate students from a small, liberal arts college. Thirty-two women and ten men participated in the study; most were white, middle to upper class, aged late teens to early twenties. The participants were members of courses in Social Psychology or Gender Studies.

Materials

Two videos were used in the study. The first video, a two-minute minute clip from the television show *Friends*, was used as the thin-depicting media. The scene concerned a romantic interchange between characters. The second video, a two-minute clip from the television show *Designing Women* was used as the control (non-thin depicting) media. The subject of this scene was buying a used van. Both clips were matched for humor and number of characters.

Each participant received a small plastic bag of Halloween candy, containing 1 chocolate bar, 2 tootsie rolls, 1 lollipop, and 2 boxed candies (Good & Plenty, Milk Duds, or M & M's).

Procedure

The experiment was conducted in two class periods. Each class was randomly assigned to one experimental condition. The instructor of the class acted as a confederate, explaining to the participants that they would be seeing a clip from a

television show to illustrate the concept of the discussion for that day. Before watching the clip, the instructor (confederate) also explained that she had some Halloween candy left over from Halloween and had brought it in for her students. She then distributed one bag of candy to each participant.

The participants were then shown one of the clips. The first course was randomly assigned to view the control clip. The second course was randomly assigned to view the thin-depicting clip. At the end of class, the confederate asked the participants to put the remaining candy, as well as the empty candy wrappers, back in the bags, and to hand them in to the confederate. The men's bags were collected separately from the women's bags.

The participants were fully debriefed. The participants were asked how they felt about the study and if they thought that their eating had been affected by viewing the clip. The confederate explained to the participants that the study concerned the effect of viewing thin-depicting media on eating behavior, as it may relate to disordered eating behavior.

Each bag was later examined; the amount and types of candy eaten was recorded. The number of pieces of candy, the total calorie consumption, and the total fat grams consumption for each participant were determined.

III. <u>Results</u>

To test the hypothesis is that college students will eat less during and after viewing a thin-ideal depicting television program than during and after viewing a non-thin-ideal depicting television program, I conducted a series of Analyses of Variance (ANOVAs) predicting the dependent variables (number of pieces of candy consumed, total calories consumed, and number of fat grams consumed) by condition (thin-ideal depicting or non-thin-ideal depicting) and sex.

In the ANOVA predicting number of pieces of candy consumed, condition was a significant predictor, F (1, 35)= 4.12, p < .05. Contrary to prediction, participants in the thin depicting group consumed a greater number of pieces of candy (M = 2.30, SD = 1.46) than did the non-thin depicting group (M = 2.11, SD = 1.10). However, this main effect was qualified by a significant interaction, F (1, 38)= 12.03, p < .01. Women in the control group consumed more pieces of candy (M= 2.46, SD= 1.05) than did women in the experimental group (M= 1.81, SD= 1.28), whereas men in the experimental group consumed more pieces of candy (M= 3.67, SD= 1.21) than did men in the control group (M=1.25, SD= .96). (See Figure 1).

In the ANOVA predicting number of calories consumed, condition was not a significant predictor. However, there was a significant interaction between condition and sex, F (1, 35)= 10.41, p < .01. As predicted, the women in the control group consumed more calories (M= 266.54, SD= 138.79) than the women in the experimental group (M=

183.56, $\underline{SD}$= 120.73). The men in the experimental group consumed more calories ($\underline{M}$= 328.50, $\underline{SD}$= 162.29) than the men in the control group ($\underline{M}$= 97.5, $\underline{SD}$= 69.58).

In the ANOVA predicting number of fat grams consumed, there were no significant main effects nor an interaction (overall $\underline{M}$= 10.55, $\underline{SD}$ = 25.77).

IV. **Discussion**

The hypothesis was supported, but in a modified form. Female college students ate less when showed an example of thin-depicting media than when showed an example of non-thin depicting media. However, male college students who watched thin-depicting media ate more than did those shown non-thin depicting media.

The first concern that must be examined as a limitation of the study was the different times of day at which each trial was conducted. The control group trial was run in the early morning (9:30 a.m.), whereas the experimental group trial was run in the early afternoon (2:00 p.m.). The experimental group might have been more hungry (especially for sugar) than was the control group.

The interaction between condition and sex on number of pieces of candy consumed and number of calories consumed suggests that men may not be affected by the media in the same way as are women. If men's eating behavior is not strongly affected by media, the men could serve as controls within each condition. As a way of factoring out the possible influences of time of day, we can compare the men within each condition to the women in that condition. The women in the experimental group showed suppressed eating (they ate significantly less than the men) compared to the women in the control group (who actually ate more than the men).

Another limitation of the study was the type of food used in the experiment. First of all, not all people like all types of candy. Therefore, some people may not have eaten candy simply because they do not like it. Also, some people may not have wanted candy early in the morning, when the control group trial was conducted. Secondly, due to the high cost of candy, it was not possible for an unlimited amount of candy to be available. If an unlimited amount of candy had been available, the people who ate larger amounts of candy may have eaten even larger amounts of candy, increasing the variance of amounts of candy consumed.

Another factor that may have affected participants' eating behavior was the presence of other people during the study. Their eating behavior may have been affected by the social context of the trial. The participants' eating behavior might be different in the absence of others, or in the presence of groups of non-classmates. Therefore, we cannot conclude that eating behavior was solely affected by the media presented.

No single study can provide definitive proof that thin-depicting media causes eating disorders, but it does support a link between thin-depicting media and the exhibition of eating disorder-related behavior (suppressed eating).

This study warrants further research into the relationship between thin-depicting media and eating disorders. Because of the great implications of the subject matter, this area of research deserves the attention of the psychology field. If additional evidence could be found that the media has a significant role in causing eating disorders, action could be taken to reduce the occurrence of thin-depicting media.

In the future, it would be my goal to continue research to try to prove a causal relationship between thin-depicting media and eating disorders. Such disorders currently disrupt and destroy the lives of many people, especially young American women. It is my opinion that thin-depicting media is an attack on American women. It is a way of suppressing women, by using the drive for thinness to lead them into a powerless state of illness through eating disorders. Anything that can be done to reduce the occurrence of these disorders is a moral responsibility of the psychology field.

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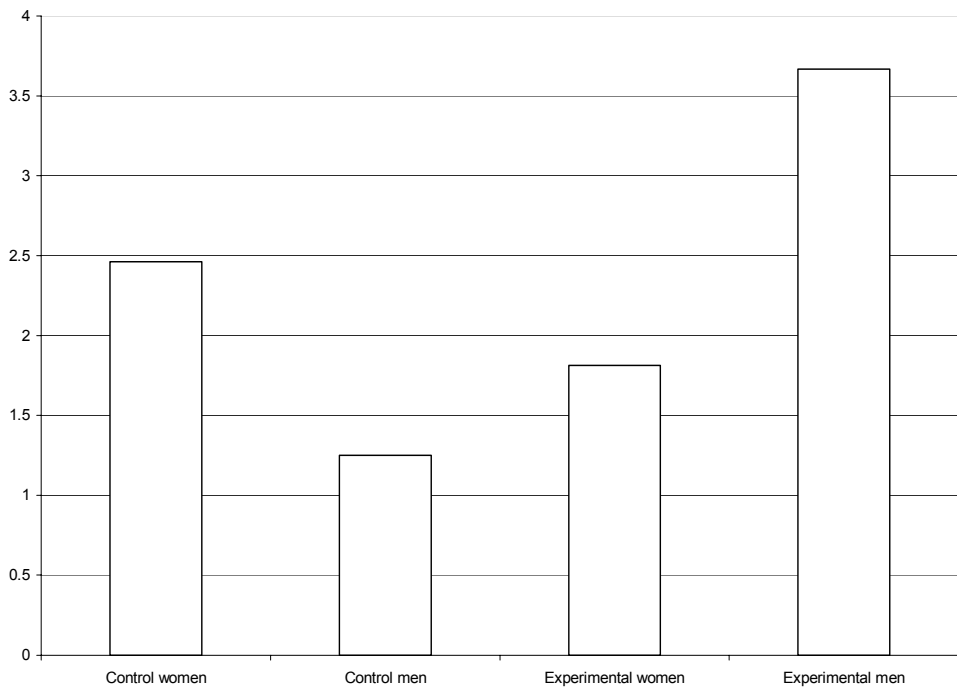
Figure 1. Mean Pieces of Candy Consumed by Condition and Sex.

The Effects of Mortality Salience on Social Evaluation

Matteo Rosselli

The current study tests the hypothesis, derived from Terror Management Theory, that reminding people of their mortality increases liking for and agreement with individuals who support their cultural worldview and decreases ratings of individuals who threaten the cultural worldview. College students evaluated the writers of essays containing either Pro-American or Anti-American content. Before doing so, mortality was made salient to half of the participants by asking them to contemplate their own death. Mortality salience led to more negative reactions to the Anti-American essayist. In addition, a significant interaction was found between experimental condition and order of essay presentation; evaluations were harsher against an Anti-American essay writer after reading a Pro-American essay. The current study supports Terror Management Theory.

I. **Introduction**

Terror Management Theory starts from the basic premise that behavior is driven by a desire for survival and self-preservation. Human beings, being distinct in the ability to think about and understand death, find the fear of death to be a source of paralyzing terror. Thus humans must, by necessity, develop defense mechanisms that buffer against the fear caused by awareness of the inevitability of death. Pyszczynski, Greenberg, and Solomon (1999) propose that people do so on two levels. On the conscious level, we establish proximal defenses which involve rational defenses against death. This might involve pushing thoughts out of consciousness by distracting oneself. On the unconscious level, we develop distal defenses which are the defensive behaviors that most concern terror management theory.

The two major components of the distal defense system are worldview and self-esteem. Worldview is the group of values that set the standard for people's aspirations in a particular culture. People can judge themselves against these values in the hope of gaining some type of symbolic immortality. A worldview gives people a sense of order in an uncontrollable and chaotic universe. The second component of the distal defense system is self-esteem. Terror management theorists define self-esteem as a "sense of value and immortality attained by successfully living up to the rules and standards provided by a particular worldview" (Janssen, Dechesne, & Knippenberg, 1999, p. 155). Thus worldview and self-esteem are merely social constructs that people have evolved to buffer against the terror and anxiety caused by awareness of their own mortality. Social inventions are by definition fragile constructions (Janssen et al., 1999). Terror management theorists propose that most social behavior is aimed "toward the defense or maintenance of either one's worldview or one's self-esteem" (Janssen et al., 1999, p.156).

It can be inferred from this that when one's mortality is made more salient or apparent, these defensive mechanisms will kick into high gear. Thus individuals who have been exposed to mortality salient conditions should more rigorously engage in behavior that defends their own worldview and self-esteem. Most empirical work on terror management follows along this line of reasoning.

Both of the articles to be discussed seek to ascertain if mortality salience can affect one's evaluation of those who appear to either threaten or bolster an individual's cultural worldview. In their article, Greenberg, Pyszczynski, Solomon, Rosenblatt, Veeder, Kirkland, and Lyon (1990) present three studies. The setup of each is basically the same. Participants, who are freshman college students, are given questionnaires. They are told that the study concerns personality and attitude variables that affect the impressions people form of others. The participants then complete a variety of personality scales. The questionnaires are the same for all of the participants until the final section.

Mortality salience is introduced to half of the participants, randomly, by asking them to write about "what will happen to them as they physically die and the emotions that the thought of their own death aroused in them" (Greenberg et al., 1990, p. 310). The control group engaged either in a parallel writing task or no writing task at all. Previous research indicates that there is no difference if the group is given no writing task or a parallel writing task (Greenberg et al., 1990).

For purposes of this review, we will focus on study 3 (Greenberg et al., 1990). After filling out the questionnaires, the students were given one of three interviews to read. All of the interviews spoke about the American political system. One was positive about the American government, another was neutral, and the final interview was downright negative. Terror Management Theory posits that those in the mortality salient condition should more vigorously favor those who are supportive of their worldview (Pro-American) and more vigorously oppose those who are perceived as a threat to their worldview (Anti-American). Following reading the interview, the students were asked to indicate their feelings about the interviewee on a nine-point Likert-type scale. They then were asked to assess how much they liked the interviewee, how much they agreed with the interviewee, and how disturbing they found the interviewee.

The basic finding of the study was that in the mortality non-salient condition, there was no significant difference in responses to the 3 different interviews. For all of the questions, the Pro-American interviewee was viewed in a slightly more positive light but not enough to be deemed significant. In the experimental (mortality salient) group, participants were significantly more negative in their evaluation of the Anti-American interviewee and significantly more positive in their evaluation of the Pro-Amercian interviewee ($p < .001$). This trend is extremely strong statistically.

The methodology of the research presented is highly satisfactory. It should be noted that in this study, the researchers also measured affect to ensure that a change in mood

was not the true cause of the difference between the two groups. Previous research has indicated that other anxiety causing stressors like a test or public speech do not cause the same effects as increased mortality salience (Pyszczynski et al., 1999). The statistical evidence in the study is well researched and well presented. The data fully support the aforementioned hypothesis. The other two studies in the article, which are not discussed in this paper, support the same general conclusion that terror management theory can partially explain social phenomena such as social prejudice. The theory attempts to explain prejudice by stating that liking for other individuals is dependent upon the impact that person might have on one's cultural anxiety buffer. The study explained does an excellent job at operationalizing these theoretical constructs. The next study to be presented does not do the job in as concrete a fashion.

Janssen et al. (1999) start from the premise that the findings of the study mentioned above are valid. They then attempt to find if youth culture can serve as an important component of worldview. They posit that if this is true, an experiment that measures participants' responses to those that either threaten or bolster concepts of youth culture should replicate the results in the previous study. They are thus replacing the Pro-American or Anti-American stimulus with a much more fuzzy and abstract concept. In the study, they find much difficulty in operationalizing this concept, yet the intention of this research should not be discounted. Adolescence is a time when kids have no clear identity of who they are in a huge and chaotic universe. Without a job, family, or kids; adolescents have not truly developed a "self" that can help them defend against the anxiety that the awareness of death brings. Thus it seems only logical that youth culture can provide an important standard to live up to in these shaky times for adolescents. Youth culture can help to bridge the gap between the childhood sense of "self" and adulthood sense of "self". This reasoning is consistent with terror management theory.

The participants in the experiment were a group of 53 high school students who were told that personality traits were being studied. The students first filled out a series of personality questionnaires, which served as a cover story. At the end of the questionnaires the students were asked to write about two different topics. Half of the students wrote about television while the other half were exposed to the same mortality salient writing assignment that was used in the previously discussed article. The students were assigned randomly to each condition.

Each group was next given two short essays to read. One essay was highly critical of youth culture while the other endorsed youth culture. Each essay was followed by questions about the student's response to the essays. A major problem with the study is the essay stimulus. Youth culture is a highly individualized concept. The researchers cannot possibly expect criticisms of youth culture, in general, to have the same effects as a criticism of a specific youth culture with which one might identify. This would be the equivalent of Greenberg et al. (1990) using interviewees who criticized the concept of

worldview instead of criticizing America. This mistake is glaring in this research. Janssen et al. (1999) admit this by stating "the essays used in the experiment were quite general in their content and, thus, rather than defending or criticizing specific symbols and practices, they addressed the more general category of youth, which may have been less pertinent to the participants" (p. 163).

Despite the flawed methodology, Janssen et al. (1999) found that the participants in the mortality salient condition discriminated between the two essays to a greater extent than did those in the mortality non-salient condition. Although the statistical analysis of these findings is supportive of terror management theory, the findings are not nearly as strong as those in the previous study.

Although the theoretical component of the research conducted by Janssen et al. (1999) is quite interesting, the experimental component needs to be better developed. Further analysis of the data might be somewhat misleading because Janssen et al. (1999) present their data in a manner that is overly supportive of their own conclusions. While this is often a flaw of research, Janssen et al. (1999) carry this flaw to its logical conclusion and thus much of what they have to say is discredited by their own biased representation.

In the present study, it is hypothesized that increased mortality salience will cause individuals to think more highly of those who reinforce their own worldview and to be more critical of those who threaten their worldview. Having people write about their own death appears to be an effective and proven method of manipulating mortality salience. Exposing participants to Pro-American and Anti-American rhetoric might prove especially effective in a time when citizens of this country have increasingly come to identify themselves as "Americans".

II. __Method__

Participants

Participants were 26 psychology students (71% female, 88% white) at Wagner College. The students volunteered to complete the study during regularly scheduled classes.

Materials

A series of questionnaires were used in the study. The students were first given a brief introduction to the study (see Appendix A). The following page contained biographical questions that could be used to ascertain the success of random assignment. This questionnaire (see Appendix B) also was used to find if any biographical data could explain the differences in response by each group. The next page (see Appendix C) of the packet was a questionnaire measuring the attitudes of participants to certain political and

moral statements. These questions were intended to help the researcher better understand the participants while also serving as a cover story for the true purpose of the research. The mortality salience manipulation was placed on the next sheet. Participants in the mortality salient condition were asked to write about what will happen to them as they physically die (see Appendix D). They were asked to write about the emotions that this thought aroused in them. Participants in the control group were asked to write about tabloid newspapers and their interest in these papers (see Appendix E). The next part of the questionnaire (see Appendix F & G) contains two essays that are purported to be written by established American college professors. One was critical of United States governmental policy while the other was supportive. The essays were each followed by a series of questions on a nine-point Likert-type response scale to measure the participants' reactions on such categories as liking of the writer and agreeing with the writer. Higher scores on this scale indicate a greater liking for or agreement with the writer. The order in which the essays were presented was counterbalanced.

Procedure

Participants in the classroom were randomly assigned to either the control or experimental condition. The students were told that they were taking part in a study about different personality variables and political opinions. Upon receiving the questionnaires, students were asked not to provide their names so that all information could remain confidential and anonymous. It was requested that students complete the questionnaires in order and not look at anyone else's questionnaire. The students were asked to follow the instructions given on each questionnaire. They were told that they would be given about ten minutes to complete participation. The researcher reminded the students that completion of the questionnaires would entail some critical thinking and encouraged the students to take each question seriously. Upon completion of the questionnaire, the materials were collected and the students were thoroughly debriefed.

III. Results

Students' responses to each target essay were summarized by averaging their positive responses and their reverse-scored negative responses. This score was used as the evaluative measure in this study, indicating liking of and agreement with the target. I conducted a Multivariate Analysis of Variance predicting responses toward each of the essay writers by the experimental condition and the order in which the two essays were presented. Responses toward the Anti-American essay differed significantly by experimental condition; $\underline{F}(1, 21) = 11.47$, $\underline{p} < .01$. Participants in the mortality salient condition ($\underline{M} = 3.65$, $\underline{SD} = 1.30$) evaluated the Anti-American writer more harshly than did particapants in the control condition ($\underline{M} = 5.00$, $\underline{SD} = 0.68$).

This significant main effect was qualified by a significant interaction between experimental condition and order in which the essays were presented; $\underline{F}(1, 21) = 4.50$, $\underline{p}<.05$. This interaction is depicted in the attached Figure. In the mortality salient condition, participants evaluated the Anti-American essay more negatively when it was presented after the Pro-American ($\underline{M} = 3.05$, $\underline{SD} = .99$) than when it was presented before the Pro-American essay ($\underline{M} = 4.26$, $\underline{SD} = 1.34$). Conversely, the control group evaluated the Anti-American essay more positively when it was presented second ($\underline{M} = 5.27$, $\underline{SD} = .49$) than when it was presented first ($\underline{M} = 4.78$, $\underline{SD} = .78$).

IV. <u>Discussion</u>

The present study attempted to replicate the findings of Greenberg et al. (1990), who found that participants exposed to mortality salience rated a Pro-American target more positively and an Anti-American target more negatively than did those in the mortality non-salient condition. The present study supported the latter half of these findings. The significant main effect in this study was limited to participants' ratings of the Anti-American essayist. It is quite interesting to note the significant interaction between experimental condition and order of essay presentation. In the mortality salient condition, the Anti-American essay writer was rated lower when this essay was presented after a Pro-American essay. In the mortality non-salient condition, the Anti-American essay was actually rated higher when it was presented second (see Figure). It is possible that by exposing participants to a stimulus that is affirmative of their cultural worldview directly after exposure to a stimulus triggering mortality salience, that the predicted effect is enhanced. Further research should seek to more thoroughly ascertain the effects of this interaction. It is possible that the nature of the stimulus presented strongly affects this interaction.

The present study provides support, albeit far from conclusive, for the basic tenets of Terror Management Theory. It should again be noted that no differences were found in the ratings of the Pro-American essayist by experimental condition. This finding does not support the initial hypothesis. Further replications of this study might involve the use of different stimuli and larger sample sizes. It seems important to investigate how different presentations of mortality salience might change the desired main effect. For example, whether there is a time length after the presentation of a mortality salient stimulus that is ideal for achieving the desired effect. Further research needs to pursue these ends. The present research provides support for earlier research in Terror Management Theory.

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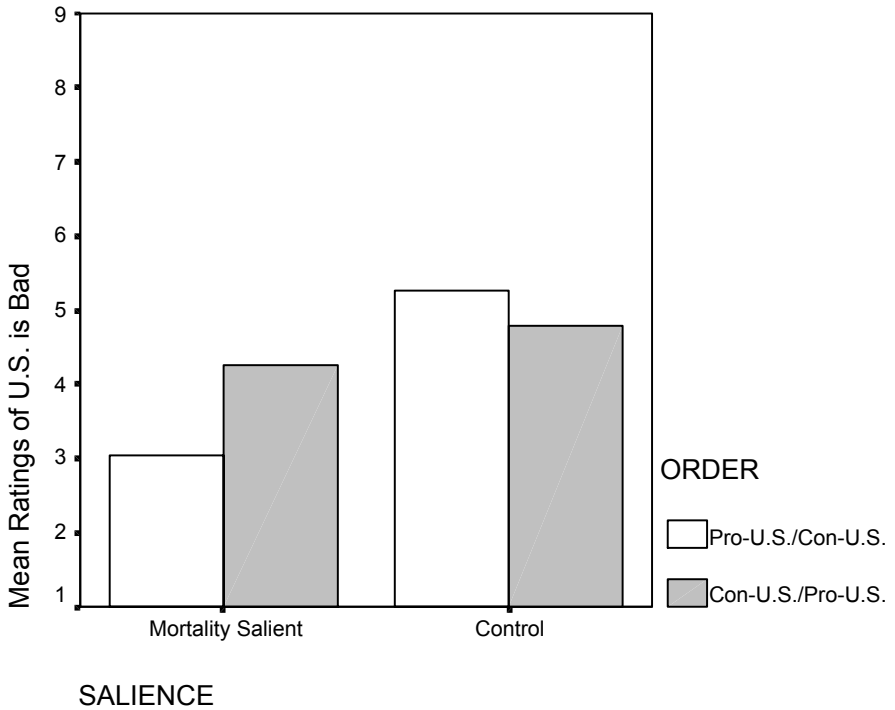
Figure 1. Interaction between mortality salience and essay order on evaluations of anti-American essay writer.

Appendix A: Introduction to the Study

On the pages that follow are a number of statements about public issues, politics, interpersonal relationships, and your beliefs about the world in general. The study will call on you to engage in some critical thinking. You will likely agree or disagree with much of what you read. Please follow the instructions and use the responses provided for each scale to indicate your opinion to each item.

You will also be asked to partake in a brief writing exercise. Please read and follow the instructions for this task.

It is important that you complete each questionnaire in the order they are given to you. Please do not skip ahead or skip back to change answers once a questionnaire is completed.

Your replies will be kept completely confidential. We want to emphasize that there are no "correct" answers to any of these items. We are simply trying to get an idea of the types of responses that students will have to various social issues and to learn more regarding students' political views. We want to be clear that we are not evaluating you or your individual responses. If we are to learn anything useful, it is important that you respond to each of the statements or questions openly and honestly.

You may begin completing the questionnaires and tasks when you finish reading these directions. After you have completed all of the questionnaires and tasks, please hand this packet in to the researcher. After all are collected, you will have the option of leaving a box number or e-mail address so that we can inform you of any interesting finding in the study.

Please follow the directions on each page of the packet. Use the scales and response options available for each item.

Appendix B: Demographics Questionnaire

1. I am a: Male / Female (Circle One).

2. I consider myself to be:

_____ Arab/Middle Eastern   _____ Central Asian/Indian/Pakistani

_____ White/Caucasian   _____ Asian/South Pacific Islander

_____ Hispanic/Latino   _____ Black/African American

_____ Native American/American Indian   _____ Other: _____

3. Politically speaking, I am: Liberal   Moderate   Conservative

Very Liberal   0   1   2   3   4   5   6   7   8   9   Very Conservative

4. Politically speaking, I am: Independent

Republican   0   1   2   3   4   5   6   7   8   9   Democrat

5. Religiously, I consider myself to be:

_____ Catholic   _____Protestant   _____Jewish

_____ Muslim   _____ Hindu   _____ Atheist

_____ Other   _____ Refuse to answer

Appendix C

Please indicate the response that most closely matches your opinion for each item

1. Families of victims of violent crimes sometimes have the right to take justice into their own hands if the criminal justice system has done a poor job.

   Very Strongly   Very Strongly
      Agree   Disagree

   1   2   3   4   5   6   7   8   9

2. A woman's right to choose belongs to her, and her alone.

   Very Strongly   Very Strongly
      Agree   Disagree

   1   2   3   4   5   6   7   8   9

3. Stealing is somewhat acceptable if the institution you are stealing from is a big company or corporation that constantly rips-off the public.

   Very Strongly   Very Strongly
      Agree   Disagree

   1   2   3   4   5   6   7   8   9

4. The criminal justice system should seek to make living conditions as miserable as possible for people who have committed severe crimes against others.

   Very Strongly   Very Strongly
      Agree   Disagree

   1   2   3   4   5   6   7   8   9

5. The United States should seek to combat not only terrorists but also those who encourage or revel in terrorist activity.

   Very Strongly   Very Strongly
      Agree   Disagree

   1   2   3   4   5   6   7   8   9

Appendix D

Please give a thoughtful answer to the following question in the space provided. Your response will remain both strictly anonymous and strictly confidential

Suppose you were to die as the victim of a crime. Please write about the feelings that your death would arouse in you. What will happen to you as you physically die? Where will you go? What emotions does thinking of this arouse in you?

_____

_____

_____

_____

_____

_____

_____

Appendix E

Please give a thoughtful answer to the following question in the space provided. Your response will remain both strictly anonymous and strictly confidential

Have you ever read a tabloid newspaper like the National Enquirer? Do you find these papers entertaining? Are there any memorable stories that you have read in these papers that stand out to you?

_____

_____

_____

_____

_____

_____

_____

_____

_____

Appendix F

Instructions: Please read the following excerpt from a passage written by a college professor at an American University and respond to the evaluative questions:

"United States governmental activity at home and abroad has been marked by incompetence and ignorance with regard to effective political leadership. Bickering between Republicans and Democrats has shown that a two-party political system is ineffective at meeting the needs of a growing American populace. The U.S. Government commonly infringes on the rights of not only its own citizens but of citizens of other countries throughout the world. The United States has inflicted great harm upon the rest of the World by doing as it pleases. Measures must be taken to curb the power of what is becoming an increasingly tyrannical regime."

Please circle the response that most closely matches your own.

1. I agree with the statements this person is making.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

2. This appears to be a likeable person.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

3. I would enjoy meeting this person.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

4. This person appears to be very intelligent.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

5. I was disturbed by the statements that this person made.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

6. I would like to see Wagner College invite this person to express their views.

        Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

Appendix G

Instructions: Please read the following excerpt from a passage written by a college professor at an American University and respond to the evaluative questions:

"The United States Government is, without question, the model of what any Democratic people should want in a government. The United States Government has been strong for over 200 years because of it's effective leadership. Although America leads the world financially and culturally, it is America's democratic ideals that still set the standard for the world. In an increasingly chaotic world, American leaders have shown that they have the leadership to effectively guide our country in troubling times. The United States government is as strong and effective as it has ever been."

Please circle the response that most closely matches your own.

1. I agree with the statements this person is making.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

2. This appears to be a likeable person.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

3. I would enjoy meeting this person.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

4. This person appears to be very intelligent.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

5. I was disturbed by the statements that this person made.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

6. I would like to see Wagner College invite this person to express their views.

    Strongly Disagree 1 2 3 4 5 6 7 8 9 Strongly Agree

Methadone Maintenance and Preference Rating of Sweet Foods

Lisa M. Scagnelli and Dr. Laurence J. Nolan

Poster presentation[1] at the 56th Eastern Colleges Science Conference in Niagara, NY

Past research indicates that patients on methadone maintenance treatment frequently have poor nutritional status and consume a large quantity of sweet foods. This study attempted to confirm this and asked whether patients on methadone maintenance might also have higher body weights as measured by body mass index (BMI). Fourteen participants on methadone maintenance and fourteen controls were administered a questionnaire containing questions regarding food preferences and eating behaviors. Participants were asked to consider a number of specific eating behaviors and rate how often they engaged in them. They were also asked to report their desires for specific foods. Statistical analyses (ANOVA) revealed that the participants on methadone had significantly higher cravings for desserts, chocolate and candy but also meat and pizza. In addition, they reported wanting to consume higher quantities of the sweet items. Significant differences were also found for their reported eating behaviors; the methadone group reported higher consumption of "junk" foods and less concern for nutrition. BMI was calculated for each participant and the methadone group was found to be significantly heavier than controls. The results support the hypothesis that patients on methadone maintenance may not maintain a healthy diet and this may be related to risk for obesity.

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[1] received outstanding poster presentation in Psychology award

Section III: Critical Essays

Heroin Abuse as Product of the Urban Environment in the Works of Burroughs, Selby, Algren, and Baldwin

Michael O'Connor
Senior Honors Project

I. The Only Tale to Tell

> "For while the tale of how we suffer, and how we are
> delighted and how we may triumph is never new, it
> always must be heard. There isn't any other tale to
> tell, it's the only light we've got in all this darkness."
> James Baldwin – "Sonny's Blues"

If, as Baldwin states, the only tale to tell is that of suffering and delight, then no genre of American literature is more representative than the drug novel. This is exactly what the characters in these novels live for: suffering and delight. The harshness of the suffering, as brought about by poverty, isolation, and poor living conditions, is matched only by the delight that comes with heroin injection. Ultimately, it is the suffering that these works attempt to expose, as the delight represented is temporary and always fading.

Through exploring the major works of American drug fiction, one can begin to see that, as Baldwin says, though these stories may not be new, they must always be heard. By putting particular emphasis on a few popular works including Nelson Algren's The Man with the Golden Arm, Hubert Selby Jr.'s Requiem for a Dream, Baldwin's own "Sonny's Blues" and William S. Burroughs' Junky, the drug novel comes forth as a uniquely American genre which exposes important flaws in our society and culture.

The expository nature of these works is something that serves as a major connection among the novels to be discussed. Because the readership of these novels is not limited to intravenous drug users, they must all be very graphic in nature in order to represent a set of experiences and way of living with which the majority of the audience is largely unfamiliar. For this reason, the drug use is never secondary. It is always on the mind of the author, the character, and thus the reader. In making drugs the overriding theme, the reader unfamiliar with drug abuse can begin to grasp the mentality of the addict.

Along with the explanatory role of the works, there is also a common reactionary element among the novels' major characters to specific aspects of their individual and collective social situations. These are all urban tales, and thus the reactionary aspect is most often located in their disdain for the "urban wastelands" in which they live. These harsh landscapes force the characters to live increasingly isolated lives where friends and neighbors, though possibly interacting on a menial level, never make genuine connections.

Sadly, the character's reaction to these situations is often to turn to drugs, and in particular to heroin. The key then is to find out "why heroin?" What is it about the

needle that attracts urban users? Only when this is uncovered can we understand more specifically the intricacies of intravenous drug use, including attempts to stop or "kick" the habit, and the physical wear and tear these drugs have on the user's body.

In addressing these questions, Burroughs, Selby, Algren, and Baldwin reach out to the readers not in tune with the mentality of drug abuse. Through careful character development, and the expository nature of these works, the goal of these pieces is to "humanize the seemingly inhuman, and by extension to humanize the reader" (Price iii). By observing their worlds, and knowing the reasons for their actions, the reader is able to connect with the characters and is able to understand the purpose of heroin use as a reaction to the harshness of their conditions.

After all, we should be able to understand suffering because it is in fact a human condition, not just a junky condition. As Nelson Algren states in <u>The Man with the Golden Arm</u>, "We are all members of one another" (198). Former addict Curtis McMaster expands on this thought in his article, "The Tragedy of Heroin Addiction," stating, "Our addiction to heroin has joined us to it and each other in a bond of utter hopelessness" (30). This bond, however, is not as restrictive, nor as fatalistic as McMaster describes. Mankind shares the communal suffering with the junk addict. We all, addicts and non-addicts alike, must acknowledge and understand our collective and individual responses to universal suffering. As Price states, we should recognize the humanity of these characters despite their drastic actions that seem alien to the non-user.

II. Reactionary Tales

"this whole country, this whole world is on a bad trip, friend."

Charles Bukowski – "A Bad Trip"

A major theme in many of the novels described is the failure of the American Dream in reaching all of its citizens. With most of the novels taking place shortly after major wars, in particular WWII, as is the case with both <u>Junky</u> and <u>The Man With the Golden Arm</u>, one notices a common economic frustration among the characters. These urban drug users encountered a post-war economy thriving and making the rich richer but offering them no kind of economic gain. The television culture showed happy white suburban families whose biggest problems revolved around bullies and prom dances. The poor urbanite could not identify with these "typical" Americans. They were not benefiting from the economy and the American Dream was not working for them. They were mired in minimum- wage jobs with no chance of advancement, lived in neighborhoods offering no hope of a home, and were often failing in their interpersonal relations.

Charles Bukowski's "A Bad Trip" offers a good introduction to the drug abuser's view of society. Why outlaw drugs, asks Bukowski when there are so many other non-narcotic agents prevalent throughout society that have the same deteriorating effects: "… [drugs] can take a man permanently out of his mind – but so can picking beets, or turning bolts for GM, or washing dishes, or teaching English I at one of the local universities" (200). What was it about drugs that made them so unacceptable? Society was already paralyzing its poor by forcing them into low-income jobs with no chance of advancement. The destructive power of narcotics was no greater than that of monotonous labor, but society didn't seem to have a problem with that. The problem with heroin, as far as society is concerned, is not with the damaging effects of the drug, but with the narcotic itself. Insanity and destruction by work is acceptable, but when caused by drug abuse it becomes a problem.

Though Bukowski is mainly referring to hallucinogens like LSD and peyote in his essay, his ideas certainly can be applied to heroin abuse. The important idea is that it was not the drugs alone that caused problems in the addict, it was that the negative effects of drug abuse were only compounding the damage that had already been perpetrated by society. As Bukowski states, "Most bad trips are caused by the individual being trained and poisoned beforehand by society itself" (201). The agents of ruin are not the narcotics, but rather the poisonous aspects of society that have sunk their claws into the users much earlier than their first drug experience. The negative psychological effects of drug use are then not attributable to the drugs, but rather to atmosphere. Bukowski states it clearly: "a bad trip? this whole country, this whole world is on a bad trip, friend. but they'll arrest you for swallowing a tablet," or using a needle (202). What kind of societal ideals allow the reaction to be punished while the initiator of the reaction is allowed to continue operating without question? This is exactly the kind of hypocrisy that is uncovered in drug literature as a major cause of addiction.

Dissatisfaction with an exclusionary society then leads to a search for "identity in a hostile society and, in a social situation which invites fatalistic compliance . . ." (Murray 353). Many people reject this compliance, though, as they realize they will never fit the narrow mold of what is accepted in society. The response then becomes to reject everything that has been deemed normal. William Burroughs' experience is a prime example of this. Though he grew up in a wealthy midwestern suburb, Burroughs still felt disillusioned by a society that rejected him. As a homosexual, Burroughs was already excluded from participating in the American Dream as, like the poor urbanite, he did not fit the narrow mold of what was deemed acceptable.

According to Beat critic Ann Charters, Burroughs' introduction to heroin came when he decided that he wanted to leave his mundane suburban life to join a "community of outlaws" (102). Burroughs himself supports this idea in the prologue to Junky. Writing under the pen name "Bill Lee," Burroughs explains that he decided to begin this

outlaw lifestyle after reading Jack Black's You Can't Win. Burroughs admired Black's tale because "The author claimed to have spent a good part of life in jail. It sounded good to me. Compared with the dullness of Mid Suburbs where all life was shut out" (Burroughs, Junky xii). Burroughs claims this to be simply a "romantic extravagance" meant to jeopardize his safe life with some "token act of crime" (Junky xiv-xv). This raises an important question: why would a wealthy suburbanite jeopardize his seemingly perfect American lifestyle for a "romantic extravagance?" There must be something lacking in the lives of those not deemed acceptable in American society. Burroughs' induction to this community of outlaws, which would eventually lead him to heroin abuse, occurred as a direct result of the fact that he was not happy with what had been nearly universally accepted as the model of American perfection: suburbia and heterosexuality. This dissatisfaction, as is seen in different yet equal terms among the poor urbanite, is indeed what led him to rebel by participating in activities that were deemed unacceptable. Drug use becomes a mode of rebellion against a society that had already deemed the individual an outsider. By using heroin, which has been especially stigmatized as a "dirty" addiction, the characters build upon their innate status as the "outsider," one who does not fit in with society.

For Burroughs, junk becomes a rejection of the monotony of American life. "You become a narcotics addict because you do not have strong motivations in any other direction," said Burroughs; "Junk wins by default" (Junky, xv). Junk may win by default, but it is an opted default. Junk does not choose the individual, rather it is chosen, and Burroughs biography offers a good example of why so many have made this choice. It comes as a direct reaction to a dissatisfaction with one's own community, status, or atmosphere.

Looking at other literature of heroin addiction one finds that Burroughs was not alone in his sentiments. In Nelson Algren's The Man with the Golden Arm, Solly "Sparrow" Saltskin reiterates Burroughs' rejection stating, "If it wasn't for trouble I'd be dead of the dirty monotony around this crummy neighborhood" (14). Though Sparrow is not an addict himself, his choice to move into crime comes for the same causes as Burroughs' experimentation with drugs: dissatisfaction with his community. Like Burroughs, Frankie, the protagonist of Algren's novel, is an intravenous drug user and, like Sparrow, his reaction is to the "dirty monotony" of his urban Chicago neighborhood. Whether this reaction be petty theft, as is the case with Sparrow, or heroin, as is the case with Frankie, they have both found socially unacceptable methods of coping with their dissatisfaction.

A final reason for using heroin as a reaction in these novels arises out of the misguided belief that drug use can become part of a pursuit of happiness. This belief clearly pertains to Selby's Requiem For a Dream in which the three main characters use heroin as a symbol of the American Dream, as it can bring them both pleasure and

monetary advancement. Selby sees this as a selfish way of thinking. "Basically what the American Dream says," said Selby in an interview with *Shout* Magazine, "…is, you have to go out and get. And the more you get, the more content and secure and happy you will be—which of course is an absolute and total lie. Because the secret of a happy life is to give…" (qtd. in Estep 29). For Selby, the characters in <u>Requiem</u> fall victim to this lie as their individual drug addictions force them to concentrate solely on themselves. "The American dream is not only futile," states Selby in the preface to his work, "but self-destructive because ultimately it destroys everything and everyone involved in it" (Selby v). The self-interest of the three characters ruins their chances at achieving happiness. As the novel progresses, their friendship degenerates until, at the conclusion, they are left separated and alone, all having fallen victim to the selfishness of the dream.

The characters in <u>Requiem</u> each meet an individual demise that comes as a direct result of buying into this dream. Selby then punishes his characters for believing the lie and, in this, we see a clear distinction between the characters in <u>Requiem</u> and the other characters discussed. Unlike Bill Lee or Frankie Machine the heroin abuse among the three characters in <u>Requiem</u> is not a rejection, but a full-scale acceptance of the American Dream. One could call these characters somewhat more optimistic than those seen in the other novels, but this optimism does not provide happiness as it is based on a lie. As result, their outcomes are just as miserable, if not worse, than either Bill Lee or Frankie Machine.

Selby's characters, like all Americans, are taught that happiness comes through individual gains, such as making money and purchasing big-ticket products. The characters in <u>Requiem</u> all buy into this ideal and for that reason Selby punishes them. "They did not know the difference between the vision in their hearts and the illusion of the American Dream. In pursuing the lie of the illusion, they made it impossible to experience the truth of their vision. As a result, everything of value was lost" (Selby vi). In believing that money will solve the problems in their lives, Selby's characters subscribe to the very same illusion that is responsible for their problems. In this way, <u>Requiem</u> becomes what critic Roland Binet calls, "[A] vitriolic attack on society's decaying influence, on what society does to us" (388). <u>Requiem</u>, like the other works discussed, shows us how society devalues and dehumanizes the poor urbanite. In doing this, these novels offer evidence to support the idea that heroin addiction comes as result of an initiating factor in their surroundings. Ultimately heroin abuse does not begin as an action of the individual, but as a reaction to the outside society.

III. Don't Hide the Madness

> "The method must be the purest meat
>   and no symbolic dressing,
> actual visions & actual prisons
>   as seen then and now.
>
> Prisons are visions presented
>   with rare descriptions
> corresponding exactly to those
>   of Alcatraz and Rose.
>
> A naked lunch is natural to us,
>   we eat reality sandwiches.
> But allegories are so much lettuce.
>   Don't hide the meat
>   *San Jose*, 1954"

Allen Ginsberg – "On Burroughs Work"

Along with the reactionary aspect of the works described, one must acknowledge the methodical nature of the authors in detailing heroin addiction. It is in the graphic descriptions and vulgarity of the texts that the authors communicate the magnitude of the condition. This success is achieved through a number of common devices. First, by creating very real characters with whom the reader can relate, the author allows us to locate ourselves inside the text as we identify with the plight of the characters. Through the use of slang terms and community vernacular the authors create characters of flesh and blood, real human beings, not representations or exaggerations thereof. In doing this, the writing becomes a method of exposing the intricacies of drug abuse. Once we commit ourselves to the characters, only then can we understand their actions.

Heroin fiction has often been criticized as being too graphic in describing drug abuse. Critic Ann Marlowe claims this flaw to be so deep that it causes the authors to neglect convention by turning their emphasis to the grotesque (Marlowe 141). Marlowe feels that authors like Burroughs, Selby, and Algren are often too concerned with portraying the horrors of drug addiction and, in doing so, ignore classic literary functions like suspense, character development, and convincing dialogue (ibid.). To Marlowe, heroin abuse is anti-fictive and attempts at universalizing heroin addiction through fiction fall short of conveying their intended message. Thus drug abuse deserves non-fiction; personal accounts which can provide closer attention to individual and personality (ibid. 142).

Despite Marlowe's claim, heroin literature does not ignore literary convention. Rather, through intense character development it actually draws the reader, and writer, into the work. Although they do concentrate on the graphic nature of drug abuse, these authors never make their characters' actions monstrous or surreal. Realism in heroin fiction draws the reader in as much as would a personal memoir and, in doing so, contradicts Marlowe's claim to the "anti-fictive" nature of heroin addiction. Done right, heroin novels become "an invitation to embark upon the journey ourselves . . . [it is] an invitation to emerge" (Tsomondo 197). The reader not only empathizes with the character but also becomes a part of the work. Though the reader may have no personal relationship with heroin, he can understand the need to eliminate suffering and begin to recognize heroin use as a means of elimination.

Selby may be the one author whose work best achieves the goal of drawing the reader into the text. Despite their often drastic actions, Selby's characters are always identifiable. This is something that the author acknowledged as a goal in his writing: "I don't want you to read a story, I want you to experience it" (Interview 319). If we can feel for the characters, no matter how externally despicable they may seem at times, Selby succeeds. If we can witness them commit a heinous act, like Marion's subjecting herself to degrading sexual humiliation at the end of Requiem in exchange for a small cut of heroin, and still identify with her, Selby has achieved his goal. It is during these intense periods of degradation that the characters are their most human. If the reader can relate to the characters at their lowest points of addiction and suffering, then he can truly understand the magnitude of suffering that the author intends to portray.

This identification is what makes Selby succeed as an expository writer. He is not simply a storyteller, but rather an explainer. He locates himself inside the work, and inside the heads of his characters, in order for his readers to understand their innermost thoughts and feelings. Requiem is not told by a third person narrator, it is told by Selby, because he feels such a close connection to these characters that he knows exactly how they think. As Robert Buckey states, "Selby does not write about or speak to his subjects as much as he locates himself in [them]" (375). To be a successful Selby reader, one must follow the author's lead into the text or else all meaning is lost. The works are only expository if we allow them to be. We too must delve into the world of the addicts to be able to understand their motivations and reactions. Selby offers us the means; it is our choice if we decide to follow.

Selby's success depends upon us taking this journey. Only if we recognize the world he is exposing does his work transcend the page and become incorporated into the world of the reader. He offers no answers, just explanations, or, as Eric Mottram puts it, Selby's art is "showing the disease without offering the cure" (363). Selby's motivation is purely expository. He urges his readers to realize the plight and understand the suffering of his characters, but at the same time refrains from offering panaceas. Roland

Binet says as much in his essay "The Mirror of Man," stating, "[Selby's] sincere desire [is] to expose our world for what it is actually, a planet inhabited by greedy, vile, debased human beings set on a course toward self-destruction, yet utterly unaware of it" (380). Selby's pessimism is not reflective of his characters, but rather of the world around them. By exposing the degradation of the society around them, Selby explains the logic behind the reaction they have chosen.

As Robert Buckey points out, Selby has often been criticized as being a crude author with no sense of art in his writing (375). This criticism could not be more incorrect. In truth, Selby's artistry is the urban dialect of his texts. Though some may view the blunt writing as crude, this is exactly the point. Selby must use the harsh dialect of the streets to portray the lives of urban characters. Were the author to be discussing a different group of characters with a different set of problems, a more artful style may be appropriate, but for these characters the writing must be harsh, brutal and improvisational to parallel the situations of the lives it describes. It is in this writing that we find Selby's insight into urban mindsets, styles, and vernacular. This ear-to-the-streets style is what makes Selby's work so powerful.

As we see in Selby's style, the detailing must be as graphic and descriptive as possible for any author attempting to describe drug addiction to a readership who may have no previous experience with the topic. Burroughs is also quite adept at this, as in his <u>Junky</u> he includes a full glossary of "jive talk": addict slang terms relevant to the text. The glossary offers detailed descriptions to aid the reader in understanding junk talk, but more importantly the junky lifestyle. One particularly exemplary entry is as follows:

> Chucks . . . Excessive hunger, often for sweets. This comes on an addict when he has kicked his habit far enough so that he starts to eat. When an addict is cut off the junk, he can't eat for several days. I have seen addicts who did not eat for a month. Then he gets the 'chucks' and eats everything in sight (Burroughs, <u>Junky</u> 154).

Not only does Burroughs give the primary description, "excessive hunger," but he also infuses it with a personal account to further describe the exact nature of the "chucks." Burroughs is not content with giving his readers a vocabulary list; rather he wants the reader to understand exactly what these terms mean, and how the junk abuser uses them. For Burroughs, understanding can only be achieved if the reader becomes completely immersed in the lifestyle, and a key point to understanding the life is knowledge of the language.

This glossary offers another key point to understanding the goal of the authors. By including this, Burroughs acknowledges that his audience is made up primarily of readers

unfamiliar with urban drug abuse. For this reason he must be as specific as possible when describing their unique lexicon of terms.   The glossary of "jive talk" again indicates that Burroughs is indeed trying to teach his readers something.

A second key support to the expository nature of the works is the graphic authorial description of the mechanical act of intravenous drug use. For an author to successfully portray the magnitude of addiction, the process of getting high must be described in terms graphic enough to convey the power of the drug. This is indeed the most important aspect of the explanatory nature of the texts. If indeed the author's purpose is to expose the conditions that lead to drug abuse, and the tragic effects afterwards, the reader must understand the act itself and the feelings it incurs.

Burroughs does this early in Junky, describing the first time the autobiographically based character Bill Lee experienced intravenous drug use. Burroughs description of his first junk experience, using a morphine syrette (a small tube with a needle protruding from the end,) reads almost like a medical text. Burroughs wants the reader to completely understand the euphoric feeling of the drug. His account describes the kick as immediate and exotic: "Morphine hits the backs of the legs first, then the back of the neck, a spreading wave of relaxation slackening the muscles away from the bones so that you seem to float without outlines, like lying in warm salt water" (Burroughs, Junky 7). Burroughs is quick to note that the first experience was not entirely pleasurable citing the jarring reaction that the drug has on his body, including "… the shutting off of breath; the stopping of the blood" (ibid.). Critics who claim that Burroughs promotes drug abuse in his writing seem to overlook this passage. He neither promotes nor condones drug use at this point, but rather explains it. His goal is for the inexperienced reader to understand the effects of intravenous drug use without actual experimentation.

Algren's method is similar to Burroughs as Algren too is very precise in describing the act of shooting up. As in Junky the first description of Frankie Machine's addiction in The Man with the Golden Arm is also that novel's most graphic. Algren is clear to state the controlling and addictive nature of the drug in his description, especially when taking into consideration that Frankie does not inject himself, but rather has his dealer Louie shoot him up. This emphasizes the inherent powerlessness of the user in the situation. Algren takes Burroughs' graphic account a step further, even describing the preparation of the drug in graphic detail: "[Louie] snuffed out the match's flame as it touched his fingers and snapped the head of another match into flame with his nail, letting its glow flicker one moment over the sieve-like smile; then brought the tube down cautiously and watched it dissolve at the flame's fierce touch" (Algren 57). This initial description, even prior to injection, conveys the control the drug has over Frankie. The meticulous description puts the reader in Frankie's shoes, anticipating the hit, waiting in agony for Louie to finish, waiting for the drug to be ready so that Frankie and the reader can simultaneously feel the effects.

Algren's shooting scene gets more detailed as the injection is finally made:

> [Frankie] couldn't feel Louie probing into the dark red knot above his elbow at all. Nor see the way the first blood sprayed faintly up into the delicate hypo to tinge the melted morphine with blood as warm as the needle's heated point.
>
> When Louie sensed the vein he pressed it down with the certainty of a good doctor's touch, let it linger a moment in the vein to give the heart what it needed and withdrew gently, daubed the blood with a piece of cotton, tenderly, and waited…
>
> It hit all right. It hit the heart like a runaway locomotive, it hit like a falling wall. Frankie's whole body lifted with that smashing surge, the very heart seemed to lift up-up-up—then rolled over and he slipped into a long warm bath with one long orgasmic sigh of relief (58).

Algren's description again places the reader in Frankie's position. The torture that he goes through waiting for the drug to hit, followed by the "orgasmic" ecstasy of the high, is meant to be simultaneously experienced by the reader. When reading these lines one cannot help but imagine the sensations that Frankie feels, and we almost want to feel these same things. This, though, is Algren's intention. By placing the reader with Frankie, Algren exposes the seductive power of morphine. Through Algren's narration, the reader becomes the junky. We, like Frankie, are sucked in by the attractive qualities of the drug. Fortunately, the reader has the ability to witness the causes and effects of the drug without trying them. Unlike Frankie, we see the destructive power of drug abuse without having to experience it.

IV. Isolation

> "The wind had blown the summer flies away. God had forgotten His own."
>
> Nelson Algren – The Man with the Golden Arm

A major catalyst for the intense feelings of hopelessness seen in a number of these characters is an urban atmosphere that does not support the individual. The neighborhoods in urban drug literature are not conducive to interpersonal support, as they force the individuals to concentrate on self-survival, a necessity more difficult to achieve in this atmosphere than it ought be. This leaves the characters isolated, often without a

single person to turn to for support. Family and friends are often dealing with their own issues and can't dedicate time to someone whose problems are seemingly no more serious than their own. This then leaves the isolated individuals searching for an agent to soothe their often all-encompassing feelings of dread and despair. All too often the answer becomes narcotics, as the abusers feels they have nothing else in this world to live for.

The first sense of isolation is often felt in a lack of support among individuals within the community. These feelings of solitude are often a driving factor toward drug abuse and crime. Throughout each of the novels, we see how the described addicts had no one to turn to before beginning their addictions. The prime example of this may be Sonny in "Sonny's Blues." Although Sonny's brother is a force in the present tense narrative of the tale, the sections that describe the past show Sonny alone, confused, and without a figure of support in his life. His father has been killed in a racially motivated murder and his single mother does not know how to relate to her rebellious son. Thus Sonny, a young teenager, is left to fend for himself. Sonny's only outlet is his music, but even that is not supported by his friends and family who hear it more as a cacophonous disturbance than the emotional outlet that it really is. These feelings of solitude in an already unwelcoming environment are for Sonny, like so many of his peers, a major contributing factor to his experimentation with heroin.

This type of isolation is seen again through a number of characters in The Man with the Golden Arm. Though not all are drug addicts, several characters in Algren's tale express feelings of despair and directly attribute them to their surroundings. A first major example of this is Frankie Machine's wife, Sophie. Sophie, crippled from a car accident when Frankie was driving drunk, spends her days housebound, and with very little companionship. Frankie is gone, supporting his habit by dealing cards, and there are few others who show any concern for her condition except for a quack doctor and the building's landlady who makes infrequent stops to Sophie's apartment to help with cleaning. Sophie's despair is compounded by her dismal surroundings. As Algren describes it:

> For the city too was somehow crippled of late. The city too seemed a little insane. Crippled and caught and done for with everyone in it… She could tell just by the way once familiar doorways had come to look menacing in the morning light, ready to be slammed in the face of anyone who knocked at all. Nobody was at home to anyone else any more. (96)

For Sophie, the environment turns what should be a supportive community of individuals into amalgam of isolated faces. Algren shows this by paralleling Sophie's handicap with the city itself. By describing the urban atmosphere as crippled, Algren shows that everyone located within will, like Sophie, feel the effects of the unwelcoming environment. Because Sophie is already battling a handicap that isolates her from others, her plight is only worsened. Sophie's lone solace in the world comes in her morbid fascination with accidents like her own. She goes as far as compiling news clippings of fatal and injurious events in a notebook entitled "My Scrapbook of Fatal Accidence."

Sophie's paralysis shows the reader another example of the unsupportive nature of the environment. Throughout the work, a number of characters attempt to convince Frankie that Sophie is faking the injury simply so that she can keep him bound to her. Though never made clear in the novel, this speculation convinced some readers enough to believe that Sophie was indeed fraudulent, as is seen in Otto Preminger's 1955 film adaptation of the novel, in which Sophie's health is found out at the film's conclusion. This scenario speaks volumes for the need for companionship and support in the urban environment. Sophie feels that she could not survive alone, and thus sacrifices her mobility just so Frankie will stay with her. Whether Sophie is indeed crippled or not is not the main issue. Rather, it is the fact that she is willing to sacrifice her mobility just so she will have some form of companionship because she feels she cannot survive in her environment without it.

Sophie's husband Frankie also feels alone in his environment, and like Sophie is on a constant search for a supportive soul. Since the accident that paralyzed his wife, Frankie has felt a tremendous amount of guilt for the injury because he was drunk behind the wheel. This is not helped by the fact that Sophie reminds him on a daily basis that he is responsible for her current state. The guilt he feels is never eased, because there is not a single person to whom Frankie can turn to discuss his feelings about the accident. Algren describes this guilt as the motivating factor for Frankie's drug abuse: "Yet-if there were just one person to whom one's answers were always straight, just that might make the whole twisted world come straight…" (144). The key to this statement is the repetition and connotation of the word "straight." The slang term that Algren uses -- "straight" -- means to be clean of drugs. So what Algren is saying is that if Frankie had someone to talk to, someone with whom he could work out his intense feelings of guilt, he would not need heroin in his life; the human support alone would be enough to make his world "come straight."

Unfortunately, Frankie is never able to find the support that he needs to "come straight." There are a few characters in the novel that aid Frankie and attempt to help him kick the habit, but it is never sufficient. Molly-O is the one character with whom Frankie does find some solace and support. In his last major attempt at kicking his habit, Frankie goes cold turkey while locked inside Molly-O's apartment. The kick does not work

because, though Molly can be with Frankie for part of the day, she cannot remain housebound with him. During her absence the intensity of the kick is too much for Frankie and he can't take it. What Frankie needs to kick is constant and unfading emotional and physical support, which Molly-O simply can't give him.

Frankie's isolation in turn leads to the demise of another character in the novel, his sidekick Sparrow. Without Frankie, Sparrow cannot survive in the uncompromising Chicago streets. Algren describes the effect that Frankie's separation has on Sparrow: "[Sparrow] wanted to feel walls and safety about him, needed to be *inside* something. Frankie had been his wall and the wall was gone, leaving him as defenseless as he had been in the years before he'd hooked up with the dealer" (120-1). Sparrow cannot survive without the support of the much stronger Frankie. When Frankie turns away from Sparrow, and from everyone else in the community, his friend cannot survive on his own. Like so many other characters in the work, Sparrow is left alone, isolated in an already overwhelming environment.

The feelings of urban isolation may be described best in Baldwin's "Sonny's Blues":

> You walk these streets, black, and funky and cold, and
> there's not really a living ass to talk to, and there's
> nothing shaking, and there's no way of getting it out—
> that storm inside. You can't talk it, and you can't
> make love with it, and when you finally try to get with
> it and play it, you realize *nobody's* listening. So
> *you've* got to listen. You got to find a way to listen
> (Baldwin 26).

Sonny attempts to find support in the community through his music. Like the characters in Algren's tale, he too realizes that "*nobody's* listening." Nobody cares to hear what Sonny has to say through his music because they are suffering just as he is and they know what that suffering feels like. Sonny realizes that he must be his own audience, he must play for himself, find solace in himself. Only after this is achieved can he speak to others through his music. Sonny is indeed successful in doing so, and in the final passage of the text we see that he can indeed reach others through his music. In that passage, Sonny's brother, who had misunderstood Sonny's drug abuse for so long, finally begins to see what his brother has been going through. As his brother notes, the transmission in Sonny's music is reciprocal: "I understood, at last, that he could help us to be free if we would listen, that he would never be free until we did" (Baldwin 32). In discovering this, Sonny may be the one true success story among all the characters discussed. Sonny's music can speak to the community, while at the same time allowing him to release years of pent up anger and frustration, but this can only occur if someone is listening. This is

something that seems to be lacking in all of the novels, a sympathetic ear to which the characters can turn for comfort or release.

Even in tales where there is a sympathetic ear, few characters find an outlet as effective as Sonny's music. While Sonny's response to his suffering is productive, most of the other characters simply isolate themselves from everyone around them and descend further into drug abuse. We see this self-isolation as a common response among the characters after they fail to find support in others. Frankie Machine in <u>The Man with the Golden Arm</u> and Harry in <u>Requiem for a Dream</u> are the two prime examples of complete self-removal from friends and family.

Both characters isolate themselves from the few people who truly love them. For Frankie, as has already been discussed, it is his wife Sophie and later his best friend Sparrow. For Harry, the reaction is much the same as he turns away from his overbearing, yet endearing mother, Sarah, and from his one true love Marion. In turning away from their closest relations, we see that Frankie and Harry are the two most hopeless characters in any of the works. Unlike these two, Sonny finds he has his brother's support at the end of "Sonny's Blues" and Bill Lee, though not keeping friends for long periods of time, never isolates himself to the extent that Harry and Sparrow do.

While not of the same magnitude as the other two, Burroughs' Bill Lee does enter periods of self-isolation. Lee's stints of self-removal are primarily reserved to short periods of time when he wouldn't leave his room and would spend his entire day concentrating on keeping up with a drug schedule. "As I began using stuff every day," describes Lee, "I stopped drinking and going out at night… I also stopped bathing" (Buroughs, <u>Junky</u> 22). His life becomes dedicated to a routine of consistent drug use: "... a cap of junk three times a day, and the time in between to be filled somehow" (Burroughs, <u>Junky</u> 75). For Lee, it is never a designed isolation from individuals in society; rather it is just a more strict concentration on his habit, which necessitates an isolated lifestyle.

Harry's self-isolation is much harsher and is directed specifically against human contact. He gets to a point where he doesn't even want to leave his house to go to the store because it may force him to interact with others. Selby describes Harry's reclusive mentality: "If only he could just call up some joint and have them send one over that would be fine, but going in a store and talking with people and everything . . . He brooded over it for a while then realized that all he had to do was take a taste and everything would be alright" (130-1). The only way that Harry can even face the world is if he shoots up first, otherwise the prospect of contact with others is simply too much to take. This is reminiscent of Burroughs' most famous quotation from <u>Junky</u> in which Bill Lee explains his reasons for using heroin: "I need junk to get out of bed in the morning, to shave and eat breakfast. I need it to stay alive" (23). For both Bill Lee and Harry Goldfarb, heroin use is the boost they need to get up and face the world. It gives them

the comfort they need to leave their self-isolation. This though is the paradoxical nature of heroin addiction: it both causes the addict to isolate himself and then becomes the only means by which they can leave that isolation.

Burroughs describes the reasons why junk is a solitary drug in his essay "Deposition: Testimony Concerning a Sickness." In "Deposition," Burroughs defines junk as a comforting "inside" and everything else in the world as a harsh "outside": "in here nice and warm nice and IN HERE and nice and OUTSIDE ITS COLD. . . . ITS COLD OUTSIDE . . ." (143). For the addict, heroin becomes home; the feeling of warmth it provides substitutes for the support of other individuals. Human contact is not needed when junk provides the warmth. For this reason, the addict voluntarily isolates himself from others because everyone else becomes part of the "cold outside" with which the addict wants no contact. Their only desire is for the warmth and comfort of heroin; everything else becomes unnecessary.

Selby seconds this mentality in Requiem describing the way the three main characters react to a communal heroin session. Though Harry, Marion, and Tyrone are very close, they begin to believe that they don't need one another as long as they have their fix. As Selby describes it, "They were all suddenly silent as they listened through the *dream on* lines, each in their own way thinking they didn't need anyone to dream on, that this boss shit did the job just fine..." (23). This description certainly foreshadows the future of their relationship. At this point in the text they are very close, but the description of their only needing heroin to survive indicates that they will inevitably turn away from each other as their addictions increase and they isolate themselves from one another. Selby emphasizes this split by changing the form of his narrative after this separation. Before the characters begin to self-isolate, their actions are often described as a group, but as they remove themselves from each other, their actions are described one-by-one, emphasizing the increasing solitude of the characters. This is especially apparent in the novel's concluding chapters, where the downfalls of each of the characters are described in alternating paragraphs, rarely melting together.

Despite Sonny's individual success, Baldwin, like the other authors discussed, also supports the idea of urban isolation. He describes it as the overwhelming problem among the inhabitants of Sonny's housing project. As critic Donald Murray notes in his essay "James Baldwin's 'Sonny's Blues': Complicated and Simple," the people in Sonny's project live in a dual darkness (354). The first darkness is the overwhelming despair of their own lives resulting from the hopelessness of their environment, and the second darkness is their sole method of escape: the movie theater. Murray notes that this form of entertainment is indicative of the separation among the neighbors. Their one form of entertainment is as isolating as their own lives, for a movie theater offers no sense of community. Although physically coming together in the theater, members of the community sit side by side, in darkness, without any form of connection or

communication (Murray 354). For Baldwin this is a perfect parallel to represent the isolated lives of the individuals.

Burroughs describes this sense of urban hopelessness as uniquely American, criticizing the US for homogenizing its population by forcing them into "Main Streets" and "Elm Streets" across the country, each with the same characteristics, same feel, and thus the same inhabitants. "There is no drag like US drag," states Burroughs in <u>Naked Lunch</u>; "Take one of those cocktail lounges at the end of a subdivision street – every block of houses has its own bar and drugstore and market and liquorstore" (134-35). The homogenized atmosphere that Burroughs describes then leads to heroin abuse as an individual response to the banality of the living space. Heroin becomes a mode through which the abuser can form some kind of identity in an atmosphere that does not support individuality. In essence, heroin becomes the individual because he has nothing else to make him stand out.

V. Urban Wastelands

> "… The city itself seemed some sort of open-roofed
> jail with walls for all men and laughter for very few."

> Nelson Algren – <u>The Man with the Golden Arm</u>

The power of the drug novel is that the reader can witness the effects of drug use without being destroyed by them. The characters, however, are not so fortunate. Their lives have already been ruined, mainly by their social status and atmosphere. Urban drug authors concentrate a good deal on describing the depravity and hopelessness of the environments that their characters inhabit. Most often these are described as industrial wastelands where constructed artificiality has taken over for nature. Coupled with a dismal workplace that instills no sense of importance in the individual, the urban environments become conducive to drug abuse. Beaten down day-after-day by their environment and with little significance or sense of hope in their lives, heroin becomes a method of self-destruction which the character's can control. The initiating cause of this feeling though is the harsh landscape of urban America.

The urban environment in these novels is often little more than a mess of bricks and steel. Allen Ginsberg's canonical poem *Howl* offers a superior description of the oppressive nature of the urban environment: "What sphinx of cement and aluminum bashed open their skulls and/ate up their brains and imagination" (Ginsberg 68). As Ginsberg notes, the harshness of the city landscape is passed on to the inhabitants, draining their imaginations and hopes. Through Ginsberg's observation we can see that the disillusionment that leads to drug abuse results from the barrenness of the poverty-stricken urban atmosphere.

The narrator of Baldwin's "Sonny's Blues" seconds the idea of the unsupportive urban environment in describing the housing project in which Sonny and his brother shared their childhood as a wasteland of disillusioned humanity:

> We live in a housing project. It hasn't been up long.
> A few days after it was up it seemed uninhabitably
> new, now, of course it's already run-down. It looks
> like a parody of the good, clean, faceless life – God
> knows the people who live in it do their best to make it
> a parody. (9)

This, though, should not be read as the brother's berating the project's tenants; rather it is quite the opposite. The narrator's criticism is intentionally contradicted earlier in the description when he describes the project as "uninhabitably new" in its nascent state. Baldwin's criticism is of the entire idea of project housing as being an uninhabitable atmosphere. This is not how people are meant to live, and the result of these cramped and unwelcoming living spaces becomes a violent and depraved atmosphere.

The narrator understands the toll the environment has had on his brother as he and Sonny return to the neighborhood following Sonny's release from prison. "The moment Sonny and I started into the house I had the feeling that I was simply bringing him back into the danger he had almost died trying to escape," explains the narrator (Baldwin 9). Sonny's brother fears that a return to the housing project will also mean a return to the drug habit that sent Sonny to jail in the first place. There is a certain danger about the landscape that pushes Sonny to use heroin and the narrator knows that as long as Sonny lives in the projects there is always the chance that he will start using again. The solace that Sonny finds in music is only momentary because "the world waited outside, as hungry as a tiger and that trouble stretched above us, longer than the sky" (Baldwin 32). For Sonny, his music offers a temporary reprieve, but in the end it does not protect him from the dangers of his own neighborhood.

For addicts like Sonny, Frankie Machine, Bill Lee, and the three main characters of Requiem, the urban environment is the major factor in pushing them towards drug abuse. What is it exactly about the urban atmosphere that supports heroin abuse as opposed to more rural, or suburban settings? The artificiality of the scenery certainly plays a major role. The effects of the constructed atmosphere of tenement housing, and high-rise buildings, takes a major toll on the characters of drug fiction leaving Algren to question, "Was there no time left for easy passages and casual pleasures down tree-lined boulevards?" (97). The comforts of nature are not made available to city-dwellers who live their entire lives surrounded by concrete and steel. Algren emphasizes this point through the actions of the mentally retarded son of the tenement landlord (appropriately nicknamed "The Jailer"). Throughout the novel, Jailer's son is constantly attempting to

plant paper daisies in the cracks of the tenements worn staircase. The flowers are constantly rejected, or trampled upon, showing the inability of anything to be nurtured in this brutal atmosphere where "only arc lamps and fire hydrants grow…" (Algren 226). Algren shows us that not only has the urban landscape removed all natural beauty, but it has also eliminated the possibility of it arising anew.

This pessimism for the future is deepened when we observe the employment opportunities in low-income urban environments. The characters in the novels are all city-dwellers, not suburbanites who commute into the city for their nine-to-fives and then return to their distant communities. They live twenty-four hours a day in the city and reap none of its economic benefits. They are not qualified for office jobs that offer economic security and thus are left with few options other than unfulfilling, minimum-wage labor. This is exactly the kind of labor that Bukowski described as leading to the same type of insanity that hallucinogenic narcotics produce.

The addicts presented in heroin literature, for the most part are, unemployed or bounce around from job to job not caring about what they do or for whom they do it as long as it pays their bills. Often, as is seen in <u>Requiem</u>, there is a large-scale rejection of any kind of work. Harry, Marion, and Tyrone forego any kind of employment and view work as yet another inhibitor of personal freedom: "…looking at the people…knowing they were either going to or coming from some job, trapped in some box in the suburbs or rat trap in the city, never knowing what was going on and never knowing what its like to be free…" (Selby 110). These three characters see work as a barricade to personal freedom and see anyone who labors as a sell-out, willing to give up personal freedom for a paycheck.

The attitude toward minimum-wage labor is summed up by Applejack Katz, a minor character in <u>The Man With the Golden Arm</u>. Explaining his life after prison to Machine, Applejack states: "For two years I was off the booze, off the women, off the horses, off the dice. I even got engaged to get married in a church. All I done that whole time was run a freight elevator up'n down, up'n down. It scares me when I think of it now: I come near losin' everything" (Algren 204). This may seem like an odd statement. His life seems to be going well according to what most people would consider a healthy lifestyle. He had stopped drinking, womanizing, gambling, had a fiancée, and a new job, but he was still unhappy. The elevator job would drive him into the ground slowly over a period of years taking away his youth, freedom, and hope. The only time he had truly felt free was when he was drinking, womanizing, and gambling because then at least he could control his own inevitable destruction. These excesses may cause this demise to occur more rapidly, but at least Katz would have some control over his own destiny and have a bit of a good time on his path down the spiral. This identity control is a major factor in heroin fiction, the sense that although the drug may destroy the addict he at least is in control of that destruction.

For critic Leslie Fiedler, Katz's statement is the rallying cry for a generation of disenfranchised who have decided that the ideas of order of the past (i.e., a job, family, home) will not work for them. So the emphasis turns towards the now and satisfying the primal needs of satisfaction rather than trying to carve out their own niche in a rather exclusive society. Fiedler reads this rejection in Freudian terms describing it as the prevailing of "'impulse over order'" (Fiedler 510). If, like Katz, we see work as ultimately unfulfilling and meaningless to personal satisfaction, why continue? If work does not fulfill the primal goal of fulfillment, then it has no place in the rebellious individual.

Ultimately for Fiedler, this rejection of work becomes a rebellion against the traditional roles a man is supposed to play in society. In his article, "The New Mutants," Fiedler argues that the rejection of work is one in a number of individual reactions that characters of rebellion fiction take on as a means of rejecting their designated roles. Rejecting the workplace incurs a disruption of the place a man is supposed to fill in society. As he states, "A job and unequivocal maleness – these are two sides of the same Calvinist coin, which in the future buys nothing" (520). Work is not needed if concentration is on the present and fulfillment of the id. In fact, as Fiedler states, it doesn't even buy anything for the future for these characters because they can't obtain the kind of employment that would offer any sort of personal or family security. Work then is purposeless, even though it is what men are taught they are supposed to do. In rejecting the workplace, the individual rebels against the constructs of society in an attempt at gaining some form of control over their own lives.

These control issues are also a major contributing factor to the character's entrance into petty crime like thievery, drug dealing, and card-sharping. Illegal employment serves as an easy way to earn a few dollars without selling one's personal freedom to an employer for eight hours a day. Harry, Marion, and Tyrone take this route initially, selling small amounts of dope to fund their habit, but eventually becoming big time dealers. Frankie Machine, nicknamed "the man with the golden arm" for his quick hands at the card table, makes his living dealing illegal card games for his drug dealer. Bill Lee, like the three characters in Requiem, makes money to support his habit by dealing drugs on the side. And Sonny, in Baldwin's tale, has just been released from prison for a drug-related infraction. This self-employment in petty crime can be paralleled with heroin abuse as simply another means of exercising personal freedom in a stifling atmosphere.

Ann Marlowe, a former heroin addict herself, takes this search for personal freedom even further when describing the reasons why people experiment with heroin. According to Marlowe, the goal of every heroin user is to form an addiction. "Getting a habit isn't an accident, or the result of the 'power of the drug,'" claims Marlowe, "it's what you were after" (145). This certainly seems to be true in looking at the characters in drug literature. Burroughs' autobiographical Bill Lee may be the prime example of this.

Burroughs had a "perfect" American life growing up in the suburban Midwest, yet was unsatisfied. He turned to heroin as a reaction to this dissatisfaction knowing very well that experimentation could lead to addiction.

Marlowe uses an interesting anecdote to explain this type of behavior. Discussing the number of addicts she knew who claimed to have thrown up after their first few times using heroin, Marlowe asks: "Would you order an entrée again if you threw it up the first time you ate it?" (145). For most of us the answer is a resounding "no," but for the heroin addict the intense initial reaction to the drug is not enough to prevent them from trying a second and third time. Marlowe continues: "We grow up hearing how destructive the drug is, how it ruins lives because people want it so very much, and so we suspect it must be enormously pleasurable. It becomes desirable because we have heard it is addictive" (181). The bodily reaction to heroin during the initial high seems to be an intensely unpleasurable experience, so why do people continue to use heroin after an initial negative reaction? They do so because the addiction is what they are after as a means of controlling their own destiny. In an urban environment where they have little to live for, heroin becomes the choice method of destruction because it is both pleasurable and something the users can control themselves.

The idea of desired addiction is supported by a number of characters in drug fiction. In <u>Junky</u>, Bill Lee notes that heroin is not even a worthwhile high: "Junk is not a 'good kick.' The point of junk to a user is that it forms the habit." (Burroughs, <u>Junky</u> 99). Frankie Machine describes his addiction as "…[rolling] up all the little troubles into one big trouble" (Algren 317). The little troubles of Frankie's life cause a sense of hopelessness, but heroin offers him the opportunity to do something about his dissatisfaction. With heroin, Machine can combine all his problems into a single one that he can control and, in doing so, gain some authority over his own life. Addiction then becomes Frankie's desperate rejection of a controlling atmosphere.

Once addicted, the users can then relate to the depravity of their own environment. Algren describes the dwellers of Division Street as having "…faces bloody as raw pork ground slowly in the giant city's grinder…" (16). The people begin to portray the hopelessness of their environment and vice versa. Algren extends this comparison by paralleling the heroin addict with the noises of an industrial atmosphere: "They heard a switch engine's burdened cough," says Algren, "But to Frankie Machine it sounded more like a man trying to cough with a thirty-five-pound monkey on his back." (119-20). For Algren, the addict is a product of his atmosphere and there is no better way of describing this than portraying the city itself as an addict. Returning to Ginsberg's "Howl" we see this idea reiterated:

> Im with you in Rockland
> Where we hug and kiss the United States under our bedsheets
> The United States that coughs all night and just won't let us sleep.
>
> <div align="right">(Ginsberg 70)</div>

The coughing again parallels the city with the addicts that it has created. Like Burroughs, Ginsberg sees this as a uniquely American condition. While it may not be uniquely American, the condition is certainly uniquely urban.

Heroin becomes an ultimate rejection of the controlling urban atmosphere; a revolt celebrating what Fiedler calls the "…programmatic espousal of an anti-puritanical mode of existence – hedonistic and detached – one more strategy in the war on time and work" (522). For the urban users in drug fiction, heroin is a way of disconnecting themselves from the society that has already rejected them as an outsider. In rebelling against their classic role as a worker and celebrating the pleasures of the moment rather than planning for the future, they desparately reject everything that society has raised them to believe.

Ultimately, heroin fiction of the mid-to-late 20th century has served as a medium by which individuals unfamiliar with drug abuse can come to understand the driving factors that lead to addiction. Of particular importance is the realization that drug abuse is a reaction, not an action. In creating addicts who are real and relatable, authors like Selby, Burroughs, Algren, and Baldwin have gone to great lengths to educate readers unfamiliar with the world of urban drug abuse as to why drugs become an option. What these authors show us is the reason why urban individuals feel they have to react to society in such a negative and destructive way. Ultimately, these authors expose the impoverished urban atmosphere as a catalyst for a unique sense of despair that drives a number of its inhabitants to experiment with intravenous drugs in a grasping attempt at some form of self-rule.

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The Biology and Psychology of Melatonin

Jene Tesoriero

I. <u>Introduction</u>

The neuronal hormone melatonin (Antolin et al., 1996), which is synthesized and secreted mainly from the pineal gland, a small neuroendocrine organ located at the bottom of the third ventricle, plays an important physiological role in synchronizing biological rhythms and neuroendocrine functions in vertebrates (Kvetnoy, 1997). Melatonin (N-acetyl-5-methoxytryptamine) acts as a chemical messenger by transducing photoperiodic information to the brain. Light is the most important factor controlling melatonin formation. Light during the dark phase of a light/dark (L/D) cycle, can suppress the melatonin synthesizing enzyme Serotonin N-acetyltransferase (SNAT) thus reducing melatonin synthesis and release from the pineal gland (Minneman et al., 1974). It is believed that melatonin levels can influence circadian rhythms through activation of melatonin receptors in the superchiasmatic nucleus (SCN) of the hypothalamus, the site for the mammalian circadian pacemaker (Ludkvist et al., 1999). It is also known that exposure to the light at different times in the night phase of the L/D cycle can change the periodicity of melatonin synthesis (Reiter, 1991).

II. <u>Melatonin Synthesis and Degradation</u>

Melatonin is mainly synthesized and secreted from the pineal gland, and to a lesser extent in extrapineal structures like the retina and gastrointestinal tract (Kumar, 1996, Kvetnoy et al., 1997). The melatonin concentration in an organism is not uniform and varies depending on the structure and time of the day (Pang et al., 1983; Skinner et al., 1999).

While the concentration of melatonin in the plasma was reported to be in the nanomolar range, (Cardinali et al., 1997), the brain tissue has the ability to accumulate melatonin periodically to a level exceeding fifty times its plasma concentration (Pang et al., 1990). It has been speculated that neurons may further have the ability to accumulate melatonin to even higher concentrations through passive uptake (Witt-Enderby et al., 2000). The distribution of melatonin within the brain is not uniform and several differences in the melatonin content have been reported between brain ventricles (Skinner et al., 1999).

Melatonin Synthesis

Melatonin is synthesized from the amino acid L-tryptophan (Figure 1). The 1st step in the synthetic pathway involves the conversion of L-tryptophan to 5-hydroxytryptophan

by use of the enzyme tryptophan 5-hydroxlase (TH). Following this 5-hydroxytryptophan is converted to 5-hydroxytryptamine (Serotonin) with the enzyme Aromatic amino acid decarboxylase (AAAD, Step 2). In the 3rd step Serotonin N-acetyltransferase (SNAT) converts Serotonin into the rate-limiting product for melatonin, N-Acetylserotonin. Melatonin is then synthesized (Step 4) from N-acetylserotonin utilizing the enzyme Hydroxyindole- O – methyltransferase (HIOMT).

Melatonin Degradation

The primary sites for melatonin degradation are the liver, the major site of melatonin hydrolysis, and kidneys. Melatonin undergoes 6-hydroxylation followed by the addition of a sulfate of a glucuronide group. The two byproducts are 6-Hydroxymelatonin sulfate (6-sulfatoxymelatonin) and 6-hydroxymelatonin glucuronide. These byproducts are then excreted in the urine (Arendt, 1995).

Small amounts of melatonin produced by the pineal can be degraded in the brain, where it can be metabolized to N-acetyl-N-formyl-5-methoxykynurenamine and N-acetyl-5-methoxykynurenamine (Arendt, 1995).

Melatonin, to a small degree, can be produced and metabolized in the retina through a unique metabolic pathway. The metabolism starts with deacylation by aryl-acyl-amide amidohydrolase to 5-methoxytrytamine. The 5-methoxytryptamine undergoes oxidative deamination by monoamine oxidase (MAO), to form 5-methoxyindoleacetic aldehyde, which is further oxidized to 5-methoxyindoleacetic acid, or reduced to 5-methoxytryptophol (Cahill et al., 1989).

III. Sites of Melatonin Action

Melatonin is a neurohormone possessing lipophilic properties, enabling it to bind to extracellular receptors and freely pass through membranes (Costa et al., 1995). This endows melatonin with the ability to regulate many cellular events from the outside of the cell through extracellular receptors, as well as intracellular events in the cytoplasm and the nucleus.

Actions of Melatonin on the Extracellular Receptors

Based on results of agonist binding assays, such as $2[^{125}I]$-iodomelatonin, the existence of two distinct melatonin binding sites, Mel-1a and Mel-1b, in the pigeon brain was postulated (Yuan et al., 1991). Recently these melatonin receptors have been renamed and reclassified, according to their order of agonist potencies.

The Mel-1a has been renamed the MT1 receptor. The MT1 receptor leads to a decrease in adenylate cyclase activity and is found in brain structures including the SCN,

hypothalamus and retina. 2-Iodomelatonin (2-Imel) is the best agonist for this receptor followed by melatonin (Mel) and 6-Chloromelatonin (6-ClMel).

The Mel1b receptor has been reclassified as the MT2 receptor and has been found to be localized in the retina and hippocampus of humans. Agonist stimulation of the MT2 receptor leads to a decrease in adenylate cyclase activity. The most potent agonist for the MT2 receptor is melatonin followed by 6-ClMel and 2-Imel.

A number of antagonists to date have been shown to have partial agonistic functions on different Melatonin receptors. For example, 4P-PDOT, an antagonist at the MT1 and MT2 receptors, has also been shown to act as a partial agonist at the MT2 receptor. Another antagonist, luzindole, also seems to act as a partial agonist at high concentration (> 1µM) at the MT2 receptor. The detailed characterization of melatonin receptors is still significantly hampered by the lack of a specific antagonist.

Actions of melatonin have been shown to be exerted through a seven loop domain, G-protein coupled receptor (Reppert, 1997). Melatonin has been shown to act on its receptor leading to a decrease adenylate cyclase activity and a subsequent decrease in cAMP. Both pertussis toxin-sensitive (Nash et al., 1995) (Garcia-Perganeda, 1997) and insensitive G proteins appear to link melatonin receptors to inhibition of adenylate cyclase. Other work has linked the action of melatonin on its receptor to the stimulus-activated hydrolysis of phosphoinosotides (PI) by phospholipase C (Mullins et al., 1997; Popova et al., 1995). This pathway produces two second messengers: inositol-1,4,5-triphosphate (IP_3) and diacylglycerol (DAG), leading to activation of the IP_3 gated calcium channels and protein kinase C (PKC), respectively.

Control of Melatonin Receptors

Melatonin receptors can be controlled, among other mechanisms, by desensitization or downregulation. Differentiation between these two mechanisms is accomplished by comparing the K_d, the equilibrium dissociation constant, or the B_{max}, maximum specific binding, before and after melatonin treatment. A decrease in the K_d value would indicate and increase in the affinity of the receptor for the ligand, while an increase the K_d would indicate the opposite. An increase or decrease in the number of melatonin receptors, would be reflected by an increase or reduction of B_{max}, respectively.

Melatonin has been shown to regulate its own receptor expression. The actions of melatonin receptors can be regulated by phosphorylation, specifically by PKA (protein kinase A) and PKC. A daily fluctuation in melatonin receptor mRNA and melatonin receptor protein in the SCN and pars tuberalis (PT) has been shown (Ross et al., 1997). In PT cells the levels of melatonin receptor mRNA are increased following an increase in cAMP. During the daylight when melatonin levels are very low, there is an increase in cAMP and subsequently an increase in melatonin receptor mRNA. During the night

when melatonin levels begin to rise, melatonin can first act on its receptor and cause a decrease in cAMP, thereby preventing any further melatonin receptor expression.

It has also been shown that melatonin can act through a pathway independent of cAMP to reduce melatonin receptor mRNA. Activation of PKC by phorbol 12-myristate 13-acetate (PMA), causes the expression of melatonin receptor mRNA in the PT to decrease (Barrett et al., 1997). Studies have shown that inhibition of PKC causes a decrease in the expression of melatonin receptor mRNA.

Localization of Receptors in the Brain

Immunohistochemical techniques have demonstrated that melatonin receptors can be localized in brain areas other than the pineal body, retina and SCN. In these other areas namely the cerebellum (Al-Ghoul et al., 1998), thalamus, cerebral cortex, preoptic area, and hippocampus (Siuciak et al., 1990), they been found in a much lower density. The density of receptors varies from tissue to tissue as well as from species to species (Vanecek, 1998). The MT2 receptor has been shown to be expressed in the human and rodent hippocampus (Reppert et al., 1995; Wan et al., 1999). In the hippocampus, melatonin binding has been demonstrated in the stratum lacunosum-molecularis (dendritic layer of the CA1 pyramidal neuron) of the hippocampus (Figure 2) (Nonno et al., 1995).

Summary

In summary, Melatonin is a neurohormone possessing lipophilic properties, enabling it to bind to extracellular receptors and freely pass through membranes. There are two major types of melatonin receptors that can be classified by their order of agonist potencies. These receptors (MT1 and MT2) have been shown to couple to 2nd messenger systems, either PLC (phospholipase C) or adenylate cyclase, to transduce a signal following binding of melatonin. Melatonin has been shown to regulate its own receptor expression via both cAMP dependent and independent pathways. Melatonin receptors have been found in different tissue throughout the body, varying in density.

Direct Intracellular Effects

After freely passing through the lipid bilayer, Melatonin can enter the cytoplasm and interact with calmodulin and kinases (Huerto-Delgadillo, 1994). Melatonin has been shown to directly bind to calmodulin (CaM) and inhibit its biological activity. In the cell, CaM can inhibit tubulin polymerization and regulate multiple protein kinases including CaM-kinase II (Benitez-King et al., 1996). When melatonin binds to CaM it causes an increase in tubulin polymerization (Huerto-Delgadillo, 1994), and blocks the activation of CaM-kinase II.

Melatonin has also been shown to directly modulate PKC in a Ca2+ dependent manner (Anton-Tay et al., 1998). This finding may support previous studies in which the activation of PKC by PMA led to a down regulation of melatonin receptor mRNA.

Melatonin can freely diffuse from the outside of the cell to sites within the nucleus. Within the nucleus melatonin has been shown to interact with orphan members of the nuclear receptor superfamily RZR/ROR (Calberg et al., 1995). These receptors act as transcription factors (Steinhilber et al., 1995). Recently very specific ligands for these receptors have been found (Karasek et al., 1999.

Antioxidant Properties of Melatonin

Another action of melatonin in the cytoplasm is the reduction of free radicals. Melatonin is believed to scavenge hydroxyl radicals, peroxynitrite anions, peroxyl radicals, and the superoxide anion radical (Poeggler et al., 1993). Melatonin has even been shown to increase mRNA levels of superoxide dismutase, glutathione peroxidase, glutathione reductase, and glucose-6-phosphate dehydrogenase, all of which are antioxidative enzymes (Reiter, 1998).

Decreases in the levels of melatonin have been implicated in aging and the many pathologies which accompany it. Most of the literature has focused on the antioxidant properties of melatonin as being protective in both instances of normal and pathological aging (Alzheimer's disease). Because of the vast amount of correlative research implicating decreased melatonin levels as we age to aging pathologies, it becomes necessary to understand why and how melatonin levels decrease as we age

IV. **The Pathology of Melatonin: Reasons and Disorders**

Pineal Calcification

Normative data on the amount of melatonin secreted within a population demonstrate high individual variability. The shape and size of the pineal gland are presumed to be genetically determined, reaching full growth at the first year of life (Kunz, et al., 1999). The weight and dimension of the pineal gland is variable. Since the majority of the pineal tissue is composed of melatonin producing pinealocytes, melatonin secretion variability can be explained by the variability of melatonin secreting tissue. Prediction of melatonin deficits within a population can not be determined by a standard numerical value. Studies implicating degrees of pineal calcification were employed to indicate instances of decreased melatonin secretion.

Little is known as to how the pineal gland begins the process of calcification. One theory suggests that the calcification of pinealocytes, the melatonin secreting cells of the pineal gland, results from the death or degeneration of the cells themselves. This degeneration would then lead to an overall decrease of pineal activity (Kunz, et al.,

1998). The degrees of pineal calcification, as associated with progressing age, can be correlated to decreased melatonin secretion. Increased calcification of the pineal gland causes a decrease in the number of functioning pinealocytes, resulting in a decrease in ability of the pineal gland to produce melatonin.

Sleep Disorders

The general decrease in melatonin levels caused by pineal calcification, has over the past several years, become associated with the occurrence of sleep disorders. Sleep disturbances in conjunction with impaired daily functioning and daytime tiredness are amongst the most prevalent difficulties facing the elderly (Kunz, et al., 1998). This group is of particular interest in regards to the prevalence if increased pineal calcification with age. Positive correlations have been made between the incidence of sleep disorders in the elderly and a decrease in melatonin production. This decreased melatonin production, as a result of pineal calcification, has been indicated to be the cause of a disturbed circadian rhythmic cycle and daytime function impairments (Kunz, et al., 1998).

As previously stated, melatonin influences circadian rhythms. This circadian timing system has been implicated in the involvement of the daily variation of a number of physiological and psychological variables (Kunz, et al., 1999). In the past several years several authors have suggested a link between pineal calcification and mental illness. The major assumption in these studies has been a decrease in melatonin secretion in response to increased pineal calcification. Studies of diagnostic patterns in sleep disorder centers also found that the most common primary diagnosis of insomnia was a psychiatric illness (Benca, 1996).

Mood Disorders

Sleep disorders have been most extensively studied in patients exhibiting mood disorders. The major categories of mood disorders include major depressive episodes and bipolar disorders. Major depressive episodes are diagnosed via the presence of depressed mood or loss of interest or pleasure (Benca, 1996). An important clinical feature of mood disorders, in most cases, is the limited period of acute symptoms with full recovery between episodes (Benca, 1996). Sleep disturbances in patients diagnosed with mood disorders are most prominent during the acute symptomatic period. Yet, the most common complaint widespread across patients is insomnia. Patients report difficulty falling asleep, increased wake time during sleep, and nonrestorative sleep; an overall decrease in sleep continuity. Patients also complain of daytime fatigue and vivid nightmares. During manic episodes there has also been reported a decreased sensation for the need for sleep (Benca, 1996). In general these patient groups exhibit decreased sleep continuity, reduced slow wave sleep and rapid eye movement (REM) abnormalities.

Anxiety Disorders

Anxiety is a basic response to a perceived stressor and is a psychiatric symptom highly correlated with insomnia (Benca, 1996). In general patients diagnosed with anxiety disorders exhibit decreased sleep continuity. The majority of studies conducted have utilized a select group of anxiety disorders: panic disorders, post traumatic stress disorders, obsessive compulsive disorder and generalized anxiety disorder.

Patient's diagnosed with panic disorder exhibit repeated panic attacks with sudden occurrences of increased anxiety (Benca, 1996). Studies have demonstrated that panic attacks occurring while the patient is asleep occur during the non-REM period, yet they can also occur during REM sleep. Sleep related panic attacks differ markedly from night terrors yet are associated as the same in that in both instances the patient awakens with severe anxiety and increased autonomic nervous system arousal. The distinguishing characteristic of a night terror is the absence of the memory of its occurrence. Evidence has shown that patients suffering from nocturnal panic attacks may develop a fear of sleeping (Benca, 1996).

Post Traumatic Stress Disorder develops in individuals who have experienced a traumatic event and re-experience this event via flashbacks, recollections or recurrent dreams (Benca, 1996). REM sleep disturbances have been observed in these patients in the form of increased REM latency, decreased REM sleep, reduced REM latency, and increased REM sleep.

Patients diagnosed with obsessive compulsive disorder have impulses or obsessions which the individual is driven to perform to reduce personal distress. Sleep studies have indicated decreased sleep continuity and reduced REM latency in patients diagnosed with obsessive compulsive disorder. It is theorized that patients of obsessive compulsive disorder may disturb their sleep patterns by the obsessions and compulsions (Benca, 1996).

In generalized anxiety disorder patients exhibit chronic anxiety. Most patients report a difficulty in falling asleep, staying asleep or a generalized insomnia. Clinically these patients exhibit prolonged sleep latency, decreased sleep efficiency, and decreased total sleep time (Benca, 1996).

Schizophenria

Schizophrenia is not a single disease but a biological collection of disease subtypes. This chronic illness is characterized by a multitude of symptoms, both biological and psychological. Several psychological symptoms include disorganization of speech and behavior, psychotic episodes of delusions and hallucinations, affective flattening, a decrease in speech ability and content, and a generalized depressed mood. Schizophrenic patients typically complain of symptoms associated with decreased sleep continuity and

often report frightening dreams (Benca, 1996). Studies performed utilizing the pineal gland of schizophrenic patients have shown an increase in pineal calcification. Indicative of a decrease in melatonin has been a decrease in HIOMT, and increased melanin deposition in the skin (Sandyk, et al., 1990).

V. <u>Conclusion</u>

The multitude of physiological and psychological research on melatonin is growing rapidly.   The understanding of the physiology of melatonin from its receptors to antioxidative actions is an important step in understanding the psychopathology of melatonin dysfunction. The associations of pineal calcification in schizophrenia and the disturbed sleep patterns exhibited in other psychiatric disorders, can be linked to a decrease in melatonin secretion. Decreases in circulating melatonin have been shown to lead to increases in melatonin receptor density during a normal L/D cycle. Understanding how these receptors may change, by either becoming upregulated/downregulated or sensitized/desensitized as we age will be an important step into understanding why lower melatonin levels in otherwise healthy individuals can lead to psychological disturbances. It can be speculated, based on the theorized protective property Melatonin has in regards to free radical destruction, that a decrease in Melatonin could lead to cell death as it pertains to neurological tissue. These areas of affected tissue could then be an explanation for neurological disorders, both biological and psychological.

VI. <u>References</u>

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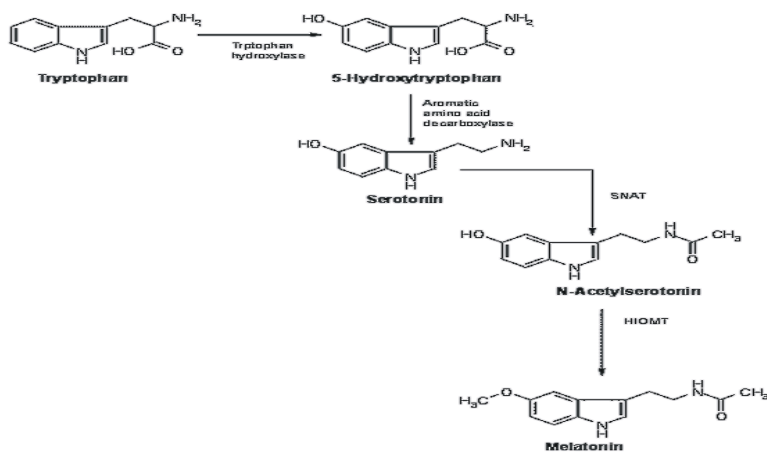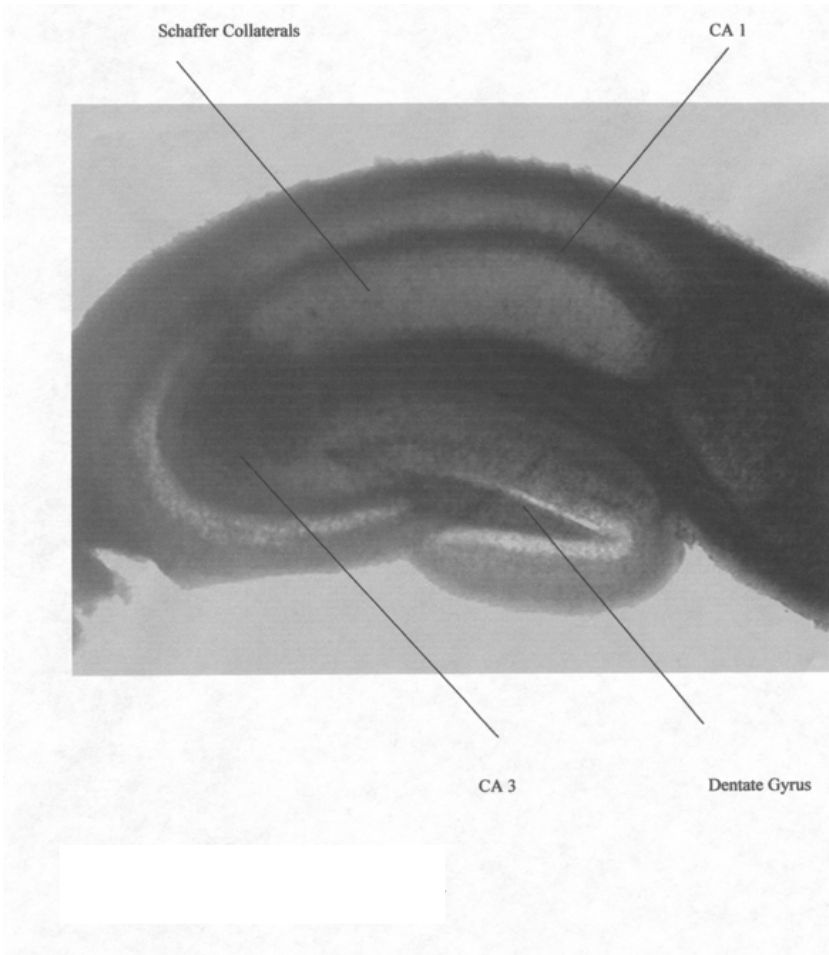
Figure 1: Melatonin Synthesis

Figure 2: Hippocampal Anatomy

Hispanic Literature in English Translation

Michael Alas

THE TRANSGENDER QUESTION: QUEER THEORY IN ALLENDE'S EVA LUNA

"In the long run, it's not breaking the code that matters—it's where you go
from there. That's the real problem" (qtd. in Garber 128).

Can a Latin American transsexual possibly be considered a figure of twentieth-century gender liberation theory? The character of Melesio/Mimí in Isabel Allende's Eva Luna certainly proves so. Her representation in the story shatters boundaries and limitations placed on gender roles. Melesio/Mimí's development from a sideshow transvestite to an actualized *individual* that exhibits both traditionally accepted masculine and feminine traits demonstrates the notion that gender is a performance.

Eva Luna relates the story of its female protagonist with the same name. The main character has been likened to a modern day, Latin American Scheherazade that is the anti-heroine of a picaresque story. Her story is a Bildungsroman--or more specifically a Künstlerroman that develops throughout her travels. It has been argued by many that the novel itself is a good example of feminine writing. Not only is Eva Luna based on the personal experiences of an author that had been politically exiled and had personally endured the tumultuous travels that its main character undergoes, it is also viewed as a novel with political implications. "The result [of Allende's writing] has been a view of Latin American society that reflects in powerful ways the contradictions inherent in a society lost in its own denial" (*About the author* par. 2).

Changing concepts of gender and sexuality have recently focused on the constrictive structuralism of gender-dualist societies. These examine, for instance, the contradictions between a socialized gender role and the individual's desire for self-expression. In Latin America, the concept of *machismo*, or a certain prescribed set of masculine roles, perpetuates a longstanding tradition of misogyny and male bravado. The challenges to this concept have been most often met with repulsion and violence. Allende's native Chile, for example, along with Ecuador and Nicaragua, has instituted laws that criminalize homosexual practices, despite the recent "growing political visibility of sexual minorities" in Latin America (Lind par. 6). A popular song in Mexico exclaims, "Puto, puto, matarile al maricon"—or, "Faggot, faggot, let's play kill the queer" (*Latin American Gays*, par. 2).

Eva Luna, indeed, is a prime example of feminine writing. There is, however, much more to be desired in simply acknowledging it as a feminist declaration of strength that

confronts the issue of male dependency and independence and self-sustenance amidst adversity. Through the portrayal of Melesio/Mimí as a societal pariah-turned-celebrity, it is also a direct confrontation to the gender-stratified dictates of Latin American society. At the same time, it is a challenge to the perceived views of homosexuality, transvestism, and most importantly, an affront to the theory of gender itself. Melesio exhibits this challenge in his actions:

> Melesio tweezed his facial hairs, then ran ether-soaked cotton over his face, so his skin was the texture of silk; he took pains with his long-fingered, slender hands, and every night brushed his hair one hundred times. He was tall, with strong bones, but he moved with such delicacy that he gave the impression of being fragile. (Allende 120)

Judith Butler's Gender Trouble: Feminism and the Subversion of Identity (1990) is an important theoretical text that pioneered what is known today as queer theory. Queer theory "is interested in any and all acts, images, and ideas that 'trouble,' violate, cross, mix, or otherwise confound established boundaries between male and female, normal and abnormal, self and other" (Leicht 2487). Applied to Eva Luna, queer theory shows how Melesio/Mimí actively *performs* her gender and how s/he is an exemplary model of rebellion against machismo and conventional gender-stratification. Furthermore, Melesio's choice to become a woman shows her agency. It illustrates Butler's belief that gender should really be the individual's choice, and not an awareness enforced by society.

Gender Trouble draws from forty years of French theory and explores "how gendered identity is socially produced through repetitions of ordinary daily activities," and explains how Butler's goal is to "uncover the assumptions that 'restrict the meaning of gender to received notions of masculinity and femininity'" (Leicht 2485). Butler is influenced by a wide variety of sources, but attributes her theory on gender performance to three major theorists: Foucalt, Lacan, and Derrida. From Foucalt she derives what she calls "resignification," or a realization that what is considered normal is actually dictated by the society that one lives in; both Foucalt and Lacan theorize on subjective formation, which is how the individual, in his desire to become accepted into the social order, must identify with "…the Law (the culture's signifying order)—at the cost of creating the unconscious and establishing a permanent split, an alienation of self from desire, within the subject" (Leicht 2485). Finally, Derrida postulates the creation of fact from certain statements, through what he calls "performative speech acts" (Leicht 2486). These three premises combine to flesh out a method of removing oneself from the attachment to gender and the notion that its expression is intrinsically natural. This can be found in deconstructing the myth that normalizes (and internalizes) the notion that male and female roles, perpetuated in norms and stereotypes, are inherent. "Today, most people would think of their gender as a core part of their identity; an integral part of 'who we

are'" (Young par. 18). Upon the realization that these are constructs of society, as mentioned previously, there is an immediate catharsis—an opening of the senses to different views, opinions and methods to approaching the supposed gender paradox that individuals such as Melesio/Mimí manifest.

To further this idea, Kilmartin's distinguishable study, *The Masculine Self*, can be examine. He defines the definition of gender: "gender…refers to feminine and masculine behaviors, mental, and social processes that are determined by biology and/or social forces," and generates certain roles that are "…expectations for behaving, thinking and feeling that is based on a person's biological sex" (14-20). These created roles further generate stereotypes and norms—accepted constant behaviors of the group as a whole.

In Latin America, these are the requirements of *un hombre macho,* or a man that actively participates in the decrees of machismo. Kilmartin maintains these as "prescriptions" for the traditional representation of masculinity, which is "defined by how the man looks, not by his inner experience" (147). This is also applied to how he acts in his environment. For example, heterosexual men are even considered manly if they can dominate the homosexual. This is evident in the Colombian saying, "soy tan macho que me cojo otro hombre," which translates to "I'm so macho that I fuck another man" (*Latin American Gays* par. 14).

The freedom of choice and self-responsibility—shown in Eva Luna as the agency of the "male" Melesio—that comes with self-awareness gives the individual the ability to transcend limitation. The conventional gender that Melesio transcends, to Butler, is a "mere masquerade…[and] a constraint to be escaped, overridden…" (Martin par. 1). As previously mentioned, conflict is crucial to the development of the individual. To the transgendered person specifically, the conflict within self and the conflict of self with society are vehicles towards self-definition. Melesio experiences this conflict early in his childhood development in Italy:

> His mother dutifully cooked the ritual pasta but stood her ground like a tigress when the father tried to force his son to kick a ball, box, drink, or, later, go to whorehouses. When she was alone with her son, she tried to find out what his true feelings were, but Melesio's only explanation was that there was a woman inside him and she could not get used to the male body in which she was trapped as surely as if she were in a straight jacket. (Allende 121)

Melesio went against what his father deemed as a true man's natural development. In this sense, Butler agrees that masculinity and femininity are very limited aspects of a gender that should not be determined as biologically inherent. She advocates a rethinking of their definition: "gender identity might be reconceived as a personal/cultural history of received meanings subject to a set of imitative practices which refer laterally to other

imitations and which, jointly, construct the illusion of a primary and interior gendered self or parody the mechanism of that construction" (Butler 2499).

On the other hand, Butler actively disagrees altogether with the necessity of established gender identities. It seems that conventional theories of gender and sexuality, to Butler, are delusions of the uneducated individual. In her call for a revolutionary readdressing of the two, she emphasizes free reign for the individual. Defining sexuality should oppose the notion that the individual's sex (male or female) produces gender (masculine/feminine): "When the constructed status of gender is theorized as radically independent of sex, gender itself becomes a free-floating artifice, with the consequence that man and masculine might just as easily signify a female body as a male one, and woman and feminine a male body and easily as a female one" (qtd. in Young par 9).

After Melesio moves to the city and encounters his confidante, La Señora, he begins working in a cabaret for transvestites. Though he was originally opposed to the idea ("Even *you* think I'm one of those"), he eventually grew into his role as a drag performer: "During those hours in the cabaret, he was a star, desired and admired, sparkling beneath the spotlights, the center of all eyes; there he fulfilled his dream of being a woman" (Allende 128). In a sense, the cabaret is where Melesio escapes the restrictive norms of society. There he is able to experiment with his identity by undoing the bindings of his male "strait jacket" and unleashing the woman within. When Melesio, however, must leave the reprieve from societal expectation that his work represents, he is extremely disheartened. Allende portrays this undressing of Melesio's true self negatively:

> After his act, he retired to the unsanitary hole he had been assigned as a dressing room and removed his diva's costume. From a hook, his feathers resembled a dying ostrich; on the table his wig was a trophy from the guillotine, and the rhinestones scattered across a tin tray were the booty of a cheated pirate. As he removed his makeup with cold cream, his masculine face appeared. He put on trousers and jacket, closed the door, and once outside, was assaulted by a profound sadness, knowing he had left the best of himself behind (128).

The feathers of a "dying ostrich" and the "trophy from the guillotine" indicate that Melesio, in being a part of the patriarchal Latin American society that expects him to be a macho man, is truly a "cheated pirate."

Butler uses drag as a prime focus for challenging gender roles. "By dressing up as a member of the opposite sex, drag artists are subverting ideas of gender norms, challenging the "constitutive categories that seek to keep gender in its place by posturing as the foundational illusions of identity'" (Young par. 10). She argues that drag establishes a clear distinction between the true anatomical self of the individual and the gender performed. In Melesio's case, the persona he performs is that of a brazen

courtesan that sings songs in French and ravishes the cabaret customers. In drag, Melesio performs this role and receives a great amount of respect. His talent is very much appreciated. This then reinforces, alluding to Derrida's performative speech acts, the notion within Melesio that being a woman is necessary for his happiness. He realizes that once he steps out of his guise he is no longer happy because he is in conflict with himself and also that his actions and effeminacy are in conflict with the ideal of machismo.

It is only after his imprisonment in the Santa María prison and his conscious decision to become a woman and assume the roles expected of that sex does Melesio truly become happy. Though having already accepted the woman within him, and acknowledging it as trapped in his male body, he transcends the shame that society places upon his effeminacy and reconstructs his gender-identity. He is thus in collusion with Butler's theory of gender performance by doing this. He manifests the idea that anatomy is not destiny, a point that Butler clearly makes in Gender Trouble. Butler further precedes the societal construct of gender with her theory on the expected roles of "the body," which she claims are also dictated by culture in lieu of reproduction. The default heterosexuality that is prevalent in most Western societies shows this. And as mentioned before, anything that goes against heterosexuality, anything "deviant" that inhibits reproduction (homosexuality, anal sex, transvestism) is shamed.

> This 'body' often appears to be a passive medium that is signified by an iscription from a cultural source figured as 'external' to that body. Any theory of the culturally constructed body, however, ought to question 'the body' as a construct of suspect generality when it is figured as passive and prior to discourse (Butler 2491).

Butler maintains that biological reproduction's favoring of heterosexuality for its purposes has severely castrated other possible forms of expression. "Further, the rites of passage that govern various bodily orifices presuppose a heterosexual construction of gendered exchange, positions, and erotic possibilities" (Butler, 2494). Melesio feels this pressure and in response to it becomes a woman. He, in becoming a she, actively performs her role as expected of women. She actively embodies the concept that gender is a performance:

> For Mimí, sex is the least vital part of her feminity. Other things attract her: clothes, perfumes, fabrics, jewelry, cosmetics. She loves the feel of her stockings when she crosses her legs, the barely perceptible whisper of lingerie, the swish of hair on her shoulders. (Allende 213)

Mimí's assumption of the feminine gender role allows her to abolish the gender conflict within herself. She is no longer an impersonator but rather has become the person she had so often portrayed in the cabaret. The appearance-based veneration she gained as a drag performer follows her into the transition. She has been described by Allende as

having the aura of a mythological being, has been compared to an archangel, and specifically referred to as "an amazon with splendid breasts and skin like a baby, whose torso culminated in masculine attributes that are atrophied but quite visible" (212). In assuming the female gender role, however, she also submits to the pervasive sexism that constrict women in Latin. She adopts the expectations of *marianismo*, or the female counterpart of machismo in which women are supposed to embody the Virgin Mary and search for "virile men" to dominate her:

> At that time, she longed for a male companion to care for and serve— someone who would protect her and offer her lasting affection—but she had not found him. She lived suspended in an androgynous limbo. Some men had approached thinking she was a transvestite, but she was not interested in ambiguous relationships; she thought of herself as a woman, and she was looking for virile men. They, however, did not dare b e seen with her, even though they were fascinated by her beauty; they did not want to be tagged as homosexuals. There were those who seduced her to find out how she looked naked, and how she made love; they found it exciting to hold such a remarkable freak in their arms. When a lover entered her life, the whole house revolved around him; she became his slave, ready to indulge him in his most daring fantasies to atone for the unpardonable sin of not being a complete woman. (Allende 213)

On the other hand, though submitting to marianismo, there are times where she transcends it through her actions. Her agency allows for her to combine her an acquired feminine beauty with the strength of will and the determination that she had as a man. Her admirer Aravena described, "She is the absolute female. We all have something of the androgyne about us, something male, something female, but she's stripped herself of any vestige of masculinity and built herself those splendid curves. She's totally *woman*, adorable…" (Allende 254). By being the "absolute female" she is able to seduce Aravena into considering Eva's script for *Bolero* as worthy for production. Allende describes this experience and Mimí's agency:

> He [Aravena] asked me how close I was to finishing the script; he glanced at the folder I handed him, picked it up in a dead-white paw, and murmured that he would read it when he had time. I reached out and took back my manuscript, but Mimí grabbed it from me and handed it to him once again, this time forcing him to look at her. She fluttered her eyelashes with deadly precision, moistened her bright red lips, and invited him to dinner the following Saturday—only a few friends, an intimate gathering, she said in the irresistible purr she had cultivated to disguise the tenor voice she had been born with. Aravena was enmeshed in a visible fog, a lascivious aroma, a

silken spiderweb. He sat mesmerized, folder in hand, totally nonplussed. I
doubt whether he had ever received such a sexually loaded invitation. (253)

Butler posits that gender is a stylized repetition of primary beliefs. In the case of the
traditional Western definition of gender, this would mean a repetition of beliefs that
further the default heterosexuality of society and promote the schism between male and
female. In Mimí's case, however, this is a repetition based on experiences from her past
experiences. She epitomizes the domineering attitude and femininity of La Señora and
the conventional submissiveness of her Italian mother. Moreover, by essentially creating
a "fictional woman painfully created to satisfy the dreams of others," she exhibits Eva's
storytelling ability. Her body, and the creation of her gendered self, transcends the
"cultural inscription" that Butler speaks of. She has taken her natural right to map out her
own definitions. In this sense, Mimí vigorously demonstrates that she has become self-
aware and has consciously shown agency in choosing and subsequently performing her
gender. After all, "genders can be neither true nor false, neither real nor apparent, neither
original nor derived. As credible bearers of those attributes, however, genders can also be
rendered thoroughly and radically *incredible*" (Butler 2501).

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