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# UC Davis McNair Scholars Program Staff

## **Principal Investigator**

Jeffery C. Gibeling, Ph.D.  
Vice Provost of Graduate Education  
Dean of Graduate Studies

## **Program Director**

Siria Martinez, Ph.D.

## **Program Specialist**

Rachel Messer

## **Graduate Student Advisers**

Jean-Yves Merilus  
Miki Mori  
Angelica Cortes  
Carmen Fortes  
Kenya Mitchell

## **Journal Editor**

Rachel Messer

## **Please address inquiries to:**

McNair Scholars Program  
2300 Student Community Center  
University of California, Davis  
Davis, CA 95616  
(530) 752-7486  
[mcnair@ucdavis.edu](mailto:mcnair@ucdavis.edu)

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## Message from the Faculty Director of the McNair Program

It is my pleasure to present Volume XII of the McNair Scholars Journal of the University of California, Davis. The McNair Scholars Program is named after Dr. Ronald E. McNair, the African-American physicist and astronaut who died in the 1986 Challenger space shuttle accident. As a memorial to Dr. McNair, the United States Congress established funding for this program in his name as a means to provide opportunities and encouragement to underrepresented and low-income undergraduate students who might otherwise not consider graduate study as an option. Funding for this program is provided through a grant from the U.S. Department of Education to assist students in attaining an advanced academic degree and a chance to succeed as exemplified by achievements of Dr. McNair. A significant component of the McNair Scholars Program at UC Davis is an individual, mentored research experience for each scholar. The research articles presented in the Journal are the culmination of a year's study and research conducted by the undergraduate students of the McNair Scholars Program. In addition to these papers, many of the scholars have presented their work at conferences and symposia throughout the country. We are justifiably proud of each of the McNair scholars whose research is presented in this journal. You will find that the papers cover a broad range of academic topics that the scholars have pursued using methodologies appropriate to their fields of study. However, the papers share a common theme in the way they exemplify the hard work, creativity and dedication that McNair scholars bring to the pursuit of their goals.



*Jeffery C. Gibeling, Ph.D.  
Vice Provost of Graduate Education  
Dean of Graduate Studies  
University of California, Davis*

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# Critical Review of Bisphenol-A and Its Effects on Birth Growth Outcomes



**Rebecca Belloso**

Mentor: Ellen Gold, Ph.D.  
Public Health Sciences

## **Abstract**

*Bisphenol-A (BPA) is a chemical used worldwide in the manufacturing of plastic products. BPA is frequently found in food-storage containers, water bottles, baby bottles, plastic wrap and metal food can linings. BPA is an endocrine-disrupting compound that induces estrogen receptor-mediated gene expression, thus potentially leading to adverse health effects. Substantial adverse effects in fetal growth and development may potentially result from prenatal exposure to BPA. We hypothesized that pregnant women with higher exposures to BPA would have a greater likelihood of having low birth weight infants and adverse infant growth outcomes, such as small for gestational age and reduced head circumference, than pregnant women with low exposure levels. We have conducted a systematic, critical review of peer-reviewed, published studies to determine whether BPA exposure during pregnancy is adversely related to infant birth weight in humans. We were specifically interested in seeing if lower human birth weight was related to higher BPA exposure levels. Additionally, we examined peer-reviewed, published animal studies relating to BPA exposure and its effect on*

*birth weight of offspring to compare their findings to the human studies we have analyzed. In total, seven human studies and four animal studies were considered acceptable for our analysis. This critical review summarizes the state of current knowledge and limitations of existing studies on this topic, suggests future avenues for research in this area, and provides information that might benefit pregnant women.*

## **Introduction**

Bisphenol-A (BPA) is a chemical compound used in the manufacturing of plastic products (Chou, 2001). BPA is a known endocrine disrupting compound (Rubin, 2009) with estrogenic properties (Ranjit, 2010) that can be found in polycarbonate baby feeding bottles, high-quality polycarbonate sports bottles, epoxy food-can linings (Volkel, 2011), and dental sealants (Fleisch, 2010). Because polycarbonate plastic and epoxy resins are in frequent use by the public, human exposure to BPA is likely to occur (Volkel, 2011). The health effects of BPA on humans, including newborns, are still being studied. The goal of this paper was to provide a systematic, critical review of the published literature that has examined if BPA exposure during pregnancy puts newborns at risk for reduced birth weight.

## **Methods**

We conducted a critical review using systematic search criteria of peer-reviewed, published studies to investigate whether BPA exposure during pregnancy was adversely related to infant birth weight. With each published study, we evaluated the study design, sample size, nature of BPA exposure and measurement, outcome variables, confounding factors and results to assess whether prenatal BPA exposure was related to infant low birth weight or small for gestational age. In addition, once usable papers were found, their reference lists were reviewed to see if they revealed additional potentially eligible and appropriate reference citations to include for review.

The databases searched were PubMed and Google Scholar. The keywords used for searching were bisphenol A, BPA, exposure, birth weight, infants, children, pregnant, and animal studies. The criteria for the inclusion of papers were: published between 2001 and 2013; the paper mentioned BPA exposure and low birth weight in infants; and the paper analyzed a relationship between the two using statistical methods. Twenty-one papers were identified

and evaluated. Of those, seven human studies and four animal studies met the inclusion criteria and are presented and evaluated in this paper. Ten publications were excluded because they focused more on factors other than low birth weight, such as BPA levels in infants fed with plastic baby bottles (Volkel, 2011) and the effects of BPA-containing dental materials on children (Fleisch, 2010).

## Results

### Human Studies

#### *Longitudinal Cohort Designs*

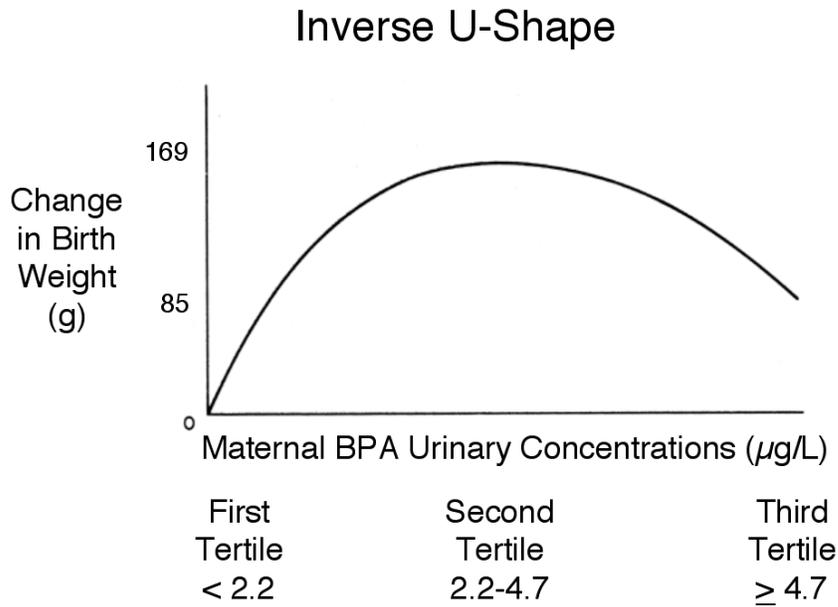
The study by Miao et al., 2011, was a longitudinal cohort study design with a sample size of 587 children. Parents' occupational exposure to BPA during pregnancy was measured through air sampling and by obtaining self-reported exposure history. The exposed groups were classified by maternal and paternal BPA exposure, and were determined as high or low exposure based on the 8-hour time-weighted average (TWA8) of an employee's exposure to BPA during pregnancy, with the median TWA8 as the cutoff. Birth weight was used as a continuous outcome variable. The confounding factors included for adjustment in multivariable models were maternal age at birth, maternal weight before pregnancy, calendar year of birth, maternal education, family income, and gravidity. Parental workplace exposure to BPA during pregnancy was significantly associated with infant low birth weight. Maternal exposure to BPA had a stronger association to low birth weight than paternal exposure. Birth weight was 168.40g less ( $p=0.02$ ) with maternal exposure and 90.75g less ( $p=0.10$ ) with paternal exposure compared to the unexposed group. Based on the TWA8, a dose-response relationship was observed with a decrease in infant birth weight with increased BPA TWA8 levels. This longitudinal study had an appropriate temporal sequence of exposure and outcome. A limitation of this study included a small sample size in exposed groups. Strengths of this study were inclusion of the temporal sequence that aids in assessing causality and evaluation of dose-response that strengthens the causal argument.

The study by Snijder et al., 2013, was a longitudinal cohort study with 9778 pregnant women. Random urine samples of women were analyzed for pesticides, BPA and phthalate levels during early, mid and late pregnancy. Ultrasound measurements were taken to estimate growth rates. Medical records at birth were reviewed for gestational age, sex, weight, length,

and head circumference. Birth weight was used as a continuous outcome variable. The confounding factors included in multivariable models were education level, race/ethnicity, parity, smoking, alcohol, folic acid use, maternal age/weight/height, and fetal gender. Higher concentrations of creatinine-based bisphenol A (BPACB) in prenatal urine were associated with lower fetal weight and head circumference. When three BPA measurements were used instead of one, the associations between BPA and fetal growth were stronger and statistically significant. The major strengths of this study included a large sample size and biologic measurements of BPA during pregnancy. Limitations included the large sample size limiting the number of measurements that could be taken on each individual; only the samples with three measurements were statistically significant; and urine samples were collected during a wide time frame (8am-10pm), but BPA has a short half-life of a few hours.

The study by Philippat et al., 2012, was a longitudinal cohort study design with a sample size of 287 mother-newborn pairs of male infants only, in which 72 pairs were in the exposed group, and 216 were in the unexposed group. Two pre-existing cohorts were used. Urine samples were collected during 6-19 and 24-30 gestational weeks and analyzed for BPA. Birth weight was used as a continuous outcome variable. The confounding factors accounted for in multivariable models were gestational duration, maternal pre-pregnancy weight/height, maternal smoking, maternal education level, parity, recruitment center, and creatinine level (urine dilution). BPA had an inverse U-shape association with birth weight, such that birth weight was larger in the second tertile than in the third tertile of exposure, and birth weight for the third tertile of exposure was larger than the first (Figure 1). BPA was also positively associated with head circumference. Limitations of this study included: sampling conditions (hour of urine sampling; storage before freezing) that might have influenced biomarker concentrations; the short half-lives of phthalates (and BPA); and residual confounding factors, such as metabolic disorders that could not be controlled. This paper, however, looked at phthalates more than just BPA.

**Figure 1: Inverse U-Shape Association**



Philippat et al. *Environmental Health Perspectives* (2012)

The study by Wolff et al., 2008, was a cohort longitudinal study design with 404 mother-newborn pairs. The cohort was enrolled before delivery, and maternal urine samples were collected in the third trimester. A questionnaire regarding maternal characteristics was administered. The birth outcomes were obtained through the hospital. The gestational age was assigned from the last menstrual period date noted. Birth weight was used as a continuous outcome variable. Confounding factors included in multivariable models were race/ethnicity (white vs. non-white), infant gender, gestational age at delivery, ln-creatinine, prenatal smoking, maternal pre-pregnancy BMI, education (high school or greater), and marital status. No effect of BPA on birth weight was observed. Strengths of this study included a reasonable sample size. Limitations of this study included BPA was studied as a phthalate, which may not be a correct assumption, and time of urine samples collected. This paper also looked at other phthalates than just BPA.

The last longitudinal cohort human study in this review was by Lee et al., 2008, on maternal and fetal exposure to bisphenol-A in Korea. This study examined 300 healthy pregnant women and their newborns. The women visited the hospital for a routine health checkup and volunteered to donate biological samples. A questionnaire was given to participants

addressing dietary habits, physical, health and pregnancy related characteristics. Maternal blood and fetal umbilical cord blood samples were collected at full-term. Birth weight was used as a continuous outcome variable. Maternal age, height, weight before pregnancy, smoking history, alcohol consumption, the time of pregnancy and baby gender were all confounding factors included in multivariable models. As the amount of maternal BPA concentration doubled, the infant's birth weight increased by 50 g. This twofold increase in BPA exposure resulted in 75 g gain in birth weight of males. No relation was found with female infants. A positive association was found between maternal blood BPA concentrations and fetal birth weights ( $P < 0.05$ ). Limitations of this study included a relatively small sample size and findings that may not represent nationwide populations.

**Table 1: Longitudinal Cohort Studies**

Ref. No.	Study Design	Sample Size	Adequate Control of Confounding Factors	Summary of Findings
1	Longitudinal Cohort	587 Children: 444 Unexposed 93 Paternal Exposure 50 Maternal Exposure	Yes	-Statistically significant relationship: pregnant mothers exposed to BPA and low birth weight in male offspring.  -Birth weight was lower with maternal exposure than with paternal exposure.
2	Longitudinal Cohort	9778 Mother-newborn pairs	Yes	-Higher concentrations of creatinine-adjusted BPA in prenatal urine $\Rightarrow$ lower fetal weight and head circumference.  -Three BPA measurements are better than one.
3	Longitudinal Cohort	288 Mother-newborn pairs: 216 Unexposed 72 Exposed	Yes	-Inverse U-shape association of BPA with birth weight.  -Birth weight: larger in

		(Male infants only)		<p>second tertile of exposure than the third, and larger in third than the first.</p> <p>-BPA was positively associated with head circumference.</p>
4	Longitudinal Cohort	404 Mother-newborn pairs	Yes	-No effects on birth weight with BPA exposure.
5	Longitudinal Cohort	300 Mother-newborn pairs	Yes	<p>-Positive association: maternal blood BPA concentrations and higher male birth weights.</p> <p>-Maternal BPA concentration increases twofold ⇒ the male infant's birth weight increases by 50 g.</p> <p>-No relation found with female infants.</p>

*Cross Sectional Designs*

The study by Chou et al., 2001 was a cross sectional study design with 97 mother-newborn pairs. BPA levels were measured in maternal blood and umbilical cord blood with High Performance Liquid Chromatography and Ultraviolet detector. Categorical outcome variables were low birth weight and small for gestational age. Low birth weight was less than the 10th percentile (<2,600g; n=20). Small for gestational age was defined as birth weight less than the 10th percentile of birth weight distribution for the same gestation week. The data were compared to gender-specific nationwide (Taiwan) data on birth weight percentiles. Confounding factors included multivariable models were maternal age, maternal body mass index (BMI), maternal smoking, socio-economic status, and maternal levels of high density lipoprotein, triglyceride, and total cholesterol. Maternal exposure to BPA was related to adverse birth outcomes and elevated risks of low birth weight and small for gestational age observed in male neonates from the highest quartile of maternal BPA exposure. The odds

ratio for low birth weight was 2.42 (95% CI 1.72-3.36) and small for gestational age was 2.01 (95% CI of 1.39-3.01). Limitations to this study included a small sample size, expectation of BPA exposures to be sustained (although the half-life is short), and maternal BPA levels possibly not being correlated with fetal BPA levels. The major strength of this study included linear dose-dependent response noted with increasing quartiles of BPA levels.

The study by Padmanabhan et al., 2008, was a cross sectional study design with 40 mother-newborn pairs. Maternal blood samples were collected at time of delivery. Other information collected was mother's weight during pregnancy, height, and weight at time of delivery; and infant's gestational length and birth weight. Birth weight and gestational length were both continuous outcome variables. The confounding factors were maternal age, maternal BMI and offspring's gender. No differences in gestational length or birth weight of offspring relative to maternal BPA levels were observed, and BPA levels were not associated with any other variables studied based on regression analysis. The overall birth weight mean was 3.3Kg, with no significant difference in exposed vs. unexposed groups. Limitations of this study included obtaining measurements of BPA at birth instead of early/mid gestation, conventional birth weight standards not being sufficient for assessing preterm infants, the sample size of 40 was small, potentially confounding variables (economic status, race) were not considered and only freely available BPA levels from blood (not conjugates) were taken.

**Table 2: Cross-sectional Studies**

Ref. No.	Study Design	Sample Size	Adequate Control of Confounding Factors	Summary of Findings
6	Cross-Sectional	97 Mother-newborn pairs	Yes	-Maternal exposure to BPA is correlated with low birth weight in males.  -Elevated risks in males from the highest quartile of maternal BPA exposure.  -No effect in females.
7	Cross-Sectional	40 Mother-newborn pairs	No	-No differences in gestational length or birth weight of offspring relative to maternal BPA levels.  -No significant birth weight difference in BPA exposed vs. unexposed.

Animal Studies

*Rats*

The study by Rubin et al, 2001, was an experimental study consisting of 18 female rats (mothers). The rats were weighed and randomly assigned to a dosage group beginning on day 6 of pregnancy. Six were given a high dose (10 mg/mL, 1.2 mg/kg bw/day consumed), six were given a low dose (1 mg/mL, 0.1 mg/kg bw/day consumed), and six were the unexposed control (water with 1% ethanol). The high or low dosage groups had daily oral exposure to BPA through drinking water during the rest of the pregnancy. The offspring for the high group totaled 28 females and 19 males. The offspring for the low dose group totaled 18 females and 19 males. The control offspring consisted of 23 females and 27 males. The pups only received water postnatally. Weight was measured on days 4, 7, 11 after birth as a continuous variable. Confounding factors addressed were that rats were bought from the same facility; glass bottles were used for feeding to avoid unwanted BPA exposure; the same

feed was used for all groups; plastic cages were evaluated for BPA; and each rat had the same light/dark cycle. Body weights were increased in pups born to BPA-treated females. Pups born to females with low BPA doses had persistently larger body weights than those at the higher dose but both significantly exceeded the weights of pups in the control group. Significant differences in birth weight were seen only in females, not in males. Strengths of this study included no maternal toxicity and use of maternal oral exposure to BPA. Limitations of this study were a small sample size and 1 dose per 24-hour period, which may have meant the half-life of BPA was not considered.

The study by Kim et al, 2001, was an experimental study that examined 72 pregnant rats. A vehicle control of corn oil solution was given to 20 pregnant rats. Another group of 20 pregnant rats received a BPA dosage of 100 mg/kg per day suspended in corn oil. A group of 18 rats received a BPA dosage of 300 mg/kg per day. A group of 14 received the highest BPA dose of 1000 mg/kg per day. Eighty female rats that had successfully mated were randomly assigned to one of these four experimental groups. The daily doses were administered through gavage. Each rat was fed every 24-hour period. Birth weight was used as a continuous variable. Confounding factors accounted for all rats being bought from the same facility at 10 weeks of age; a maintained room temperature of 23 +/-3°C; relative humidity maintained at 50 +/- 10%; artificial lighting hours were consistent for all rats; air changes occurred 13~18 times per hour; only healthy animals were used; clear polycarbonate cages with stainless steel wire lids were used for all animals; and tap water given was sterilized. The exposed male offspring had reduced body weights compared to the unexposed group. Administering BPA during the entire pregnancy also resulted in pregnancy failure, increased pre- and post-implantation loss, and decreased fetal body weight. Both males and females had significantly reduced weight when their mothers were exposed to BPA levels of 300 and 1000 mg/kg/day. Strengths of this study included an adequate sample size. Limitations of this study included maternal toxicity when doses over 1000 mg/kg/day were administered, which could be too high for comparability to doses for humans; the timing of fetal weight measurement was unclear, as well as whether it was taken at the same time for all fetuses; and the description in the Methods section of dosages was unclear.

### *Sheep*

The study by Savabieasfahni et al, 2006, was an experimental study consisting of 26 pregnant ewes, 16 in the control group and 10 in the BPA exposed group. The exposure group received a BPA injection dosage of 5 mg/kg per day from day 30 to day 90 of gestation. The

vehicle used was cottonseed oil. Blood samples were collected from six controls and six prenatal BPA-treated animals at days 50, 70 and 90 of gestation. The offspring of the control group consisted of 11 females and 18 males, and offspring of the BPA exposure group was 11 females and 6 males. Birth weight was used as continuous outcome variable. Potential confounding factors included: the ewes were from the same farm; food was purchased in bulk from a single supplier; the ewes were fed the same daily in weeks 2-3 before breeding; they all mated on the same day with fertility-proven rams; the ewes were housed under natural photoperiod in the same pasture after breeding; and all ewes were fed the same daily diet and same amount of bulk food. The birth weights of female BPA-exposed offspring were lower than those of the control group offspring ( $P < 0.01$ ). No significant difference was found for the birth weights of males. The gestation length did not differ among the exposed and unexposed offspring. The postnatal growth rate was higher in prenatal-BPA-exposed offspring compared with the control offspring between gestational months 2 and 4. The limitations of this study included: a small sample size; uncertainty if the ewes were randomly assigned because the sizes of the control and exposed groups differed considerably, suggesting it was not randomized; the male-to-female ratio of offspring was not 1:1; maternal baseline weights might not be comparable in each group but data were not shown; no table was provided with the prevalence of confounding factors in each group; and an inability to examine a dose-response because only one dosage level was tested; additionally the dose used may have been too low to see an effect.

### *Mice*

In the study by Alonso-Magdalena et al., 2010, pregnant mice were purchased from the same location and individually housed in standard housing conditions. The sample size was not clearly stated in the text, so we assumed from the Methods section that each of the three groups (10 ug/kg/day, 100 ug/kg/day and control) had 11 pups. The vehicle control was tocopherol-stripped corn oil, which was administered subcutaneously (just below the skin) during gestation days 9-16. Pups were weighed on postnatal days 1, 3, 5, 8, 10, 12, 16, and 21. Birth weight was used as a continuous outcome variable. Confounding factors accounted for were: all mice being purchased from the same location; mice were individually housed under standard housing conditions; and mice were all maintained on the same diet. Mice given 10 ug/kg/day were 3% heavier than the control mice at birth and 7% heavier 21 days postpartum. In addition, mice given 100 ug/kg/day had body weight 4.5% lower than the control mice at birth, and this difference persisted through 21 days postpartum. Body weights of offspring were comparable among the different groups for males through 6 months of age

and for females through 3 months of age. Exposure during pregnancy to 10 ug/kg/day BPA was associated with higher birth weight. Limitations of this study included an unclear sample size; no confounding factors table included within the text; and lack of clarity regarding if the pups were all weighed at the same time each day.

**Table 3: Animal Studies**

Ref. No.	Animal Studies	Sample Size and Dosage	Adequate Control of Confounding Factors	Summary of Findings
8	Rats	n=18: -Vehicle (control): water in 1% ethanol: n=6 -Low Dose: 0/1 mg/kg bw/day: n=6 -High Dose: 1.2 mg/kg bw/day: n=6	Yes	-Increased body weight in female pups born to BPA-treated females.  -Significant difference only in females
9	Rats	n=72: -Vehicle (control): corn oil: n=20 -Low Dose: 100 mg/kg per day: n=20 -High Dose: 1000 mg/kg per day: n=14	Yes	-Reduced body weight of male fetuses at every dose.  -Males and females ⇒ reduced weight at medium and high doses
10	Ewes	n=26 -Vehicle (control): cottonseed oil: n=16 -Only dose: 5 mg/kg/day: n=10	No (No table shown)	-Female BPA offspring ⇒ birth weight lower than control group.  -Males: No significant difference
11	Mice	-Sample size: assume 11 per group.  -Vehicle control: tocopherol-stripped corn oil. n=11 -Low Dose: 10 ug/kg/day: n=11 -High Dose: 100	No (No table shown)	-Low dose mice ⇒ 3% heavier than the control mice at birth.  -High dose mice ⇒ 4.5% lower weight than the control mice at birth.

		ug/kg/day: n=11		
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## Discussion

In summarizing all of these studies, it is clear that no consistent answer has emerged as to whether BPA affects risk of low birth weight. Each human study was conducted somewhat differently, causing it to be difficult to compare all the studies on all aspects. Each study included different confounding factors, although some studies had more similar confounding factors than others. Different study designs were also used, which could affect the results obtained. Maternal smoking has been correlated with lower birth weight; so, it is important that each study included data on maternal smoking and adjusted for it accordingly. Perhaps the biggest difference among studies was the time of measurement of BPA. BPA has a short half-life of a few hours. It can make a very big difference in the study if the BPA measurement was taken a long time after exposure because of its short half-life. It is best to measure BPA within a couple of hours after exposure so that the measured levels of BPA more accurately reflect the levels of exposure. Measuring BPA levels too late after exposure can misclassify exposure levels and lead to misleading results. Therefore, the exposure assessment and measurement need to be properly timed and consistent among studies to have more comparable data.

The strongest paper reviewed was the longitudinal cohort study (Miao, 2011), which found that parental, particularly maternal, workplace exposure to BPA during pregnancy was significantly associated with infant low birth weight. The longitudinal design is the strongest study design and helps to make observations more informative with regard to potential causality by determining a temporal relation of exposure to outcome. The large sample size of this study also allowed for increased precision of effects estimates resulting from the data analyses. Because this study controlled for confounding variables, it was unlikely that the result was due to uncontrolled factors. The separation of maternal and paternal exposure effects also allowed for more specific analysis of data.

The studies using cross-sectional designs did not permit assessment of a temporal relationship, which is important for determination of causality. Most of the studies were also limited by their small sample size, expectations of BPA exposures to remain constant throughout the study or during the time of BPA measurement, comparisons to conventional birth weight standards (which may not be appropriate for the gestational ages of infants

studied), and not including all potentially confounding variables, such as economic status and race. All the studies controlled for different confounding factors, which makes direct comparisons among studies impossible.

The results of each study varied. The first human study showed a statistical significant relationship between pregnant mothers exposed to BPA in the workplace and male offspring with low birth weight (Miao, 2011). The second study found that maternal exposure to BPA was related to risk for low birth weight and being small-for-gestational-age in male neonates when their mothers had high BPA exposure during pregnancy (Chou, 2001). The third study found no relationship in birth weight or gestational length of the offspring related to maternal BPA levels (Padmanabhan, 2008). The fourth study showed that higher concentrations of creatinine-based bisphenol A (BPACB) in prenatal urine may result in lower fetal weight and head circumference, and three BPA measurements instead of one was more strongly related and showed statistically significant associations between BPA and fetal growth (Snijder, 2013). The fifth study showed that BPA had an inverse U-shape association of an increase in male birth weight (Philippat, 2012). The sixth study resulted in no effects found between BPA and birth weight (Wolff, 2008). The seventh study found an increase in birth weight in males (Lee, 2008). Thus, the human studies were inconsistent with some finding an association of BPA exposure with low birth weight, some finding an association with increased birth weight, and some finding no association. The studies also differed in their findings regarding sex differences in these associations.

In addition, each animal study was conducted differently, causing it to be difficult to compare all the studies on all aspects. Each study included different confounding factors, although some studies had more similar confounding factors than others. The results from each study also varied. In addition, it was difficult to compare the animal studies with the human study because they are different organisms and metabolize chemicals differently, and some of the exposure levels used in the animal studies were not relevant to those of human exposures. This needs to be taken into account when comparing the effects on animals and predicting what may happen with human exposure. Although the animal studies may lead to an awareness of what may happen with human exposure, it is never certain that their reactions will be the same. The dosages among the animals were perhaps the biggest differences among the studies. Use of more consistent dosages among studies is needed to be able to compare them appropriately. Therefore, each study needs to be assessed while keeping the dosage in mind.

## Conclusion

Several gaps still remain in our knowledge regarding the relation of BPA exposure to risk of low birth weight. It is still unknown if BPA exposure is a cause of low birth weight in humans. More consistent and well-designed longitudinal studies with sufficient sample sizes and sufficiently diverse study populations need to be conducted to provide additional dose-response data, as well as control of appropriate confounding variables and inclusion of information about potential interactions of socioeconomic status and race/ethnicity with exposure in affecting risk of low birth weight. If enough evidence is found to conclude a causation relationship between BPA exposure and low birth weight, the recommended maximum daily intake levels of BPA may need to be updated to provide adequate safety levels.

**Table 4: Summary of Findings**

Reference No.	Effect of BPA Exposure - Human Studies
1, 6	Decreased birth weight in males
3, 5	Increased birth weight in males
2	Decreased birth weight; no sex difference
4, 7	No effects on birth weight
Reference No.	Effect of BPA Exposure - Animal Studies
8	Increased birth weight in females
9	Decreased birth weight in males and females
10	Decreased birth weight in females
11	Increased birth weight; sex differences not studied

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# Angular Correlation Functions of High-pT Hadrons in PbPb and pp Simulations



**Gabriel Bonilla**

Mentor: Manuel Calderón de la Barca Sánchez  
Physics

## **Abstract**

*The quark-gluon plasma has a role in understanding the strong force, which is described by the theory of quantum chromodynamics. To probe the quark-gluon plasma, heavy ions are collided at high energies to recreate the conditions present in the early universe. Experiments like the Compact Muon Solenoid (CMS) at the Large Hadron Collider examine the results of colliding heavy nuclei together at high energies to recreate the quark gluon plasma. One such observation is jet quenching, which is believed to occur when the jets of particles produced in the collision interact with the plasma and lose energy. In this project, we use the HYDJET (Hydrodynamics plus Jets) program to simulate the jet quenching effects. The simulated HYDJET results will be cross-referenced with the real results from the CMS experiment in order to achieve a deeper theoretical understanding of the quark gluon plasma. In particular, we will look at the angular correlations of the jets of particles created in such an event. We will look to see how these angular correlations behave as a function of centrality and transverse momentum to help us understand the mechanisms of energy loss.*

## Introduction

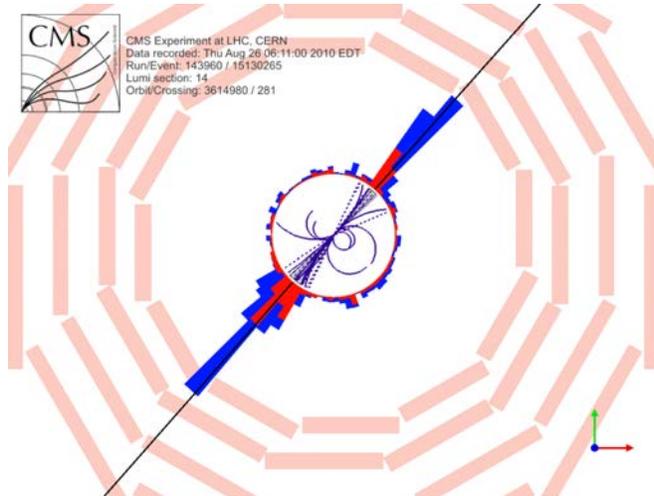
The Large Hadron Collider (LHC) at the Conseil Européen pour la Recherche Nucléaire, also known as CERN, collides protons and heavy ions together such as 7TeV at high speeds in order to probe the finer structures of matter. Scientists look at the debris from the collision collected in special detectors to measure defining properties of the resulting particles. These include energy, momentum, position, and species of particle, among other things. Performing a large amount of collisions and collecting a large amount of data allows us to carry out data analysis, which will help uncover finer details of the nature of the collision.

The nature of a proton-proton collision is characterized by collisions of their internal partons, which include quarks and gluons. The strong force dictates that the force between two partons grows as a function of the distance between them. This idea, known as confinement, does not allow a lone parton to exist. Instead, when the color force field between two quarks grows sufficiently large, it becomes energetically favorable to produce more quarks out of the vacuum to reduce the color force field. Given this, in a pp (parton-parton) collision where the constituent partons are blown apart, there is much energy to create many more particles alongside the original particles. This process is the one by which a parton turns into a jet and is known as hadronization. Here the difference between a final and non-final particle becomes significant: a parton cannot be observed alone and hence it is never a final particle. We must infer the partons' existence through the presence of their resulting hadrons. Due to the conservation of momentum, when a particle hadronizes, its daughters travel in the same initial direction as the mother particle. The daughters spread out a bit, leading to a cone shape, but due to the high momentum the resultant hadrons are still detected very near to one another. Looking at a proton-proton collision in more detail now, we can look more closely at what happens in a parton-parton collision. Due to the conservation of momentum, these particles will fly off in opposite directions in the plane transverse to the beam, that is, the angular distance between the two quarks will be 180 degrees, or  $\pi$  radians. This will also be the same for the resulting jets. Therefore, when we look at all possible pairs of particles, we will see a multitude of particles pairs with a  $\Delta\phi$  of 180 degrees between them as in fig.1.

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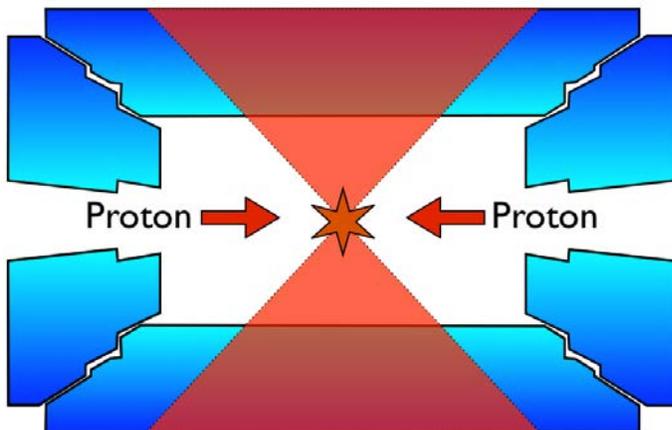
**Figure 1: A cross-sectional view of the CMS barrel along the beam axis: the  $\Delta\phi$  separation of  $\pi$  radians between the jets is visible here.**



Di-Jet Event within the CMS Detector – CERN via QuantumDiaries (2013)

There is also a multitude of particle pairs with a  $\Delta\phi$  of approximately 0 degrees, because particles in a jet are closely spaced together.

**Figure 2: A side-view of the CMS barrel: Low values of  $\eta$  are in the red region, with  $\eta=0$  being at the center, and with  $\eta=\pm\infty$  being at the beams.**



From Jim Hirschauer – QuantumDiaries (2010)

Given that a jet is characterized by a cone of final particles that are close together, we can begin looking for evidence of such jets given the information of the particle lists that Pythia

generates. The two variables that characterize the positions of particles, and thus the distances between them, are the detector coordinates  $\eta$  and  $\phi$ . To find a jet, we need to compare how far one particle is from another. Therefore, we will look at the distances between pairs of particles. We will call such distances  $\Delta\eta$  and  $\Delta\phi$ . These distances between pairs can also be observed according to the rules of a theoretical model. Theoretical physicists compare constructed computer models against data collected at the LHC in order to gauge the accuracy of their models' predictions. Two such computer models are Pythia and HYDJET.

Pythia is the computational event generator through which proton-proton collisions are simulated and the Lund String Model is tested. Event generators are used to simulate the data collected by particle colliders such as the LHC or RHIC. In essence, Pythia generates a list of particles involved in a proton-proton collision from which we can then sort and analyze according to various parameters. This is where the majority of data analysis will happen. Consequently, the Pythia event generator is composed of three main parts: Initialization, Event Looping, and Particle Looping.

## Methods

### Objective

This study explores the angular correlation functions (ACFs) created by event generators Pythia and HYDJET at various  $p_T$ -trigger and  $p_T$ -associated by calculating measurable quantities such as yield as a function of various observables. The data analysis will be done using the C++ programming language using the Pythia, HYDJET, and ROOT libraries.

In this analysis, we specifically look at the ACFs formed by the distribution of particles created during hadronization. This requires information on the azimuthal angle  $\phi$  and the pseudorapidity  $\eta$  of each particle created in a pp collision, as well as the angular separations  $\Delta\eta$  and  $\Delta\phi$  of each possible pair in an event. In order to most closely emulate results collected at the Compact Muon Solenoid (CMS) detector, we restrict ourselves by only looking at final particles (given that non-final particles decay into final particles by definition, which we then detect), and charged particles at that. We also only consider particles within the region  $-2.4$  to  $2.4$  in  $\eta$ , as that is the range of the CMS detector.

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For data analysis purposes, we look at these particles in separate transverse momentum (pT) ranges, so information about each particle's transverse momentum should be kept as well. Specifically, we compare particles from a higher pT range (known as the trigger particles) to a lower pT range (known as the associated particles). A jet is characterized by a leading trigger particle that carries the highest transverse momentum. This highest transverse momentum is then followed by trailing associated particles, which carry a lower transverse momentum [1].

Analysis is performed using C++, Pythia, and ROOT

#### *Initialization*

A Pythia function call allows us to initialize beam parameters analogous to how a particle beam in a detector would be set up, such as center of mass energy and particle type. There are also additional settings for playing with various physics, such as turning various QCD processes on or off. The Pythia event generator will generate events based on these parameters. In this analysis, the beam was set to a proton-proton collision at 2.76 TeV, with all processes turned on.

#### *Event Looping*

Given a set of parameters, the Pythia event generator can now simulate a collision between two predetermined particles at a predetermined energy. This allow Pythia to generate a list of all the particles created in such a collision. Each collision is known as an event. This include the initial particles as well as their daughters, through their designated processes. This creates what is known a particle list. A C++ for-loop allows us to simulate a predetermined amount of collisions in a Monte-Carlo fashion.

#### *Particle Looping*

Within the Event loop, we can look at each particle involved in the collision/event and access various information about that particle, such as charge, energy, location, momentum, and whether or not it is a final particle, among other things. These values are what the Pythia simulation generates. We can then take these data points and use them in our data analysis. Another C++ for-loop within the Event Loop allows us to store information from each particle in the event into a statistical histogram. These histograms will be created according to which transverse momentum ranges the particles belonged.

### *The Angular Correlation Function (ACF)*

A constructed C++ program will generate the object of this analysis, the ACF, from the data collected from Pythia simulations. The ACF is a 2-dimensional histogram of the angular differences between all possible pairings of particles over an event cumulated over many events. The characteristic features of the ACF are its peak at  $(\Delta\eta, \Delta\phi) = (0,0)$ , denoting a large multiplicity of pairs of particles with small angular separation, as well as a bump at  $(\Delta\eta, \pi)$ , denoting a multiplicity of pairs of particles with back-to-back angular separation, spread out over  $\Delta\eta$ . As the structure of the ACF is very qualitative in nature, part of the analysis is to calculate quantities that will allow us quantify how the ACF varies as a function of  $p_T^{\text{assoc}}$  and  $p_T^{\text{trigger}}$ .

## **Results and Figures**

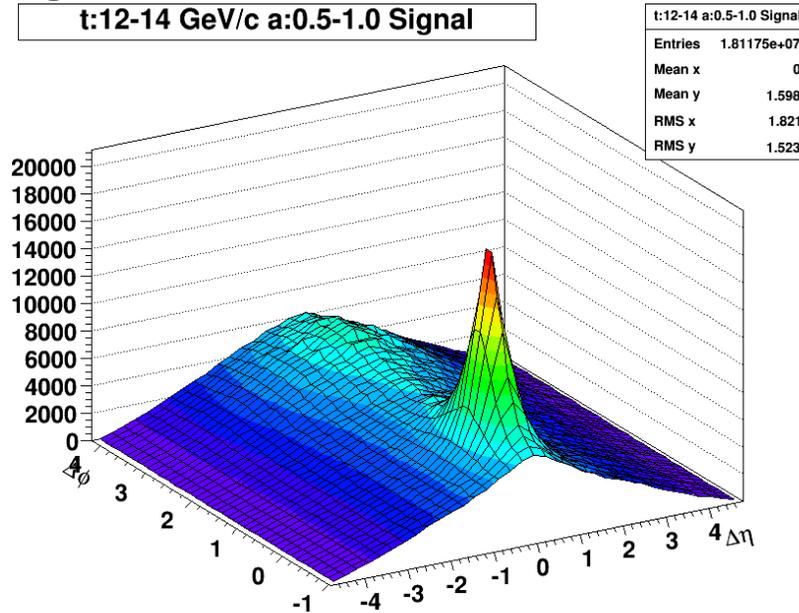
### The Signal ACF

The Signal ACF is constructed by filling an appropriate histogram with the angular separation  $\Delta\eta$  and  $\Delta\phi$  between two particles in a pair for every possible pair. Possible pairs are determined by looking at the particles of a single event that fall in a certain pT range. When considering trigger particles and associated particles, every particle pair we look at will be a particle from a trigger particle bin compared against a particle from an associated particle bin. Given that the trigger and associated particle bins are based on different pT ranges, we never worry about comparing a particle against itself, which would result in a separation identically zero.

**Figure 3: A signal ACF created from pairs taken from the  $12 < p_T^{\text{trigger}} < 14$  and  $0.5 < p_T^{\text{assoc}} < 1$  range**

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## Angular Correlation Functions

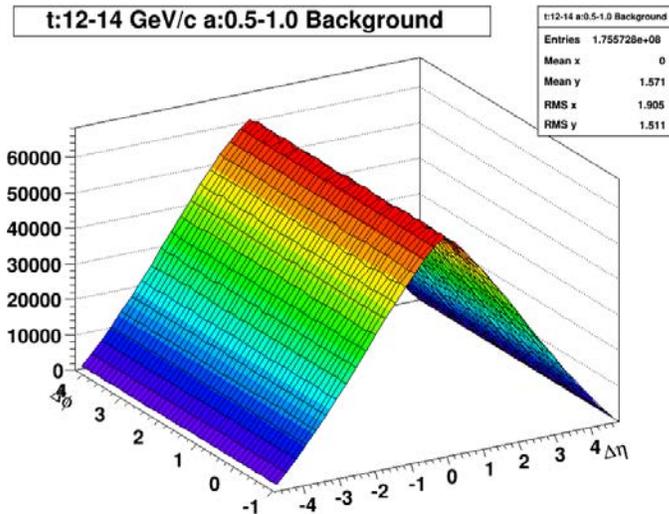


The peak at (0,0) which results from the geometry of a jet in that a jet is characterized by a cone of particles that are close together. The smaller peak that forms at  $\pi$  radians and is spread out over  $\Delta\eta$  results from the geometry of back-to-back jets in that they are composed of particles that are  $\pi$  radians from each other in  $\Delta\phi$  but can take on any value in  $\Delta\eta$ . The explanation for the structure of the triangular background over the  $\Delta\eta$  axis comes from the fact that there is a detector acceptance: If we can only accept particles which fall into the range -2.4 to 2.4 in  $\eta$ , there are many pairs that can fall in that range that can have a  $\Delta\eta$  of 0 between them. However, if one wants to have a particle pair that has a  $\Delta\eta$  of 4.8, one particle at 2.4 and another particle at -2.4 is needed, a condition very few particle pairs satisfy. This explains why the triangular shape in  $\Delta\eta$  has a peak at 0 and drops off as it approaches 4.8 and -4.8. This behavior is also observed in the  $\Delta\phi$ -axis if the  $\phi$  values are restricted to be between some two values like 0 and  $\pi$ . 0 and  $2\pi$ ,  $-\pi$  and  $\pi$ , and so on. However, a  $\Delta\phi$  of 0 is the same as a  $\Delta\phi$  of  $2\pi$ . For this, reason, we require that the histogram be periodic in  $\Delta\phi$ . Given any range, it is most probable to find a  $\Delta\phi$  of 0 than any other value, which is why we see a peak at zero (even without jet phenomena). Plotting  $\Delta\phi$  and  $\Delta\phi \pm 2\pi$  satisfies this periodicity requirement. In essence, we take the original triangular structure with a peak at zero and now add two more triangular structures that are shifted plus and minus  $2\pi$ . This results in a flat structure in  $\Delta\phi$  from  $-2\pi$  to  $2\pi$  [1].

The Background ACF (Mixed Events)

The peaks at 0 and  $\pi$  radians in  $\Delta\phi$  in the signal ACF (Fig. 3) provide evidence for jet phenomena. What would happen if we took particle pairs among different events? There is no preferred  $\phi$  value for jets to shoot off in, thus, taking a random event results in a jet shooting off in a random direction in  $\phi$ . However, there is a remaining preferred structure in  $\eta$  and  $\Delta\eta$  due to non-jet physics, such as particle production, and the detector acceptance, as well as random combinatorial effects [1]. The goal of the background ACF (Fig. 4) is to illustrate non-jet physics so that it may be later subtracted. The signal ACF is a combination of jet physics and non-jet physics. Given that we want to study the consequences of jet physics, we want to eventually produce a plot that solely illustrates jet physics. This is accomplished by taking particle pairs across events. By construction, it is now impossible to find a pair of particles that belong in a single jet and thus all evidence of jets should be nonexistent in the background ACF. The remaining angular correlation structure is that which arises from other physical effects, which we should remove if we wish to examine only the effects of jets on the ACF.

**Figure 4:** A background ACF created from pairs taken from  $12 < p_T^{\text{trigger}} < 14$  and  $0.5 < p_T^{\text{assoc}} < 1$



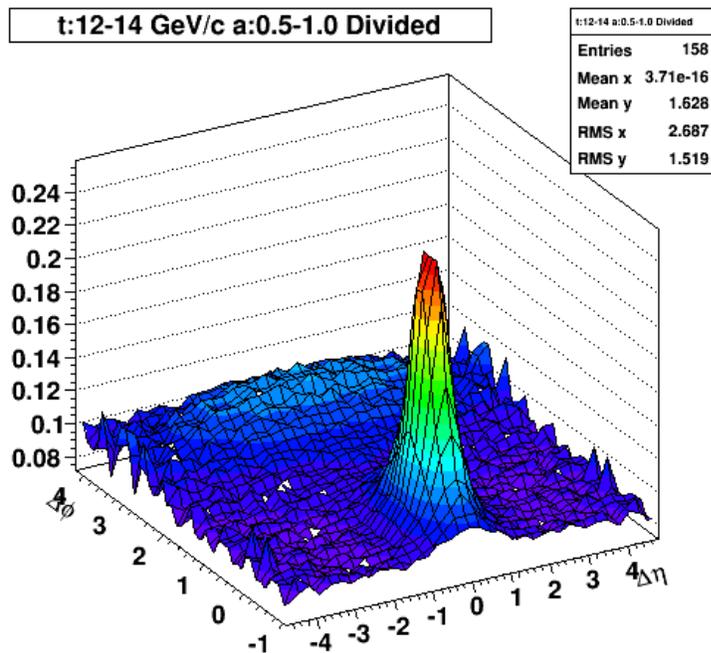
The structure of the background 2D angular correlation histogram is that which is flat in  $\Delta\phi$ , but with all of the  $\Delta\eta$  structure from the signal plot remaining. The  $\Delta\eta$  structure is nearly triangular in this plot, but in fact has two inflection points. This is a result of the non-jet physics we wish to remove from our signal plot to more closely examine the effects of jet

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physics. When creating the 2D background plot, we typically take a particle from the trigger bin and pair it up with all the particles in the corresponding associated bins in the subsequent 10 events. The background ACF histogram is then filled with all these angular separations, which are evenly distributed over  $\Delta\phi$ . Given that the background plot can be created from any number of events, normalization is required. We then take the previous signal plot and divide it by the created background plot to create the resulting divided plot. It is in this plot where we can see the effects of jet-physics.

**Figure 5: A divided ACF created by dividing the contents of each cell in the signal ACF by the contents of each cell in the background ACF**



### Numerical Analysis Tasks on the Divided Plot

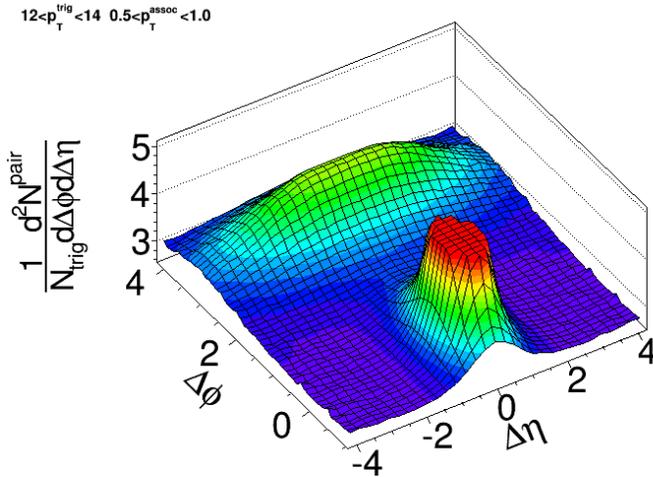
Once we have obtained the divided plots (there should be several plots, each corresponding to a specific pair of trigger bin with associated bin), we can conduct numerical analysis on them, which this section describes. The first task is to normalize the divided plots in order to compare them among different runs that have varying numbers of events. The normalization is done by scaling the divided plot by the number of trigger particles in the trigger bin (1). For example, if there were 500 particles in the trigger bin used to generate the plot, we would divide the divided plot by 500 to obtain a “per-trigger-particle” plot. We would also multiply 30

by the height of the background at (0,0) to negate the scaling effects that resulted from dividing by the background plot in the previous section [1].

**Equation 1:** This equation describes how the normalization is preformed to produce a divided plot that can be compared with other plots created using a different number of events.

$$\frac{1}{N_{trig}} \frac{d^2 N^{pair}}{d\Delta\eta d\Delta\phi} = B(0,0) \times \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)} \quad (1)$$

**Figure 6:** A normalized ACF, which is now comparable to other normalized ACFs regardless of how many events it took to generate it.



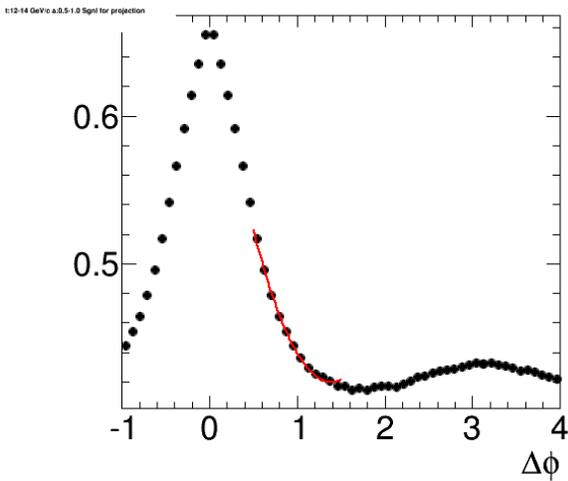
Once the normalized ACF is obtained, a useful value known as the associated near-side yield can be calculated. This is first done by finding the zero-yield-at-minimum (ZYAM) point. Given a  $\Delta\eta$  slice of the 2D normalized plot, giving us a 1D plot, we can find the ZYAM point, which is a  $\Delta\phi$  value, by finding the minimum of a fitted second-degree polynomial to the region between the two  $\Delta\phi$  peaks [2]. This range is from 1.1 to 2 on the  $\Delta\phi$ -axis. If the y-axis of the 1D plot gives us yield, then by the definition of ZYAM we should take the y value at the ZYAM point to be zero. This is how we achieve a zero yield at the minimum point. The associated yield is then obtained by integrating the 1D histogram from 0 up to the ZYAM point. This allows us to obtain an associated yield value per 2D plot per  $\Delta\eta$  slice.

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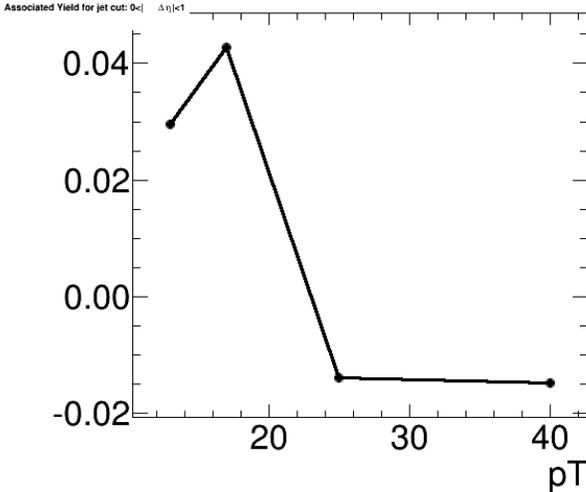
Doing multiple slices, we can obtain many associated yield values as we move from the short-range region ( $-1$  to  $1$  in  $\Delta\eta$ ) to the long-range region (the region outside of  $-2$  to  $2$  in  $\Delta\eta$ ).

**Figure 7: A ZYAM plot created by projecting the normalized ACF along the  $\Delta\phi$  axis, keeping only short-range pairs:  $-1 < \Delta\eta < 1$ .**

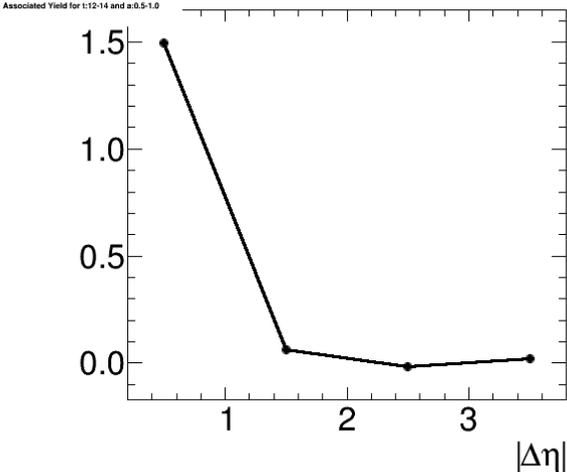


We can assign 2D-histogram an associated yield value per  $\Delta\eta$  cut, and thus see how the associated yield changes as a function of  $p_T^{\text{trigger}}$ ,  $p_T^{\text{assoc}}$ , and  $\Delta\eta$  cut.

**Figure 8: Associated yield as a function of  $p_T^{\text{trigger}}$  for fixed  $p_T^{\text{assoc}}$  and  $\Delta\eta$ .**



**Figure 9:** Associated yield as a function of  $\Delta\eta$  for fixed  $p_T^{\text{assoc}}$  and  $p_T^{\text{trigger}}$ . Yield falls off due to jets characterized by a small  $\Delta\eta$ .



### Discussion

These plots give us more opportunities to compare data collected from pp-collisions from both collisions at the CMS detected and from collisions simulated on Pythia. If we want to be able to compare theoretical and experimental data for lead-lead (PbPb) collisions, then we would use the event generator HYDJET instead of Pythia. HYDJET is built on top of Pythia

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and allows the user to simulate collisions between heavy nuclei. Due to the presence of nuclear matter involved in the collision, the process is much more complicated. There is enough nuclear matter to undergo a phase change into quark-gluon plasma (QGP) instead of evolving as a relatively easier scattering problem in the case of the pp collision. In fact, this quark-gluon plasma leads to additional computational complications, as the jets that once freely passed through empty space are now forced to travel through this color-charged medium with which they will interact and lose energy [3].

**Figure 10: Normalized ACF created from pairs of particles in Pb-Pb collisions generated in HYDJET.**

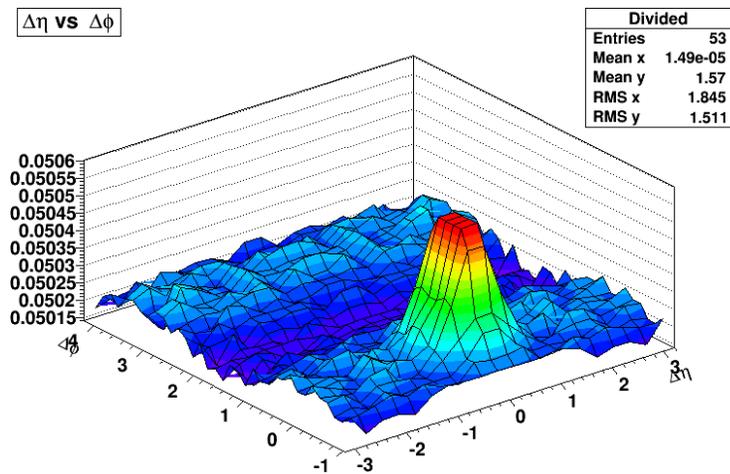
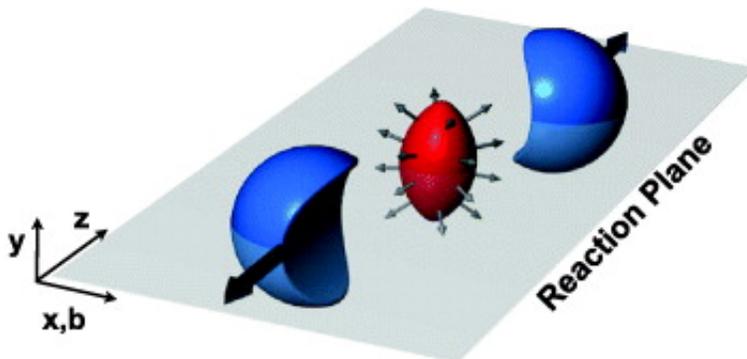


Fig. 10 shows what a normalized ACF looks like using PbPb collision events. This structure differs from the ACF of pp events in that there is an additional structure in  $\Delta\phi$ , which results from the effects of elliptic flow [3].

**Figure 11: An illustration of the QGP formed after a heavy-ion collision.**



From New Journal of Physics via IOPScience (2011)

Fig. 11 shows that a heavy-ion collision leaves behind QGP that then expands outwards, affecting the angular correlation in a way that is characteristic of its initial almond shape. Jets will be quenched more strongly along the long axis of the almond, and will lose a large portion of their energy [3]. All of these are effects that HYDJET must take into account when simulating the collisions between two lead ions. The methods used to perform data analysis will change in comparison to the study of pp collisions, which serve as a baseline when looking at the data collected from PbPb collisions. The next steps include computing the corresponding yields from ACFs obtained using HYDJET, and taking the ratio of the PbPb yields to the pp yields to obtain IAA, which will help us see how jet-quenching affects yields.

## Conclusion

In conclusion, this study explored the structure of angular correlation functions and extracted qualitative values that helped us compare correlation functions across various transverse momentum ranges. A large portion of the methods used in pp analysis are transferrable to the generation of PbPb angular correlation functions, but additional techniques including vn subtraction are required to account for the effects of the quark-gluon plasma and energy loss. It is hoped that the study done with pp collisions and Pythia will serve as a suitable stepping-stone for when the analysis is extended to include PbPb collisions in HYDJET.

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- [2] The CMS Heavy Ion Group, “Di-hadron correlations in central PbPb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV” (2011) Draft
  
- [3] CMS Collaboration, “Measurement of the elliptic anisotropy of charged particles produced in PbPb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV” (2013) arXiv: 1204.1409v2 [nucl-ex]

# Improve Fatigue Resistance for Concrete Using Recycled Rubber



**Patricia Chavez**

Mentor: Lijuan Dawn Cheng, Ph.D.  
Civil and Environmental Engineering

## **Abstract**

*Incorporating scraps of tire rubber into concrete could both strengthen concrete and divert a hazardous waste into a recycled material. Every year, 290 million scrap tires are produced in the United States and 91% of them end up in huge stock piles around the country, which pose problems for proper and safe disposal and exhaust considerable economic resources. In the last decade, many researchers have explored using recycled tire rubber to reinforce materials such as plastic, landfill covers and concrete. A substantial amount of research has been done on the geotechnical applications of recycled rubber; however, research on rubberized concrete is limited. Conventional concrete is extremely stiff and strong in compression, but it lacks ductility (the ability to deform under stress) and tensile strength (maximum stress that a material can withstand while being stretched before breaking). We*

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*hope to improve concrete's ductility and tensile strength by adding rubber and reinforcing it with fiber.*

## **Introduction**

This research examines how concrete's fatigue performance is affected by the addition of fine and coarse rubber particles at 10% and 15% by volume respectively and fiber reinforcement. To measure the effectiveness of adding rubber and fiber reinforcement, standard fatigue tests will be performed on concrete beam specimens. As the concrete is subjected to cyclic loading, the computer program will record the number of cycles to failure when the concrete specimen breaks. We expect that utilizing rubber in concrete mixing will improve behavioral aspects such as fatigue life and energy absorption. Utilizing rubber aggregate in concrete will help prevent the current detrimental environmental impacts, engendered by tire waste, thereby providing a green alternative to current unsustainable waste management practices.

Every year approximately 290 million scrap tires are generated and a small percentage of this number is exported, recycled, or repurposed into fuel and civil engineering applications. Most tires are placed in stockpiles. Stockpiles are an issue to the environment and to human and environmental health. When stockpiles are placed outdoors they become great breeding grounds for mosquito larvae because tires can accumulate water. A large mosquito population is alarming because mosquitos carry diseases such as West Nile virus and Le Crosse Enciphalitis which can then be transmitted to humans and/or animals.

Another concern of stockpiles is tire fires because they can affect the environmental and human health (see Figure 1). During a tire fire, large amounts of hazardous gases & emissions such as hydrocarbon and benzene are introduced into the local ecosystem and the ground water system.

**Figure 1: Tire Fire**



The dangers to the environment and human health are only one motivation to research rubberized concrete. Conventional concrete is extremely stiff and strong in compression, but lacks ductility as well as tensile strength. Utilizing rubber in concrete may improve concrete's ductility and tensile strength by adding rubber and reinforcing it with fiber.

## **Literature Review**

A significant amount of research has been done in some applications of recycled rubber specifically focusing on large pieces of tires being used as a backfill material in soil. However, research on rubberized concrete is limited and especially on the use of this concrete as a building material. There is research on the use of rubber in asphalt, pavement, and construction applications.

### **Effects of Rubber Structural Parameters**

There is current research on the effects of rubber aggregate on the concrete's structural parameters and they come to the same conclusion. Using rubber particles decreases the

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compressive and flexural strength of concrete. Both of these parameters make concrete unique and if the strength decreases, the addition of concrete has a negative effect. The modulus of elasticity, dynamic modulus, and brittleness index have also shown a reduction with the addition of rubber aggregate. On the other hand, there has been research showing positive effect on ductility and impact resistance.

### Flexural Strength

Researchers have performed tests to investigate the effect rubber particles have on flexural strength. Benazzouk (2007) used rubber particles comprised of one size, all smaller than 1mm. Unlike previous research, Benazzouk utilized rubber as a substitute for cement instead of aggregate. The cement was replaced at 10% increments from 0-50%. In addition to the cement, the beams supplemented cement paste mix with polypropylene (PP) at 20% by volume. The flexural strength tests were based on English Standard (EN) where a 3-point loading is applied instead of the 4-pt like other specimens. The results show that there exists an optimal rubber content rate that increases the flexural strength higher than the control specimen. This result is different than the results found by Ganjian (2008).

Ganjian tested samples according to the British Standard (BS) 188: part 117: 1983, which appear to be comparable to ASTM C78. Results show a decrease in flexural strength of up to 39% of samples utilizing chipped rubber and up to 29% of samples utilizing ground rubber with a rubber replacement of 10%. The flexural strength decreases with the increase of rubber particles and the researcher concludes that the decrease in strength was due to weak bond strength between the aggregate and cement.

### Compressive Strength

The compressive strength of rubberized concrete is reduced when compared with traditional concrete. Zheng, L. (2008) used powder and chipped rubber in a compressive strength experiment. 80% of the powder rubber particles were smaller than 2.6mm and the chipped rubber particles varied from 4 to 15 mm. The specimens consisted of various replacement percentages ranging from 15-45%. The compressive strength for rubberized concrete was 30MPa and the control group had a compressive strength of 40MPa. Data shows that the compressive strength decreased with the increase of rubber content. These decreases ranged from 46 to 90%. In general, it was found that the use of crushed rubber resulted in a large decrease in compressive strength when compared to the powdered rubber.

Ganjian (2008) did research using chipped rubber by replacing course aggregate and ground rubber as a replacement of cement. Each experiment used 5, 7.5, and 10% replacement rate by weight. The results of the test showed that the control specimen obtained a compressive strength of approximately 32MPa. The compressive strength decreased with the increase of rubber content and the specimens containing chipped rubber showed a smaller decrease than the specimens containing ground rubber.

Generally, the research performed has shown a decrease in compressive strength when aggregate or concrete is replaced with rubber. In addition, the magnitude of compressive strength loss increases with rubber content.

### Brittleness Index

The Brittleness Index measures a material's ductile or brittle behavior. The BI is a measure of the ratio of elastic deformation energy to irreversible deformation energy. Generally, a ductile material will have a lower BI, and a brittle material will have a higher BI. Zheng (2008) obtained BI values for all of the variations in rubber content and type previously discussed. Zheng's findings show that as rubber content increases, the BI decreases. In general, the largest reduction was found in the ground rubber at 15% replacement.

## Methods

### Materials

Rubber was supplied by a recycling company located in Hollister, California. The course recycled rubber is composed of shredded and ground tire rubber from autos, trucks and motorcycles. The rubber pieces were graded between ½" to #6 (3.36 mm) sieves. The rubber particles have different shapes and sizes; some are relatively square and some are long with a rectangular shape. Most of the particles fell in between these categories and could be described as oblong or rectangular.

### Figure 2: Recycled Rubber Pieces Graded ½"



**Figure 3: Recycled Rubber Pieces Graded #6 (3.36 mm)**



The aggregate added to the concrete in the concrete beams is gravel mined from a quarry in northern California. It is composed of crushed rocks of  $\frac{3}{4}$ " size and provided by a local hardware store. The cement is standard Type II-V Portland cement and was also supplied by a local hardware store. The water used was recycled, non-potable water.

The fiber reinforcement used is Fibermesh 650 manufactured by Propex Concrete Systems. These fibers are micro-synthetic, polypropylene fibers with a density of 56.8 lbs/ft<sup>3</sup>. The fiber

is recommended to be used at a minimum addition rate of 3.0 lbs/yr<sup>3</sup> and complies with ASTM C1116 Type II 4.1.3. The aspect ratio of the fiber was 96.5.

**Figure 4: Fibermesh 650 Fiber Reinforcement**



Beam Construction

**Table 1: Beam Construction by Batch**

Batch	G10	G10F	G15
Description	10% Gravel Replacement	10% Gravel Replacement w/ Fiber	15% Gravel Replacement
Cement (lbs)	64.7	64.7	35.28
Water (lbs)	28.66	28.66	15.98
Gravel (lbs)	181	181	96.29
Course Rubber (lbs)	3.81	3.81	379
Sand (lbs)	129	129	85.46
Fine Rubber (lbs)	0	0	
Fiber (lbs)	0	1.17	0

For the fatigue flexure tests, specimens were plain un-reinforced 6” x 6” x 20” beams. The framework of the beams was made from plywood. An initial concrete mix design was performed using the procedures outlined in ACI 211.1-91 (Reapproved 2009), “Standard

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Practice for Selecting Proportions for Normal Heavyweight, and Mass Concrete.” The target concrete strength was 4000 psi.

**Figure 5: Plywood Framework for Fatigue Flexure Tests**



Batches were designed with an abbreviation to easily identify and differentiate each batch. The first letter of the designation describes the aggregate content, a C represents the control (unmodified aggregate), and a G for aggregate replacement with rubber. The second designation being the amount of rubber, either 10, 15% (by volume). Finally, if fibers were used in the mix, an F was added to the end of the designation.

There was an initial miscalculation of actual batch yield, which resulted in the G10F batch containing higher fiber content, approximately 0.68%. The miscalculation also resulted in an inadequate amount of rubber to complete all of the originally planned batches. Therefore, batches S15 and G5, in addition to some G15 specimens were not mixed or constructed. An additional  $0.032 \text{ ft}^3$  (2 lbs) of water was added to the batches containing fiber reinforcement to increase workability and to account for moisture absorbed by the fibers.

Concrete was placed into the beam specimen forms until they were full, and then vibrated with an electric shaft vibrator. The shaft was placed inside the concrete and form, and slowly withdrawn and repeated. Additional concrete was placed into the form once the concrete had been vibrated and settled. The top of the beam was then finished with a trowel to create a smooth finish. The additional concrete that was placed before finishing did not always settle completely with the vibrated concrete. This resulted in some concrete beam specimens with voids near the top of the form, around the edges. Flexure specimen preparation included marking the support and loading positions along the beams. The imperfections and voids of the beam specimens, if they contained any, were photographed and noted.

### Beam Testing

Six concrete specimens tested under flexural strength. The test was conducted with standards established in ASTM C78, “Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)”. The testing was performed with an 18” span and a point load being applied at 6”.

**Figure 6: Fatigue Testing Machine**



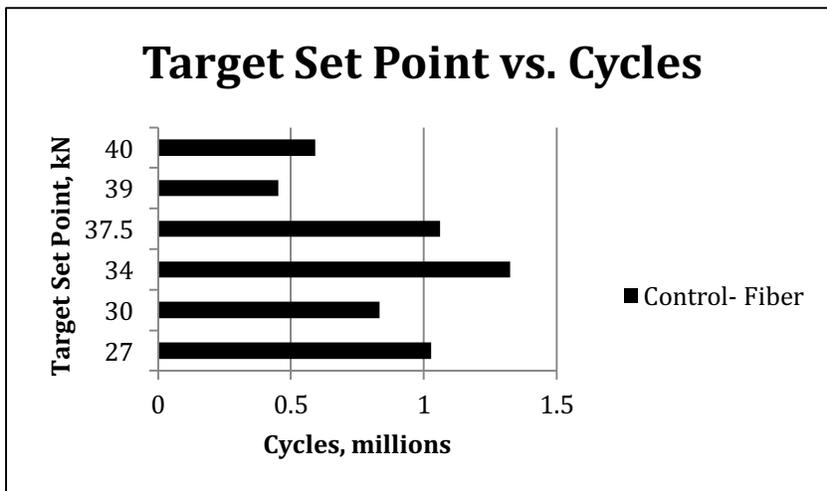
**Figure 7: Concrete Beam After Fatigue Testing**



## Results

The results for the control specimens can be seen below and the total cycles was 5.29 million with a maximum force of 40kN.

**Figure 8: Results for Control Specimens**



The control beam with fiber reinforcement was able to withstand a larger force. It reached 45kN and a total of 8.66 million cycles. This shows that the fiber reinforcement does strengthen the concrete.

As we look at the data for the gravel replacement at 10% gravel replacement, at 15% gravel replacement, and 15% with fiber reinforcement, it is noticeable that the replacements do have effects on the behavior of the beams. Some beams withstood more force and others were able to withstand a constant force for a longer period of time. However, the data for the 6 beams being tested are not sufficient and further analysis needs to be made. There were multiple people performing these tests, so there could be some inconsistencies as well as incorrect data sets.

## **Conclusion**

Given the limited information available during this experiment, it is concluded that the gravel replacement beams show increase in fatigue life. Additionally, the specimens with fiber reinforcement have minimal increase in fatigue life and the fiber control beams are stronger than typical concrete beams. The expected results were that the fatigue life increase with an increase in rubber replacement and in order to verify this hypothesis more data needs to be collected.

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# Wire Electrical Discharge Machining Tool Path Offset Optimization for a Miniature Medical Component Fabrication



**Destiny Garcia**

Mentor: Kazuo Yamazaki, Ph.D.  
Mechanical and Aerospace Engineering

## **Abstract**

*Wire electrical discharge machining (WEDM) is a non-traditional manufacturing field that is used to efficiently and accurately cut notoriously difficult-to-machine medical materials such as stainless steel or titanium. Many medical applications, however, require WEDMing of very delicate components, which are subject to deflection and distortion during cutting, due to the high cutting temperatures experienced during the WEDM process. To compensate for such geometric changes encountered during WEDMing, the wire motion during cutting operations must be compensated in order to achieve a geometrically accurate and uniform quality component. Goals for this project are aimed at improving the tool path, which will enhance the stable fabrication of the medical component. Findings from the new tool path offsets may be useful in future studies involving other various applications in the industrial field of WEDMing.*

## Introduction

Micromachining is a necessary tool because of “the tendency of high accuracy and miniaturization of components used for electro-mechanical instruments, aerospace equipment and medical devices, etc.” (Cheng, 2014). As technology advances, so do the methods by which many products are being manufactured.

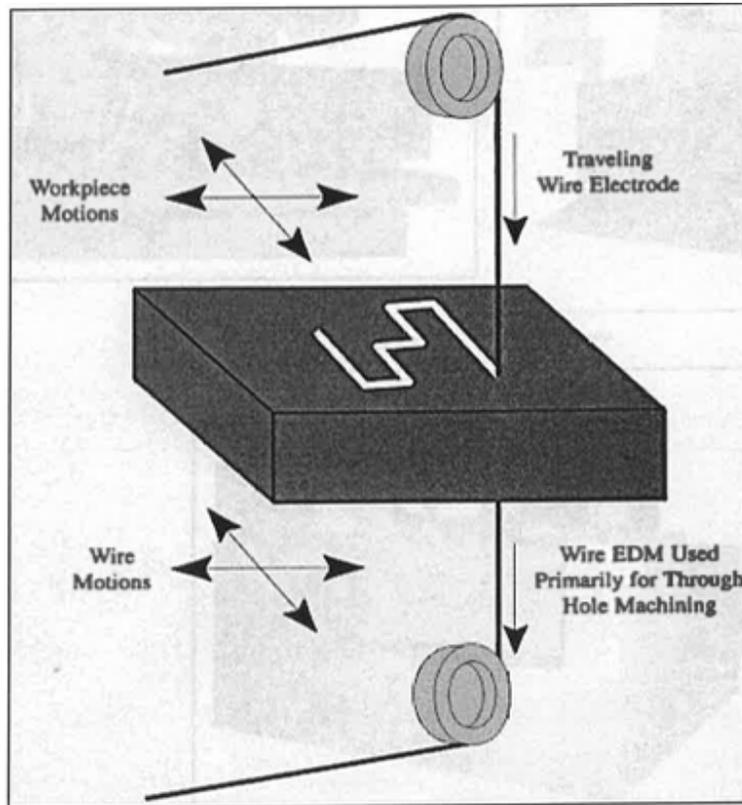
Advanced machining is needed for manufacturing due to the poor machinability of material properties such as high hardness, high strength, and high brittleness. In order to machine difficult to machine materials such as high strength titanium alloys, it is crucial to use methods of manufacturing that will prevent different types of work hardening, which affects the materials properties (Garg, 2014). Advanced machining is also needed to fabricate custom desired work piece shapes and structures. Many original custom-made parts have complex geometries that cannot endure cutting forces of traditional manufacturing and are difficult to fixture.

Wire Electrical Discharge Machining (WEDM) is a nontraditional machining process that uses thermal energy to create material removal. It can cut any electrically conductive material through the use of an electrode wire tool made of brass, copper, graphite, and other materials. WEDM is essential when mechanical milling or turning is not a viable option for difficult to machine materials such as titanium or stainless steel, which are main materials used in the field of medicine.

WEDM creates a superior finish compared to traditional manufacturing cutting methods such as sawing, milling, or turning. The material removal process involved in this type of non-traditional manufacturing includes a charged electrode wire that “erodes materials from a work piece by a series of discrete sparks between the work and the tool electrode immersed in a dielectric medium” (GARG, 2014). The electrical discharges of heat melt away material from the work piece. The dielectric material then washes the small amounts of material away.

The material removal process is a continuous flow of melting away work piece material and washing away the debris with the dielectric fluids in the gap space. The general work piece direction and movement of the wire can be seen in Figure 1. The wire moves about the work piece and the electrode sends sparks to remove the unwanted material.

**Figure 1: The basic operations of a WEDM movement is shown**

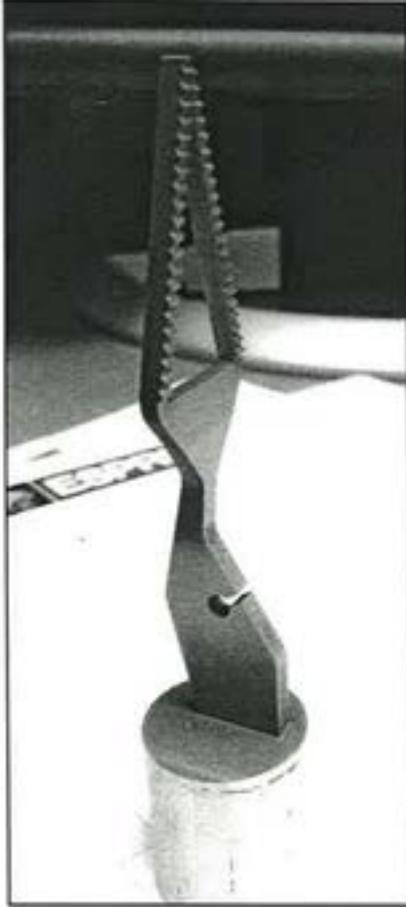


Medical components used in biomedical engineering applications, and other medical components that are used inside the body, require material specifications to meet environmental acceptance of the body and the foreign materials. Conventional biomaterials used in implant surgeries include “stainless steel 316 L, Co-Cr-Mo based alloys as well as titanium (Ti) and its alloys” (Tavares, 2014). Titanium promises greater future results compared to the stainless steel alloys. Titanium is a preferred material choice in biomechanics and biomedical applications. It has a great biocompatibility with the body, corrosion resistance, low elastic modulus, and low mechanical resistances (Tavares, 2014).

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**Figure 2: Half of a medical pincer fabricated using WEDM**



The product of interest in this case study involves a medical pincer, half of which is shown in Figure 2, made from a titanium alloy and used to crimp bodily tissues and organs. Current fabrication methods in use on the pincer leave a dull surface on the medical component. Through the use of WEDM, very precise and smooth surfaces can be fabricated for difficult to machine materials, such as the pincer.

Researchers at the University of California, Davis, predict the cause of the dullness resulting from current fabrication methods is due to deflections from high cutting temperatures. A tool path offset can help compensate for the dull surface. In this paper, we will discuss the importance of nontraditional manufacturing practices for complicated geometries used in medical applications such as medical implants and medical instruments used inside the body.

## Experimental Methods

The experiment design was set up to first understand the offset parameters of a typical WEDM cutting procedure. The experiments were conducted using a Sodick AQ327L WEDM, as seen in Figure 3. The electrode wire used for this experiment was of 0.02mm brass material.

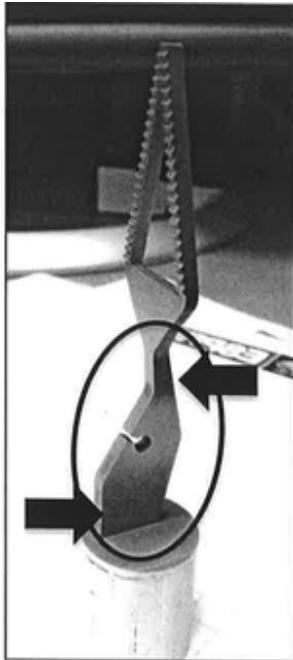
**Figure 3: A Sodick AQ327L wire electrical discharge machine is shown.**



Using ESPRIT, a computer aided manufacturing (CAM) software, fabrication of the medical component was simulated. The software allowed the user to create a tool-path in which the piece will be manufactured. The user is also able to define offset parameters in the cutting sequence, as seen in Figure 4.



**Figure 5: The dullness of the medical pincer is seen where the arrows are pointing.**

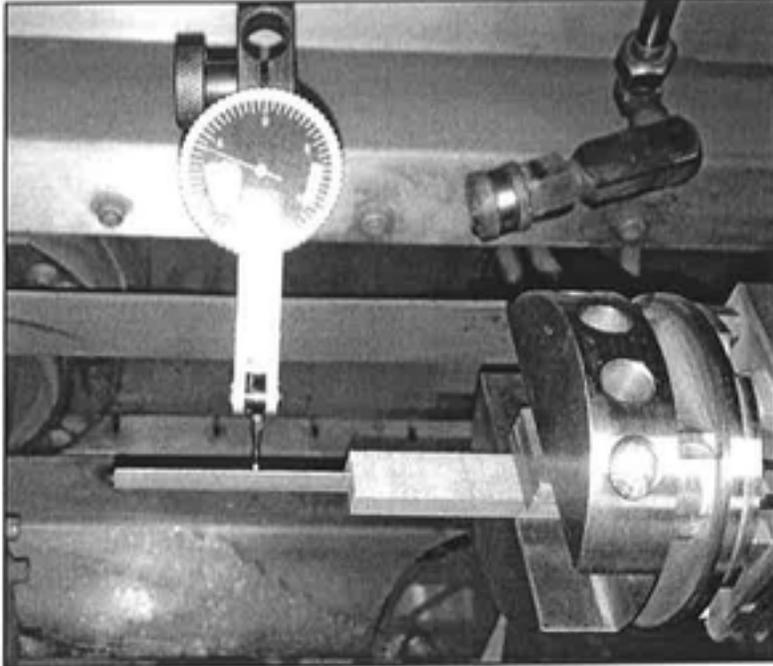


Deflection tests, carried out by taking different thickness work pieces and cutting them with the WEDM, helped investigate the dullness phenomena with the medical pincer. The tests consisted of cutting stainless steel and titanium samples with WEDM of different thicknesses, 1mm, 1.25mm, 1.5mm, 1.75mm, 2mm, and 3mm thick. The deflection caused by the heat from the electrical discharge was measured two different ways: mechanical probing and by machine wire sensitive touch capabilities. Mechanical Probing can be seen in Figure 6.

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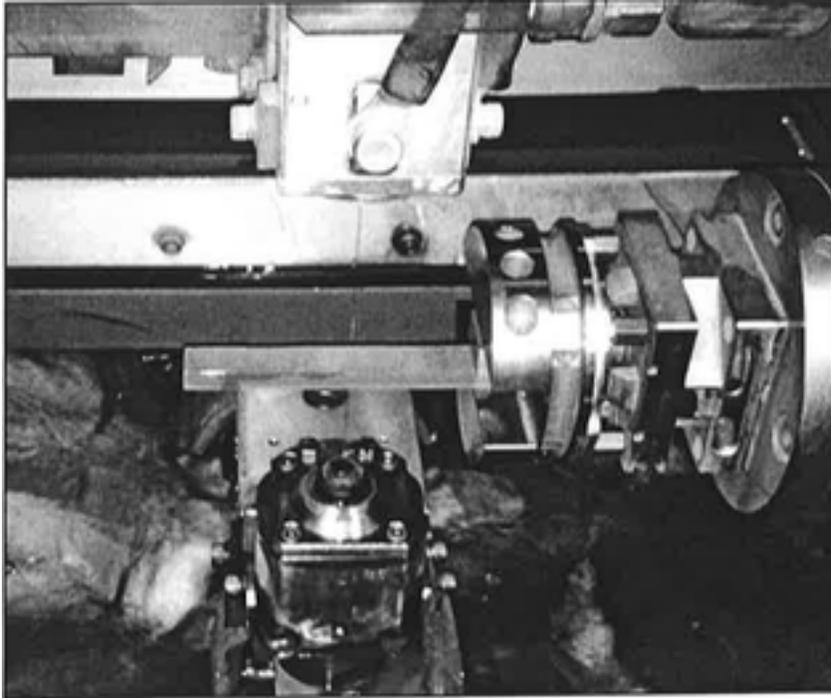
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**Figure 6: This image shows a probe measuring the deflection of a 1mm thick cut sample.**



Sample tests were cut using the WEDM at different thicknesses as seen in Figure 7. Stainless steel and titanium samples of different thicknesses were tested. The CNC codes for the tests were basic rectangular cuts to fabricate single “fork like” extrusions as seen in Figure 6.

**Figure 7: WEDM wire cutting a titanium sample with the CNC code.**



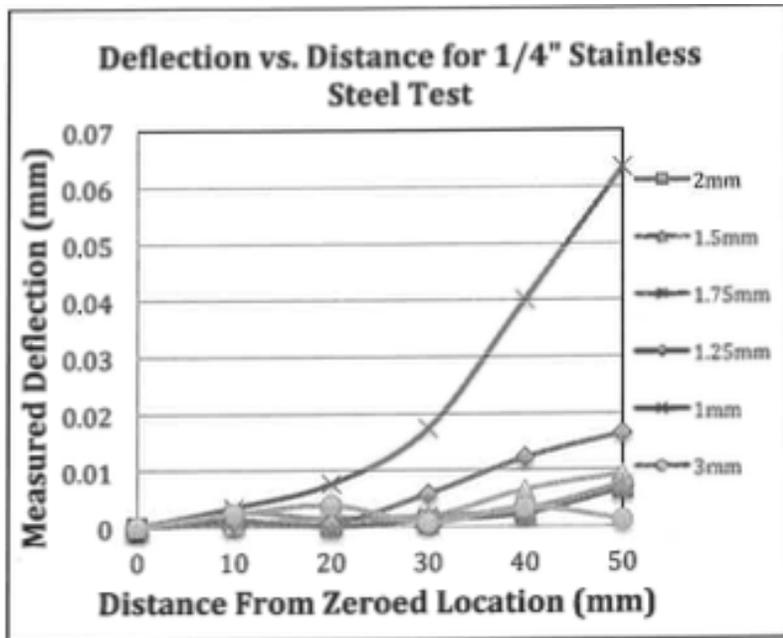
## **Results**

After the different deflections were recorded, they were plotted against thickness of the sample piece for any correlation between the two. The results were recorded as follows.

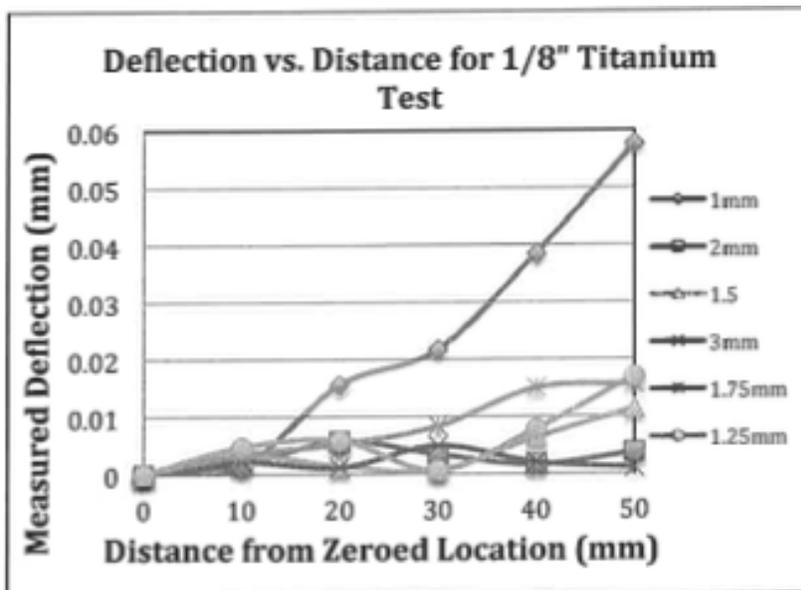
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Graph 1: The deflection of 1/4" stainless steel sample is shown.



Graph 2: The deflection of 1/8" titanium sample is shown.



Test	Comments
1/4" Stainless Steel	The stainless steel samples tended to deflect in a linear fashion.
1/8" Titanium	These samples exhibited a similar deflection pattern as the stainless steel samples.

## Discussion

After cutting the stainless steel and the titanium stock, a certain trend was observed in both of the cutting materials. The thinner the NC code was set, the more it would deflect. This occurred in both the 1/4" and 1/8" materials of stainless steel and titanium respectively.

The deflection increased as the thickness of the NC code was reduced from 3mm to 1mm. The 1mm cuts had a 0.0634mm and a 0.0576mm detected deflection for the stainless steel and titanium respectively.

Interpreting the data suggests that the thinner the work piece is cut, the more deflection that part will experience. Using this understanding of the material properties associated with thermal distortion of the wire, the original prediction of the deflection associated with high temperatures relative to the wire when it is sending sparks from melting work piece materials, is deemed valid.

As the wire from the EDM conducts electricity, it erodes the material from the work piece by sending continuous impulse sparks across the dielectric fluid to the highly conductive work piece. As the wire slowly approaches the end of the sample cut, more deflection is observed in the piece.

Another phenomenon noted in the experiment was that as the work piece was cut thinner, more deflection was observed. The smallest sample was cut to be 1mm thick. Graphs 1 and 2 reveal that the 1mm work piece shows the greatest amount of deflection. This was caused by the thermal distortion energizing a smaller area with a great force against the thickness. Therefore, the smaller the thickness, the more likely the energy was observed as deflection.

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## **Conclusion**

In conclusion, this experiment was completed with an open-ended discussion as to how to fix the dull finishing on the medical pincer. The project was deemed completed by the principle investigator of the Intelligent Manufacturing Systems, IMS Laboratory at the University of California, Davis, Professor Kazuo Yamazaki.

This project helped contributing undergraduates learn the basic knowledge of operating the wire electrical discharge machining manufacturing methods. In the process of concluding this experiment, participating students expanded their understandings of CNC and CAM tools used in industry as valuable fabrication tools.

It was observed and recorded that the 1mm cut had the most deflection compared to the rest of the other thickness cuts. It is appropriate to state that the thinner the workpiece is cut, the more deflection that part will undergo.

This project still has some open-ended discussion experiments to be conducted to further understanding of the fabrication processes and material limitations of the medical pincer. Experiments needed to fully understand the medical pincer fabrication will be determined by continuing undergraduates at the University of California, Davis.

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# **Love Dominoes: The Mate Selection of African-American Women at Research Universities**



**Jhamere Howard**

Mentor: Bruce D. Haynes, Ph.D.  
Sociology

## **Introduction**

The opening paragraph of an excerpt from CNN by Sarah Springer (2012) describes the new television series *Scandal*: “Olivia Pope is smart, runs a successful business and is the center of attention when she enters a room. She’s the kind of woman who magazines say every woman can be, and the type that others love to hate. There’s just one thing: She is also Black.” In an article written in *The Atlantic Monthly*, Enuma Okoro (2014) describes the protagonist of the show *Being Mary Jane*: “Mary Jane Paul—a single, young, successful African-American television news anchor who juggles her demanding job with a complicated personal life.”

These statements summarize the two main characters of shows with African-American women as the lead character. The primary characteristics of the characters are that they are

successful, African-American, and most importantly, they are single women. Much of the success of the two respective shows can be attributed to the exciting drama generated from the two women's social lives. The two shows boast a combined 15 million viewers (TV by the Numbers, 2014). Olivia Pope runs a successful crisis management firm. She completed her undergraduate at Princeton and received her law degree from Georgetown. For all of her educational accomplishments and career success, she has a complicated family life. Despite being in the proximity of successful men, she maintains romantic relationships with a married man, and she is single. Mary Jane, much like Olivia Pope, has a successful career as a news anchor on a burgeoning television network. Yet her family life is in disarray and her romantic relationship is with a married man. The lifestyles of the respective women are eerily similar to the lives of educated African-American women in the United States. These women achieve high levels of educational attainment and career success, but they struggle to establish stable, meaningful relationships once they have accomplished such professional feats.

Cassie<sup>1</sup> is a college junior from Southern California. Her immediate family consists of two older sisters, a single mother who is a nurse, and an absent, negligent father. She began her experience at university in a long distance relationship with her previous boyfriend, whom she met in high school in Los Angeles. Her boyfriend was not in college. He did not have goals and did not understand her lack of time for investing in a long distance relationship as a student. Cassie was frustrated early on during her freshmen year from strenuous physics classes and was upset that her relationship counterpart had less and less in common with her due to her formal education. Cassie assumed that she would eventually find another boyfriend in college due to her attractiveness as a candidate. She is a petite, quiet, studious physics major. She wants a counterpart who shares her ambition and supports her.

Fast forward two years. Cassie is enrolled in a research program, maintains a competitive GPA, and is involved in several extra-curricular clubs, but her dating life has remained stagnant and unchanged since her freshman year. She has since become increasingly more pessimistic about finding a counterpart in college. She has become ambivalent about whether she will have a meaningful relationship in college and has elected to focus on her academics. While this strategy may lead to her obtaining a certain level of academic success, it will not equate to a successful romantic life despite her professional accomplishments. The television narratives of Olivia Pope and Mary Jane are not cautionary tales or anomalies, they are

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<sup>1</sup> All names of respondents are pseudonyms used to protect confidentiality.

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trends. What can be done at the college level, to stop Cassie from becoming another Olivia Pope or Mary Jane?

Much of the existing research focuses on educated African-American women and how they participate in the social phenomena of having constrained dating pool. Yet there is a gap in the literature, where the college environment should be studied to analyze how African-American women's future dating pool is influenced by the college environment.

## **Literature Review**

The intimate relationships of college educated African-American women have been a major area of study in American society for years. Although the trend of African-American women as the heads of households has been salient in media and popular culture, research has not been proportionally performed in this area. Research conducted by sociologists has given a variety of explanations and theories pertaining to the problems of African-American women in relationships (Banks, 2011; Johnson & Staples, 2005; Moran, 2001). For example, many studies propose the optimistic expectation that after enlightening the African-American community of the salient problems of women, there will be an effort to solve the collective problems of the African-American community. Holistically, research shows that African-Americans in general are the least likely to marry; the least likely to stay married; are more likely to marry at later ages; and are likely to spend less time married compared to their white counterparts (Banks, 2011; Bureau of Labor Statistics, 2013). These phenomena have been attributed to many factors, with the most significant factors being individual and cultural reasons.

There are several cultural changes that have affected the institution of marriage such as: marriage not being a prerequisite for sex; the increasing economic independence of women from men; and cohabitation as an increasing option for union formation. The individual factors that impact the institution of marriage are focused on the different genders' perceptions and expectations of potential mates and marriage, aversion to divorce rates, and economic stability (Barr & Simons, 2012; Edin et al, 2005; Kalmijn, 1998). The resulting increasing selectivity based upon the attitudes toward marriage formation has a negative relationship with the likeliness to get married, a problem that is increasingly more problematic in African-American relationships (Blackwell & Lichter, 2004; Dixon, 2009; Goldscheider et al, 2009).

There are a multitude of issues surrounding the tribulations that African-American women specifically face in regards to marriage prospects. Scholars in the field have examined and identified why African American women have the most limited and non-diverse dating pool in comparison to other ethnic groups. Some results include: increases in unequal male counterparts; competition for quality dateable partners; poor media representations that perpetuate damaging stereotypes; self-esteem issues resulting from dominant Eurocentric ideals of beauty; and the disparity in sex ratios between African American men and women (Bell et al, 1990; Childs, 2005; Crowder & Tolnay, 2000; Dixon, 2009; Patton, 2006).

One of the most essential aspects of the marriage dilemma for African-American women has to do with the external constraints of the availability of African-American men. Every year there are large numbers of African American men imprisoned by the United States criminal justice system. There is an overt and direct impact on the marital prospects of African-American women resulting from incarceration, or the removing of African-American men from the proximity of women, as well as from the pool of possible marriage partners. Afterwards, those same imprisoned men are disparately overrepresented on probation and parole, adding rigid parameters to their daily interactions, that if violated have punitive consequences. Probation and parole constrains African-American men further by keeping the men from effectively rejoining society and thereby contributing to the high recidivism rates of African-American men, which in some states is three times higher than that of their white counterparts (Boulger et al 2012). Attaining a criminal record is one of the paramount reasons behind the African-American male demographic being treated as second class citizens by legal standards, as they can be denied the right to vote, are automatically excluded from juries, and are legally discriminated against in employment, housing, public benefits and accessibility to education.

Another barrier for African-American men would be the homicide rates in the United States. In 2011 alone, there were almost 6,200 cases of homicide in which African-American men were the victims according to the FBI Supplementary Homicide Report (2012). These same crimes resulted in almost 5,900 convictions of African-American men for murder. The number of homicides and convictions were consistent with previous years, a trend that if continued over a decade would result in over one million ineligible men in the marriage pool for African-American women. The plight of African-American men structurally, has a symbiotic relationship on the marital market for African-American women, and the collateral damage impacts the formation of nuclear African-American families. Those men already in marriage or relationships are often directly removed from their relationship, restricting or negating union formations. The stigma of having a criminal record often deters potential

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marriage partners for these men, as it decreases the likelihood of meeting the desired traits in potential candidates. That is, those who are released from prison into society often experience reduced earnings and employment, placing them at a disadvantage relative to those on the marriage market with more attractive economic prospects (Alexander, 2012; Lane, 2004; Lopoo & Western, 2005).

The unemployment rate of African-American men is more than double that of their white counterparts according to the Bureau of Labor Statistics (2013). The economic prospects of a relationship counterpart is increasingly important due to the impact that socioeconomic status has on upward mobility. The plight of African-American men in regards to obtaining employment, and establishing careers, impacts their desirability to potential partners. The socio-economic status impacts the opportunities of women in producing intergenerational wealth and educational stability. Traditional patterns in mate selection show that women employ a strategy of hypergamy—the practice of marrying someone with higher socioeconomic and educational levels. This practice of hypergamy results in women assuming the socio-economic status of their husbands (Blackwell & Lichter, 2004; Dixon, 1998). Thus, economic prosperity is particularly important in regards to union formation. As Ralph Banks (2011) points out, African-Americans follow a trend where they “postpone marriage in the hope that they’ll get the stable job and nice apartment that they think should precede it” (46). Westernized societal norms have been shown to be disadvantageous for African-Americans, a bind that disparately affects African-American men. For example, the conceptualization of masculinity by Western standards results in African-American men floundering by society’s standards, which then results in an inferior sense of masculinity. This inferior masculinity is a by-product of presumed failure to fulfill the needs of women in heterosexual relationships as breadwinners (Hamer, 2001). The deterioration of African-American masculinity is further exacerbated by the importance of economic stability when evaluating potential partners, as it has been shown to be most influential within African-Americans (Fry & Cohn, 2010).

The potential economic gaining power is undoubtedly affected by the educational attainment of an individual. African-American women, according to the National Center for Education Statistics (2014), obtain bachelor’s degrees at twice the rate of African-American men. The college environment is centered in the importance of educational attainment’s influence on marriage formation. The importance of educational background has usurped ascriptive social and religious backgrounds in recent decades. Sociologists consistently point out the influence of personal achievement on marriage formation (Arum et al, 2008). College is now viewed as the most likely institution to foster romantic relationships—the local marriage market that

trumps both workplaces and neighborhoods. The college institution has also been proven unequal for African-American women who are seeking equal counterparts due to the sex-ratio imbalance, resulting in low social returns from their college experience (Arum et al, 2008; Kalmijn, 1998). Further research is needed in order to determine how the college environment can be navigated to influence the marital prospects of African-American women and how the institutions can be navigated in order to circumvent stratification.

## Methods

A total of 30 African-American women were contacted for their participation in the study. 20 women were undergraduate students at the University of California, Davis. Respondents were selected for participation using a combination of the non-probability sampling methods, both convenience and snowball techniques. The small, tight-knit African-American community at the University of California, Davis allowed for the primary investigator to establish rapport with some the participants, while the other participants were obtained through referral from those who had already participated in the study. There was no shortage of willing participants on the UC Davis campus, with 100% acceptance rate of participation in the study. The remaining 10 participants in the study were African-American women at the University of Arizona. The primary researcher relied solely on the snowball technique in order to obtain participants. There was also a similar success rate in obtaining the participants, as there was only one refusal to participate.

The researcher conducted in-depth one-on-one interviews with all 30 women. Once consent was obtained, participants were asked to fill out information on their background. Here the participants were asked to provide information such as their hometown, place of birth, age, the occupation of their parents, marital status of their parents, their religion, national and cultural identity, socio-economic class, major, their high school and their status as transfer students. This information was requested based on previous research regarding union formation and the importance of such factors. The average age of the participants in the study was 20.96 years of age; 53% identified as coming from middle and upper class backgrounds and 84% identified as being Christian.

The participants were recorded being asked 23 questions that represented a variety of factors, such as: their peer and family network influence, their expectations, how their background (ethnicity, religion, culture, socio-economic status) influences their mate selection, their courting patterns, their thoughts on interracial dating, what factors shrink/widen their dating

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pool, and their thoughts on the institution of marriage. Once the interviews concluded, the primary researcher transcribed the audio. The transcripts were analyzed by the primary researcher looking for major themes, trends, and patterns. Once the themes were established, the documents were placed into qualitative research analysis software in order to mitigate perceptual bias from the primary investigator. This process allowed for the primary investigator to further analyze patterns that were found without the software, as well as patterns that may have not emerged in the initial analysis of the research.

## Results

There were several emerging themes that resulted from the data. Many are consistent with current research on African American women's relationships. The women in the study also exhibited behaviors that were consistent across all ethnic groups.

### Race Matters

From the onset of the interviews, the recognition of the theme of race/ethnicity was established by the participants. When asked the simple question of "How do you feel about dating?" the women appeared to analyze the interview in the context of race, and made efforts to display how race does or does not influence how they date. This type of racial discussion is done in two manners. The first is by accepting that race has an influence on who they are attracted to. The second is by stating how their family background or environment is culpable in their racial preferences.

### Same-Race Attraction

Cecily, a junior from central California, who was adopted by White parents, states "I'm open to date to anyone who wants to date I guess, however as an African American female I am attracted to African American males, and that's who I've always had relationships with." Similar sentiments were expressed by Deidra, a junior from central California, who was raised in an environment with miniscule African-American representation. She states "So I was raised in a home where you are not supposed to date anyone who's not your race. But I did anyway, so I'm pretty open to who I date. Since I've come to UC Davis, black men would be my preference. I don't really find any other race attractive, and there is no cultural similarity." Both of these women emphasize their almost "natural" attraction to men of their own race.

The physical attractiveness of African-American men is held in high esteem comparable to other groups. 57% of the women interviewed stated that dating someone who was African-American was important to them. Those in that section who agreed, cited the cultural understanding of the plight of African-Americans as to the importance in dating someone in their ethnic group. Cecily, who was raised in a predominantly White area, and by a White mother, exemplifies this thinking when she states,

I am actually adopted and my mother is white... But my mother did a fantastic job of making sure that I understood my culture in a way that I need to know it. So that came with Black males, and being integrated into that lifestyle I guess you can say.

This was a common sentiment. Most expressed the need to have a seamless transition into dating as well as the appreciation of a cultural understanding that often comes from African-American men. Having to not answer questions about their cultural aesthetic was prominent in their responses. 20% of the women in the study stated that race was not important to them as much as it was their preference to date someone in their culture for many of the same reasons as those who stated that it was important to date someone African-American.

### Interracial Dating

50% of the women who participated in the study stated that they have dated interracially before, but of that group, 87% admitted that their experiences were all before they began college. In regards to interracial dating, most women were open to dating interracially and sometimes encouraged it, but often frowned upon it when they saw African-American men dating interracially. They feel this is due to those African-American men who are in interracial relationships having vitriolic and internalized opinions about African American women. Elsa, a blond, short-hair, petite, psychology major from Tucson, AZ, expresses in jest how this manifests itself within the African-American community:

I think when it comes to Black men and white women or Asian women or whatever, it's like this stigma, like it's horrible and I agree, I mean I don't like it[Laughs]. But when it comes to Black women and someone outside of their race, it's like, good! Yay for you because these Black men don't want you. They don't understand you, so go somewhere else. To me it feels encouraged, like just do it girl! Go get it, it's ok, Trayquan don't

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want you anyway. Go get Ben or Bob. Bob will love you and Trayquan will just get you pregnant and leave and get locked up. That's the way [African-American women] make it seem... We're our own worst enemy.

When asked to express their thoughts on seeing interracial relationships on campus, many of the women state that initially when coming to college, they were more displeased at the sight of interracial dating and developed spiteful thoughts. However, as they evolved throughout their time on campus, they became more accepting of interracial dating and those who participated in these relationships. For instance, Diamond, an outspoken Neuroscience and Cognitive Science major from Tucson, AZ, describes how she has evolved in her thinking about interracial relationships since she started attending college by stating:

So I used to be very angry, I used to get very angry. Me and my sisters, we would see a Black man out with a girl, and she's not Black and most of the time, I feel like 95 percent of the time, she's not very attractive, at least by our vain standards. So we'll say like oh he's taking his pet out to the zoo. Which is really bad and very derogatory. And I feel like it's a defense mechanism. Because obviously I hang around a bunch of black people, so I know how black men feel about black women. And I feel like a lot of them when they date outside their race, it's to justify why they don't like black women. As opposed to saying I'm with her because I like her, she's great. They say I only date white girls because black girls are ghetto and this and that. So it fostered early on that I was angry when I see an interracial couple, I immediately assume he's with her because he don't like black women, he must not love his mother [laugh] because otherwise he would love black women.

When asked if non-African-American people court them, many provided the expression of "they don't know" after carefully pondering. The researcher found that the women employed a strategy of "tactful inattention" when non-African-Americans courted them. This resulted in the women not taking those who have courted them seriously enough to notice. For instance, Deidra talks about her experience:

There was one guy, in my freshman year of college that seemed interested in me, and was trying to ask for my number and walked me home all the time. I don't know if it because he was white, that I didn't pay him any

mind, and I was just kind of like, uh, I wish this guy would get away from me.

Others who haven't been courted by someone outside of their ethnic group, cite the internalization of stereotypes of African-American women as the essential reason why it has not happened. Jalisa, a tall, Afrocentric, junior from Los Angeles when asked if she has been courted, states:

No. I'm trying to think if anyone has ever tried, maybe vaguely but I don't think I took it very seriously. I think it's because the black woman is feared. I think that people think of black women and don't know what to do...they are strong willed women.

Jalisa expresses the feared aspect of interracial courting, while Cassie, from the opening excerpt provides an answer that is more consistent with research about the exotic, sexual relationships that white men express interest in. She states:

Personally, I don't feel that they ever want to date me. They just found me attractive, like oh she's cute, I wonder what she can do. And this one guy, blatantly said I really want to try you. He was just like I just want to see what it would be like... Because he said he had jungle fever.

### Toolkit

The women in the study are aware of the college environment and how the surrounding community may constrain their dating pools. College can be viewed as an environment that provides an "unsettled" phase in life and the participants must employ certain strategies in order to navigate the environment differently depending on the context of a situation. People develop a toolkit upon which they rely to understand and guide their experiences in romantic relationships (Swidler, 2001) and the women in this study developed informal toolkits in order to navigate the institution.

Due to the prevalence of concurrent physical relationships within the African-American community (Banks, 2011), some of the women rely on a previous history of a counterpart in order to ascertain whether or not a current counterpart is a viable candidate. The reputation of a counterpart is of great importance and it dictates how the women behave. Deidra, the

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biochemistry major from Central California talks about how her experiences differed before she got a boyfriend due to the small community of Africa-Americans:

When you come to college and there is such a small group of your community, word gets around so quickly. So it was like as soon as I stepped on campus, they were like okay avoid him. He's a player. He hits on every freshman. So that's like half the people gone off the list you know. Plus the others that are already taken. So I would say it was pretty difficult. I met a lot of African American friends that were male, but from a dating perspective, you are pretty limited, especially if you are looking for an African-American male. Especially if you are looking for stuff in particular, like if ethnicity is something that is really important to you, like looking for cultural background, like Nigerian. If I was looking for someone Nigerian, it just becomes very limited. And I don't know. I feel like, so many people, have just cycled through the African American males, the ones that were here when I first started. They just passed around. I feel like everyone just kind of dated. Like this one girl dated him, and the next time he was with another girl. So I guess that kind of happens when there are so few people, they just get passed around. I don't know.

In order to navigate an environment with small representation, the women employ their own personal strategies. In order to avoid counterparts with extensive reputations that may impact her homo-social relationships, Destiny, a dark-complexioned, Afro-Latina, Sociology major utilizes incoming students before they have had the chance to gain a reputation:

Every time I mention a guy my friends always like "oh yeah I know him" or my friends will say "well my friend used to," so I give up. That's why when transfers come in, I'm just looking at you all, because no one knows who they are.

The "hook up" culture is prevalent on college campuses. In order to gain entry level status into a potential relationship, some women may participate more vigorously than others due to the imbalanced sex ratio. The imbalance provides an advantage to the men who have more options because of the imbalance. Nicki, an outgoing, sophomore from Central California discusses this process, while also shedding light on the attractiveness of dating outside of campus to combat the effects of reputations:

Like I could choose a lot of men who go to UC Davis, and go down the list of everybody they been with or talk to. And they would be the same group of females that I say hi to everyday, or that I talk to everyday. If there was a STD, if one person in Davis, like one black male or one black female, almost all the black community would be infected. That is how pervasive open relationships are here... have you ever been around a group of girls, and a black male comes around? And he's not necessarily from Davis area; he might come from Sacramento and come to some Davis [events]. But if you see this man come around, all the girls start flocking to this same one dude. And these girls will have no forethought to the fact that every other woman in the room is trying to get with the same dude. And that dude practically has the pick of whichever female he would like. And that's community dick, because there could be one dick and ten girls. And the dude will be able to have his choice, of how long he wants to mess with those girls, if he wants to be in a relationship with one and mess with all the other girls. It's almost like, every guy in Davis, has a harem at his disposal. I feel like the men are grossly outnumbered by women here, and I feel like a lot of times, women accept that fact. And settle for relationships that they don't necessarily want to be in, or agree with being in, just because of the fact that they can say they are with somebody.

In order to avoid the types of men that participate in concurrent physical relationships, all of the women expressed the preference to date someone older than themselves in order to combat the immaturity that can be associated with having multiple partners. The women desire candidates that are already more stable and prepared for more serious relationships. Kandace, an easy going, junior, Human Development major from Southern California discussed her preference for older men:

I think younger are usually more immature than older or not as mature. Like they don't always know what they want and they play games. The older ones they know what they want...And plus the older ones normally have a job, they normally have some income, a vehicle, so yeah stuff like that.

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Similar sentiments were brought up by Sierra, a senior, Sociology major, who is a transfer student from Sacramento:

I've never dated anyone that's younger than me. Usually I date older maybe 2-3 years or something...I never thought why. Like they seem smarter, they seem like they already have everything put together or they have an idea what they want to do. Because I'm so confused so I'm definitely looking for stability I guess.

Another facet of the toolkit that women employ is to skip dating altogether. Focusing on academics or placing an emphasis on personal growth, instead of a relationship. Dating can involve investing energy into someone else without the certainty that may exist if that energy were placed into personal growth or academics. This line of thinking is exemplified by Leslie, an eccentric, mature, sophomore, Art Studio major:

Waiting till after college to focus on [a meaningful relationship]. The thing is people glorify relationships as the end all be all to happiness and I don't see it that way. I don't think a person can fulfill you 100%. I think you'll get 20% of what you want out of a relationship, but you have to give 80% to them. So, I'm not in a relationship or think I have to be in a relationship. I feel like college is the time to figure out who you are. I think if you have a better footing on who you are as a person then you can have a relationship, that's more meaningful. I guess you're still learning about yourself as you get older but I just think you're a little more sure of yourself after college than about who you are now; especially when you come into college saying "man I don't know what I what I want to do, I don't know what I want to do with this major" stuff like that. Things are more uncertain in college than things are outside.

## Discussion

Results from this research suggest that race and ethnicity play an essential role in mate selection. The women who participated in the study do not prefer to date outside of their ethnic groups. While the educated sector of the population across all ethnic groups are the most likely to date outside of their in-group, the results of this study challenge the notion that African-American women struggle with interracial dating due to not fitting the hegemonic

standard of beauty in society. The women seem to have internalized it as a result of their decision not to date interracially, seemingly creating higher standards for non-African-Americans. Even if African-Americans don't fit the standard of beauty, they are making the choice to not date outside their ethnic group based upon their own preferences. While there were several who stated that they dated interracially before, only one was in an actual relationship with someone that was not African-American, and he was Latino. Dating interracially before college, where the likelihood of having an enduring relationship was not as likely, was a common narrative for those who stated that they had dated interracially before. There is a certain level of attraction or desirability and perhaps it is the white counterparts that are not attractive to African-American women. This is most evident in the courting process of African-American women by non-African-Americans. The women seem to subconsciously disregard the subtle courting attempts by non-African-Americans, not taking the attempts seriously or acknowledging the attempts. The actions that are perceived as courting are dictated by the ethnicity of those courting. African-American men are the most likely ethnic group for the women, so their efforts are taken more seriously and the African-American women constrain their own prospective dating pool.

Another interesting theme that emerged when analyzing the data was the different factors that influence the women based on if they are native born Africans or African-Americans. This study shows several differences based on cultural differences between African-Americans and native born Africans. Native Africans look to have a more restricted dating pool, due to family and cultural influence. The participants came from various countries; Kenya, Nigeria and Ghana and they all exhibited similar behaviors. Those from African countries seem to be more connected and attached to their families, so the family's expectations impact who the women would or would not date. African families tend to want their daughters to marry within their specific tribe, which limits who they can date. Families who have assimilated less, do not want their daughters dating at all throughout college but instead want them to focus on their academics. The expectation is that they are immediately married after they have fully completed their education up to the graduate level. Education is extremely important, so the trend of hypogamy—the practice of marrying someone with lower socioeconomic and educational levels, is less likely to occur within those native born African women. In contrast, the majority of the African-American women consider the circumstances of each dating option on a case by case basis in terms of having less formal education, a criminal record or being unemployed. It is those from African countries who would not consider dating anyone—period— if they fit into any of those respective categories. Given the statistics on African-American men and mass incarceration, low levels of college attendance and high unemployment rates (Alexander, 2010), it appears that a fair amount of

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African-American men don't meet the expectations of the native African women, which can have a constraining effect on their dating pool.

#### Future Research

This research could benefit from becoming a longitudinal study. Being able to assess the romantic outcomes of the women who participated over a period of time would allow researchers to observe whether the phenomena continues post-graduation. Also, it would reveal what strategies they employ after they are no longer primarily in a predominantly white institution.

The study could also benefit from being conducted on different campuses to allow for more generalizations regarding the research. Being able to conduct the research at different universities will allow for an analysis into the geographical factors influencing the women. Rural college towns where the city is "built around the campus" will likely produce different results than colleges in an urban, metropolitan area. The surrounding demographic of the campus will also play a role and produce varying results. Areas that have larger African-American populations may impact the dating prospects of the women, due to the research showing that there is a preference to date off campus. For example, the same methodology could be reproduced at a historically black college as opposed to predominantly white institution. Doing a comparative study to analyze how African-American women navigate the different institutions would allow for the prominent themes that are consistent with the respective types of institutions to emerge more easily.

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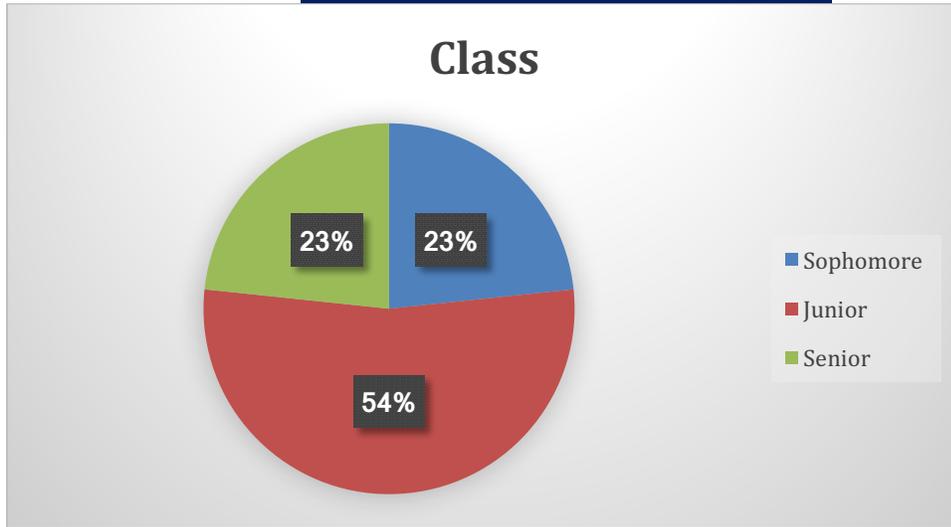
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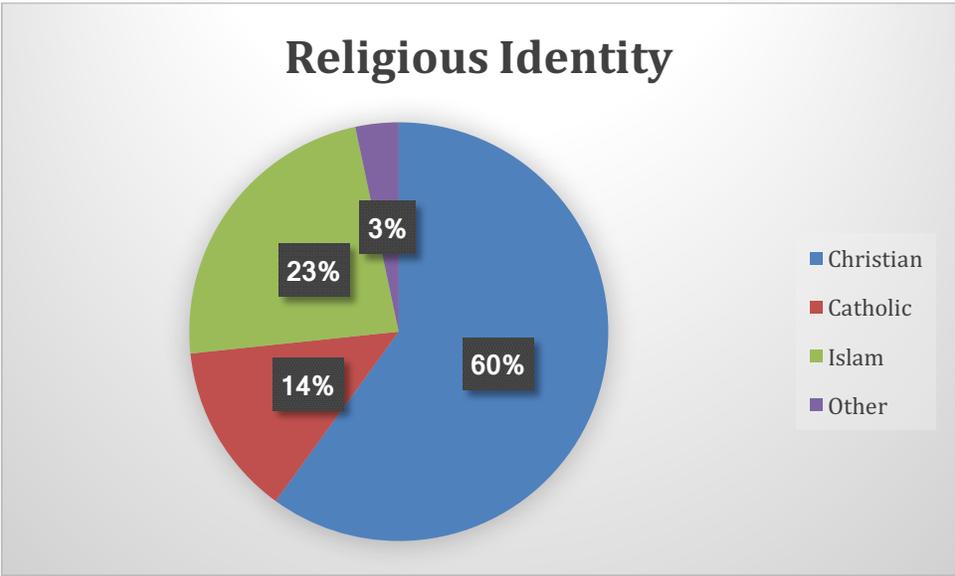
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**Appendix A**

Sophomore	7
Junior	16
Senior	7

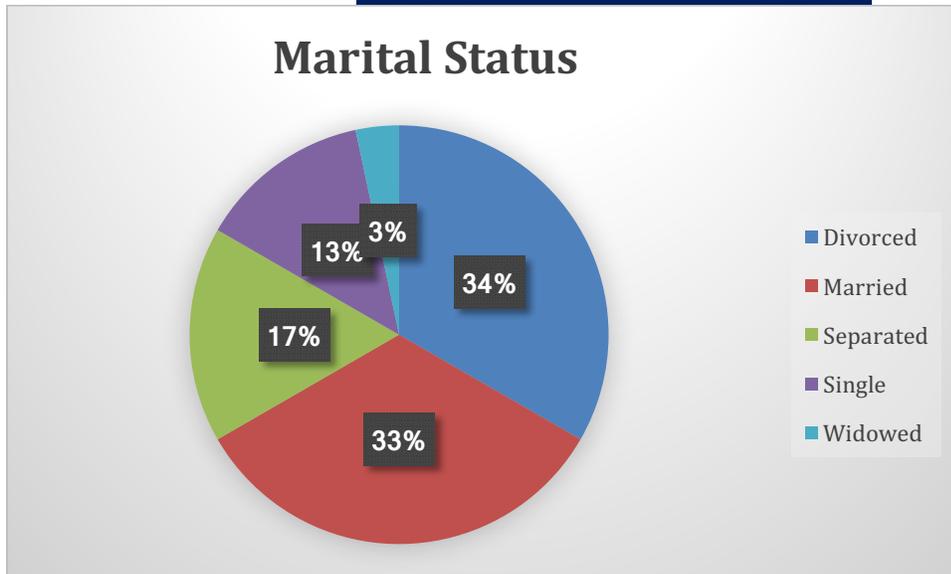


Christian	18
Catholic	4
Islam	1
None	7

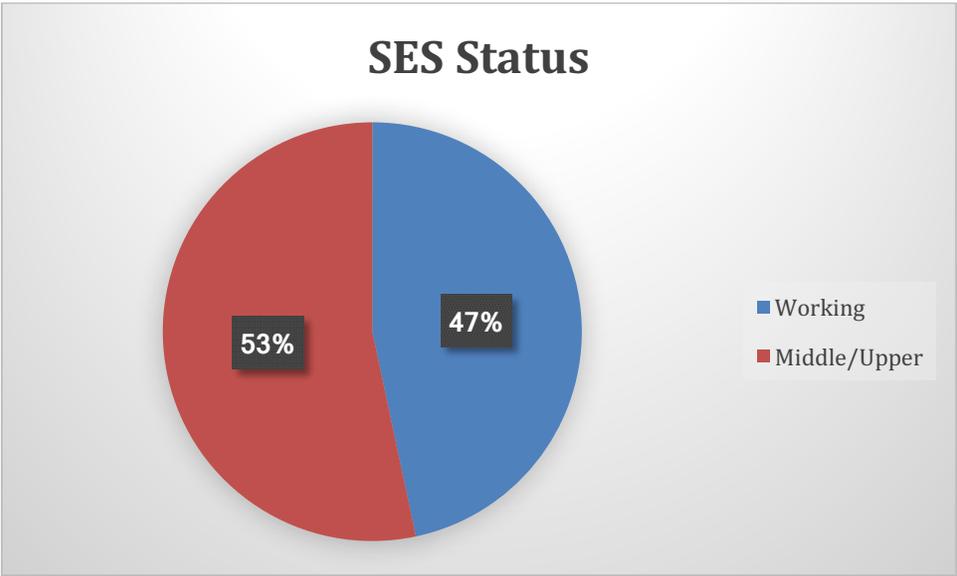


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**Appendix B**

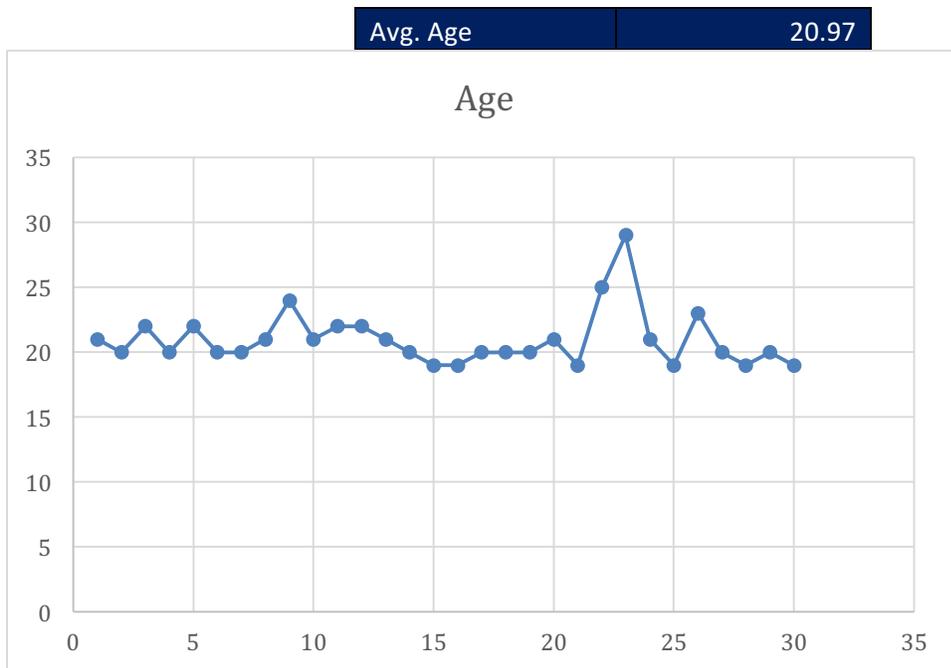
Divorced	10
Married	10
Separated	5
Single	4
Widowed	1



Working	14
Middle/Upper	16



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**Appendix C**



## Appendix D

1. What do you feel about dating (who, when, how)? Explain your overall dating experience while attending University of Arizona?
2. What messages do you hear from your immediate family about dating (who you should date, when you should date, how seriously you should date)?
3. Do family/friends have opinions about who you should date? Have your family and friends ever encouraged you to date different people? Have you ever dated someone that made your family/friends upset? How were they upset? What was the outcome of relationship?
4. How important is it to you that your parents have a good relationship with your partner? Why?
5. Is going to church important to you? Is it important that your mate go to church? Explain?
6. Is it important for you to date someone within your culture? Why?
7. Do you share a similar background (race, class, ethnicity, and neighborhood) with the people you've dated? Explain?
8. In general how often do you see African American men in interracial relationships on campus? In general how often do you see African American women in interracial relationships on campus? Who are most likely to be involved in these relationships when you see them? Explain your thoughts when you see this?
9. Is it important for you to date someone African American? Why?
10. Have you ever dated interracial? If yes, explain experiences? If not, explain why not?
11. Do non-African American people court you? Explain?
12. How does living in an area with 5% African American population impact your dating life? Explain?
13. Have you ever approached someone as opposed to waiting to be courted? Explain why or why not?
14. Have you primarily dated students from on campus or outside the campus? Explain the reasoning behind the preference? Explain where you met your current/most recent partners?
15. Have you primarily dated younger or older counterparts in your relationships? Why?
16. Is there a scarcity of quality potential partners on campus? If so, why? If so, explain your thoughts on this? Is there a competition for them? Are you in competition? Explain how this impacts whom you've dated?

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17. Explain how you view someone with a lesser education? Criminal record? Unemployed? Are people with lesser education, criminal background, and unemployed options for you? Why?
18. Are you interested in having a meaningful relationship in college? Or waiting until after college? Why?
19. What are the most important characteristics in the people you've dated/dating? Which characteristics are you looking for in long term partners?
20. How important is the institution of marriage in society? Why should and shouldn't people get married? Do you plan to get married? What are the reasons that you want to get married? Do you expect to get what you are looking for in marriage?
21. Are your parents married? How has this impacted your outlook on marriage? Partners?
22. How has your outlook on marriage changed as you have gotten older? What was it like before? What factors/things have changed it?
23. How important is it that you meet someone with all your standards? Would you compromise on some of the qualities/expectations?

## Appendix E

1. What do you feel about dating (who, when, how)? Explain your overall dating experience while attending UC Davis?
2. What messages do you hear from your immediate family about dating (who you should date, when you should date, how seriously you should date)?
3. Do family/friends have opinions about who you should date? Have your family and friends ever encouraged you to date different people? Have you ever dated someone that made your family/friends upset? How were they upset? What was the outcome of relationship?
4. How important is it to you that your parents have a good relationship with your partner? Why?
5. Is going to church important to you? Is it important that your mate go to church? Explain?
6. Is it important for you to date someone within your culture? Why?
7. Do you share a similar background (race, class, ethnicity, and neighborhood) with the people you've dated? Explain?
8. In general how often do you see African American men in interracial relationships on campus? In general how often do you see African American women in interracial relationships on campus? Who are most likely to be involved in these relationships when you see them? Explain your thoughts when you see this?
9. Is it important for you to date someone African American? Why?
10. Have you ever dated interracially? If yes, explain experiences? If not, explain why not?
11. Do non-African American people court you? Explain?
12. How does living in an area with less than 3% African American population impact your dating life? Explain?
13. Have you ever approached someone as opposed to waiting to be courted? Explain why or why not?
14. Have you primarily dated students from on campus or outside the campus? Explain the reasoning behind the preference? Explain where you met your current/most recent partners?
15. Have you primarily dated younger or older counterparts in your relationships? Why?
16. Is there a scarcity of quality potential partners on campus? If so, why? If so, explain your thoughts on this? Is there a competition for them? Are you in competition? Explain how this impacts whom you've dated?

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17. Explain how you view someone with a lesser education? Criminal record? Unemployed? Are people with lesser education, criminal background, and unemployed options for you? Why?
18. Are you interesting in having a meaningful relationship in college? Or waiting until after college? Why?
19. What are the most important characteristics in the people you've dated/dating? Which characteristics are you looking for in long term partners?
20. How important is the institution of marriage in society? Why should and shouldn't people get married? Do you plan to get married? What are the reasons that you want to get married? Do you expect to get what you are looking for in marriage?
21. Are your parents married? How has this impacted your outlook on marriage? Partners?
22. How has your outlook on marriage changed as you have gotten older? What was it like before? What factors/things have changed it?
23. How important is it that you meet someone with all your standards? Would you compromise on some of the qualities/expectations?

# Feulgen staining within whole ovules of *Vanilla planifolia* for Confocal Scanning Laser Microscopy



**Caprice Lee**

Mentor: Sharman D. O'Neill, Ph.D.  
Plant Biology

## **Introduction**

Tens of thousands of marginalized smallholder farmers in developing countries, mostly women and indigenous groups, rely primarily on vanilla to generate cash income for basic subsistence living. Many biotic and abiotic stresses affect sustainable vanilla cultivation among these groups, such as pathogen infestations by *Fusarium* and climate change, among others. Despite such challenges and long-standing biological and evolutionary interest, the orchid plant family Orchidaceae remains to be a widely under-investigated lineage. In particular, *Vanilla planifolia*, which has extraordinary reproductive biology and is the second most expensive spice crop in the world, is lacking detailed studies of post-pollination ovule development regarding development of the female reproductive structures, individual generative cells, and the female gametophyte.

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Feulgen staining within whole

In flowering plants the embryo sac is contained in the ovule. This structure is the female multicellular haploid generation in the plant cycle that develops from the process of megasporogenesis (formation of megaspores) and megagametogenesis (formation of the female gametophyte) within the ovule (Grossniklaus and Schneitz, 1998; Yang and Sundaresan, 2000). A single cell with the surrounding nucellar cells differentiates into the archesporial cell, which develops into the megaspore mother cell. This cell enters meiosis and the products of meiosis I are a pair of cells called a dyad (Armstrong and Jones, 2003; Bhatt et al., 2001; Zickler and Kleckner, 1999). In meiosis II, the two cells of the dyad divide and produce a tetrad of haploid spores. In most flowering plants, three of the spores degenerate and the fourth develops into the megaspore. Through a series of subsequent divisions, the megaspore typically gives rise to the 8-nucleate haploid embryo sac (Cooper, 1937; Drews et al., 1998; Grossniklaus and Schneitz, 1998).

Post-pollination ovule development in *Vanilla planifolia*

In *Vanilla planifolia*, macrosporogenesis takes place after pollination of the flower (Yeung and Law, 1997) and the microsporocyte usually results in the formation of a linear tetrad of macrospores. In this case, the chalazal macrospore makes three mitotic divisions, resulting in the eight-nucleate embryo sac which is present in many species in Orchidaceae (Maheshwari, 1937; Swamy, 1947; Yeung and Law, 1997). However, occasionally, the micropylar diad cell does not divide after meiosis I resulting in a linear formation of three macrospores instead of a tetrad. Several observations of the chalazal nuclei degenerating prior to the second division (resulting in a six-nucleate embryo sac) have been made (Pace, 1907, Sharp, 1912; Prosina, 1930; Swamy, 1945, 1947, 1949; Law and Yeung, 1989). A number of authors disagree whether six or eight-nucleate embryo sacs are present in *Vanilla* and if embryology in Orchidaceae is reduced compared to other angiosperms.

These conflicting observations have yet to answer the central question: What is the developmental process of the female reproductive structures (ovule to seed) of *Vanilla planifolia*? How does the embryo sac mature and does endosperm develop? Despite much excellent work on anthesis, oogenesis, and embryology, scholars examining this in *V. planifolia* have not yet fully explored the implications and importance of understanding these processes. Yet, without such an understanding, we are left with an inadequate analysis that creates susceptibility of crop abandonment due to outbreaks of pathogen infestation such as the fungal pathogen *Fusarium*. This study will remedy this gap in the literature by examining embryology in *V. planifolia* to more fully elucidate solutions and help make *V. planifolia* a

more sustainable crop that produces hardier, more disease resistant plants that offer more flavor.

### Staining and Imaging *Vanilla planifolia* ovules

Although many techniques for staining DNA within tissues have been published, few techniques have been documented for staining megasporogenesis and megagametogenesis because of the difficulties in accessing the gametophytic tissue. In particular, ovule types in which multiple layers of epidermis surround the embryo sac make staining of the embedded sporophytic tissue difficult. Golubovskaya and Avalkina (1994) experienced similar difficulties dissecting individual embryo sacs in maize. Techniques involving fixation, embedding and sectioning have also been used to gain access to female gametophytic tissue. However, individual dissections are technically challenging to obtain. Embedding and sectioning are time consuming and damaging and reconstructing viable three-dimensional images is difficult.

Confocal technology (Wilson & Sheppard 1984) can pinpoint optical sections through three-dimensional tissue, thus avoiding artifacts in mechanical sectioning. Stained or unstained ovules in clearing fluid can be studied individually. Fredrikson et al. (1988) imaged autofluorescence in fixed, unstained ovules of *Dactylorhiza maculata* using Herr's clearing fluid (Herr 1971). Additionally, Ovules of *Arabidopsis* have been stained for confocal techniques using Feulgen staining with Schiff's reagent (Barrell and Grossniklaus, 2005). Schiff's reagent covalently binds DNA in a quantitative way (Chieco and Derenzini, 1999; Hardie et al., 2002). Here follows our investigation of Feulgen staining procedure and Herr's clearing techniques for *Vanilla planifolia* confocal analysis to optimize imaging of female gametophyte development.

## Methodology

### Plant Material

*Vanilla* fruits were collected from UC Davis conservatory. Flowers were manually pollinated by moving the rostellum (flap of tissue between the pollinia and stigmatic surface) using a dissection probe. Pollinated fruits were recorded and tagged. Fruits were harvested based on successive maturation times and imaged to capture different stages of maturation relative to time after pollination.

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 Fixation

Dissected sections of fruits were fixed in .2% Paraformaldehyde (PFA) in phosphate buffered saline (PBS) at pH 7.4 for 24 hours and then dehydrated in and stored at 70% ethanol. Formaldehyde fixatives are crosslinking fixatives act by creating covalent chemical bonds between proteins in tissue. This anchors soluble proteins to the cytoskeleton, and lends additional rigidity to the tissue. Aldehyde fixatives also, however, impart fluorescence to tissues as well.

### Feulgen Staining

<b>Procedure for Version 1</b>	<b>Duration</b>
Rehydrate tissue in 50% ethanol (2x)	30 minutes each
Rehydrate tissue in 30% ethanol	2 hours
Rehydrate tissue in 15% ethanol	2 hours
Incubate tissue in 1N HCl at 60C	30 minutes
Stain with Schiffs Reagent (cat. no. S5133; Sigma, St Louis, MO, USA)	45 minutes
Wash with De-ionized water (3x)	1hour each
Incubate in SO <sub>2</sub> water at room temp.	5 minutes
Dehydrate tissue in 15, 30, 50, 70% EtOH	1 hour each
Dehydrate tissue in 95, 100, 100% EtOH	2 hours each
Transfer to BB-4 ½ clearing solution	Overnight
Mount in welled slide with .01% calcofluor + ring	

Ovules were incubated in SO<sub>2</sub> water at room temperature for 5 minutes. SO<sub>2</sub> water is comprised of water, potassium, metabisulfite and 1N HCl. BB-4 ½ clearing solution is comprised of lactic acid, phenol crystals, zylene, clove oil and chloral hydrate

### Confocal Microscopy

A Zeiss LSM710 was used to analyze samples. Feulgen-stained material was viewed with either 40 or 63X oil immersion lenses. Excitation wavelength was 488 nm, and emission light was

detected between 640 and 740 nm. Pictures were recorded at 512 x 512 or 1024 x 1024 pixels. Sections in Z of approximately 100 nm were recorded.

## Results

0 weeks after pollination

Figure 1A shows primordial ovules in which the cell walls are fuchsia colored and nuclei are colored red.

**Figure 1: 0 weeks after pollination**

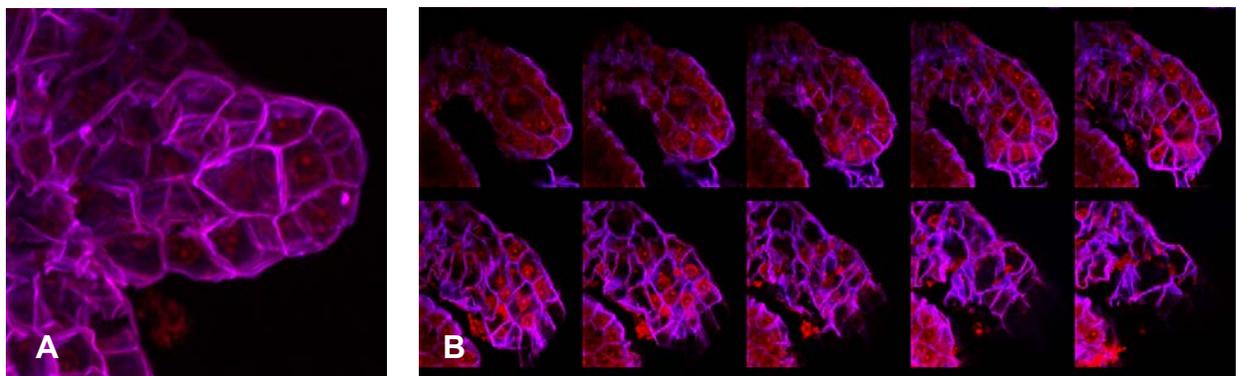


Figure 1. Nacient ovules fixed in .2% PFA in PBS pH 7.4 and stained using the Feulgen Technique. A: projection of single ovule. B: z stack of an unpollinated ovule.

2 weeks after pollination

Figure 2 shows ovule development 2 weeks after the flower was pollinated. Here we see cell walls colored blue (figure 2B). Nuclei and other cellular constitutes colored red (figure 2C). Possible tetrad cells can be seen in the overlaid images (figure 2A) as well as in figure 2B.

**Figure 2: 2 weeks after pollination**

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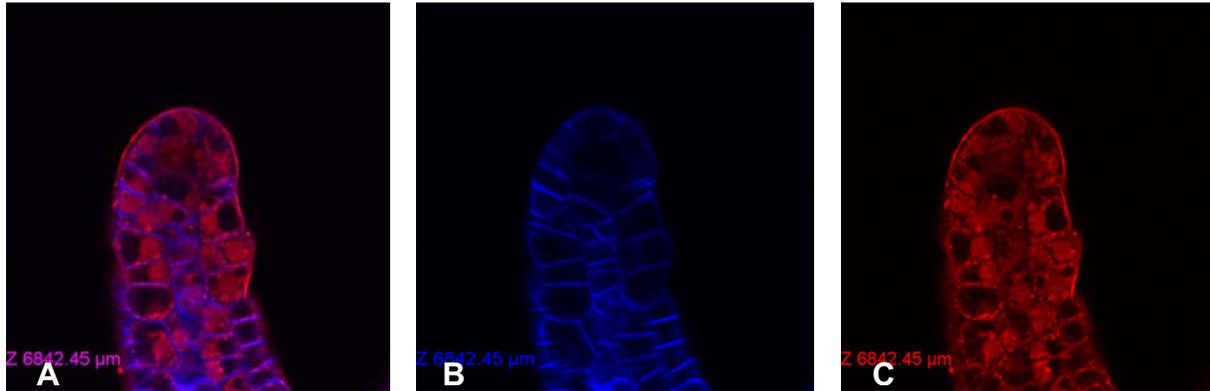


Figure 2. Ovule fixed in .2% PFA in PBS pH 7.4 and stained using the Feulgen Technique.

6 weeks after pollination

*Vanilla planifolia* ovules 6 weeks after pollination and stained using the feulgen technique appear in figure 3. Figure 3A and 3B show nuclei colored red, clearly defined funiculus and distinct cell layers. Figure 3A shows a unique structure which was stained very well. Upon looking for autofluorescence, figure 3B shows a sheath around the wells stained structure found in figure 3A.

**Figure 3: 6 weeks after pollination**

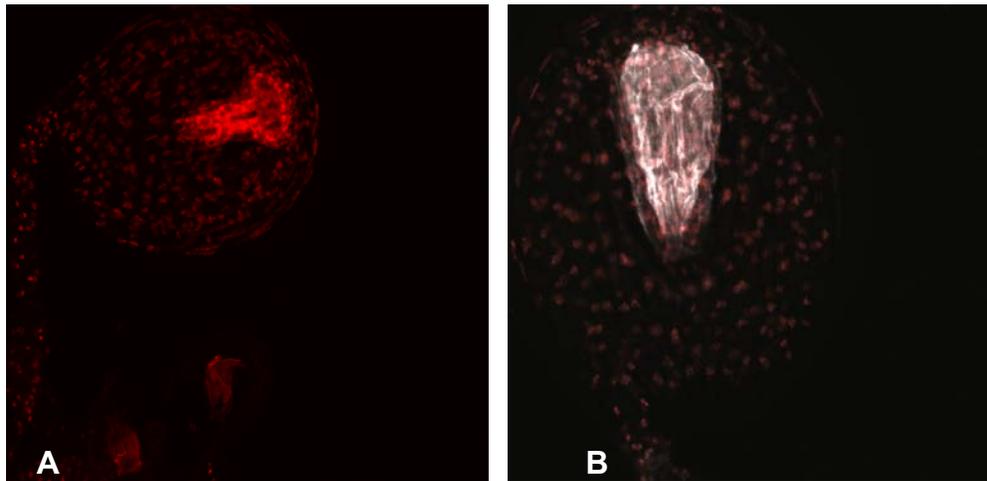


Figure 3. Ovules fixed in .2% PFA in PBS pH 7.4 stained using the Feulgen technique. Cell wall staining inconsistent but nuclei stained well for both. A. Confocal projection showing well stained body within ovule. B. Autofluorescence revealing wrinkled sheath around well stained body.

## Discussion

Confocal images produced from 0 weeks after pollination (Figure 1) show cell walls as well as nuclei. The tissue is not yet an ovule, but rather a mass of primordial cells that stain can easily access. The acquired images show cells in layers and a central nuclei that may prove to be the archesporial cell.

A possible tetrad of cells can be seen in the confocal images produced from ovules 2 weeks after being pollinated. Figure 2C shows that more than just the nuclei were stained when using the feulgen technique. Because aldehyde fixative impart fluorescence, it is possible that the excess fluorescence is due to the fixation methods.

Imaged ovules that were 6 weeks old after pollination exhibit a peculiar well-stained structure within the ovule. Individual cells could not be made out and there is no literature from which to reference this finding. Further analysis is needed to elucidate the importance of this structure in the developmental process of *Vanilla planifolia*.

A method for staining Vanilla reproductive tissue using Feulgen staining with Schiff's reagent is described here, optimized for identification of cell types in conjunction with confocal microscopy. Tissue can be examined in a series of optical sections using confocal microscopy. The Schiff's-based method utilizes longer depurination steps of tissue using HCl. Later we will assess embedding the tissue in immersion oil after alcohol dehydration. This helps to remove excess, nonbound Schiff's reagent within the tissue.

## Conclusion

Future research will include propidium iodide staining technique. The stained tissue will be observed with a 63X glycerol immersion lens with excitation by a 543 nm laser, and detection between 580 and 700 nm. Additionally, Vanilla fruit will be analyzed for pollen tube development and endosperm development will be assessed.

There are many implications regarding this research. The first is to advance crop improvement. With climate change and crop diseases such as Fusarium, it is important to use traditional and modern plant breeding techniques to develop varieties of vanilla with fruits with enhanced flavor and increased abiotic and biotic stress resistance. This research is also

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important for enhancing foundational scientific and technological understanding regarding embryological studies as well as confocal microscopy.

This research will help develop sustainable vanilla cultivation among tens of thousands of marginalized small producers in developing countries, mostly indigenous groups, who rely primarily on vanilla cultivation to generate income for basic subsistence living. Madagascar, one of the major suppliers of vanilla to the world, is a primary example. Initially a part of the landmass that would become India, the island was detached by tectonic plate movement 88 million years ago. Due to its isolation, 90 percent of Madagascar's flora and fauna are endemic, meaning they can only be found on the island. Vanilla is an orchid vine that grows up trees. Therefore, it is a non-timber crop that maintains habitat and can even buffer protected areas. Increasing our understanding of the mechanisms of *V. planifolia* reproduction will help to improve the viability of sustainable vanilla cultivation and aligns with environmental and biodiversity conservation projects.

## **Acknowledgements**

I would like to thank my mentors, Professor O'Neill, Professor Jernstedt and Dr. Little for all of their help and support. Also, UC Davis, the McNair Scholars Program and the Howard Hughes Medical Institute.

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# Investigating Efficient Environments to Burn Glycerol



**Obdulio Ochoa**

Mentor: Benjamin D. Shaw, Ph.D.  
Mechanical and Aerospace Engineering

## **Abstract**

*The purpose of the project is to identify possible processes that will burn glycerol faster and efficiently to minimize the accumulation of the by-product in a combustion chamber while implementing the use of thermocouples to improve the accuracy of temperature readings. The problem is that glycerol is a very viscous compound that does not gasify quickly due to its low heat of combustion. This research will attempt to decrease glycerol's viscosity by mixing the glycerol compound with propanol using a process called blending. By blending glycerol with propanol, the auto-ignition temperature of the overall compound is lowered making the glycerol into a more burnable and droplet-like compound and increase its solubility. Precise methods for measuring temperature could be implemented including using Arduino and thermocouple technology to acquire accurate temperature readings. So far, accurate and reliable data does not exist on the gasification of glycerol in a peer reviewed paper. Therefore, this research would offer insightful data about a different glycerol*

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*gasification/burning process along with reliable data. Through the research experimentation, the temperature readings attained can be used in the development of engine environments that would allow a quicker burning of glycerol so that acidification consequences are minimized and a more efficient engine can be developed. The conclusions attained will determine the most efficient and ideal environment for the burning of glycerol and serve as a tabulated reference for properties of glycerol not yet explored.*

## **Introduction**

Glycerol is a compound that is difficult to burn due to its high auto-ignition temperature; further complication arises from its high viscosity. Interest in burning glycerol has grown because it is the main byproduct when biodiesels are consumed. The purpose of this research project is to identify possible processes that will burn glycerol efficiently and thus maximize the use of glycerol as a by-product. One possible use for glycerol is for the compound to act as an onsite fuel for heat or power generation. Achieving this feat could potentially decrease fuel consumption of a given engine and increase its efficiency. In order for this to be made possible, one needs to explore the environmental conditions necessary to burn glycerol efficiently.

Many fuels today have a low auto-ignition temperature that allows for a fast and sometimes clean burning of the fuel. At 360 Celsius, the auto-ignition temperature of glycerol is high compared to fuels like diesel and kerosene whose auto ignition temperatures have been found to be 210 C and 280 C (M D Bohon and W L Roberts). A fuel needs to produce more heat energy at the time of ignition than the amount of energy spent to burn the fuel to be an effective and efficient fuel source. Glycerol is known to have a moderate heating value of about 16 MJ/kg; in the past, this relatively low heat discouraged research into exploiting this compound as a fuel. (Myles D. Bohon et al.) The abundance of this byproduct in the burning of biofuel make it an appealing and well-worth effort to find a use. It was previously thought that burning glycerol was a dangerous process because of the belief that it released highly toxic fumes into the ambient and was concluded that it might have more negative repercussions than benefits. This concern arose since the chemical compound of glycerol highly resembles that of acrolein, an unstable form of carbonyl (Myles D. Bohon et al.). In the same paper, these concerns were discarded as no longer viable, opening the door for research into the use of glycerol as fuel.

## Methodology

This research project aims to find the ideal temperatures and environments in which glycerol can be burned and efficiently exploited so that different uses for its internal energy could be found. The procedure to be used is similar to that of Professor Benjamin D. Shaw from the Mechanical and Aerospace Engineering Department at the University of California Davis. The setup consists of a high capacity furnace that can reach temperatures upwards of 800 Celsius. Further investigation of engine temperatures and environments will be researched and replicated so that actual, rather than solely, ideal environments could be explored.

The temperature readings of the ambient temperature will be made using type-K thermocouples exposed to the environment of the furnace. Furthermore, to increase the accuracy of the data and results of the experiment, the thermocouple will be used to actually measure the inner radius temperature of the glycerol droplets. This would allow a more concise data set such that the actual temperature of the glycerol is known as a function of time. Furthermore, this setup will allow for the tabulation of heat properties of glycerol that have not yet been explored. The potential return of this experiment can be seen having some immediate benefits and contributions to the field as well as long term benefits and data that can be used to further explore engine efficiencies.

Glycerol will be manipulated such that this compound will be researched in droplet form. This follows the example of the gasification of sulfuric acid droplets experiment by Dr. Benjamin D Shaw. It was found that by studying individual droplets one could more accurately acquire data. The droplet form of the compound would be placed on a thermocouple so that the temperature of the glycerol droplet before any burning occurs can be read and tabulated. The thermocouple, attached to a simple one degree of freedom piston would be lowered into the furnace opening until it is fully emerged into the furnace. All the while the thermocouple will be constantly read to attain temperature readings throughout the experimentation process. To further improve the project's data, a camera will be used to record the burning and gasification of the compound and accurate measurement of the droplet can be made. Another functionality of the camera is to attain a sense of how fast the droplets burn so that this data can be later used. The droplet's radius or diameter can then be compared with time in a graph to help find insightful data as to whether glycerol burns exponentially or linearly. By understanding the rate of droplet size decrease at a given temperature, one can extrapolate the most efficient burning size of these droplets which can be used in fuel-injection engines.

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**Figure 1: Thermocouple attached to end of piston**



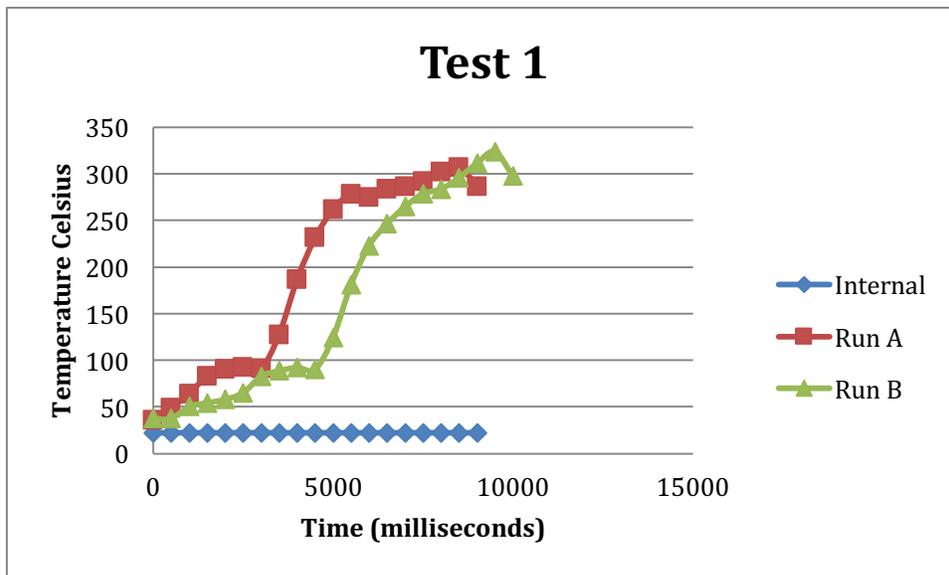
This accurate reading of temperature can be achieved using Arduino technology along with the thermocouples. Depending on the thermocouple type, the temperature readings with respect to time can be linear. The size and material makeup of a thermocouple determine the accuracy of the readings. An interface is also required to successfully and efficiently translate and log temperature readings into usable data. Research into the technology revealed that Arduino has an adaptation that sends electrical signals and pulses that can be read by a computer program giving temperature readings as a function of time. This technology will be imperative in attaining the desired results with a high degree of accuracy such that the data can be publishable and usable.

## Results

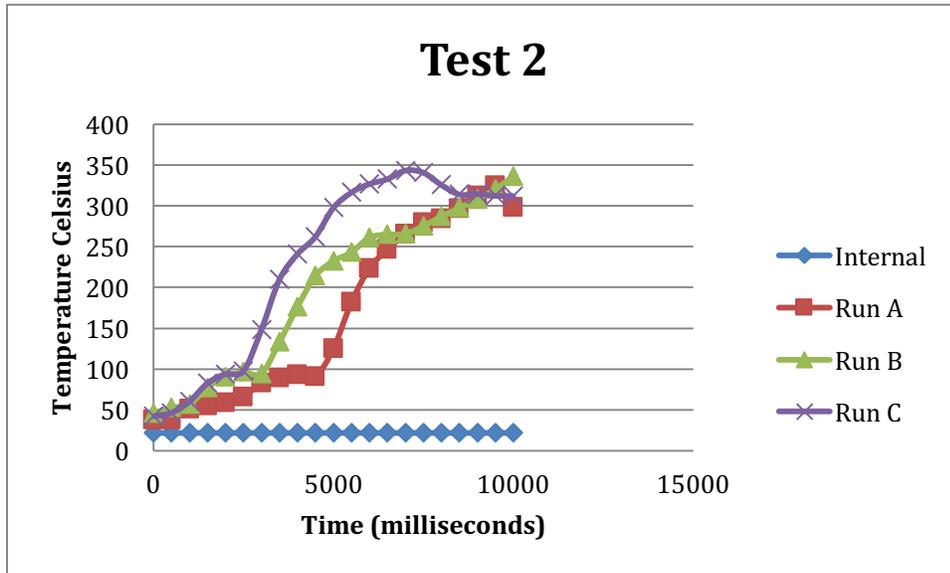
**Table 1: Content Detail by Test**

Test #	1	2	3	4	5	6	7	8	9
Propanol	100%	90%	80%	60%	50%	40%	20%	10%	0%
Glycerol	0%	10%	20%	40%	50%	60%	80%	90%	100%

**Figure 2: Temperature Readings – 100% Propanol & 0% Glycerol**



**Figure 3: Temperature Readings – 90% Propanol & 10% Glycerol**



**Figure 4: Temperature Readings – 80% Propanol & 20% Glycerol**

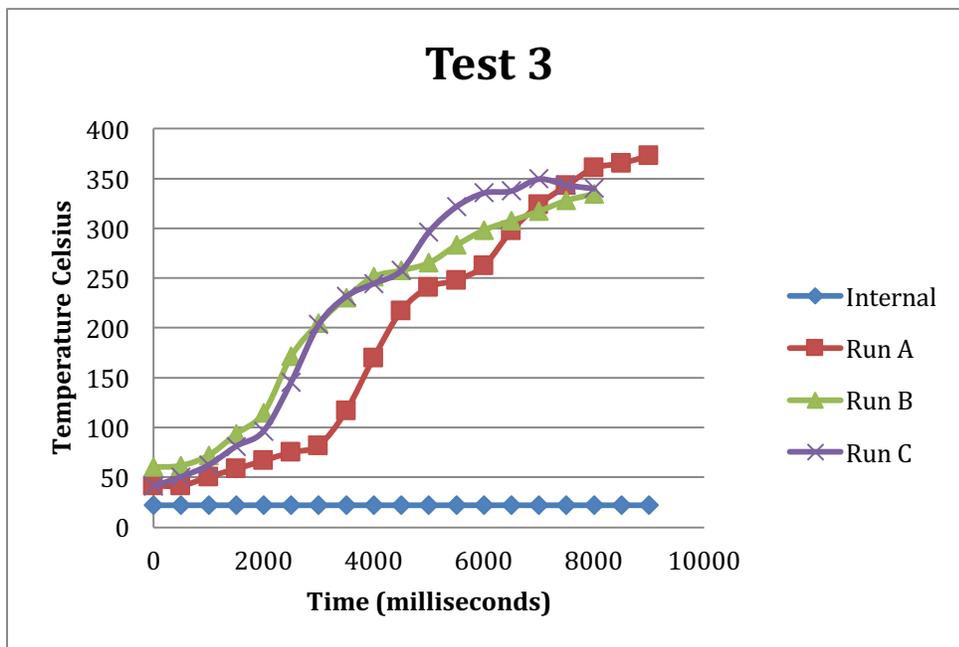


Figure 5: Temperature Readings – 50% Propanol & 50% Glycerol

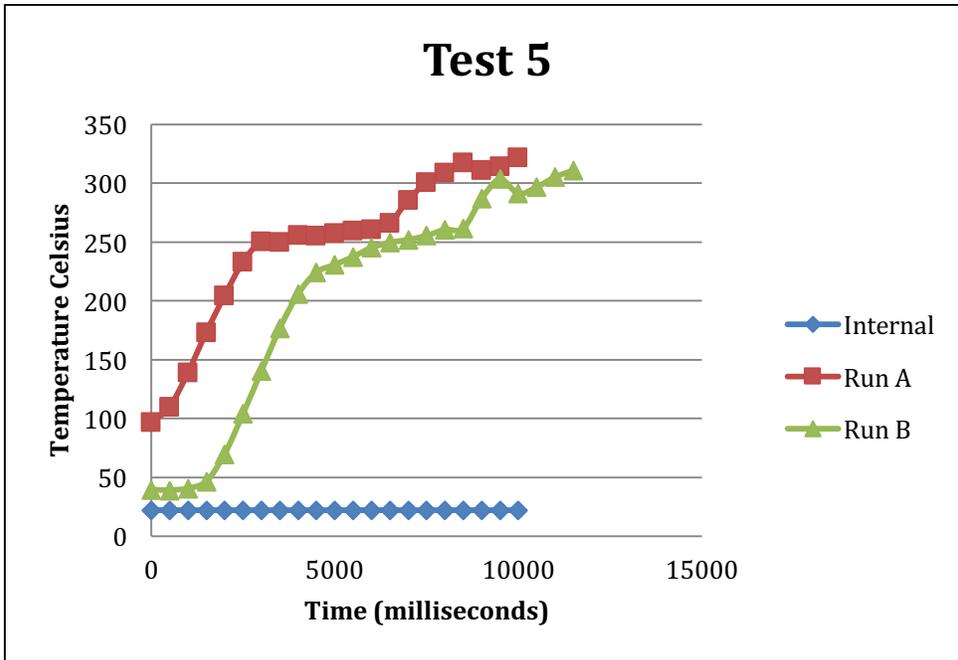
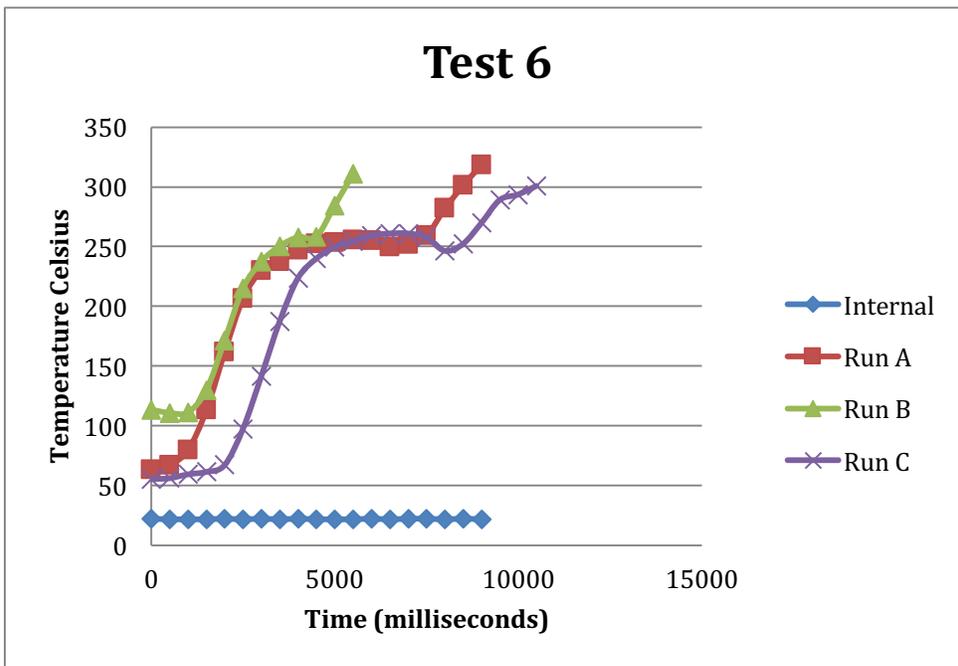
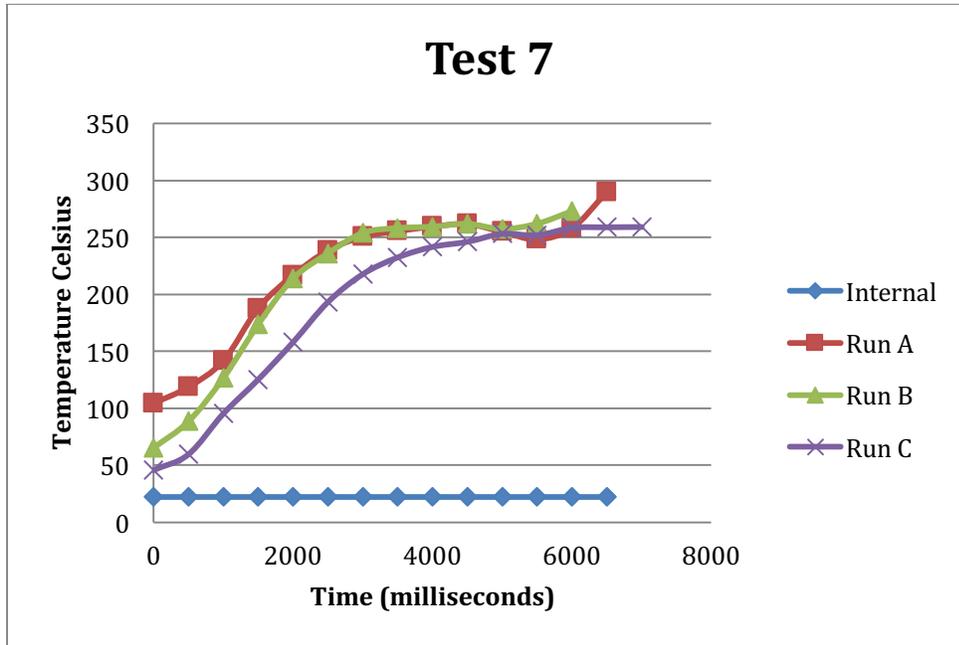


Figure 6: Temperature Readings – 40% Propanol & 60% Glycerol



**Figure 7: Temperature Readings – 20% Propanol & 80% Glycerol**



**Figure 8: Temperature Readings – 10% Propanol & 90% Glycerol**

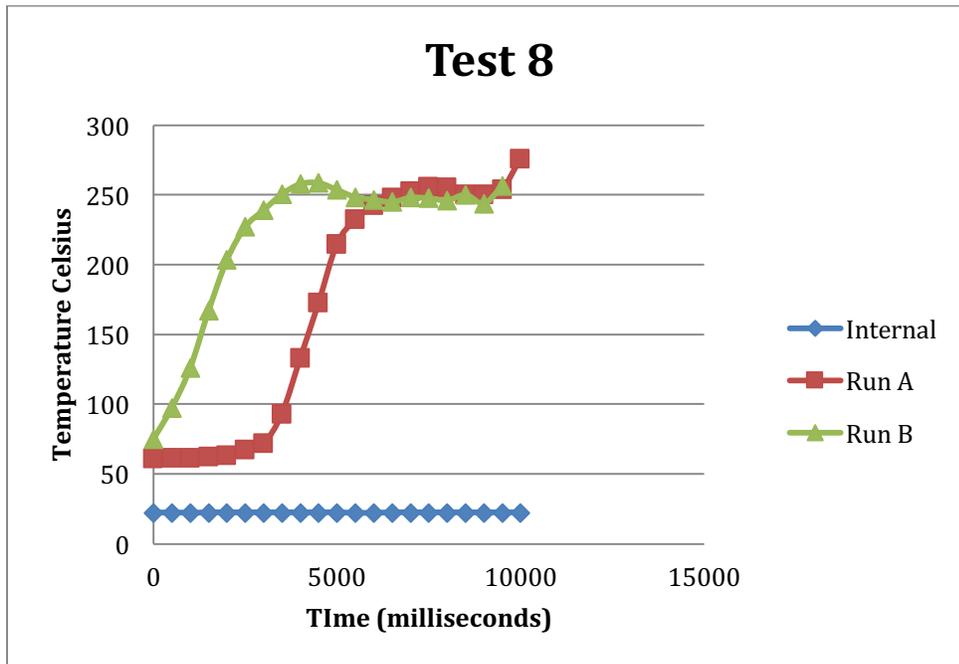
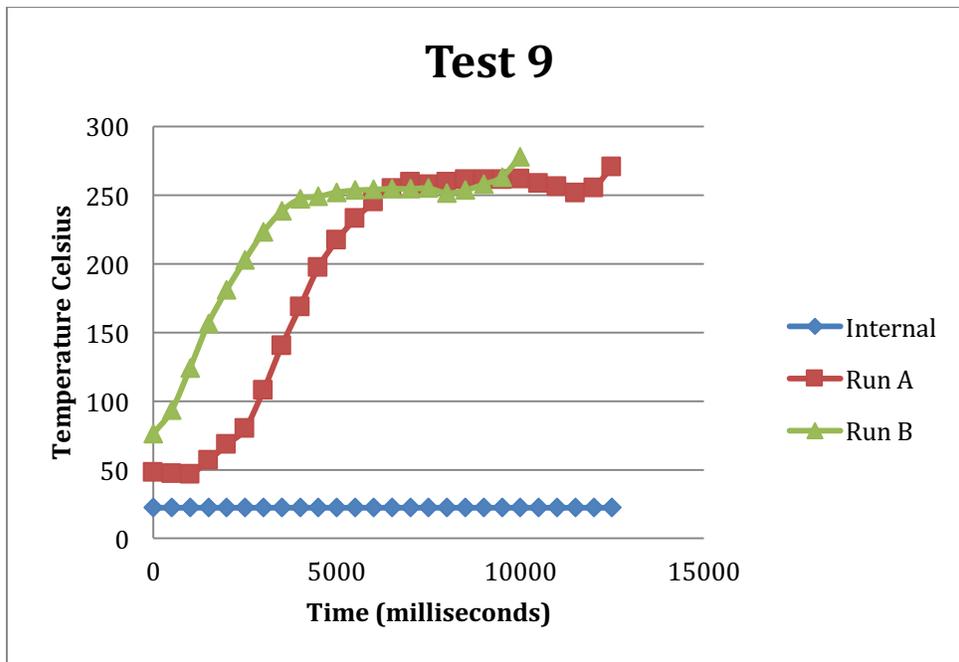


Figure 9: Temperature Readings – 0% Propanol & 100% Glycerol



## Discussion

The internal temperature refers to ambient/room temperature at which the Arduino microcontroller was exposed to. From the results, one can see that the internal temperature for each trial was at a constant 22 degrees Celsius. As expected, the temperature readings for Test 9 are lower than that of Test 1. This is attributed to the fact that Test 1 is entirely propanol and Test 9 consists of only glycerol and is consistent with what was previously discussed; glycerol has a lower energy output than propanol.

The results do not show consistent temperature readings. As can be observed, for example, the results for Test 7 vary much less than the results attained for Test 8. These inconsistencies can be attributed to many factors, some of which are later discussed. Furthermore, all the tests seem to follow a similar pattern. The temperature curves plotted behave and look like cubic curves. The first spike in temperature may be the temperature adjustment from the differential of the at-room-temperature thermocouple and the heat furnace. It is hypothesized that the plateau that the curves hit is the point of auto-ignition of

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the compound tested. The exothermic reaction taking place is constant and thus should not burn at higher temperatures than that observed. The beginning of the second spike in temperature is then correlated with the time at which the compound has been completely ignited. At this point, the thermocouple is reading the furnace temperature. Although the results attained may be inconclusive, by performing similar, repeatable experiments at different furnace temperatures one could extrapolate time required to completely burn a droplet of each compound. The following is a discussion of errors and complications that arose during data collecting.

One systematic error faced had to do with proper alignment of the droplet to the camera line of sight and could not be efficiently achieved. The wire used for the thermocouple was thin and could not be properly deformed to attain the desired shape that would hold a glycerol droplet. This hindered the collection of data because without proper thermocouple wire configuration, accurate droplet temperature readings could not have been guaranteed. There were times were instead of taking droplet readings, furnace environment temperature readings were taken instead.

This was attributed to bending that occurs when a metal is exposed to high temperatures. Thus, it was difficult to achieve a properly placed droplet at the end bead used to take the temperature reading. Further, another complication to the experiment was the size of the bead at the end of the thermocouple. Although the thermocouples that were used were made of thin wire, the bead at the temperature-reading end was comparatively large to the droplet size. This size difference incurred improper temperature readings by the glycerol droplet thermocouple. At the beginning of each run, it was observed that the bead was exposed to the environment rather than being entirely engulfed by the glycerol droplet.

From this systematic error, another inaccuracy was discovered. Although the temperature inside of the furnace was set at about 800 C, the thermocouple readings would suggest a temperature of no more than ~450 C. This led to hypothesize that the temperature control of the furnace was malfunctioning. It was noted that the camera openings in the furnace greatly contributed to the unexpected temperature reading.

To help solve this error, modifications to the furnace were made. The ceramic tube openings extruding from the furnace were removed and in their place a glass window was installed. After this modification, temperature readings were found to be closer to the expected furnace temperature, but not exactly the same. The error in the temperature reading was now attributed to the opening on the top of the furnace. To prove this hypothesis, several

thermocouples were used to take the temperature readings and they all showed a gradient of unexpected cooler temperatures the closer the probe was to the top opening. To have a complete set of data, three temperature reading must be taken:

- 1) Set furnace temperature.
- 2) Glycerol droplet thermocouple temperature reading.
- 3) Environment thermocouple temperature reading.

Lastly, the compounds used for each of the trials were not at their prime. It is important to note that the compounds had not been recently mixed. This is a problem because the older that a mixture is, the more impure it becomes and does not have the balance of each compound desired.

## **Conclusion**

The purpose of the experiment was to produce a tabulation of thermodynamic properties of glycerol. Although this goal was not achieved, important methodology processes were learned that will aid in future experiment runs. The results attained showed a higher temperature reading the more that the compound was composed of propanol rather than glycerol. This is consistent with other findings and with the conclusion that glycerol has low energy output. Implementing this experiment in various furnace temperatures can prove much more effective and would allow for much more conclusive results and discussion. Although the temperature measurement method is noble to the experiment setup, a more consistent process needs to be adapted with the same hardware in order to attain better results.

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# Scared to Death: Anti-Communist Rhetoric and Promoting Fear in California



**Scott Pittman**

Mentor: Kathryn S. Olmsted, Ph.D.  
History

In 1948, the Los Angeles Times reported that a local student had been literally “scared to death” by communist indoctrination.<sup>1</sup> The bizarre circumstances surrounding Everitt Hudson’s death sparked fear and paranoia amongst anticommunists. In response, the California State Senate Fact-finding Committee on Un-American Activities began a two-year investigation into communist indoctrination within schools.<sup>2</sup> Anticommunists in California heralded Hudson’s death as the worst-case scenario attributed to communist indoctrination. Their fear of the Red Menace’s potential to devastate American institutions caused many Californians to practice what historian Richard Hofstadter describes as the “paranoid style.”<sup>3</sup> Anticommunists used Hudson’s death to argue that communists were indoctrinating children with their degraded morals and values.<sup>4</sup> Through investigating Hudson’s death, anticommunists hoped to understand the process by which communists were recruiting and

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<sup>1</sup> “Fear of Reds May Have Killed Youth,” *Los Angeles Times*, December 15, 1950.

<sup>2</sup> *Ibid.*

<sup>3</sup> Richard Hofstadter, *The Paranoid Style in American Politics* (New York: Vintage Books, 1965), 32.

<sup>4</sup> Lionel S. Lewis, *Cold War on Campus: A Study of the Politics of Organizational Control* (New Brunswick: Transaction Books, 1988), 101.

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indoctrinating California's impressionable youth. In particular, the committee believed it could discern the recruitment and indoctrination methods through correspondence between Hudson and his family and friends.<sup>5</sup> Although Everitt Hudson's death was tragic and premature, anticommunists used it to promote their paranoid, hyperbolic rhetoric about the dangers of communist infiltration in California schools, which resulted in the persecution of numerous educators.

Anticommunists have sought to eradicate communism in the United States, especially in California, since the 1917 Bolshevik revolution in Russia. Because of their connection to the Soviet Union and policies of secrecy, American communists were believed to be part of an illegal conspiracy to overthrow the United States government. This belief caused many to consider communism alien to American ideals and values and in need of eradication, which gave rise to the anticommunist movement.<sup>6</sup> According to Hofstadter, anticommunists' "central image is that of a vast and sinister conspiracy, a gigantic and yet subtle machinery of influence set in motion to undermine and destroy a way of life."<sup>7</sup> Anticommunists particularly worried about education, so legislative bodies began implementing loyalty oaths and/or investigative committees to root out subversives during the first red scare that followed World War I. Loyalty oaths targeted the academic profession as a whole while investigative committees targeted specific individuals or institutions. However, this initial panic subsided after a few years only to reemerge during the Great Depression.<sup>8</sup>

In California, the state legislature established a committee in 1939 to investigate communist infiltration in the State Relief Administration, but this new committee would quickly adopt a new modus operandi.<sup>9</sup> In January 1941, two resolutions were introduced calling for the creation of an investigation into possible infiltration of subversives within California's education system. While constructing a single resolution, the Assembly Rules Committee placed a substantial emphasis "on charges of communist activity at the University of California."<sup>10</sup> The committee, however, had little impact on education until it began its in-depth investigation into communist indoctrination prompted by the death of Everitt Hudson.

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<sup>5</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 81-83.

<sup>6</sup> Ellen Schrecker, *Many Are the Crimes: McCarthyism in America* (Princeton, New Jersey: Princeton University Press, 1998), xiv-xv.

<sup>7</sup> Richard Hofstadter, *The Paranoid Style in American Politics* (New York: Vintage Books, 1965), 29.

<sup>8</sup> Ellen Schrecker, *No Ivory Tower: McCarthyism & the Universities* (New York: Oxford University Press, 1986), 68-69.

<sup>9</sup> Senate Fact-finding Committee on Un-American Activities, "Un-American Activities in California: 6-7 1951-53" (Sacramento, California: California Legislature, 1951-53), 1.

<sup>10</sup> Edward L. Barrett, Jr. *The Tenney Committee: Legislative Investigation of Subversive Activities in California* (Ithaca, New York: Cornell University Press, 1951), 12-13.

Anticommunists chose to investigate and analyze Hudson's death because it seemed to offer definitive proof of communist indoctrination. The California Senate's Un-American Activities Committee analyzed Hudson's death as a case study of indoctrination, and the members anticipated it would illustrate the nefarious nature in which communists recruited and indoctrinated California's youth.<sup>11</sup> The committee set out on a two-year investigation collecting facts and background evidence "to obtain the story of his indoctrination with Communism at Stanford University and at U.C.L.A."<sup>12</sup> Through this investigation, the committee used Hudson's letters to establish a timeline, and it used his own words as irrefutable proof of his indoctrination. Moreover, the committee introduced into evidence 35 books of so-called subversive literature.<sup>13</sup> According to the committee's Chief Counsel, Richard E. Combs, the books "are referred to and offered as exhibits for the purpose of linking them up to [Hudson's] ideological development during this period."<sup>14</sup> With this evidence, the committee believed it uncovered the Communist Party's methods of indoctrination, and it analyzed other cases using these techniques as its base, which allowed it to conclusively argue that indoctrination occurred in the same manner every time.<sup>15</sup>

The Senate report laid out Hudson's upbringing in detail, especially his final two years. Hudson grew up in a middle-class household in Los Angeles with parents who provided a strong, stable home for their son.<sup>16</sup> Indeed, the committee claimed that Hudson "was raised under almost ideal circumstances and his home was an example of an average American home."<sup>17</sup> The committee implied that since Hudson was an average or typical American, communist indoctrination could happen to anyone. He attended University High School in Los Angeles where, the committee notes, he began the process of his indoctrination: he started receiving readings from his teachers about leftist values and ideas.<sup>18</sup> Yet, at this time, his parents were not overly concerned because they were Democrats and considered themselves liberal thinkers, so they encouraged Hudson to obtain the best education possible.<sup>19</sup> The next step in Hudson's indoctrination occurred while attending Stanford

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<sup>11</sup> Senate Fact-finding Committee on Un-American Activities, "Un-American Activities in California: 6-7 1951-53" (Sacramento, California: California Legislature, 1951-53), 127.

<sup>12</sup> *Ibid.*, 103.

<sup>13</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 24-26.

<sup>14</sup> *Ibid.*, 26.

<sup>15</sup> Senate Fact-finding Committee on Un-American Activities, "Un-American Activities in California: 6-7 1951-53" (Sacramento, California: California Legislature, 1951-53), 127.

<sup>16</sup> *Ibid.*, 102-3.

<sup>17</sup> *Ibid.*, 102.

<sup>18</sup> *Ibid.*, 103.

<sup>19</sup> *Ibid.*, 103.

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University, but he earned a short reprieve when the Army drafted him in April 1946.<sup>20</sup> But, according to the committee, his time in the military only made him more desirable to communists. When he returned to Stanford, Hudson had learned several languages. Combs testified, “[H]e was unusually proficient in languages, speaking Japanese, Russian, some Chinese, Spanish, some French, and I believe some Italian.”<sup>21</sup> Some of the languages he acquired before the military; the others he studied at the Military Intelligence Language School in Monterey, California.<sup>22</sup> According to the committee, it was Hudson’s unique ability to master languages that made him desirable to the Communist Party seeking his rapid political indoctrination.<sup>23</sup> Thus, the committee contended that the bulk of his indoctrination occurred when he returned to Stanford.

According to investigators, upon his return to Stanford, he started to read and learn all about communism and its dark secrets.<sup>24</sup> Hudson was reading Marx, Lenin, Stalin, and much more. But the more he learned about communism, the more depressed he became. Ultimately, his depression led him to transfer to UCLA, according to his father. William A. Hudson told the committee that “he felt his son was trying to get away from the Communist influences at Stanford, and that he recalled the boy having told his mother that he was indoctrinated with Communism at Stanford” (Committee’s Italics).<sup>25</sup> Yet, if Hudson transferred to escape communism, his actions did not reflect that fact. As at Stanford, he became involved with leftist organizations such as Young Progressives of America, American Youth for Democracy, and Students for Wallace.<sup>26</sup> Combs argued that Hudson’s indoctrination was so engrained that he had little trouble identifying and connecting with student communists at UCLA.<sup>27</sup>

Nevertheless, Hudson’s parents did have cause for concern because of a macabre letter he wrote to them. In a letter from February 1948, Everitt Hudson made an eerie request: “If I should die in any manner please give my body promptly to one of the college medical

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<sup>20</sup> Senate Internal Security Subcommittee (SISS). Ralph Van Deman Papers, 1929-52 (62 ft.). Record Group 46: Records of the U.S. Senate, National Archives Special Collections: Washington D.C., Boxes 73, file 9740-9749.

<sup>21</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 10.

<sup>22</sup> Senate Fact-finding Committee on Un-American Activities, “Un-American Activities in California: 6-7 1951-53” (Sacramento, California: California Legislature, 1951-53), 103.

<sup>23</sup> Ibid.

<sup>24</sup> Ibid.

<sup>25</sup> Ibid., 115.

<sup>26</sup> Ibid., 118.

<sup>27</sup> Senate Internal Security Subcommittee (SISS). Ralph Van Deman Papers, 1929-52 (62 ft.). Record Group 46: Records of the U.S. Senate, National Archives Special Collections: Washington D.C., Boxes 73, file 9740-9749.

schools. This isn't the product of being depressed today. It's just something I want done in case something happens."<sup>28</sup> Therefore, when he turned up dead a few months later, Hudson's parents remembered his ominous request, but they thought it was a request for investigation rather than simply being their son's final wishes.

Shrouded in mystery, Hudson's death was difficult for many to comprehend. Not just because of the letters he sent to his parents, but the way in which his body was discovered also caused concern for investigators. Everitt Hudson's last night alive was spent with three other friends attending a communist meeting.<sup>29</sup> Upon returning home, the group disbanded, and Hudson was never seen alive again. According to the committee, around 10:30 in the morning, his body was discovered.<sup>30</sup> Hudson was found in the rough, dusty concrete basement of his co-op dormitory. His body lay at the bottom of a four-and-a-half foot deep furnace pit, curled around one of the galvanized iron furnaces. His sweater was found neatly folded on a portable gas heater.<sup>31</sup> Yet, the body's position was not the strangest part. Investigators could not identify any signs of foul play. Detectives noted that the gas and lights were all turned off and the door was open, indicating no possibility of death by asphyxiation.<sup>32</sup> Additionally, the thick layer of standing dust seemed virtually unmolested. Investigators only noted a single streak in the dust on the furnace near Hudson's body and soot on his forehead.<sup>33</sup>

With no physical evidence, investigators hoped that the autopsy would reveal who killed young Hudson. Two autopsies were conducted on the body. A standard autopsy surgeon performed the first exam while Los Angeles's Chief Autopsy Surgeon, Fredrick Newbarr, conducted the second. Adding to the mystery, even the reputable Dr. Newbarr could not find any signs of trauma or toxins resulting in Hudson's death; nevertheless, he ruled out all manner of death except homicide.<sup>34</sup> He established the cause of death as pulmonary edema (fluid in the lungs), but he could not explain why it occurred. When Dr. Newbarr testified about his findings, Combs asked blatantly leading questions. He described Hudson's alleged story of indoctrination: education, books, language skills, and so on. Then, Combs asked Dr. Newbarr, "Would that add anything to your conclusion, by a process of elimination, that this

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<sup>28</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 90-91.

<sup>29</sup> Senate Fact-finding Committee on Un-American Activities, "Un-American Activities in California: 6-7 1951-53" (Sacramento, California: California Legislature, 1951-53), 133.

<sup>30</sup> *Ibid.*, 121.

<sup>31</sup> *Ibid.*

<sup>32</sup> *Ibid.*, 122.

<sup>33</sup> *Ibid.*

<sup>34</sup> *Ibid.*, 123.

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death was caused from homicide?”<sup>35</sup> Dr. Newbarr emphatically responded, “It would definitely add to the conclusion that here is an individual under extreme emotional tension, and death from inhibition is likely in individuals who are suffering from intense emotional tension.”<sup>36</sup> Pushing this further, Combs asked, “And by process of elimination you have eliminated the three basic causes of death, natural and suicide and accidental causes, which of course leaves only one?” Dr. Newbarr agreed.<sup>37</sup> Therefore, he testified that the manner of death was homicide caused by “inhibition.”<sup>38</sup>

For clarity, Dr. Newbarr defined inhibition as “the depressing effect of certain stimulus or stimulæ which affect the central nervous system, and the action of the heart and the respiratory mechanism immediately ceases.” In other words, he implied that Hudson was literally “scared to death” from communist indoctrination.<sup>39</sup>

The media picked up this sensationally outlandish anticommunist rhetoric. The Los Angeles Times had reported on Hudson’s case since his body was found. Immediately after his death, the paper reported it as potentially involving a “tussle with a dog,” and investigators were waiting for the autopsy to confirm potential trauma to the head.<sup>40</sup> The article implied that authorities already suspected Hudson was murdered, but investigators had documented no signs of foul play. Two years later, towards the end of the committee’s investigation, the Times reported that California’s Un-American Activities Committee claimed Hudson may have been “scared to death” because of Communist influences.<sup>41</sup> Two additional articles promote this ridiculous notion. In “Unspeakable Fear of Reds May Have Killed Student,” Dr. Newbarr was reported stating Hudson’s death may be caused by “Fear or shock.”<sup>42</sup> The anticommunist rhetoric continued in the final article. The last article publicized the “scared to death” notion prominently in its title and subtitle: “Fear of Reds May Have Killed Youth: State Probers Hear UCLA Student Might Have Died of Acute Terror.”<sup>43</sup> Blatantly preying on the public’s fear, the article not only suggested Hudson was “scared to death,” it reported that Combs submitted into evidence definitive proof illustrating how educators indoctrinated

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<sup>35</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 10-11.

<sup>36</sup> *Ibid.*, 11.

<sup>37</sup> *Ibid.*, 12.

<sup>38</sup> Senate Fact-finding Committee on Un-American Activities, “Un-American Activities in California: 6-7 1951-53” (Sacramento, California: California Legislature, 1951-53), 125.

<sup>39</sup> Hearing transcripts, 1941-1958, California Un-American Activities Committee Records, 93-04-12, California State Archives, Office of the Secretary of State, Sacramento, California, 12.

<sup>40</sup> “Body of UCLA Student Found in Furnace Pit,” Los Angeles Times, September 29, 1948, 2.

<sup>41</sup> “Red Link Probe in Second UCLA Death Ordered,” Los Angeles Times, December 16, 1950, A8.

<sup>42</sup> “Unspeakable Fear of Reds May Have Killed Student,” Los Angeles Times, December 9, 1950, 3.

<sup>43</sup> “Fear of Reds May Have Killed Youth,” Los Angeles Times, December 15, 1950, 2.

Hudson.<sup>44</sup> Each article progressively became more and more outlandish and unbelievable. From this paranoid rhetoric, the committee, and anticommunists in general, sought justification for their harassment and/or removal of liberal educators.

The press, however, was not the only purveyor of anticommunist rhetoric. E. Merrill Root, a poet, English professor, and ardent anticommunist at Earlham College in Richmond, Indiana, described Everitt Hudson's death as "the grimmest example of what communism has done to wreck and then destroy the life of a student."<sup>45</sup> Root wrote throughout the 1950s on how American schools needed to be cleansed because communism was entrenched in education.<sup>46</sup> Moreover, Root argued that Hudson was a case study of what happens to an individual when his allegiance to communism falters.<sup>47</sup> Root was trying to instill fear in Americans about more than communism; he seemed to argue against any leftist thought. Although Root's rhetoric represented one of many, it carried more prestige because of his position in academia.

The Hudson investigation occurred at a moment when American public officials across the political spectrum were united in blacklisting and purging Communists from teaching and government jobs. Historian Ellen Schrecker argues that when President Truman issued Executive Order 9835, establishing a new loyalty security program as a political gesture to conservatives, he consequently legitimized "anticommunism as the nation's official ideology."<sup>48</sup> Truman essentially justified anticommunists' use of paranoid, hyperbolic rhetoric such as Everitt Hudson being "scared to death." According to historian Richard Hofstadter, anticommunists understood communism as pure malice, and "since the enemy is thought of as being totally evil and totally unappeasable, he must be totally eliminated—if not from the world, at least from the theater of operations to which the paranoid directs his attention."<sup>49</sup>

The political repression and eradication had a profound impact on colleges and universities. State and federal investigative committees subpoenaed and heard testimony from numerous educators. Exact numbers are hard to ascertain because the anticommunist purges consisted of two distinct phases. In the first phase, investigators identified potential subversives to the American public, and in the second phase, employers punished the alleged subversives. By

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<sup>44</sup> Ibid.

<sup>45</sup> E. Merrill Root, *Collectivism on the Campus*, (New York: Devin-Adair, 1955), 126.

<sup>46</sup> —, *Brainwashing in the High Schools: An Examination of Eleven American History Textbooks*, (New York: Devin-Adair Company, 1958), 263.

<sup>47</sup> —, *Collectivism on the Campus*, 127.

<sup>48</sup> Ellen Schrecker, *No Ivory Tower: McCarthyism & the Universities* (New York: Oxford University Press, 1986), 4-5.

<sup>49</sup> Hofstadter, *The Paranoid Style in American Politics*, 31.

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having this split, individuals enforcing the second phase could deny any culpability in the anticommunist crusade of the first.<sup>50</sup> However, most scholars acknowledge that around ten to twelve thousand Americans lost their jobs, a few hundred were jailed, and only two people – accused spies Julius and Ethel Rosenberg – were killed because of anticommunism.<sup>51</sup> According to Schrecker, “Almost 20 percent of the witnesses called before congressional and state investigating committees were college teachers or graduate students.”<sup>52</sup> Thus, even taking the low estimate, roughly two thousand educators were affected by anticommunist witch-hunts. And, in California, anticommunists were exceptionally effective because of the strength of the Un-American activities committee.

California’s Un-American Activities Committee established its power through investigations and promoting fear of communism through outlandish rhetoric such as it did with Hudson case. Throughout the 1940s and well into the 1950s, with a broad definition of what constituted as subversive activities, California established “the most comprehensive system for keeping politically undesirable applicants out of academic positions.”<sup>53</sup> Moreover, after releasing its report on communist indoctrination and the Hudson case, the committee gathered the presidents for all the colleges and universities in the southern region in March of 1952, and in June the northern region, to devise a plan to ensure the eradication of communist influence in education. The committee planned to inform schools about potential subversives on campus and among faculty, assist in screening potential applicants, and assist larger institutions with hiring men with extensive anticommunist experience as security officers.<sup>54</sup> The committee made it clear that it would subject individuals and institutions to public hearings if any school did not fire or if it hired people the committee deemed dangerous. Therefore, during the height of the McCarthy era, Shrecker argues, “the California Senate Un-American Activities Committee, and most probably the committee’s staff of professional anti-communists, exercised a veto over every single academic appointment in the state of California.”<sup>55</sup> In part, the committee established such a powerful role in education because of its investigation into communist indoctrination that Everitt Hudson’s death spawned and the subsequent paranoid, hyperbolic rhetoric that got promoted.

By demonizing communism, anticommunists ensured public support for its eradication, especially in education. According to one scholar, “Public schools are appropriately seen as a means by which a society’s fundamental sociopolitical-economic values are conveyed to

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<sup>50</sup> Schrecker, *Many Are the Crimes*, xvi.

<sup>51</sup> *Ibid.*, xv.

<sup>52</sup> Schrecker, *No Ivory Tower*, 10.

<sup>53</sup> *Ibid.*, 279.

<sup>54</sup> *Ibid.*

<sup>55</sup> *Ibid.*, 280

impressionable young minds.”<sup>56</sup> By publicizing cases like that of Hudson, the extremist anticommunists demanded that local school districts align their curriculum with their perceived notions of American morals and values.

Hudson’s case continues to be one of the more bizarre cases of the Cold War in California. Yet, his death is significant because it illustrates the severity of anticommunists’ paranoia. Their fear of the Red Menace’s potential devastation to American institutions caused an extremely paranoid outlook about education and the possible indoctrination of impressionable youths. The anticommunists manipulated Hudson’s death as a tool to ingrain paranoia and heighten the sense of danger pertaining to communist infiltration in California’s schools. Unfortunately, for many individuals who sought to uplift their community, the result from this fear was their persecution.

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<sup>56</sup> Martin H. Redish, *The Logic of Persecution: Free Expression and the McCarthy Era* (Stanford: Stanford University Press, 2005), 16.

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# Living in the Fruit Bowl and Only Getting the Twigs: Exploring the Lack of Healthcare Access in a Rural Farmworker Community



**Gladys E. Preciado Ramirez**

Mentors: Bruce D. Haynes, Ph.D. and Jesus Hernandez  
Sociology

## **Abstract**

*California agricultural laborers are essential to the U.S. economy, yet the communities in which they reside have been characterized by high unemployment rates, high levels of poverty, and especially poor quality medical care (Arcury and Quandt, 2007; Danenberg, Jepsen, and Cerdán, 2002; Taylor and Martin, 2000). These social factors have a well-documented link to disease and compound the conditions that reproduce poverty and poor quality of life within agricultural worker communities (Marmot and Wilkinson, 2006). Using interviews and fieldwork conducted in the town of Knights Landing, California, I identify the barriers that Mexican farmworkers and their families face when they attempt to access*

*healthcare services. My research indicates that the current range of healthcare services provided is both inadequate and inaccessible to farmworkers and their families due to the high financial cost of medical care, citizenship status, limited transportation to health clinics, information asymmetry, and language barriers that characterize the healthcare system.*

## **Introduction**

The community of Knights Landing, California, is surrounded by vast agricultural wealth. Tomatoes, rice, and wine grapes are just a few of the crops that grow in the area and contribute to Yolo County's \$550 million dollar a year agricultural industry (California Department of Transportation, 2013). Essential to this economic process are the people who cultivate and harvest the fields—they are farmworkers. In fact, a large proportion of Knights Landing residents are employed in farming, fishing, and forestry occupations (U.S. Census Bureau 2008-2012 American Community Survey 5-Year Estimates). Despite their economic contributions, Knights Landing farmworkers and their families do not reap their fair shares in the rewards of Yolo County's agricultural wealth. As a result of state budget cuts, Knights Landing's only clinic and elementary school were closed (Sangree, 2008; Calfee, 2012). Complicating the lack of essential resources in Knights Landing, one out of ten people are unemployed and almost two out of ten families lives in poverty (2010 U.S. Census; U.S. Census Bureau 2006-2010 American Community Survey 5-Year Estimates). Clearly, farmworkers in Knights Landing are not thriving.

Farmworker labor, however, is essential to agricultural industries at the national, state, and local level. In 2010, the United States earned about \$134 trillion in net cash income from farm revenues (Economic Research Service, 2014). In 2010, California's farm revenues totaled \$43.5 billion making it the most agriculturally productive state (National Agricultural Statistics Service, 2013). At the county level, Yolo County's Supervisor to District 4, Dave Rosenberg, recognized the impact of agriculture to the county: "Agriculture drives our economic engine, providing jobs and a tax base for our governments. Agriculture surrounds us and gives Yolo County its special character. Agriculture was the genesis of the great University of California at Davis" (Rosenberg, n.d.). In fact, agriculture accounts for 20% of Yolo County's total income and constitutes about 14% of Yolo County's total employment (Rosenberg, n.d.).

U.S. agricultural growers have historically depended on immigrants as a source of cheap labor for crop production (Calavita, 1992). Approximately 95% of farmworkers in California

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are from Central America and Mexico (Aguirre International, 2005). The issue of legal documentation, however, continues to permeate farm labor. More than half of the farmworking population (52%) is undocumented (Villarejo, 2003). Farmworkers are essential to agricultural production in the United States and despite their economic contributions, farmworkers remain a vulnerable population with unmet health needs (Villarejo et al, 2001; Rosenbaum and Shin, 2005; Arcury and Quandt, 2007; Villarejo, 2003; Villarejo, 2010; Holmes, 2013). Therefore, the present study explores access to healthcare in the specific Central Valley farmworker community of Knights Landing, California. Although there are large-scale statistical studies on rural migrant farmworkers, such as the National Agricultural Workers Survey and the California Agricultural Workers Health Survey, little is known about individual farmworkers and their healthcare utilization (Arcury and Quandt, 2007). This research hopes to amplify migrant workers' voices and may have broader implications for policy, particularly as the Obama administration tries to incorporate more young Mexican workers into the Affordable Care Act.

In this study, I interviewed seven farmworkers and their families. By including family members in my study of migrant health, I highlight the mechanisms by which farmworkers access healthcare including how access varies within the family unit. This is particularly important because farmworkers are often breadwinners for their families. Thus, farmworker's income tends to support not only themselves but also spouses, children, parents, and extended family members. Income directly affects the types of state health programs for which farmworkers' family members qualify. Income indirectly affects other resources, such as transportation and nutrition, that family members will have access to for meeting their health needs. Angel, Lein, and Henrici (2006), found that it was common for poor families to lack full family health care coverage. Consequently, the lack of full family health insurance compromised access to care for various family members leaving some healthcare needs unmet (Angel, Lein, and Henrici 2006). Studying family members provides a broader picture of farmworker's health care needs. In-depth interviews reveal that there are huge costs associated with being a farm laborer. As a bilingual researcher, I gained entrée into the Knights Landing migrant worker community and learned through their narratives about their lack of access to medical care. Many of the barriers to healthcare result not only from individual-level factors, but also from local, state, and national policy decisions. These political forces and processes are external to farmworking communities. Immigration "reform laws" exclude farmworkers from obtaining formal citizenship status and current labor laws provide only limited rights to migrant farmworkers. This study has critical implications for medical care service providers and policy makers through its exploration of the nuanced needs of farmworkers.

## Historical Background

The area of land that would become Knights Landing was first settled by the Patwin indigenous peoples around 700 A.D. In 1843, the town was founded by William Knight, a physician from Baltimore, Maryland (Walters, 1992). The geographical location of Knights Landing is significant because the land, located next to the Sacramento River, is fertile and well-suited for cultivating crops, particularly wheat and corn (Walters, 1992; Larkey and Walters, 1987). From 1853 to 1890, Knights Landing was the leading river port for exporting grain from central and northern Yolo County (Walters, 1992; Larkey and Walters, 1987). During this time, the Yolo agricultural market was booming (Walters, 1992). Shops opened in Knights Landing catering to travelers and to agricultural businesses (Walters, 1992). The years from 1869 to 1890 were the most prosperous for the town. The lucrative corn and wheat market at the time brought a lot of revenue to the area (Walters, 1992; Larkey and Walters, 1987). However, in the 1890s, Knights Landing's wheat was no longer competitive in the world market and business in Knights Landing declined (Walters, 1992; Larkey and Walters, 1987). During this time Knights Landing also experienced floods. Both the stock market crash in wheat and environmental disaster caused many people to leave. Knights Landing's population decreased from 1,000 people in 1869 to 621 by the early 1900s (Walters, 1992).

Later, in the years during the Second World War, the agriculture industry experienced substantial growth because of the increase demand for food. Additionally, many men left overseas to fight in the war creating a huge demand for labor. Mexican immigrants quickly filled this need for labor. In 1942, the United States and Mexico signed The Bracero Act, establishing a guest worker program. The Bracero Program recruited Mexicans to immigrate to the United States to fill the demand for farmworkers (Calavita, 1992). From 1942 to 1945, the Bracero Program provided over 219,500 Mexican laborers to U.S. farm owners. This piece of legislation not only encouraged immigrant labor, it helped to institutionalize Mexican immigration to the United States (Calavita, 1992). Many U.S. growers further encouraged immigration of undocumented Mexicans: rather than contracting Mexican laborers through the Bracero Program, U.S. growers recruited undocumented laborers directly at the Mexican border. The U.S. Immigration and Naturalization Services (INS) agency also supported U.S. growers' hiring practices (Calavita, 1992). Late in the 1940s, the INS established a de facto legalization program in which undocumented immigrants who worked in agriculture were legalized on the spot and contracted as braceros (Calavita, 1992).

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From 1942 to 1947, about 74,600 braceros were contracted. During this time, the INS also legalized and contracted 142,200 undocumented workers directly to U.S. farm owners.

The federal government and U.S. growers, thus, encouraged and institutionalized both legal and illegal immigration to the United States (Calavita, 1992). Although the guest worker program ended in 1964, immigrant workers from Mexico continue to come to the U.S. and fill the demand for farm labor decades later. For this reason, we see migration from Mexico to Knights Landing today. It is important to note that although the U.S. economy depends on the labor of these immigrant farmworkers, their healthcare needs are not considered a priority. If the doors are open to immigrants to work as farmworkers in the United States, then as a country we must also support them once they are here.

## Literature Review

The presence of farmworkers has been proven to increase the overall economic output of the regions in which they work. Eliminating the presence of farmworkers or switching to less labor-intensive crops has been shown to negatively impact productive agricultural regions and significantly reduced the number of jobs available to permanent local residents.

~ Doris P. Slesinger and Steven Deller in *Economic Impact of Migrant Workers on Wisconsin's Economy*

Only about 30% of California's farmworkers have health insurance coverage (qtd. from National Agricultural Workers Survey and California Agricultural Worker Health Survey in The California Endowment, 2009). The lack of health insurance coverage deters many from obtaining needed medical care due to the high cost of health care services (Villarejo, 2010). At least half (52%) are undocumented which adds to a limited ability to use government resources and benefits (Villarejo, 2003). The California Agricultural Workers Survey (CAWS) found that 1 out of 5 farmworkers (18%) travel to Mexico to obtain healthcare services (Villarejo, 2010). Many seek medical care in Mexico rather than the United States because Mexico offers both lower cost medical care and culturally and linguistically competent doctors (Maldonado, Loya, & Rivera, 2011; Villarejo, 2010). This fact is important to note since the availability of doctors in the U.S. may be limited. Many of the rural communities in which farmworkers reside qualify as "medically underserved"

populations (Villarejo, 2003). A 1999 report by Villarejo (qtd. in Villarejo, 2003) reported that for every 1000 people there are three times fewer doctors serving in rural areas than in urban areas.

The problem of Farmworkers' and their families' unmet health needs, in terms of access to healthcare, is complex. Current literature shows that cultural, structural, legal, financial, and geographic characteristics work intersectionally to impede farmworker access to healthcare (Rosenabum and Shin, 2005; Arcury and Quandt, 2007; Villarejo, 2010). More specifically, these characteristics include: 1) language and culture; 2) low educational attainment; 3) jobs that are migratory or "follow the crops"; 4) inadequate transportation; 5) financial strains (poverty); 6) lack of health insurance; 7) lack of documentation; and 8) limited number of health care facilities (ibid). Thus, access to healthcare for these individuals is not a simple issue that has singular cultural, linguistic, or economic solutions. Rather, it is a combination of all of these factors magnifying and undergirding each other which make getting adequate health care especially difficult.

#### Farmworker Health Outcomes

A majority of farmworkers are young—more than half (52%) of the U.S. farmworking population and their family members are under the age of 25, while the age range of farmworkers shows that 79% of the U.S. farmworking population is between 18 to 44 years of age (Villarejo, 2003). In California, the median age of farmworkers is 36 for males and 34 for females (Villarejo, 2010). Despite the relatively young age of farmworkers, many show health outcomes that are typically seen among the bodies of people 30 to 60 years older than what is typical of their age (Roza, 2013). Much of the wear and tear that farmworkers' bodies experience is a result of their occupational and lifestyle exposures (Arcury and Quandt, 2007). In the Binational Farmworker Health Survey, 27% of current workers reported at least one injury during their working lifetime (Arcury and Quandt, 2007). The most frequently mentioned repetitive motion injuries were pain, sprains, and dislocation (Arcury and Quandt, 2007). For single events, the most frequently reported were cuts or tears, followed by fractures or crush injuries (Arcury and Quandt, 2007). A medical anthropologist and public health professor, Dr. Seth Holmes, reports that "medical professionals are unable to treat the workers' problems because they are unable to solve the context that produces them" (Roza, 2013). Another physician supported this statement: "I see an awful lot of people wearing out. In their early forties, they have the arthritis of a seventy-year old, and they're not getting better. They're told 'sorry, go back to what you're doing,' and they're stuck. They're screwed, in a word, and it's tragic" (Roza, 2013). The comments from these doctors

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exemplify the damage agricultural labor does to the bodies of farmworkers. The labor strain is such that it causes people to age faster than average. Young farmworkers even develop health problems, such as arthritis, that are typical among the elderly. The doctor also speaks of the limitations of medical care to treat the root cause of the ailments and diseases farmworkers experience. Even if farmworkers receive medical treatment, many of these health outcomes result from the very environments they work in—that is, the back-breaking positions and repetitive motions they must undergo to pick and harvest crops.

Besides occupational injuries, farmworkers also suffer from occupational skin diseases. Exposure to pesticides, other chemicals, and plants irritate the workers' skin and eyes (Arcury and Quandt, 2007). The exposures are so significant that crop production workers have the highest incidence of skin diseases of any industrial occupation (31.0/10,000 workers) (Bureau of Labor Statistics qtd. in Arcury and Quandt, 2007). Based on research studies, many farmworkers (up to 46%) report rashes (Arcury and Quandt, 2007). Others also reported irritated, itchy eyes (23%) and blurred vision (12%) during the course of their work lifetime (California Agricultural Workers Health Survey qtd. in Arcury and Quandt, 2007).

The California Agricultural Workers Health Survey (CAWHS) also found a high prevalence of risk factors for chronic disease among California farmworkers. A majority of farmworkers (81% of males and 76% of female farmworkers) who participated in the survey were overweight or obese (Villarejo, 2010). Also, the population of male farmworkers has a higher prevalence of high serum cholesterol than the U.S. general population (Villarejo, 2010). And, the incidence of high blood pressure was also greater among the male and female farmworker population than among the U.S. general population for both males and females (Villarejo, 2010). The incidence of high blood pressure was particularly high for 20 to 44-year-old farmworkers (Villarejo, 2010).

### Use of Healthcare Services

The multiple negative health outcomes that affect the farmworker population require urgent attention. With so many health needs due to occupational and lifestyle exposures, it is imperative that farmworkers obtain healthcare services. However, only a small percentage of farmworkers visit the doctor. In the National Agricultural Workers Survey (NAWS), 49% of California farmworkers reported using any type of healthcare service in the U.S.—whether from doctors, nurses, dentists, and hospitals—at least once in the two years prior to the date the survey was administered (The California Endowment, 2009). This means that more than half did not visit a doctor in the two years prior to the survey interview. According to the

California Agricultural Workers Survey (CAWS), undocumented male farmworkers (38%) were less likely than documented male farmworkers (23%) to have visited a doctor or clinic in the U.S. Undocumented and documented female farmworkers were both just as likely to have visited a doctor or a clinic (Villarejo, 2010).

To show the complexity of farmworkers' access to healthcare, I use Knights Landing, California, as a case study. Knights Landing is located in the Central Valley, California's agricultural hub. It has a population of 995 people (U.S. Census 2010) and a majority of its residents are non-white (U.S. Census Bureau 2008-2012 American Community Survey 5-Year Estimates). Although this community is located in the middle of economic wealth derived from the agricultural industry, many of the residents of Knights Landing do not reap its benefits. According to 2008-2012 U.S. Census data, about 10.1% of Knights Landing's labor force is unemployed and about 17.0% of all families live in poverty (U.S. Census Bureau 2008-2012, American Community Survey 5-Year Estimates).

## **Methods**

I used an ethnographic approach to investigate healthcare access in Knights Landing that included participant observation and in-depth interviews with migrant and seasonal farmworkers and their family members. I did my participant observation as a student volunteer at the Knights Landing Clinic. In this student volunteer position, I alternated between working at the reception desk and translating for Spanish-speaking clients in the clinic rooms. My field notes described various interactions of farmworkers with medical professionals in the clinic from June 2012 through January 2013. I gained entrée to my interview participants through my volunteer work in the community. Lourdes, an outreach worker for the California Rural Legal Assistance (CRLA) who worked in this community for several years, formally introduced me to farmworkers. On one day, Lourdes drove me to several of the migrant labor camps within Knights Landing and in the outskirts of the town. At the camps, I knocked on doors to speak with workers and recruit interview subjects. I introduced myself as a UC Davis student conducting research on the healthcare options among farmworkers. I asked if they would like to participate in my study. Participants gave me both verbal and written consent to the interviews.

### Subjects

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I conducted seven formal interviews with Mexican farmworkers or a family member of a farmworker. Of the seven participants, four were women and three were men. Most were approximately middle-aged with the oldest being 75 years old. All had been born in Mexico. Most of the interview participants are from La Piedad, Michoacán, a state located in Central Mexico. The primary language spoken by the subjects was Spanish. All interviews were conducted in Spanish.

For the formal interviews, I designed a semi-structured interview guide that asked open-ended questions about health-care seeking experiences. All of the interviews were audio-recorded except for one. For the participant who did not want to be audio-recorded, I took written notes of the interview. To maintain confidentiality and protect the identity and privacy of my interview subjects, I used pseudonyms.

Data Analysis

I transcribed the formal interviews and translated them into English, verbatim. None of the subjects were compensated monetarily for their time. The field notes and transcriptions were coded into themes. The coding process and analysis of the data is based on grounded theory method.

Barriers to Healthcare Access

Through in-depth interviews, I identified four recurring themes that indicate barriers to healthcare access for individuals in the Knights Landing farmworking community: 1) financial costs; 2) citizenship status; 3) limited access to information; and 4) transportation costs. These themes were recurrent and reflected in direct quotes of interview subjects.

*Financial Costs*

The high cost of medical care discouraged most of the interviewed subjects from using the healthcare systems available to them in the community. Five of the seven subjects felt burdened by the high cost of medical care. Five of the seven interview subjects did not have any type of medical insurance. Instead, for the most part, subjects indicated that they used free and low-cost community clinics in the local area. They also reported that they used over-the-counter medicine and traditional remedies. Only Francisco, the 75-year-old retired farmworker, had medical insurance through Medicare and received regular medical care. Lack of health insurance had a significant effect on whether my interview subjects sought out medical services. For example, Rosa, the 45-year-old wife of a handyman, told me that she

visits the doctor for yearly mammogram check-ups because they are free. However, she said that she opts not to get dental care because of the high financial cost. In fact, several of my interview subjects indicated that they avoided seeking medical care because of the high financial costs.

In Rosa's case, she did not seek dental care until she absolutely could not stand the pain. She told me that the pain got so bad she had to get a root canal and it cost her about \$1,000, which she charged to her credit card. Because Rosa has five children under the age of 18, medical costs are a grave concern for her. The lack of health insurance ends up costing more because she has to use a credit card to pay for the medical services and is then charged interest. Similarly, Roberto, the 47-year-old farmworker, told me that he tried to use over-the-counter pain killers rather than visiting the doctor for abdominal pain. Eventually the pain was too great and doctors discovered that his gallbladder was infected and it had to be removed in an emergency operation. According to Roberto, the cost of the operation was \$32,000. He explains:

Me puse muy malo. Y no quería ir. No quería ir al doctor. Quería ver si con pastillas o con algo se me quitaba. Pero ya no aguante. Y tuve que ir. Y me operaron en Marysville.

I became very sick. And I did not want to go. I did not want to go to the doctor. I wanted to see if taking pills or something would take the pain away. But I couldn't take it. And I had to go in. They operated on me in Marysville.

Roberto's quote exemplifies the barriers to healthcare due to financial concerns. Although my interview subjects realized they should seek medical treatment, the costs were prohibitive. Many postponed important medical decisions because they said they could not afford the care. This is reflected in the low numbers of migrant workers in the U.S. who actually use healthcare services. For example, according to the National Agricultural Workers Survey, in 2000, only 20% of migrant and seasonal farmworkers reported to have used healthcare services in the previous two years (Rosenbaum and Shin, 2005). Consequently, when my participants did seek medical care, three of them reported having obtained needlessly more complex and expensive procedures due to delayed treatment. The high cost of healthcare also pushes farmworkers and their families to re-evaluate their emergency care needs. Roberto's story illustrates how delaying medical care resulted in being treated in the emergency room. Additionally, when Roberto had his emergency

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surgery, days spent in the hospital meant lost wages for him and his family. Delaying visiting a doctor because of the high financial costs of medical care demonstrates the need for affordable and preventative healthcare.

### *Citizenship Status*

The fear of deportation may be another reason for putting off a visit to the doctor. According to the 2009 California Health Interview Survey, undocumented immigrants in California were twice as likely (28.4%) to have fewer doctor visits than U.S. citizens (15.3%) (qtd. in Wallace et al, 2013). Additionally, undocumented immigrants in California were more likely to have no usual source of care (34.7%) than U.S. Citizens (15.1%) (California Health Interview Survey, 2009). Despite undocumented immigrants' low use of preventative healthcare compared to naturalized citizens and U.S. born individuals, undocumented immigrants were the least likely to have visited the emergency department (California Health Interview Survey, 2009). If farmworkers—regardless of citizenship and immigration status—had access to preventative services, the health and financial costs would not have been as high both in terms of the health of the individuals and the financial strains to themselves and their families. Rosenbaum and Shin (2005) reported that in 2000, a majority (85%) of migrant and seasonal farmworkers and their families were uninsured. In fact, migrant and seasonal farmworkers are the least likely of all low-income groups in the U.S. to have medical insurance (Rosenbaum and Shin, 2005). The recently passed Affordable Healthcare Act increased the number of insured U.S. Citizens (U.S. Department of Health and Human Services, 2014; Schoen et al, 2014). However, it does not cover undocumented persons (Wallace et al, 2013).<sup>1</sup>

In addition to high financial costs, citizenships status also affected whether my interview subjects sought medical care. As a naturalized citizen, Francisco, the 75-year-old retired farmworker, said that he receives health check-ups every three months. He is very happy with the medical care he has received and explained that he does not have to pay for any of it. In contrast, however, Francisco explains that his friend, Roberto, the 47-year-old undocumented farmworker, had to pay for all his medical visits and pharmaceuticals.

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<sup>1</sup> Although this is outside the scope of my research study, a future direction would be to investigate how the introduction of the Affordable Care Act has affected healthcare utilization among my participants by citizenship and immigration status.

Como le digo, yo no pago nada. Y como este señor [Roberto] si...Este, si dan medicina, él la paga. Y tiene que pagar todo él y yo no.

Like I tell you, I don't pay anything. And like this gentleman [Roberto] yes...If they give medicine, he pays for it. And he has to pay for all of it and I don't.

Roberto does not have health insurance and said that he visits the doctor only when he feels really sick such as when he had unbearable abdominal pain and had to go to the emergency room. In fact, undocumented individuals do not qualify for any state or federal health insurance coverage other than emergency Medi-Cal (Broder and Blazer, 2011). Medicaid is a federal program providing health services to low-income individuals and Medi-Cal is California's version of Medicaid. Emergency Medi-cal is available for catastrophic or life-threatening health situation but does not provide for preventive check-ups. (Broder and Blazer, 2011). This is a huge concern especially for undocumented people who suffer from chronic or terminal illnesses. Rosa, the 45-year-old wife of a handyman, is a legal resident and at the time of the interview was investigating possibilities signing up for health insurance programs under the Affordable Care Act (ACA). Rosa speaks about her friend who is undocumented and is having difficulty searching for county programs to treat her kidney failure.

Ahorita tenemos de una persona que tiene deficiencia en los riñones que no le trabajan los riñones y ella no tiene papeles y pues anda batallando pues este...con la ayuda de doctor.

Right now we have someone who has kidney failure. Her kidneys don't work and she doesn't have legal status and well, she is struggling with...getting help from a doctor.

After researching information online, Rosa was unclear about the programs she could qualify for as a legal resident. Rosa said she traveled to Woodland to find more information about the ACA at the county office because in Knights Landing, information about programs often reaches her late, is limited, or is non-existent. Knights Landing is a rural community—sparsely populated and isolated. In fact, public transportation is nearly non-existent and the largest city proximal to Knights Landing is Woodland, which is about 11 miles away. Rosa informed me that information about workshops is often passed around by word of mouth and

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knowledge about the workshops is often a few days late or it reaches her on the day of the event.

### *Lack of Healthcare Information*

Complicating my subjects' access to healthcare is the fact that healthcare information is not available in the community and even within the confinements of the clinic room. Two of seven participants asked questions about how the Affordable Care Act would affect them and which health insurance programs would be the most and least beneficial. Rosa, the 45-year-old wife of a former farmworker, said that although the local family resource center provides information about health insurance programs, one needs to seek out information as it is not always delivered to those in need.

Tú necesitas llegar y preguntar 'edad...de lo que tú sabes para que te den información. La información no viene de allá para acá.

You need to go in and ask right....based on what you know so that they can give you information. The information is not coming from there to here.

Work responsibilities, however, affected two of my participants' decisions to seek healthcare information. Roberto, the 47-year-old farmworker who suffered from a gallbladder infection, was concerned about being able to pay off a \$642 hospital bill. He was confused about receiving the bill because he had applied to Emergency Medi-Cal and was under the impression that the Emergency Medi-Cal would cover all of the emergency care expenses. After talking to him about his situation, I referred him to the Knights Landing Yolo Family Resource Center so that he could receive more guidance about what steps he could take to reduce his monthly hospital bill. However, Roberto said he could not visit the center because of his work responsibilities. Roberto wakes up at 3 AM to allot enough time to commute one hour to Napa. Roberto starts work at 6 AM and ends work at 4 PM and doesn't arrive home until 6:30 PM to 7 PM. He works six times a week and only gets Sundays off. This demanding schedule does not mesh well with the 8 AM – 5 PM, Monday to Friday, schedule of most offices and clinics such as the Knights Landing Family Resource Center.

Es nomas que yo como no tengo a veces no tengo tiempo porque [...]  
Porque o sea trabajo en Napa y traigo gente me entiende? O sea que soy mayordomo. Y o sea no puedo perder. O sea traigo 15 a 20 cuadrillas. Y

este se me hace trabajoso pues perder un día porque me desacomodo.  
Tengo que estar constante, diario, diario, diario.

It's just that I sometimes don't have time because [...] Because I mean I work in Napa and I bring people you know what I mean? I mean I'm a foreman. I mean I can't miss work. I mean I bring 15 to 20 crews. And, it becomes difficult to miss a day of work because it's an inconvenience. I have to be there constantly, daily, daily, daily.

Complicating Roberto's situation was the fact that he does not receive phone reception in the vineyards where he works. Thus, he would be unable to call the center during regular business hours to resolve his emergency healthcare expenses. Roberto's work schedule reflects barriers to obtaining healthcare information. Farmworkers do not have employment benefits such as paid days off work. They earn their wages based on the amount of crops picked and the amount of hours worked. Therefore, missing an hour from work means a significant cut in income. Roberto's job responsibilities would not allow him to visit the Knights Landing Yolo Family Resource Center or to make phone calls to seek that information. However, missing a hospital bill payment because he could not afford it could result in a report to the credit bureau or being turned over to a collection agency and consequently affect Roberto's credit score.

A lack of health care information also takes place in the confinements of the clinic room. Rosa, the 45-year-old wife of a former farmworker, said she was afraid she had cancer. A family member had recently passed away from breast cancer; in addition, living in a rural area with exposure to pesticides was a cause of worry for Rosa. She asked her doctor to test her for cancer, but she did not receive satisfactory information about her health status. She wanted access to specialized care, but the doctor did not refer her.

Y así abecés que me duele algo sí voy al doctor. Pero te digo, el problema es que pues nunca te mandan con un especialista [...] Y pues uno quisiera cuando va al doctor decirle 'ay sáquenme estudios como estoy de aquí como estoy de acá.' No, es lo que ellos dicen 'edad?' [...] 'Háganme un estudio de cáncer,' le digo. 'Ay no no, tu no tienes,' me dice. Y tú sabes que allá en Méjico nomas les dices 'háganme esto' y pues te lo hacen.

And like that sometimes when something hurts I go to the doctor. But I'm telling you, the problem is that they never refer you to a specialist [...] And

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well one would like it that when one goes to the doctor to tell them ‘ay test me and check how I’m doing here and how I’m doing over here.’ No, it’s what they say right? [...] ‘Test me for cancer,’ I tell him. ‘Oh no no, you don’t have any,’ he tells me. And you know that in Mexico you just tell them ‘do this for me,’ and they do it.

Rosa’s experience with the doctor demonstrates that patients are not always provided with specialized care and that clinicians doubt the complaints of their patient’s ailments. This is different from the care received in Mexico where clinicians respond to patient’s requests for more specialized care. In Rosa’s case, she was left questioning the quality of healthcare services she was receiving. Francisco, the 75-year-old retired farmworker, also expressed concern about exposure to pesticides and the danger of fieldwork. Roberto, the 47-year-old foreman and Francisco’s friend, explained that as a foreman he is required to take blood tests every fifteen days to check exposure to pesticides from the grapes. When asked if everyone in the job site was also tested, Roberto responded that only the foremen are tested for exposure to pesticides. Francisco responded:

Y a los trabajadores que les lleven leche. Que se mueran.

And to the workers, they should give them milk. Let them die.

Using dark humor, Francisco expresses concern for the risks of working in agriculture and implies that the lives of farmworkers, like himself, are valued less than the life of the foreman and even less than a human being. “Give them milk. Let them die,” may be symbolic of how absurd it is that only the foreman is required to visit a doctor for exposure to pesticides when there are hundreds more people working in the fields. Employer’s lack of concern for the health of farmworkers reflects how little their lives are valued in our society.

### *Limited Transportation*

Transportation is another significant factor that affects access to healthcare. Most farmworkers work outside of the town of Knights Landing. This can be seen by a larger outflow of job counts leaving Knights Landing in comparison to the inflow of job counts coming to the town. In 2011, the outflow was 244 job counts and the inflow was 63 job counts (Center for Economic Statistics, 2011). Among the groups of workers that need to commute outside of Knights Landing proper are farmworkers. Many farmworkers own cars but these cars are used almost exclusively for work. This leaves family members who stay at

home, often women and children, without transportation. Many must depend on public transportation and others ask friends and relatives for a ride to the doctor. Rosa, the 45-year-old wife of a former farmworker, summarized the effects of limited transportation in Knights Landing:

Pero también edad ay personas que, de esas personas que estoy hablando, que no tienen carro tratan de que alguien las lleven [...] Entonces eh como ya hay tres días bas a la semana ellas procuran poner sus citas en esos días...mhmm. Para irse en el bus y venirse y regresarse en el bus.

In the above statement Rosa says: “But there’s also people that, those people that I am talking about, that do not have a car, they try to find someone who can take them. [...] So now since there is a bus three days during the week they seek appointments for one of those days...mhmm. To take the bus and to come back and return on the bus.” Even with transportation options, in Knights Landing public transit is only available three times per week and only on the 2nd Sunday of every month (Yolo County Transportation District, 2009). The days that public transportation is available, it is also insufficient. For example, it only passes twice a day—once in the morning and once in the afternoon (Yolo County Transportation District, 2009). For those who depend on public transit, the limited availability of the bus also limits the times they are available to schedule an appointment. Furthermore, for those who use public transportation, a 15-minute appointment with the doctor means an entire day of traveling. The bus leaves at 9:42 AM from Knights Landing and the next available bus returns to Knights Landing about five hours later at 3:03 PM (Yolo County Transportation District, 2009).

## Discussion

The high cost of medical care discourages many farmworkers from using the U.S. healthcare system. A significant factor that increases the burden of medical care costs is lack of health insurance. In 2000, a majority (85%) of migrant and seasonal farmworkers and their families were uninsured (Rosenbaum and Shin 2005). With regards to cost, we can see the effect that it has on people. The high cost of healthcare causes farmworkers and their families to postpone seeking preventative healthcare services. This is reflected in the low numbers that actually use healthcare services. For example, in 2000, only 20% of migrant and seasonal farmworkers reported to have used healthcare services in the previous two years (Rosenbaum and Shin, 2005). Consequently, this causes them to obtain needlessly more complex and

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expensive procedures due to delayed treatment. The high cost of healthcare also pushes farmworkers and their families to re-evaluate their emergency care needs as was the case with Roberto's stomach pain which resulted in a visit to the emergency room for gallbladder surgery and Rosa's \$1,000 dental care visit for a root canal procedure. Many use more cost-effective means of healthcare such as traditional remedies and self-medication (Arcury and Quandt, 2007). Traditional remedies are knowledge passed down through generations about ways to heal the body using herbs and massages. These traditional remedies originate from Aztec, Spanish, Native American, and African medicines (Avila and Parker, 1999). Many often travel to and procure medical services and pharmaceuticals in Mexico where the cost of healthcare services is cheaper than in the U.S (Villarejo, 2010). This phenomenon of cross-border utilization of healthcare services has been documented across the nation, particularly in the U.S.-Mexico border region (Bergmark, Barr, & Garcia, 2010; Maldonado, Loya, & Rivera, 2011; Su, Pratt, Stimpson, Wong, & Pagan, 2013). Additionally, the high cost of pharmaceuticals in the U.S. pushes people to purchase pharmaceuticals from Mexico. Most importantly, people are purchasing medicine thousands of miles away in Mexico that is often available only a few miles away from where they reside in the U.S.

Citizenship status also affects access to healthcare for farmworkers and their families. For example, many live in socio-economic statuses that qualify them to obtain Medicaid or other government-provided, needs-based, health insurance coverage. However, only between 7-11% are able to obtain Medi-Cal or government sponsored health insurance (Villarejo, 2003). A barrier to accessing needs-based health insurance coverage from the government is legal status. As was previously mentioned, more than half (57%) of farmworkers are undocumented (The California Endowment, 2009). Without health insurance, many must pay out-of-pocket for health services (Villarejo, 2003). Furthermore, seeking county assistance for specialized care is difficult without citizenship. Many farmworkers are undocumented and, therefore, do not qualify for many of the national, state, and local government assistance programs. The only current form of state subsidized health insurance for undocumented people is emergency Medi-Cal which allows people to obtain free emergency healthcare (Rosenbaum and Shin, 2005). Even when emergency Medi-Cal services are available, many undocumented farmworkers and their families fear using emergency care because police securities tend to guard the hallways and entrances. Even among farmworkers and their families who face life-threatening health issues, it is difficult to obtain healthcare services without legal status. One example was Rosa's undocumented friend who has kidney failure and who is having trouble receiving help from a doctor. Rosa commented: "Right now we have someone who has kidney failure. Her kidneys don't work and she doesn't have legal status and well, she is struggling with...getting help from a doctor." The result is that life

becomes contingent upon legal status. The threat of deportation compounds the effects that high financial costs of healthcare have on undocumented persons. A lack of citizenship status has similar outcomes as cost because it prevents people from accessing care. The lack of citizenship status pushes people to self-medicate. People also re-evaluate their emergency care needs and use these services only when mainstream services can no longer be avoided resulting in more expensive and complex procedures.

Recently introduced legislation from the Affordable Care Act (ACA) will reduce the impact of medical care costs by increasing the numbers of insured citizens and legal residents in California (Wallace et al, 2013). However, undocumented persons are excluded from obtaining subsidized health insurance through Covered California—California’s version of the Affordable Care Act’s health insurance exchange program (Wallace et al, 2013). This is a concern because in 2000, 57% of farmworkers living in the United States were undocumented (The California Endowment, 2009). This is more than half of the population of farmworkers. Thus, the Affordable Care Act systematically excludes a majority of the U.S. farmworking population from obtaining subsidized health insurance. During the time of my interviews, the ACA and Covered California had been approved, but had just begun to enroll clients. Future research could study how the ACA has affected healthcare access among Knights Landing farmworkers and their families.

Information is also critical to preventing bad health. Rosa, the 45-year-old wife of a former farmworker, described how she asked her doctor to get tested for cancer, but rather than getting referred to a specialist or getting tested, the doctor said she did not have cancer. She received minimal information about the state of her health. Receiving limited information from the doctor raises doubts about the quality of care that is provided. Akna, the 48-year-old wife of a farmworker, expressed similar dissatisfaction with the information and healthcare services she has received. When her daughter asked to be taken to the dentist because her wisdom teeth were hurting, Akna replied:

Mija, no te van hacer nada. Yo sé que no te van hacer nada porque pues las muelas del juicio apenas te están saliendo y esas te van a salir y te van a recorrer todos los dientes y te vas a enfermar le dije. Vas a sentir ese dolor. Le dije pero no te las pueden sacar hasta que ya estén salidas y que te empiecen a dar problema.

Daughter, they aren’t going to do anything. I know they won’t do anything to you because well your teeth are just coming out and they will come out

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and cover all your teeth and you will get sick, I told her. You are going to feel that pain, I told her, but they won't be able to take them out until they are all out and they start giving you problems.

Although Akna has a certain belief about her daughter's health options, she believes dentists won't do anything to help her daughter. There is distrust for how much dentists will be able or willing to do. This may partly stem from the fact that Akna was not given the correct information about her daughter's health options.

Furthermore, limited access to information is also found outside of the confinements of medical care. Language barriers can prevent patients from receiving necessary healthcare information. Roberto, the 47-year-old farmworker who suffered from a gallbladder infection, received a medical bill in English. He wasn't sure why he was receiving it. His primary language is Spanish and he asked me if I could translate the medical bill. The hospital bill was the final notice for payment. Roberto was worried about how he would pay for the \$642 medical bill. I wondered how many medical bills he had received similar to the one he shared with me. I was concerned. Even for families with financial resources, medical expenses are one of the leading causes of bankruptcy (Angel, Lein, and Henrici, 2006). Lack of healthcare information in a patient's preferred language, therefore, can increase the financial costs of healthcare especially if patients do not pay their bills on time. Two interview participants also questioned how the Affordable Care Act would affect them and which plans they should choose. They wanted to know more information about the Affordable Care Act, but workshops and information about the ACA was non-existent in Knights Landing. Rosa, the 45-year-old wife of a former farmworker, traveled to the county's office to find more information about the program. However, in Rosa's situation, other farmworkers and residents of Knights Landing may not have the time, transportation, and knowledge to know where to go and ask for help.

## **Conclusion**

These barriers to healthcare access should be addressed because farmworkers significantly contribute to the U.S. economy. Not only do they contribute to the American economy, but if we want to improve the health status of all Californians, we must also pay attention to the health needs and access to healthcare services among farmworkers and their families. My findings indicate that the high financial costs of medical care prevent my interview subjects from accessing healthcare. Citizenship status limits the state and federal health programs

available for my research participants. Consistent with the research study on poor families in the U.S. by Angel, Lein, and Henrici (2006), poor families tend to lack full healthcare coverage. In fact, all of my interview subjects' families did not have full healthcare coverage. The families I interviewed were mixed-status families meaning that not every family member shared the same citizenship status. Consistent with the 2009 California Health Interview Survey (see Wallace et al, 2013), I found that one research participant with U.S. citizenship status who was older and received Medicare, visited the doctor more frequently than those who were either legal residents or undocumented. Most significantly, even when one interview participant and her family qualified for Medi-Cal, they did not have any source of health insurance coverage. Fragmented family health insurance coverage for my interview participants had financial and medical costs. There were times when a family member required health care but a doctor visit had to be postponed. Postponing preventative care resulted in more expensive and complicated healthcare services. This means that the healthcare needs of one family member, who lacks health insurance, financially affects the rest of the family who otherwise has health insurance. The protective character of health insurance, therefore, may not be equally beneficial for individuals who live in mixed-status families as compared to families in which all members are U.S. citizens. My findings have direct implications on current state and federal health insurance services such as Medi-Cal, Medicare, and the Affordable Care Act because these government programs exclude undocumented people and will affect low-income, mixed-status families. Cherry-picking who qualifies for health services programs based on legal status continues to perpetuate the poor health outcomes that result from fragmented family coverage (Angel, Lein, and Henrici, 2006).

Healthcare information is another factor that affects farmworkers and their families' access to healthcare. Within the context of the health clinic, four of my interview subjects were dissatisfied with the information they received with regards to their health status. One participant was not referred to a health specialist even when she had requested getting tested for cancer. Consequently, participants who were dissatisfied with the information they received about their health status also questioned the quality of care they were receiving. Even outside the clinic room, medical bills were not available in the patient's preferred language and information about the ACA was non-existent in the town of Knights Landing. Interview participants reported that information about health resources and community health events are often distributed late to interview participants. Although a resource center exists in Knights Landing, services provided in this center were inaccessible for two of my interview participants due to time conflicts with their work schedule.

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Lastly, limited transportation affected the times and days my interview subjects could access healthcare. Participants must travel outside the community because the only health clinic was closed in 2008 due to state budget cuts. In 2012, a UC Davis student-run clinic was opened, but the student-run clinic also has limited funding and can only open twice a month. Thus, Knights Landing residents are forced to seek medical care elsewhere. Public transportation is only available three times a week and on some weekends, which further complicates access to medical care.

Farmworkers are at risk for contracting diseases and injuries by the nature of their work—they are exposed to pesticides, other chemicals, dust, repetitive hand motions, and machinery (Arcury and Quandt, 2007). Given their socioeconomic position, farmworkers and their family members also make up a portion of California's vulnerable populations. Yet, their healthcare needs and the healthcare needs of their family members are not a priority. Extending health insurance coverage to all people regardless of citizenship status can be a step closer to improving healthcare coverage for Knights Landing farmworkers. Access to healthcare among Knights Landing farmworkers and their families is more complex, however, and would include improving access to healthcare information such as writing medical bills in a patient's preferred language and providing information about health events with advanced notice and more outreach to farmworkers in Knights Landing.

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# **Teen Torment: Emotional and Physical Abuse Among Latina Teens**



**Susan Samborsky**

Mentor: Angie Chabram, Ph.D.  
Chicana/o Studies

## **Introduction**

This thesis examines psychological and experiential aspects of emotional and physical abuse among Latina teens. The review of the literature sets the stage for understanding short-term and long-term consequences on victim's mental health. Much of this research reflects a dearth of cultural and linguistic competencies that make exiting abusive situations more challenging for people of color, people with disabilities, and low-income people. My thesis stands as a corrective to this state of affairs. The heart of my thesis is a unique Latina teen love story that unravels the depths of harmony, strong rich young love, and the trap of abuse. It is my hope that my personal healing narrative can effectively support Latina victims of abuse and help them to exit abusive situations services for victims must be culturally competent, recognizing the importance of traditional families and religion. Because culture is a key factor that may debilitate women or encourage them to break the cycle, special

attention is focused here. My research indicates that abused women can heal through narrative.

## Literature Review

The power of verbal abuse can dehumanize the soul once the victim lives the abuser's reality. (Evans) As early as 1979, Walker introduced the concept of emotional abuse as an important aspect of abusive relationships. Through interviews with over 400 women from rural and urban environments in the Western United States, Walker found that emotional abuse was more extreme than physical abuse and had more long-term effects. (Walker, 2003 p.3) Pico-Alfonso further elaborates "that the short-and long-term effects of abuse on women may include posttraumatic stress disorder, depression, anxiety, sleeping disturbance, and social dysfunction." (2005, p.182)

### The Value of the Narrative Approach

"Listening to victim's stories without judgment was important." (Walker)

When Latinas share their cultural narratives, they also incorporate culture to heal, express, advocate, help make sense of their conditions, and empower themselves and their communities. (Chabram, 12) "I felt broken, I feared change, financial insecurity, and leaving the familiar." (Patricia Evans) "I thought I was crazy and somewhat dumb or empty headed, not intelligent enough." (Evans) "I feel frustrated, helpless, angry, frightened, crazy, and frozen in thought." (Evans) I realize how well conditioned I was to his voice, when he called my name.

Domestic or intimate violence rates in the United States have reached epidemic proportions. Between 1993 and 1998, women ages 16 to 24 experienced the highest per capita rates of intimate violence (19.6 per 1000 women). During the same time period, only about half the intimate partner violence against women was reported to the police; Black women were more likely than other women to report such violence (U.S. Department of Justice, 1999). Intimate violence, however, is not just a crime against women: nearly half of the female victims of intimate partner violence lives in households with children under age 12, which represent 27% of U.S. households. Thus, although women may be the primary victims in cases of intimate violence, children are also significantly affected (Flores-Ortiz, 2000b). It is not clear

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how socioeconomic status, race, and ethnicity contribute to the incidence of domestic violence. Intimate violence occurs in all social classes. However, detection and reporting of these crimes is more likely among the poor and working classes. However, class, thus creating the false impression that domestic violence is more prevalent among the economically disadvantaged. Overall, in terms of reported cases of domestic violence between 1993 and 1998, African American were victimized by intimate partners at significantly higher rates than persons of any races. Black males experienced intimate partner violence at a rate about 62% higher than that of White males and about 22 times the rate of women of other races. No difference in intimate partner victimization rates between Hispanics and non-Hispanics emerged, regardless of gender. Specific figures concerning the rates of domestic violence among Chicana/os are not available, as the government does not disaggregate data in terms of national origin or ethnic identification among Hispanics. Straus et al. (1998) found high rates of domestic violence, particularly serious physical abuse, in a sample of Hispanics who participated in his national study. However, the national origin of these respondents is unknown. Clinical and anecdotal data do suggest a serious violence problem within Chicana/o families (Flores-Ortiz, Esteban, & Carrilo, 1994; Flores Ortiz, Valdez Curiel, & Andrade Palos, in press; Rodriguez et al., 2001). The manner in which Chicana/os understand and define violence may have a bearing on rates of reporting and tolerance of the problem within Chicana/o families.

Women accounted for 85% of the victims of intimate partner violence, men for approximately 15%. (Bureau of Justice Statistics Crime Data Brief, Intimate Partner Violence, 1993-2001, February 2003) Between 600,000 and 6 million women are victims of domestic violence each year, and between 100,000 and 6 million men, depending on the type of survey used to obtain the data. (Rennison, C. (2003, Feb).

Emotional abuse takes place in many spaces in our lives and it should be recognized. However as, Loring has argued, “emotional abuse may be the most unrecognized form of abuse.” (Loring, p.10) Women suffer from hidden psychological abuse that can hinder their everyday life, work, school, and even future relationships. For this reason, it is important to understand the relational facets of abuse, including the physical, verbal, psychological, social and emotional dimensions. Promoting this type of understanding can be challenging especially because it is a form of hidden abuse.

In addition, historically, when researchers focused on abuse, the main concentration was on physical not psychological abuse. Psychological abuse has grown in the last decade, however, there is not enough information on the frequency of psychological or emotional

abuse (Loring, Chang, p.1), and especially when there is no physical abuse or it is infrequent. (Loring, Chang, 1996, p.1) This is unfortunate because as Schumacher argues, psychological abuse is not only a correlate “but also an antecedent or cause of physical violence in relationships.” (Julie A. Schumacher and Kenneth E. Leonard, 2005, p.28)

Women who are abused often live with guilt and shame, but once women reclaim their minds and bodies they can live a healthier life. Key to this healing is an understanding of the psychological and social contexts of their mental health. This is important because in today’s society, emotional abuse has been normalized and dismissed. Women can live feeling hurt, guilt, and depressed for never having acknowledged their emotional abuse.

To make matters worse, in many cases the law will not respond to emotional abuse. (Lachkar, 14) Women often don’t have any record of emotional abuse to defend them while trying to get a restraining order. Educated women who have prominent careers suffer a double whammy. High functioning women can be ridiculed when they admit to being abused through phases in their life. As one scholar noted, women can be asked! “What! You, an attorney, and you’re abused? What’s a woman like you doing with a man like that?” (Lachkar, 14)

Cycles of Emotional Abuse: The self- Help Literature.

In order to begin to answer this question of why high functioning professional women as well as smart working class can be abused, it is necessary to acknowledge how difficult it is to make sense of the cycle and contexts of abuse. Many self-help books explain dynamics of psychological abuse that are difficult to absorb for so many women caught in the web. For instance, in *Stalking the Soul*, Marie France-Hirigoyen tells us that emotional abuse has two phases: (1) “identity erosion” and (2) “open violence”. The first phase, which the psychoanalyst Racamier has termed brainwashing, can take place over several years.” (Hirigoyen, 92) The first step in brainwashing is stalking, in which the abuser overpowers his partner and gradually controls her, which disables her independence. (Hirigoyen, 90) The abuser also wants to erase his partner’s identity, for example employing narcissistic seduction which “confuses and erodes the boundaries of one’s own identity and that of another individual.” (Hirigoyen, 89-90) The victim is then discombobulated and loses self-esteem and confidence. (Hirigoyen, 90) Here the abuser is a wolf in sheep’s clothing. He attacks his victim deceitfully, seeking to gain great respect from others, in order to get back a positive image of himself. (Hirigoyen 90) Many women are stuck in this illusion of romance, safety, protection, and real love.

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Evans in her book: *The Verbally Abusive Relationship*, agrees that verbal abuse gradually destroys a women's confidence, self-worth, and belittles her value without her awareness. (Evans, 78) The abused woman may even try to accommodate her behavior so as to not upset her partner, and he can then stop hurting her. (Evans, 78)

Evans explains that a person that is verbally abusive can be mischievous and deceptive. This is a very common behavior for an abuser; the result is that the abusive person can leave their mate delusional, hurt, and caught off guard. Abusers can be also very sarcastic, mad, and make debilitating remarks. Women can be highly educated but still be blind to the verbal abuse that exists in their relationship. In fact, this is why abused women cannot control the reoccurrence of the emotional abuse. Also, a verbally abusive man can be very contradictive. The abuser can be misleading with his words and the emotion he puts into it. The abuser may say, "I love you so much," but his facial expression and tone of voice don't match his words. For instance, he might tell his mate everything is okay with a tender voice while putting her down, or in an angry voice confuse her with a stern voice and say that he is not angry. In the book, *The Verbally Abusive Relationship*, one of Evan's interviewees observes: "He says he's accepting of everyone but he criticizes me and won't accept my views or feelings," (Evans, 78). Another example, he may take her out and give her the cold shoulder, thus nullifying her existence.

As I suggested before, emotional abuse is relational – it is present in physical abuse because not only is a woman's body affected when she is abused, but her psychology, spirit, and mind are traumatized. All of this can start with foul put-downs, escalate to glares, and progress to physical aggressiveness and even murder.

In Walker's interviews, she identified a battering cycle of abuse. (Clarke, 40) This cycle has three phases: (1) "the tension building phase; (2) the explosion or acute battering incident; (3) and the calm, loving respite." (Clark, 40) Phase one included, yelling, verbal abuse, and tantrums. In this phase the women is trying to alleviate the abuser's anger and make him happy. In phase two she cannot predict when her abuser will attack and is left with little control. (Clarke, 41) She is now living on edge and thinking about the next attack. Her guard is up and she may even have not appetite and may suffer from inner tension. (Clarke, 41) According to Walker, this signifies a shift in power and control: "When that acute battering incident happens, it is entirely in the man's control." (Clarke, 41) Literally the battered woman is often in disbelief on her reality and can disconnect her body from the abuse. (Clarke, 41) In phase three is the storm has ended and love is exaggerated. The abuser can

get on his knees to get her back, makes promises to be a better man, and makes things all better again. (Clarke, 42) However in reality, the abuser has very little remorse towards his partner; he believes it was all her fault. As Clark suggests, “He believes he has taught her a lesson so she will never behave in such a way as to make him do it again.” (Clarke, 42)

In *The Verbally Abusive Relationship*, Evans incorporates the cycle. For her, abusers suffer from hidden inner tension. They release anger by attacking their partner with emotionally charged outbursts that are cyclical. This repeats itself with more anger outbursts. (Evans, 102) Evans refers to this as the “a cycle of anger addiction”. For her, the abuser who follows this pattern of behavior is an “anger addict.” (Evans, 102) The cycle, however, is not always a regular everyday occurrence; the abuser can be unpredictable and does not always show his anger to his partner. During this cycle, there are two rewards that are a fix for an abusive addict. One reward is a feeling of relief, a high after releasing tension that has been built up since the last abusive episode. The second reward: the abuser gets a sense of power and control of his mate. He has total control to keep her feeling caught in the web. (Evans, 102)

When women face the cycle of emotional abuse, they may become silent and never take charge of the real situation. This often stems from fear. But there is a price to be paid. In the *Language of Letting Go*, Beattie states, nothing makes us feel, “crazier than expecting something from someone who has nothing to give.” (Beattie, 352) People may spend too much time with abusers and try to change someone’s feelings and actions.

Being in denial (the honey moon) is destructive and it is best to stop trying to make somebody something he or she is not. Dealing with feelings and walking away from this destructive system is best for women’s well-being. It is very important to know that if people are abused, it is not their fault. They do not have to feel shame or guilt. Some may have been abused physically, sexually, or have been around the addiction of others. The true guilt is for the abuser, not the one receiving the abuse. Many people are victimized, sometimes more than once. (Beattie, 353)

### Critique of Self-Help

The reviewed self-help literature helps to unravel the difficult psychological dynamics of the abuse cycle. However, a major flaw in this literature is that it constructs a representation of people involved in the cycle along the lives of one theory and generic identity fits all. In reality, people from different ethnic backgrounds, economic status, and intelligence react differently to psychological abuse and physical abuse notwithstanding the presence of

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commonly cited abuse. People who abuse or are abused are also viewed as the perpetrator or victim, the wolf or the sheep, within the self-help books. These identities are labels that don't represent who these people are in real life. In sum, the generic woman and man are counterfeit role models that lack the authenticity of real life and the reality of abuse in diverse cultures, ethnicities, social classes, and health status. Also, the self-help literature erases society's role in propagating abuse. For Mahoney and Sharma, "Intimate partner abuse and women's responses to violence cannot be understood simply as the result of individual pathology." (Mahoney, 1994; Sharma, 2001, 819)

In the case of Latina women, they are more vulnerable to violence because of language barriers, poverty, migration, and lack of community services, includes, shelters, literature, and ecological niche. (Rivera, 235) Latinas' value their culture and reputation among their family and friends, which determines many of their major decisions. Many Latinas face barriers that limit their options in exiting the relationship. Also, according to Bauer et al., "abused Latinas' may be impacted by the influence of their cultural, female roles, and their worth according to theory and research." (Bauer et al., 2000; Perilla, 1999; Vera, 2002 819) These values include traditional gender expectations, which reinforce the idea that Latino men take charge of the household, make major decisions, and acts as the head of the house. Within this gender ideology, Latina women are supposed to be submissive, quiet, and loving in all areas. In the Mexican tradition, this is referenced to marianismo. Here women were meant to suffer and at the same time keep a strong face in front of the family. This tradition is rooted in a patriarchal relationship that supports the superiority of men. (Flores-Ortiz, 819) In marianismo and familismo the socialization of Latina children incorporates the idea that marriage is the most important thing in their lives. Here the role of women is to submit to their mate by not speaking their opinion. However, this only increases the severity of intimate partner violence among Latino couples. (Perilla, 1999 #819)

### The Value of the Narrative Approach

As suggested, women that were victims of abuse were first studied by psychologist Lenore Walker (Clarke, 36). Walker realized that listening to victim's stories without judgment was important. (Clarke, 36) In some instances, family or friends have a tendency to make negative remarks that only make the situation worse. Battered women at times felt like they cannot entirely express how they really feel when they know they will be looked down upon. Walker believes that listening to victim's stories is key to understanding the dynamics of each woman's history. She also believes that listening to battered women is important because from listening comes understanding." (Clarke, 37) When Latinas share their cultural

narratives, they also incorporate culture to heal, express, advocate, make things right, help make sense of their conditions, and empower themselves and their communities. (Chabram, 12) Part of the problem is that the conventional counselor/patient relationships have lost touch with (or never understood) the real life experiences Latinas face each day. Counselors need to take into account Latina narratives to build a strong health care system. (Charm, De La Torre 12) Such understanding of Latina vulnerabilities will create a comfortable atmosphere between patient and doctor, which will help patients deal with their abuse and produce narratives. (Chabram, De La Torre 188) Angie Chabram and Adela De La Torre believe it is important to incorporate a system of care that will bring forth traditional remedies and medicine that involve, body, mind, and soul. (Chabram, 188) Narrative is important because it can bring forth the real experience and the core understanding of an ailment.

## **Discussion**

### What can Be Learned

In the following, my personal narrative is a unique story that entails living in the projects, teen love, poverty, Mexican American cultural, small city, and struggling with a learning disability while being verbally and physically abused.

I believe Latina cultural narratives like mine are crucial because they help articulate cultural influences in health that must be woven into healing the description, understanding, analysis and healing. Early research, conducted by the psychologist confirms my position on the importance of having previously silenced groups speak was therapeutic as well. For example, Lenore Walker realized that listening to victim's stories without judgment was important. (Clarke, 36) In some instances, family or friends have a tendency to make negative remarks that only make the situation worse. Battered women at times felt like they couldn't entirely express how they really felt when they know they would be looked down upon. Walker believed that listening to victim's stories was key in understanding the dynamics of each woman's history.

As a disabled Latina that has endured teen abuse. I agree that there is a lack of attention to Latinas who have lived my predicament in the literature on abuse, or the analytical frameworks used to describe it. In my own case, comparing my story to Patricia Evans books, I could not find stories that were relatable in my recovery. These books paid attention

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to gender but lacked Mexican American culture, which plays a role in recovering from domestic violence and breaking the cycle. In so far as the abuse was concerned, when reading through Evans books, I could not find one Latina that had similar experiences of verbal and physical abuse in the barrio.

Socioeconomic status was also an issue for me unlike in some self-help books in which survivors are told to just get up and leave their homes. There are many families like mine that can't afford to escape. What do they do? In my case, I couldn't afford to move to another country to save my life. My family did not grow up licking the silver spoon: they had no backup plan. Some women in the books had backup plans that would help them get away from their abuser. I came from the projects where I had to help with food, rent, and often live off food stamps. I was surviving, not living. I had to fight my way in school to get out of special education classes and at the same time fight off my abuser that lived in the same small city. I was the abused Chicana, disabled, living in poverty, and surviving each day. My family didn't grow up licking the silver spoon. I call this the generational curse that has suffocated the life out of Chicanas today.

## **Conclusion**

My narrative on domestic violence is unique because I also suffered from a learning disability that interfered with my education, health, self-esteem, and lack of resources in my hometown. My disability was a barrier along with growing up in a very traditional Mexican American collectivistic family that lived with low social economic status. In the meantime, I was trying to finish college while being abused. I did not have the opportunity to have a backup plan and leave the country. I could not afford this and leave my parents behind because they needed me to help them financially.

There were times I felt dependent on my abuser to help me understand things that I didn't acquire in school, such as writing, reading, and even basic math. He was my other half that taught me things. There were times he would take advantage of my disability so I would be forced to rely on him more. Patricia Evans didn't cover any of these situations, so this would make it difficult for women to leave a situation without some sort of guidance on how to escape these particular circumstances.

My abuser feared that I would one day leave him, so he would threaten his life and make everyone in his family believe that I was the cause of his choices. I was crippled in fear by

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his threats. He was angry at the world and needed someone on whom to dump his barrel of shit. He was a walking canon ready to destroy anybody that did not fit his way of thinking.

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Teen Torment

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# Virtual Reality and the Occurrence of False Memories



## Deborah Scearce-Miles

Mentor: Andrew Yonelinas, Ph.D.  
Psychology

### Abstract

*Casual observation revealed that video game enthusiasts sometimes confuse memories from the virtual world of video games with those of the physical or real world. This inspired the present work by a realization that memory is very fluid, which was discovered during a trip to an unfamiliar place where an individual in our group believed she had previously been. Knowing that this was impossible, upon further examination it was discovered that she had visited a virtual replica of the place in a first-person video game. The conviction with which she declared that she had visited before coupled with her knowledge of the spatial layout of the place, was convincing evidence that she had a strong sense of episodic memory for interactions that occurred in the virtual world through her avatar.*

### Introduction

Physical or real world memories as well as the occurrences of false memories have been studied for quite some time. Some examples are studies of memory development in children (Ghetti, DeMaster, Yonelinas, & Bunge, 2010; Ghetti, Qin, & Goodman, 2002), memory

impairment through lesion studies (Aly, Yonelinas, Kishiyama, & Knight, 2011), and studies of false memories in eyewitness accounts of events (Goodman & Reed, 1986). A variety of research has been done on violence in video games and aggression most showing that there is a correlation between violent video games and aggression (Anderson & Bushman, 2001; Huesmann, 2010). However, some studies have shown no correlation between violent video games and aggression (Christopher J. Ferguson, 2011; Christopher J. Ferguson et al., 2008; C. J. Ferguson, San Miguel, Garza, & Jerabeck, 2012). Furthermore, other research has shown that the use of video games and other digital media actually improves working memory (Colzato, Wildenberg, Zmigrod, & Hommel, 2012) and increases creativity (Gee, 2003). Conversely, little attention has been paid to the issue of how memories are influenced by exposure to these virtual worlds and more particularly first person video games. The purpose of this research is to identify factors that lead to the occurrence of false memories from the virtual world of a video game becoming confused with memories of the physical world.

## **Background**

The area of focus of this research is cognitive psychology, or the study of thought processes and knowledge, although it has implications for a myriad of other disciplines including psychosocial, behavioral, and cultural studies. However, to narrow the focus, this work is concerned with the cognitive aspects of memory which are malleable and subject to errors. In their work on false memories, Garoff-Eaton et. al. examined the neurological correlates of false memories and categorized false memories as “unrelated recognition” or “related recognition,” which is rooted in true memories. In fMRI scans the same areas of the brain were active in “related recognition” and true memories (Garoff-Eaton, Slotnick, & Schacter, 2006). This may account for the development of false memories when exposure to the places, objects, and situations of the virtual world become confused with those of the physical or real world.

Implications of this exposure can be both positive and negative. The advantages include improvement of working memory (Colzato et al., 2012) that can lead to better problem solving, increased creativity (Jackson et al., 2011), and enhanced cognition and perception (Boot, Blakely, & Simons, 2011; Oei & Patterson, 2013). There are possible drawbacks in false memories coming from virtual worlds, as well as benefits. With a plethora of research on the correlation between video games and violence there are debates as to the validity of any correlation to violence (Anderson & Bushman, 2001; Beaver, Barnes, May, & Schwartz,

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2011; Christopher J Ferguson, 2010) and other drawbacks may be discovered with further inquiry.

Also, when we understand that our self-concept is derived from our autobiographical memories (Prebble, Addis, & Tippett, 2013) – who we think ourselves to be is a reflection of these memories and interpretations of how we have behaved (or how we think we have behaved), it becomes clear that there can be long range effects on behavior from false memories (Geraerts et al., 2008). Other research shows that interactions in video games, especially social interactions, seem to provide the players with fulfillment of some basic human needs (Rigby, 2011), which makes the identification of possible false memories important as an influence on the player's sense of fulfillment. Additionally, if as some researchers suggest, violent crime is declining (Cunningham, Engelstätter, & Ward, 2011) in direct contrast to the growing video game industry and rising violence in these games, then underlying processes need to be understood. With this catharsis of violence there may be an attendant catharsis of other positive aspects of human behavior.

## Methods

The observation that led to this inquiry was of a false memory from a replication of a physical environment in the virtual world of a video game that became confused as an autobiographical memory of having actually been at the physical place. To produce a test of this in a controlled setting, participants would have to be exposed to a virtual environment that replicated a physical environment where they had never been. Then they would have to be taken to the physical environment to discover if they had memories of being there. This presented a challenge to create in a laboratory setting as replication of a physical environment in a game simulation was not practical. Game development companies with a cadre of designers, programmers, and developers can take years to develop and launch a game. Because of this challenge, the concept of a model for testing memory from a virtual encounter required a shift from replicating spatial locations to replicating objects.

The design and development of a virtual world that would mimic the feeling of a campus environment where the testing was to take place required extensive programming and the assistance of a character modeler and programmer. Using Unreal Development Kit (UDK) from Epic Games (Unreal, 2013) a virtual game simulation was developed that contained 20 virtual objects (e.g. watering can, party mask, violin case, ebony African mask, etc.) which were placed throughout the four rooms of the simulation. The development of an interactive

game simulation containing these objects that were modeled from the physical world in enough detail to ensure that the physical or real objects and simulated objects were virtually indistinguishable was a long process.

First, each item chosen had to be fairly unique and not consistent with the environment. Schemas or knowledge structures about objects belonging in a particular environment are an important consideration in the choice of objects. Mania et. al. of the University of Sussex in the UK suggests that “an individuals’ prior experience will influence how he or she perceives, comprehends, and remembers new information in a scene.” (Mania, Robinson, & Brandt, 2005) It is important to consider the participant’s schemas of what is consistent with an environment and attempt to ensure that only inconsistent objects are used for all conditions (in the pilot study this became very clear). Then, the rooms and simulation had to be scaled and populated with realistic furnishings. We chose to create a computer room, an anthropology room, a laboratory, and a private library with a hallway down the center of the four rooms in the simulation. After several months in development we began data collection.

## **Data Collection**

### **Pilot Study**

Fourteen students at the University of California, Davis participated in this research study for credit. They had a median age of 22 years and consisted of 50% male and 50% female. Participants were brought into the interview room (physical world room), which was an approximately 100 square foot generic office with a desk, two chairs, and a foot stool. Participants were asked to fill out consent forms and left in the room for a minimum of four minutes as timed on a stopwatch. Several objects were scattered to the left of the participants in this room. These objects are different than the objects that were placed in the computer simulation (the virtual rooms) and contained 10 modeled objects among several noise (miscellaneous) objects. Participants were then taken to the Human Memory Lab, given written instructions on the computer simulation navigation, and instructed to solve puzzles and find keys within the simulation. Once the participants understood the directions, the virtual simulation began. As they explored the four virtual rooms, participants moved freely in each room for 60 seconds. At the end of 60 seconds, they were teleported (so to speak) to the hallway where they could choose another room to explore. Once they entered a virtual room in the game, the participant could not return. This ensured that each participant had a

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total of exactly four minutes of exposure in the virtual rooms to match the four minutes they were allowed in the physical (interview) room.

After exposure to both environments, participants were given a sheet of paper that contained a forced-choice test with confidence ratings. They were instructed to indicate 'yes' or 'no' to whether the objects were from the physical world of the interview room and rate how confident they were in their 'yes' or 'no' answers using a 20, 40, 60, 80, or 100 percent scale. The list contained thirty items; 10 items that were in the game – the virtual world, 10 items that were in the interview room – the physical world, and 10 'lures,' which the participants were never exposed to as a control – the new objects.

### Pilot Study Results

The results of the pilot study revealed confounds in the lure or 'new' objects that were on the 30-item list at test. Participants responded 'yes' more often to the lure objects than to either items that were actually in the interview room or to those modeled and placed in the computer simulation. Unfortunately, many of the lure objects were consistent with an office or academic environment making them more salient than the inconsistent objects found in the physical room and virtual rooms. Participants' responses to the physical world objects and the virtual world objects showed no significant difference. These confounds illustrate that the lures need to be as unusual or as inconsistent as the objects in the physical world and virtual world and that there was a need for counterbalancing.

### Study #2

Twenty-four students at the University of California, Davis, participated for credit in a research study. They had a median age of 19.45 years and consisted of 41.67 percent male participants. The physical or real room was smaller than the pilot study at approximately 50 square feet, and it contained an "L" shaped table against two walls with a computer at one end and a cupboard containing consent forms on the side. On the table between the cupboard and the computer in front of the participants were 10 memory objects and miscellaneous noise objects. In this study participants were instructed to fill out the forms and were timed for a minimum of four minutes. While still in the interview room, participants were interviewed about their video game-playing habits and asked grouping questions about their gaming exposure. They were then taken to another office within the Human Memory Lab and placed before the computer simulation as in the pilot study. To allow for counterbalancing, participants were randomly exposed to simulation A or simulation B. The

two simulations were identical with the exception that the modeled objects placed within the four rooms were switched. For simulation A, physical world objects 'B' were placed in the interview room while modeled virtual objects 'A' were in the virtual world. Conversely, for simulation B, physical world items 'A' were placed in the interview room and modeled virtual objects 'B' placed in the virtual world. At test, participants were given a verbal query of the 30-item list that contained the 10 items from the A group, the 10 items from the B group, with 10 lures (new) that were not displayed in either the physical world condition or in the virtual world condition. Unlike the pilot study, these lures were not consistent with an office or academic environment.

### Study #2 Results

The means (M) of saying 'yes' across counterbalanced conditions revealed no compelling evidence for false recognition. Although participants recognized old items better than new items, the performance was low (.49 vs .24), which seems to indicate very conservative responses. While looking at confidence ratings, there was a slightly higher false alarm rate in the game as compared to the lures (32 vs 28), but this was not significant.

### Discussion

While neither the results of the pilot study nor study #2 provided any compelling evidence for false memories, other trends may be revealed as game-playing data is correlated by gaming level or experience and hours played. The exposure or lack of exposure to virtual worlds may make a difference in the results. Other analysis on an item by item basis may also reveal item-specific irregularities or confounds that could have effectively skewed the data. During study #2, there appear to be two lure objects in particular that often caused participants to register false alarms. In the pilot study we found that too many of the lures were consistent with what Mania et. al described as schemas (Mania et al., 2005) since they fit with the setting and may have been responsible for confounding the results.

There were major difficulties in development of this study. Starting with the impracticality of producing a virtual world that replicated an environment that none of our participants had ever visited. Even if that hurdle was overcome, there would have been the challenge of how to test their memory of the physical environment, for example: their memory for the spatial layout of the environment, what comes next around the corner, etc. To solve this dilemma,

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objects were chosen to test memory instead of spatial locations. This may also account for the lack of replication of what was a natural (not staged) observation.

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# Investigating the Interaction Between the LEAFY COTYLEDON1 and bZIP67 Regulators in Embryogenesis of *Arabidopsis*



**John Tran**

Mentors: John J. Harada, Ph.D. and Russell Baden  
Plant Biology

## **Abstract**

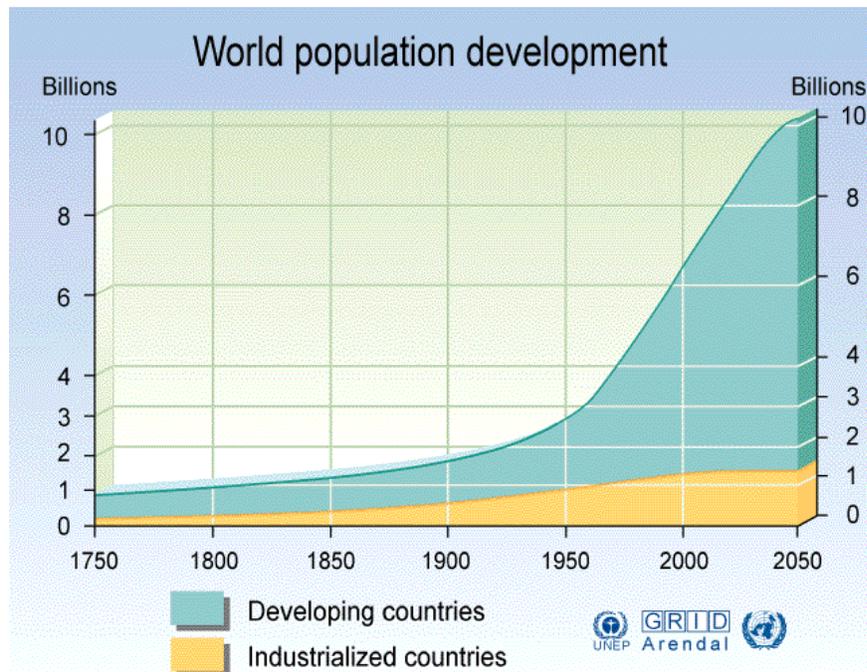
*Seed development, an important period of the angiosperm life cycle, is divided into two distinct phases: morphogenesis and maturation. Seeds have the capability to promote desiccation tolerance of the embryo and, in addition, store protein and lipids, which are synthesized during the maturation phase. Hence, the maturation phase makes seeds an excellent food source for humans. This research investigates two transcription factors, LEAFY COTYLEDON1 (LEC1), which has been shown to be a vital regulator of embryo development, and bZIP67, which data from our lab and others suggest may act with LEC1 to initiate maturation. LEC1 regulates seed development by encoding for a subunit of a transcription factor complex. Specifically, LEC1 is an AHAP3 subunit of the CCAAT box-binding factor, which includes AHAP2 and AHAP5. Therefore, our goal is to determine*

*whether bZIP67 physically interacts with the entire complex to initiate seed maturation by conducting a series of yeast hybrid experiments. My research has shown that a specific AHAP5 can be used to test with LEC1 and bZIP67 in order to understand the entire transcription factor complex responsible for the initiation of seed maturation.*

## Introduction

By the year 2050, the world population is estimated to reach 9 billion, an increase of 28% (see Figure 1). Consequently, this dramatic rise in population will increase the demand of food production and present society with the challenge of finding a way to produce more food than it ever has in the history of mankind. One way of addressing this challenge is by studying seeds, since most of the calories that humans consume come either directly or indirectly from seeds. Understanding how seeds develop is critical to improving the quantity and quality of seeds. This is even more important in the face of climate change, decreasing water supplies, and less arable land. As such, seed development is critical to food security.

**Figure 1: World Population Growth (UNEP, 2005)**

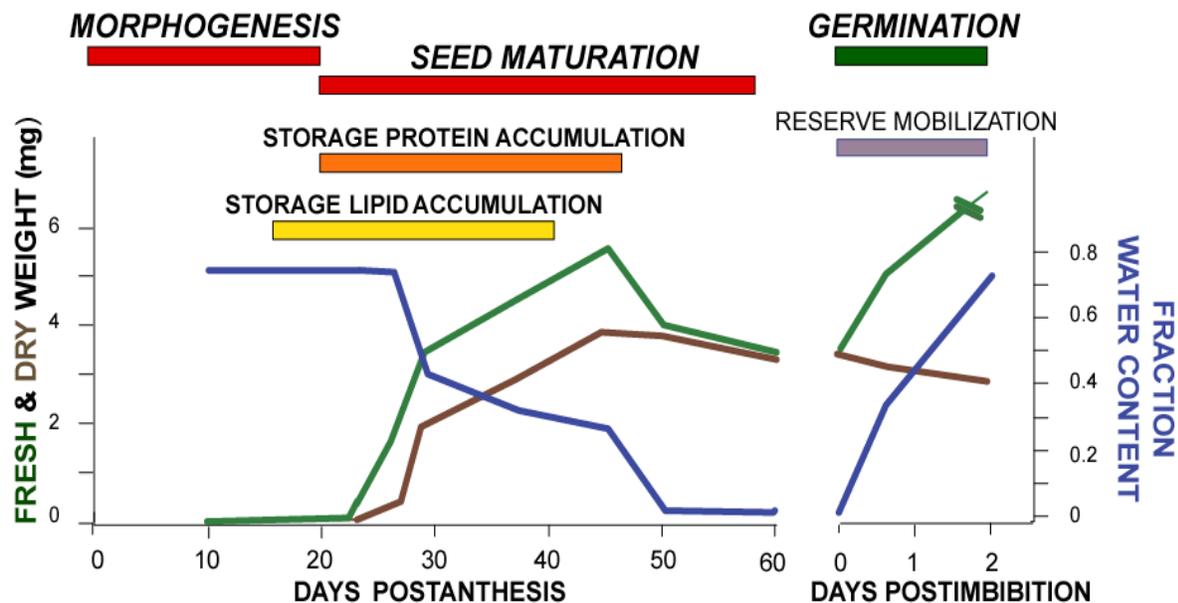


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Investigating the Interaction

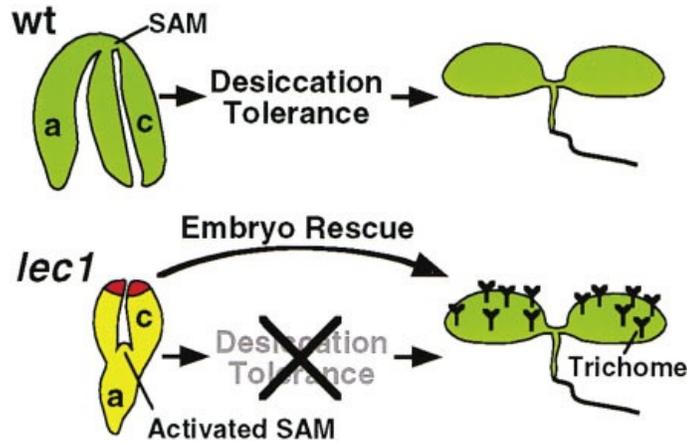
Seed development is divided into two distinct phases: morphogenesis and maturation, respectively (West and Harada, 1993) (see Figure 2). During morphogenesis, the embryo, endosperm, and seed coat, which constitute the basic body plan of the seed are established. After morphogenesis, the seed will enter the maturation phase, which is when the embryo fills the seed. In addition, seed maturation is when storage proteins and lipids are synthesized. These macromolecules, which serve as nutrients for the plant during germination, are the same nutrients that make seeds nutritious for human consumption. Therefore, one of the questions that this project attempts to address is how seed maturation is initiated.

**Figure 2: Phases of Seed Development**



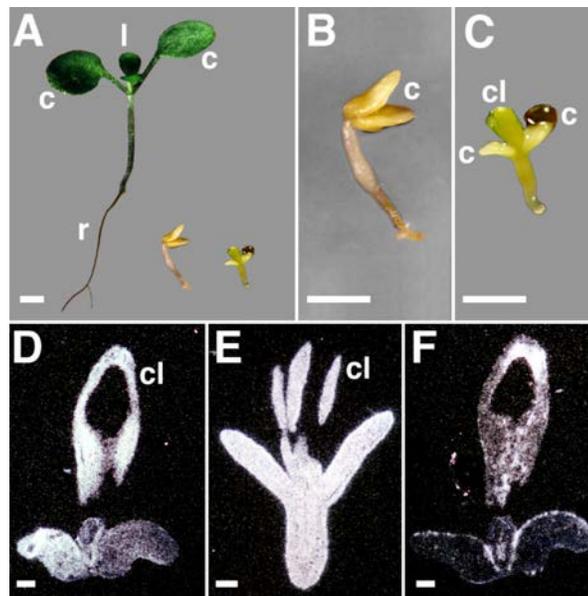
In *Arabidopsis*, *LEAFY COTYLEDON1 (LECI)* has been identified as one of the central regulators of seed development (Meinke, 1992, 1994; West et al., 1994; Parcy et al., 1997). Experiments conducted by Lotan et al have shown that when *LECI* is mutated, the plant embryo is unable to tolerate desiccation and seedlings possess trichomes on cotyledons (see Figure 3).

**Figure 3: Effects of the *LEC1* Mutation on Embryo Development**



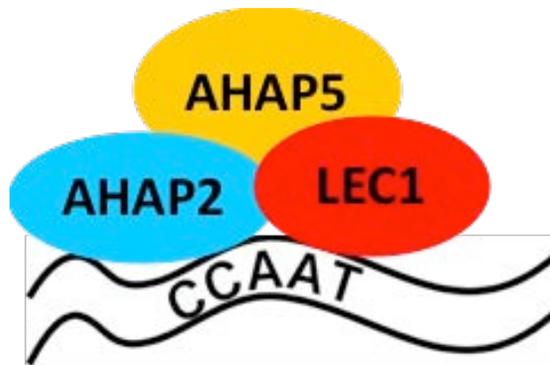
Furthermore, they showed that overexpression of *LEC1* caused seedlings to display embryo-like characteristics (see ‘A’, ‘B’, and ‘C’ in Figure 4) and the presence of RNA storage proteins normally produced during embryo development (see ‘D’, ‘E’, and ‘F’ in Figure 4). Therefore, these experiments suggest that *LEC1* is required for proper development of the seed and is, thus, a central regulator of seed development.

**Figure 4: Seedlings Overexpressing *LEC1* Have Embryonic Characteristics (Lotan et al, 1998)**



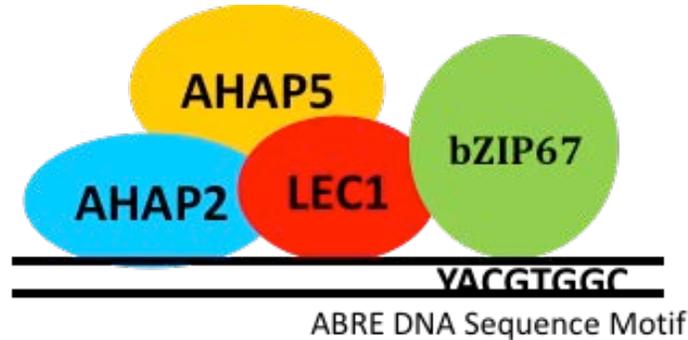
*LEC1* regulates seed development by encoding for a subunit of a transcription factor complex that binds to the CCAAT sequence (Lotan et. al, 1998; Lee et. al, 2003). Specifically, *LEC1* encodes the AHAP3 subunit of the complex, which also includes AHAP2 and AHAP5. Other experiments have shown an interaction between *LEC1*, HAP2, and HAP5 (see Figure 4). Furthermore, *LEC1* interacts with proteins outside of the CCAAT complex as well, one of which is bZIP67.

**Figure 5: CCAAT box-binding Transcription Factor Complex**



Experiments have shown that bZIP67, a protein detected during seed maturation, interacts with *LEC1* and HAP5 (Yamamoto et. al, 2009). Others have shown that bZIP67 RNA accumulates primarily during the maturation phase and that co-expression of *LEC1* and bZIP67 activates storage protein genes. However, no experiments have accounted for the HAP2 subunit of the CCAAT transcript factor complex and its interaction with bZIP67. I hypothesized that bZIP67 interacts with the entire CCAAT transcription factor complex (HAP2, HAP5, and *LEC1*) to initiate seed maturation using yeast two hybrid assays (see Figure 5).

**Figure 6: Hypothesis: bZIP67 interacts with the entire CCAAT box-binding transcription factor complex**



## Experimental Procedures

### Bacteria Plasmid Prep

Previously prepared frozen bacteria stocks, stored in  $-80^{\circ}\text{C}$ , and transformed with the desired plasmids were plated onto solid media and incubated overnight in  $37^{\circ}\text{C}$ . Bacteria liquid culture was prepared by selecting a single bacteria colony from the overnight solid media culture and suspended in liquid media and incubated overnight with shaking in  $37^{\circ}\text{C}$ . After overnight incubation, the liquid bacteria culture was transferred into a 1.5 mL microfuge tube and microfuged for 30s at 15.2 rpm. After centrifugation, supernatant was removed and the transfer and centrifugation step was repeated. After the second centrifugation step, procedures from the Thermo Scientific GeneJet Plasmid Miniprep Kit were used to isolate the plasmid from bacteria. Plasmids were quantified by a Nanodrop Spectrophotometer.

### Yeast Maintenance and Growth

Auxotrophic yeast cells, stored in  $-80^{\circ}\text{C}$ , were plated onto URA- solid media plate and incubated overnight in  $30^{\circ}\text{C}$ . Yeast colonies from overnight culture were selected and suspended in liquid media and incubated with shaking overnight in  $30^{\circ}\text{C}$ . Yeast cells were then harvested for transformation experiment.

### Yeast Transformation

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#### Investigating the Interaction

The OD600 for the liquid culture, described in the previous section, was obtained. The culture was diluted to a desired OD600 between 0.2-0.3, which would promote the yeast to enter the growing log phase. After dilution, the culture was incubated with shaking in 30°C for 3 hours. After incubation, the expected OD600 is 0.4-0.6. 5.0 mL of culture was pelleted by centrifugation at 4000 rpm for 5 minutes. The supernatant was then removed. The cells were resuspended in 10 mL of glass-distilled water (GDW) and centrifuged again at the same setting. The supernatant was removed and the cells were resuspended in 1 mL of GDW. The cells were transferred to a 1.5 mL tube, centrifuged at 5000 rpm for 1 minute, and resuspended in 1.5 mL 1XTE/1XLiAc. The cells were centrifuged again and resuspended in 250 uL 1XTE/1XLiAc. Per transformation, 50 uL of yeast cells, 5 uL of Herring Sperm DNA (HSDNA), and 1 uL of plasmid were added, quick pulsed immediately, and 300 uL of PEG/LiAc solution was added. The transformation was incubated with shaking for 30 mins at 30°C. After incubation, DMSO was added and the transformation was heat shocked at 45°C for 15 minutes and chilled on ice for 1-2 mins. Then, 800 uL of sterile GDW was added and centrifuged at 5000 rpm for 1 minute. The cells were resuspended in 250 uL of 1X TE Buff and plated on selective solid media.

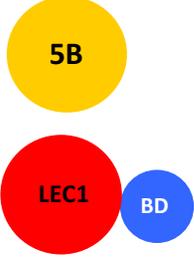
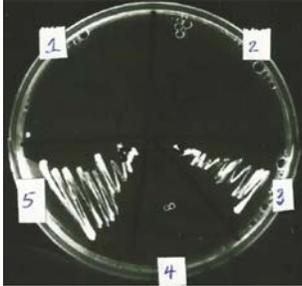
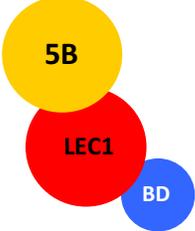
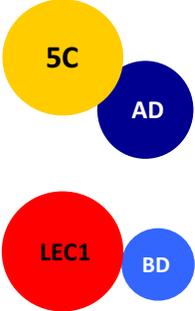
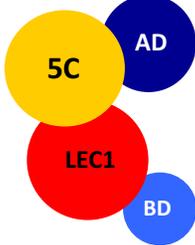
#### Yeast Hybrid Experiment

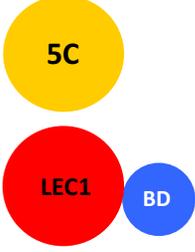
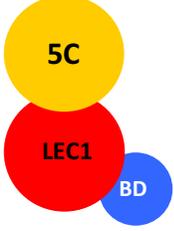
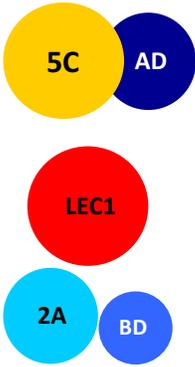
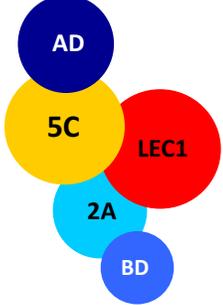
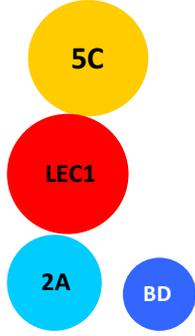
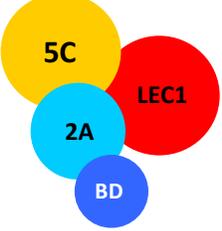
Yeast-two hybrid assays utilizes recombinant DNA plasmids. In my experiment, I have designed plasmids to encode for the proteins that I am interested in testing. These plasmids also have an ‘activation domain’ and ‘binding domain’ that play an important role in the yeast-two hybrid assay. The binding domain, or BD, is produced along with a particular protein that essentially brings the protein to the binding site of a reporter gene. The activation domain, or AD, is produced along with the second protein and if both proteins interact, the AD will turn on the reporter gene, which produces a compound that the yeast needs for growth. Thus, yeast growth would suggest that there is an interaction between the two proteins that we are testing.

**Figure 7: Table Identifying the Proteins in the Yeast-Two Hybrid Test**

Arabidopsis HAP5B Protein (HAP5B)	
Arabidopsis HAP5C Protein (HAP5C)	
Arabidopsis LEC1 Protein (LEC1)	
Arabidopsis HAP2A Protein (HAP2)	
Binding Domain (BD)	
Activation Domain (AD)	

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**Figure 8: Yeast Hybrid Assay Results**

Test	Results	Proposed Model
1. 		
<p>Test 1 Notes:            I was interested to see if having both transcription factors, <i>LEC1</i> and <i>5B</i>, on the same vectors as opposed to separate vectors had any effect on yeast growth. The plate was divided into five sections. Section #3 and #5 both tested for <i>BD-LEC1</i> and <i>5B</i> on separate and same vectors, respectively. Both tests resulted in yeast growth, or activation. Sections #1 and #2 were controls that tested only for <i>BD-LEC1</i> and <i>BD-5B</i>, respectively; no activation. In Section #4, I was interested to see if there was still activation when <i>5B</i> had the binding domain in the presence of an <i>AD-LEC1</i>; no activation.</p>		
2. 		
<p>Test 2 Notes:            Since <i>5B</i> could not be used in further assays because of the activation observed in Test #1, another homolog of <i>HAP5</i> was necessary. Therefore, I tested <i>BD-LEC1</i> and <i>AD-5C</i>; the result suggested that <i>LEC1</i> and <i>5C</i> interact.</p>		

<p>3.</p> 		
<p>Test 3 Notes: No activation is observed when the AD is removed from 5C, which indicates that 5C could be used for yeast three-hybrid and eventually yeast four-test.</p>		
<p>4.</p> 		
<p>Test 4 Notes: Experiments by other people have shown that all three of these proteins interact. However, it is unclear if the colonies observed are growth due to protein interactions. Based on previous tests, activation showed more colonies. Therefore, it is possible that these colonies are not a result of protein interactions and instead the result of cells building on top of each other during the streaking process or a number of other experimental errors.</p>		
<p>5.</p> 		

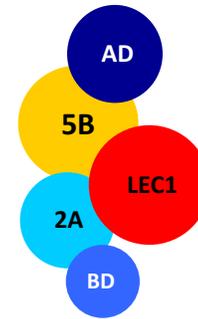
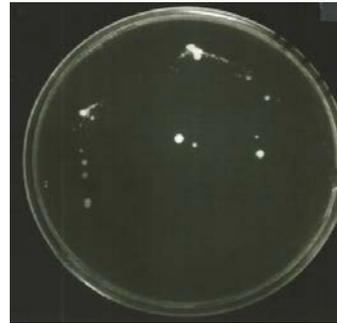
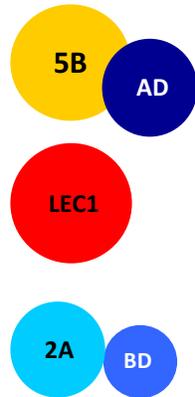
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Test 5 Notes:

To determine if the AD from Test #4 had any effect on activation, I removed the AD. This resulted in more colonies. It is unclear if the growth observed is due to protein interactions. Like Test #4, it is possible that these colonies are not a result of protein interactions and that the colonies may be a result of cells building on top of each other during the streaking process or several other experimental errors.

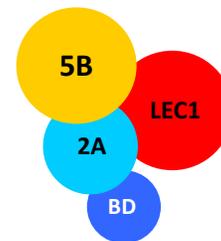
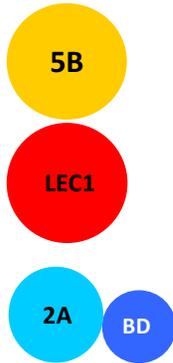
6.



Test 6 Notes:

I was interested to see if 5B had the same results in the presence of *LEC1* and BD-2A as 5C did. Similarly, 5B also resulted in the presence of yeast colonies, but it is unclear if it is due to protein interactions. Again, it is possible that these colonies are not a result of protein interactions and that the colonies may be a result of cells building on top of each other during the streaking process or a number of other experimental errors.

7.



The removal of the AD from 5B displays more colonies, which is similar to the result of 5C upon removal of the AD.

## Analysis of Results

Results show activation for BD-*LECI* and 5B (Test #1). Controls for Test #1 (Test #1, Sections #1 and #2) showed that when either BD-*LECI* or 5B are alone there is no activation. Since it has been shown that *LECI*, HAP5, and HAP2 are in a complex, it is unclear why there is activation with just *LECI* and 5B. Several explanations may account for this activation, which include anything from transforming the wrong plasmid to unsuccessful cloning of the transcription factor into the vector. Other reasons from a biological standpoint may be that there is some sort of structural modification of the proteins that takes place when 5B and *LECI* interact, which lead to activation. For this reason, I was interested to know if 5C, a homolog of the HAP5 protein, would also result in activation in the presence of *LECI* as 5B did.

Results showed activation in the presence of a BD-*LECI* and AD-5C, which would suggest that the two proteins interact in order to bring the AD to the binding domain of the reporter gene that is required for activation (Test #2). Furthermore, in the absence of an AD, there was no activation (Test #3). Together, these experiments suggest that 5C would be a suitable HAP5 homolog to use in further yeast hybrid assays.

I followed up this test with the introduction of 2A into my assays. In both experiments where 5C and 5B were in the presence of BD-2A and *LECI*, more activation was observed in the absence of an AD (Test #5 and #7, respectively) when compared to Test #4 and #6 where there was an AD. A possible explanation is that the presence of an AD interferes with the interaction between the proteins, not allowing for strong activation of the reporter gene. Therefore, when the AD is removed, the proteins interact with high affinity and recruit transcription factors that are necessary to turn on the reporter gene. Future experiments are required to validate the interaction between 2A, 5C, and *LECI* before testing with bZIP67 in order to understand if bZIP67 is required to activate this transcription factor complex.

## Conclusion

Although others have shown that bZIP67 interacts with the HAP5-*LECI* dimer, no experiments have accounted for interaction with HAP2. I have data that suggest that HAP5C, and not HAP5B, is the homolog that could be used in yeast hybrid assays to test along with HAP2, *LECI*, and bZIP67. Further experiments must demonstrate a system that could test for

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the interaction of *LEC1*, *HAP5C*, and *HAP2A* in yeast two-hybrid assays. Once this is achieved, *bZIP67* can be introduced into the assay to determine whether *bZIP67* physically interacts with the entire CCAAT box-binding transcription factor complex to initiate seed maturation in *Arabidopsis*.

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