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(Next deadline for submission: June 1, 2009)

MANUSCRIPT SUBMISSION

This section is intended to provide you with some guidance regarding the final structure and format your research manuscript should possess to warrant publication in the *SDSU Journal of Undergraduate Research*. Student authors wishing to have their work published in the *Journal* are advised to follow these guidelines as closely as possible, as manuscripts submitted to the *Journal* that are not of high quality in content and format may be rejected by the editor. The *Journal* editor understands that research products and manuscripts from different disciplines may take on quite different forms. As such, if these guidelines do not adequately answer your questions, simply follow the format and guidelines utilized by a major scholarly journal in your field of study. Professional journal articles in your field of study are a guideline for manuscript length. (When in doubt, article conciseness is important.) Your faculty mentor should be able to advise you in this regard.

All manuscripts must be submitted by your faculty mentor to the *Journal of Undergraduate Research*, Administration Building, Room 130. **E-mail electronic versions** to Linda.Winkler@sdstate.edu by June 1, 2009. Manuscripts submitted by students will not be accepted for publication.

TECHNICAL GUIDELINES

Your *Journal* manuscript must be submitted both in hard copy (printed) form **AND** electronic format (via e-mail)**.**

1. **HARD COPY SUBMISSION** Use Microsoft Word® to prepare, print and submit your manuscript with all graphics, figures and captions in place, exactly as you would like to see them appear in the final *Journal* article. Every effort will be made to reproduce your manuscript in a form most closely resembling your hard copy, however, slight variations may occur in converting your files to those used by the publisher. **Your careful adherence to the information in the next few paragraphs will ensure that your manuscript is reproduced with minimal errors.**

2. **ELECTRONIC SUBMISSION** Submit your Microsoft Word® file and all graphic and photo files as attachments to the *Journal* e-mail address. Sending one e-mail message with multiple attachments is preferred over several separate e-mails. **Manuscripts with special characters and/or symbols must also be provided in a pdf file of the highest-possible resolution with the fonts embedded**.

   All graphics (artwork, photos, graphs) **must be submitted as separate files**, saved in EPS, TIF or JPG format with a resolution of no less than 300 dpi (dots per inch) for optimum quality reproduction. The graphics will be inserted into the positions within your article as you've specified on the hard copy. Microsoft Publisher files cannot be translated and, therefore, will not be accepted.

By default, the *Journal* will be reproduced in black and white. Color printing is available, at the expense of the author, for those who have graphics they would like to portray in color. Cost of color printing is approximately $50 per page.

If you have further questions about submission, or if additional questions about content and format arise, please do not hesitate to contact the *Journal* editor, George Langelett, Economics Department, 688-4865 or George.Langelett@sdstate.edu.

MANUSCRIPT REVIEW

After your manuscript has been submitted to the *SDSU Journal of Undergraduate Research*, it will be reviewed by the editorial staff, and, if deemed acceptable for publication, converted into a "publication-ready" format (proof). A hard copy of the manuscript proof will then be returned to your faculty mentor by July 1 for final review. At that time, it will be your mentor's responsibility to make any final changes to the document and return it to the editors by the noted deadline (July 15).

It is imperative that all proofs be returned to the *Journal* staff in a timely manner so that any final changes can be incorporated before the volume goes to press.

FINAL PRODUCT

The final form of your paper will depend greatly on the nature of your topic and certain publishing conventions that may exist within your discipline. It is expected that the faculty advisor for each project will provide substantial guidance in this matter. An excellent general resource providing details of the content, style and organization of a typical journal article is the *Publication Manual of the American Psychological Association*, which is accepted as a definitive source in many disciplines. While the emphasis there is on empirical research reports (based upon original research and data collection), other types of papers are also described (review articles, theoretical articles), and an appendix: "Material Other Than Journal Articles," may be useful.

Your discipline may have its own publication style preferences, and you should explore this matter with your faculty advisor. For most all disciplines, however, articles should follow a standard format and begin with a descriptive title, the name of the author(s), the name(s) of the faculty advisor(s) and an abstract describing in brief the purpose, methodology and findings or conclusions of the project (see below). Manuscripts describing empirical research will typically be organized into further subsections, labeled: Introduction, Method, Results, Discussion, (or variations on those subheadings), along with a complete list of References.

The rest of these guidelines are intended to provide you with a sense of the appearance and content of a typical final research report, as it should appear in the *SDSU JUR*. Beginning with "Title of Your Article" below, the remainder of this document is written in the *SDSU JUR* style. Please note font sizes, format and section content, and use this example to guide you.

*** Sample Format ***
Title Of Your Article
Author(s): Your Name, Your Partner's Name(s)
Faculty Sponsor: Faculty Mentor's Name
Department: Economics

ABSTRACT

This will be a brief statement of what was done in your research, along with your principal results and conclusions. Only the most important facts should be related here, in nonindented paragraph form. Offset the abstract by using margins that are indented 0.5" on each side relative to the body of your manuscript. You may list key words to aid in online computer-search applications, if that is appropriate. For example, **Keywords**: undergraduate research, manuscript, submission, guidelines.

INTRODUCTION

This is the first formal section of a research report. This and the sections to follow should be single-spaced and laser-printed on only one side of the paper (8.5" x 11"). Early in this section, provide a general description of the research problem or activity. Attempt to identify and define whatever terms your reader will need to understand your project. The remaining paragraphs are often used to summarize relevant findings from previously completed research. Always be sure to cite your sources. Sarbin and Coe (1969) state that "in preparing a . . . report, the student must pay careful attention to the problems of documentation." In these examples of citations, "the documentation is contained in the parentheses . . ." (Sarbin and Coe, 1969). To find the remaining information, the reader examines the reference list at the end of the paper. This citation style is sometimes called "scientific notation." Other citation styles may be more appropriate to your own disciplines. Be sure to be consistent and to discuss this with your faculty advisor. Ultimately, you should use a citation style that is commonly accepted within your discipline.

The last portion of an introduction is often used to state the specific expected outcomes of the project; sometimes this appears as one or more formal testable hypotheses.

METHODS

The content of this subsection may vary greatly, depending upon the nature of the research project. You should refer to publication manuals or published research for information specific to your type of project. Sometimes this subsection is labeled "Materials and Method." Figures (see below) are often used to clarify and explain important details. In general you should use this subsection to explain to your reader, in as clear a way as possible, what you did, in the order that you did it. In an empirical research report, you should try to provide enough detail that another researcher could essentially duplicate your study without referring excessively to other sources.

RESULTS

This should be a clear description of any data (or other material) generated as a result of your research. It must start out as a written description, but this subsection is often supplemented with FIGURES and TABLES, or PLATES, or other types of graphic images. These are never sufficient by themselves. Figures and Tables should not appear in your paper until after they've been mentioned or referred to in the written portion of this section. They should appear as soon as is reasonable after such mention, either on the same page, or on the next page (see Figure 1, and Table 1). Notice, in particular, that in most scientific papers, the number and title of a Table appear above the data being described, but the number and title of a Figure appear below the data. Any units of measure must appear either in the title, or independently in the column or row headings. A table is useless unless the reader can understand exactly what is represented. **Graphic materials, properly labeled, should be included IN THE BODY of your paper, not grouped at the end.** (See the above section labeled "Submission" for further details.)

The Results section is also the place to include any statistical interpretation of the data, if such exists. Be sure to point out any important features of your findings, but AVOID to the extent possible, any THEORETICAL INTERPRETATION unless you are combining this with the next section (DISCUSSION or CONCLUSIONS).

DISCUSSION (AND/OR CONCLUSIONS)

This section is sometimes combined with the previous RESULTS section, especially when that permits a more efficient presentation. Your "Discussion" should include any theoretical interpretation of your data, including, when appropriate to your topic, the following: (1) WHETHER your results support any specific hypothesis or hypotheses you may have stated in your introduction; (2) HOW your results compare with the results in your cited research sources; and

(3) WHAT theories or explanations seem to best explain or account for the results that you are describing.

Again, be sure to cite (Sarbin and Coe, 1969) the sources for theoretical ideas and explanations provided by other writers or sources. Also, address whether there any practical applications for the results or methods used in your research.

LIMITATIONS

It is often useful, particularly in undergraduate research, to provide a summary of the limitations of the research from methodological, theoretical or other points of view to provide perspective and to serve as a possible basis for improvements in future projects.

ACKNOWLEDGEMENTS

Feel free to use this section to BRIEFLY acknowledge any and all who helped you bring your project through to fruition. You may also thank any funding sources if appropriate.

REFERENCES

Provide a complete list of all cited materials in a format that is consistent with publications in your area of study.

APPENDIX

This section is optional and generally unnecessary. In some cases, it may be included to provide a more complete description of materials used. The editor of the *SDSU Journal of Undergraduate Research* would prefer that no appendices be used. However, if absolutely necessary, the number of pages in an appendix should be kept to an absolute minimum!

The Journal of Undergraduate Research would like to thank Dr. Kevin Kephart, Vice President for Research, and Dr. Michael Reger, Executive Vice President for Administration, for their efforts to secure funding for the Journal.

^{15}N Effects on *Chlamydomonas Reinhardtii*

Authors: Ryan Geraets, Brett Kollars
Faculty Sponsors: Dr. Marie-Laure Sauer, Dr. Fedora Sutton
Department: Plant Science

ABSTRACT

Non-radioactive isotopic labeling has become a regular technique for efficiently labeling a wide range of macromolecules. The overall goal for this project was to develop a method of globally measuring plant protein turnover rates. In order to do so, an isotopic labeled environment that does not induce stress had to be used. The objective of this particular segment of research was to develop a ^{15}N-labeled Tris-Acetate-Phosphate (TAP) media in which *Chlamydomonas reinhardtii* can successfully grow without eliciting stressed physiological responses. Our results illustrate that we have successfully developed ^{15}N-labeled TAP that does not stress *Chlamydomonas reinhardtii*.

INTRODUCTION

Over the past few years, proteomics has become an increasing field in both molecular and cellular biology. It is often described as an extensive analysis of proteins at both a molecular and cellular level. Proteomics generally uses an extensive amount of technology and information with its origin tied to 2-D gel electrophoresis. However, due to the ongoing advancements in technology, mass spectroscopy (MS) has become an uprising program for protein analysis. Isotopic labeling is heavily used in mass spectroscopy for it allows thorough examination of both free amino acids and peptides. ^{18}O, ^{15}N, ^{13}C and ^{2}H are some common isotopes used to label and examine proteins. Due to the recent completion of genomic sequencing for *Saccharomyces cerevisiae, S. cerevisiae* has become a model organism for proteomics (Shrager et al., 2003; Merchant et al., 2007).

The overall goal for this project is to develop a global measurement of plant protein turnover rates with the use of isotopic labels. ^{15}N, ^{2}H, and ^{13}C isotopes will be compared to determine the most efficient form of labeling proteins. The organism of study was *Chlamydomonas reinhardtii*. *Chlamydomonas* is a fresh water unicellular; double flagellate green algae that comes from the algal family of *Chlamydomonadaceae* (Proschold, Harris, and Coleman, 2005). Currently there are approximately 459 different species of *Chlamydomonas* that can often be characterized by common morphology, for example cell wall and cellular shape. *Chlamydomonas reinhardtii* CC-1266 (American Type Culture Collection, Manassas, VA) is the particular species that was used during the experiment. *Chlamydomonas reinhardtii* was selected based on the algae's capabilities to grow both photosynthetically by fixating carbon dioxide and non-photosynthetically by

using acetate as the primary source of carbon (Proschold, Harris, and Coleman, 2005). *Chlamydomonas* can be grown in a wide array of media, consisting of both solid and liquid forms. This particular experiment will utilize Tris-Acetate-Phosphate (TAP) media.

The primary goals for this segment of research was to modify TAP media so that all nitrogen containing chemical compounds were ^{15}N-labeled (^{15}N-TAP) and culture *C. reinahrdtii* in the newly modified media. The algae grown in both TAP and ^{15}N-TAP will also be examined for physiological responses, such as growth rates and flagella detachment.

MATERIALS AND METHODS

Material

The *Chlamydomonas reinhardtii* strain CC-1266 was used in this study.

Growth Media

TAP media was modified by either substituting nitrogen containing chemical compounds with ^{15}N-labeled chemicals or by replacing by nitrogen free chemicals. The composition of the TAP media is presented in Table 1. In order to substitute or eliminate nitrogen containing chemical compounds the following changes were made: ammonium chloride within TAP salt stock was replaced with ^{15}N-labeled ammonium nitrate (Table 2) and ammonium molybdate within Hutner's Trace Element stock was replaced with molybdic acid (Table 4). Therefore, the ^{15}N-TAP media was made up exactly the same way as the TAP media but using the modified Salt stock and the modified Hutner's Trace Element stock.

Table 1. Composition of TAP media. For the ^{15}N-labeled TAP, the ^{15}N Salt stocks and ^{15}N Hutner's Trace Elements were used.

	TAP
Salt stock (40X)	25 mL
Tris	2.42 g
Phosphate stock	0.375 mL
Glacial acetic acid	1 mL
Hutner's (1000X)	1 mL
H_2O	to 1 L

Table 2. Salt stock solutions for both the regular TAP and the ^{15}N-labeled TAP.

	Salt stock	^{15}N Salt stock
NH_4Cl	16 g	
$^{15}NH_4{}^{15}NO_3$		23.91 g
$MgSO_4{\cdot}7H_2O$	4 g	4 g
$CaCl_2{\cdot}2H_2O$	2 g	2 g
H_2O	to 1 L	to 1 L

Table 3. Phosphate stock.

	Phosphate stock
K_2HPO_4	288 g
KH_2PO_4	144 g
H_2O	to 1 L

Table 4. Hutner's Trace Element Stock for both the regular TAP and the ^{15}N-labeled TAP.

	Hutner's Trace Elements Stock	^{15}N Hutner's Trace Elements Stock
Na_2·EDTA	50 g	50 g
$ZnSO_4·7H_2O$	22 g	22 g
H_3BO_3	11.4 g	11.4 g
$MnCl_2·4H_2O$	5.06 g	5.06 g
$FeSO_4·7H_2O$	4.99 g	4.99 g
$CoCl_2·6H_2O$	1.61 g	1.61 g
$CuSO_4·5H_2O$	1.57 g	1.57 g
$(NH_4)_6Mo_7O_{24}·4H_2O$	1.10 g	
$Na_2MoO_4·2H_2O$		1.51 g
H_2O	to 1 L	to 1 L

The algae was grown in 10 mL culture tubes containing 6 mL of either TAP or ^{15}N-TAP. Each tube was inoculated with 100 µL of a saturated culture of *C. reinhardtii* (Fig 1).

RESULTS

The growth of the algae in TAP and ^{15}N-TAP was similar as can be seen on Fig. 2. For each media, 5 tubes were inoculated and their absorbance at 600 nm measured over time. The data was combined, the means calculated and the results are presented in Fig.2. *C. reinhardtii's* growth was not affected by the changes made to the media to incorporate the stable isotope.

No morphological differences were observed between the algae grown in TAP and ^{15}N-TAP. This was true for color of the cultures as well as for microscopic evaluation of the cells (Fig.3).

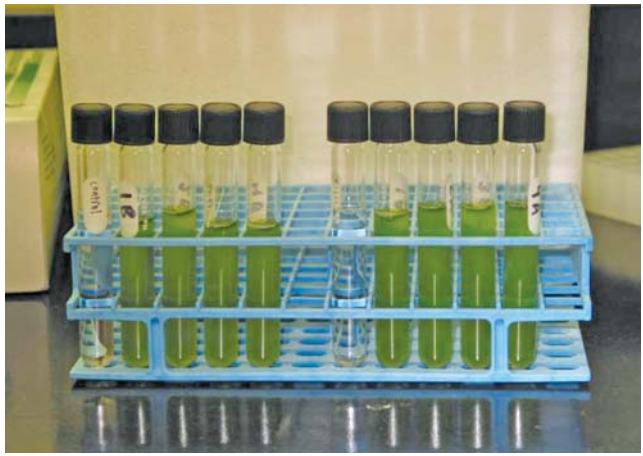

Figure 1. Culture tubes containing 6 mL of media and *C. reinhardtii*

Culture tubes were placed on a shaker and exposed to fluorescent light on a 16-hour (light) to 8-hour (dark) photoperiod under constant shaking. Culture tubes were placed directly in a spectrophotometer (Spectronic 20, Milton Roy Company) for direct determination of the absorbency at 600 nm. The data was recorded once or twice a day depending on the growth stage of the algae.

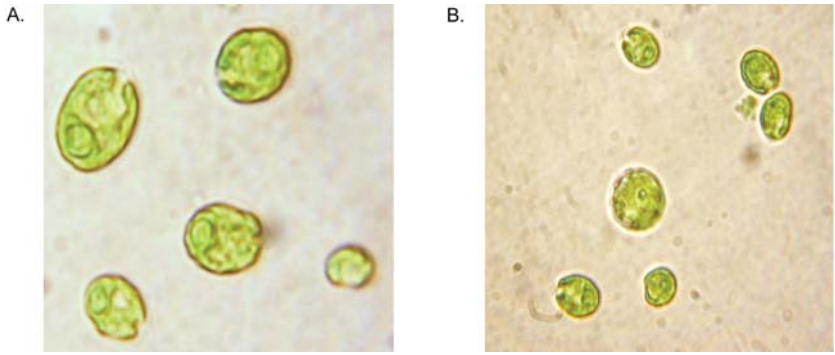

Figure 3. Microscopic observation of *C. reinhardtii* grown in TAP (A) and ^{15}N-TAP (B).

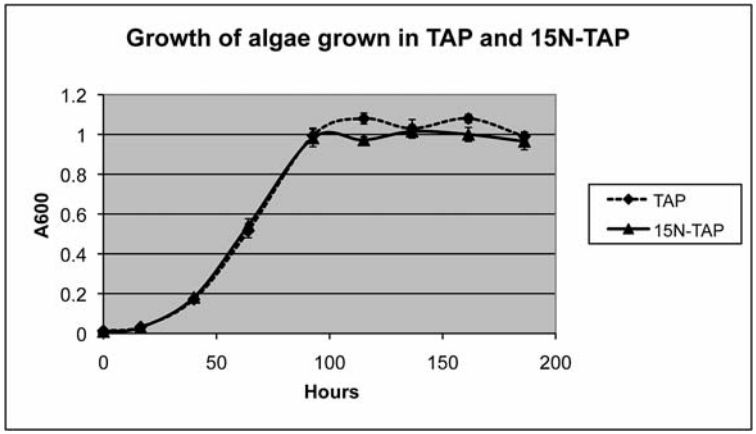

Figure 2. Growth rate comparison of *C. reinhardtii* grown in TAP and ^{15}N-TAP. Each data point is the mean of 5 replicates, the error bars represent the standard deviation.

CONCLUSIONS

The development of ^{15}N-TAP media was successful: ^{15}N-ammonium nitrate was made the sole source of nitrogen in the media. The growth or development of the algae appeared completely unaffected when grown in the media containing 100% label.

As *Chlamydomonas reinhardtii* showed no signs of stressed physiological responses to the modified media, ^{15}N is now used in our laboratory to label free amino acids and proteins. We are now positioned to verify the efficiency of isotopic labeling of free amino acids by GC-MS and of peptides by LC-MS-MS. Once we determine that the labeling efficiency is 100%, we will be able to perform chase experiments to determine protein turnover rates.

ACKNOWLEDGEMENTS

This research was made possible through funding from NSF 05-603 (sub award to F. Sutton) and the SD Agricultural Experiment Station, in house grant on algae (awarded to M-L. Sauer). We thank our collaborator Dr. Jerry Cohen and his scientific group at the UMN, St Paul for helpful exchange of ideas and materials.

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Documented Struggles and Triumph: African American Art

(winner of a 2008 SDSU Schultz-Werth Award)

Author: Holbrook Lauren
Faculty Sponsor: Dr. Leda Cempellin
Department: Visual Arts

"I am not unmindful that some of you have come here out of great trials and tribulations. Some of you have come fresh from narrow jail cells. Some of you have come from areas where your quest for freedom left you battered by the storms of persecution and staggered by the winds of police brutality. You have been the veterans of creative suffering. Continue to work with the faith that unearned suffering is redemptive." These words were spoken by Martin Luther King Jr., a major leader of the Civil Rights Movement, in the famous speech, "I Have a Dream" (King 361). King's speech undoubtedly captures the profound struggles and immense strength of African Americans in American history. African Americans have been enslaved, traded, bought, sold, treated as property, freed, segregated, and demoralized. Throughout all of their hardships and struggles art has been present.

The emergence of African Americans as artists began in the Colonial Era with simple portraits. The first African American artist to gain recognition as a portraitist was Joshua Johnston who worked in the late eighteenth and early nineteenth century. The majority of his portraits were of wealthy European American families, who were slave owners (Fig. 1). Johnston was formerly a slave, and as rumors suggests, his former owner was also a portraitist from which Johnston acquired his skills. Interestingly, Johnston did not sign or date any of his works (Lewis 15). It seems as though a suggestion to his name might reveal his race which would make the work less valuable, or seem insufficient to the other works created at the time. Another African American portrait artist of the Colonial era was Julien Hudson. Although the artist is of African descent, his piece *Self Portrait* (Fig. 2) shows the artist as a well dressed man with European features. The nose on the gentleman in the painting seems quite Romanesque. He is dressed in a tuxedo, complete with a bow tie around his neck. The portrait has a deep connection to the European artist Charles Bird King's piece, *Young Omawhaw, War Eagle, Little Missouri, and Pawness*. While King's piece, with subjects bearing Romanesque noses and European features, referred to the ability of Native Americans to be assimilated to American ways, Hudson's work may have implied that African Americans also had the nobility to fit in with the Europeans, not as slaves but as equals.

As the 1860's approached the Northern and Southern United States began to conflict, the main difference being economy and slavery. The Northern United States did not keep African Americans as slaves, instead they were free. The North did not have the need for as much free labor because the economy was based on industry. In the South cotton controlled the economy. Slaves were numerous and seemed essential to keep the plantations afloat. As anti-slavery became stronger in the North and slavery remained a

standard of the South Abraham Lincoln's statement, "A house divided against itself cannot stand" became a reality. The Civil War took place from 1861 to 1865. Lincoln, the leader of the Northern states, fought with the Emancipation Proclamation, which would free all slaves, as a war goal. Upon the Northern victory in 1863 the slaves were freed in the South.

Following the Civil War, African American art became more prevalent in the United States. The work from this time seemed to contain undertones relating to the injustice of slavery, and the newfound freedom that African Americans were experiencing. As McElroy, author of *African American Artists 1880-1987*, points out, "The African-American artists who reached maturity following the Civil War experienced the broadened opportunity afforded by emancipation but suffered the ostracism and limitations imposed by new forms of institutionalized racism" (15).

An amazing artist that emerged after the Civil War was Henry O. Tanner. His ambitions to become an artist were met with difficult detours. He sought to gain instruction from white artists of the time but was quickly rejected. He did not falter in his goals to become and artist and after working independently for numerous years he began school at Pennsylvania Academy of Fine Arts (McElroy 23). Eventually, Tanner would use his skills to teach to other African American artists, allowing them to better develop their skills using his studio. In 1880, during his first year at the Pennsylvania Academy, Tanner created his piece *After the Storm* in monochromatic blue (Fig.3). To the left of the painting is a ship that has been ravaged by the storm, and although this seems to be quite a disaster, it is not the main focus of the work. The main focus lies in the middle of the painting where there is nothing but calm, soothing, serene water. The piece seems as though a metaphor for the end of a disastrous era and the awakening of a new, bright beginning.

Another successful piece that Henry O. Tanner created is entitled *The Banjo Lesson*, from 1893 (Fig. 6). The piece was created with very muted colors, which gives it a somber tone. An old African American man sits with a child on his lap in the center of the painting. The child is holding a banjo, which was an original African instrument. This is significant because it shows that the old man is passing down a cultural tradition to the next generation, even after slavery, the African Americans still held on to their African roots and wanted to pass them on. However, what is more significant about the banjo is the technique in which the man is teaching the young boy to play. Originally, Africans played the banjo with downward strums, but when the European Americans adopted the banjo they wanted to have a way to make it unique and to disconnect it from the African culture. Instead of the downward strumming, European Americans developed a new technique in which they would pluck the strings with their fingers. In *The Banjo Lesson*, the old man is teaching the young boy to pluck the strings, instead of downward strumming (Pohl 354). The man and child are able to keep a part of their past, while adapting to the European ways.

Similar to Henry O. Tanner's piece, *After the Storm* (Fig. 3), in 1886 artist Edward Mitchell Bannister similarly used a storm as a metaphor for struggles of African Americans in the United States. His piece *Approaching Storm* (Fig. 4) was created around the same time that the Jim Crow laws were put in place to enforce segregation. "Separate but equal" was the motto for segregation, however, black facilities were often inferior to

the white facilities. Jim Crow Laws included such absurd laws as, "No person or corporation shall require any white female nurse to nurse in wards or rooms in hospitals, either public or private, in which Negro men are placed. Alabama." Or "Books shall not be interchangeable between the white and colored school, but shall continue to be used by the race first using them. North Carolina" ('Jim Crow' Laws). Although African Americans were freed, they were still treated as though they were not equal with the European Americans. They were still treated as vile, destitute humans who should not be allowed to have the same opportunities, or even be in the same vicinity of people of Caucasian descent. Segregation could definitely be represented as a strong storm, and Bannister's piece represents this quite well. The piece is largely a landscape painting. The sky is filled with the deep grays and dark colors of a strong approaching storm, the trees in the background seem as though they are rustling with the wind. In the foreground is a figure that appears to be minute compared to his overpowering surroundings. The figure is struggling against the elements that surround him, but he is still fighting to stay on his feet. His piece seems to relate to the struggle to remain dignified as and African American during segregation. Bannister fed off of a statement printed in the New York Herald in 1867 which claimed, "'While the negro may harbor an appreciation of art, he is unable to produce it.' Bannister accepted the statement as a personal challenge" (Lewis 30). Bannister's story highlights the mistreatment of African Americans even after slavery ended. One of his pieces entitled *Under the Oaks* was selected for an honorary prize at an art museum. Bannister arrived at the museum to receive the award only to be turned away due to his race.

Although African Americans were facing struggles such as segregation, the amount of joy that the Emancipation Proclamation brought was still significant. Freedom became the subject of many pieces of art, including works from Edmonia Lewis and other pieces by the above mentioned established artist Henry O. Tanner.

Forever Free by Edmonia Lewis is a marble sculpture from 1867 (Fig. 5). The sculpture seems to be a response or chronology to European American artist John Rogers' piece *Slave Auction* from 1859. Rogers' mass produced plaster sculpture shows African Americans as slaves, and the hardships they faced being auctioned from one person to another. He is able to capture the sorrow and anger that slaves experienced. A gentle man stands with great anger on his face, and his wife embraces her children with the knowledge that she will soon be separated from them. The emotion that the piece evokes is phenomenal. Similarly, Lewis' piece touches the viewer. The subjects in the sculpture also are encased in emotion, but instead of sorrow it shows great joy. It shows the overwhelming feeling of relief that must have been felt by slaves when the injustice had finally come to an end. The man in *Forever Free* stands with broken shackles around his arms and legs. The constraints that held him down for so many years were finally gone. The man's wife is kneeling on the ground. She is bent in prayer and together with the male looks towards the heavens in thankfulness.

The Thankful Poor, by Henry O. Tanner in 1894 (Fig. 7), also carries a theme of thankfulness for the end of slavery. The background of the oil painting is very muted. The colors are neutral and dull. Because the elements of the painting are not distracting the viewer is able to be drawn into the lives of the subjects in the artwork. An African

American man and a young girl sit alone at a small table for a meal. On the table sits the meal which consists of one small plate of food. It is apparent to the viewer that these two people do not have much in life. The house is small, and so is the meal that they will soon be sharing. Often times these Americans lived in ghettos, not being allowed to integrate with white Americans. However the two people are bowing their heads in prayer. Tanner liked to capture the "everyday activities of ordinary people" (Lewis 47). It is amazing to see these two people who have been kept as slaves, then released to a life of poverty and segregation, still being thankful for what they have.

The early twentieth century brought about new changes in the character of African Americans, which can be seen with the emergence of the "New Negro." As Neil Irvin Painter, author of *Creating Black Americans* states, "The 'New Negro' of the period during and after the First World War was self-confident, urban, and Northern. Earlier stereotypes of 'the Negro' depicted rural Southerners full of Southern humility and deference to white people, signs of an acceptance of black inferiority. The figure of the new Negro of the early twentieth century denied charges of racial inferiority. He- for the race was still envisioned as one man- was proud to be a Negro. He fought back when attacked and proclaimed pride in his race. The New Nergo emerged from his times" (189).

Viewing the "New Negro" as a self-confident, urban, and Northern individual inspired many African Americans to migrate to the North. The Great Migration, which took place from 1916 to 1919 resulted in more the 500,000 African Americans leaving the South. Painter conveys, "It suddenly multiplied the black population in cities where African Americans had hardly been noticed before." Cities such as Cleveland and Detroit more than tripled their percentage of African American population (Painter 191). This newly found sense of culture, confidence, and pride reflected in the artwork of the Harlem Renaissance.

Beginning in the 1920's and continuing to the 1950's, the Harlem Renaissance marked an era in African art. McElroy claims, "The art of black Americans underwent numerous changes between 1920 and 1950. These changes in aesthetic points of views and degrees of racial and cultural consciousness can be attributed to the ideological shifts within black America as a whole. It was in the period that African Americans experienced spells of heightened self-awareness and optimism about the future, as well as moments of despair and disillusionment concerning their role in American society" (41). The art of the Harlem Renaissance revolved around "realism, ethnic consciousness, and Americanism" (Lewis 59). This art movement was very notable because white Americans did not believe that African Americans could be successful at making art, and they were not creating work of the same style that was popular with European Americans of the time. African Americans proved everyone wrong and came up with a style all of their own. This movement was also quite notable because the artists of this time were struggling, along with all of the United States, with the Depression of the 1930's, which took place in the middle of the Harlem Renaissance. This movement was lead by Aaron Douglas.

Aaron Douglas gained a degree from University of Nebraska and taught for a year following his graduation, but discovered that was not his calling. Instead he joined a group of realist painters and began adding geometric African style shapes to his paintings. He hoped this would express his "racial commitment" in his art. In his piece *The Creation*

(Fig. 8), Douglas is able to explore the visual representation of the creation of man in a very distinct style. The background of the work contains rolling waves in muted tones, along with geometric, seemingly transparent circles. In the foreground a man stands amidst free flowing mountains and a very organic shaped plant. The man stands appearing as a silhouette with very square, geometric shoulders. In the sky is what appears to be a very abstract hand, although it is made up of only organic shapes, and is not defined by fingers or minute details. It looks as though early African art has been redefined, and used in an improved way, along with new techniques to deal with significant issues of the time, or in this case religious events from the past.

The bright colors of Palmer Hayden's watercolor piece, *The Subway* from 1930 (Fig. 9), instantly draw the viewers in. It also is a distinctive Harlem Renaissance piece, but has a very different subject matter and style. The subject in the work is Americanism. The painting is a small portion of the inside of a subway car. A very dark skinned African American man stands holding onto a handrail, next to him stands a mixed race African American, also holding onto the same handrail, almost in companionship, or support. Meanwhile, a white lady glares at the two men from across the car with disapproving eyes, and two other white people stand within reach of the handrail, but holding on to nothing, as if they refuse to touch the same handrail as a person of color. The problems of discrimination in America were beginning to be pointed out, as they were in this artwork, and soon action would be taken to put an end to the prejudice.

The Harlem Renaissance did not only revolve around art. Literature and music were also advancing in African American culture during this time. An example of the mixing of literature and art in the Harlem Renaissance can be seen in Charles Alston's piece from 1934 entitled *Girl in a Red Dress* (Fig. 10). The artist abandoned old beliefs that the standard of beauty lied within European features. Alston found African features to be a standard of beauty and pride (McElroy 53). The girl in this painting appears to be tired, and looks as though she has had a hard life. Her face is fixed in an expression of anger, and maybe even meanness. However, if the viewer looks closely there is also a hint of serenity and contentment in the young face. She wears a bright, beautiful red dress with pride. The piece was made for African American poet Langston Hughes' poem *When Sue Wears Red*, in which the final lines of the poem read, "And the beauty of Susanna Jones in red, Burns in my heart a love-fire sharp like pain." ('Poetry by Langston Hughes').

The new confidence and self-reliance that African Americans gained through success of their art and the knowledge that they have gained is shown to its fullest during the Civil Rights Movement. The first big stride for the Civil Rights Movement was the ruling of the Brown vs. Board of Education Movement in the early 1950's. This ruling stated that 'Separate but Equal' laws were unjust. It was discovered that the African-American students were not getting the equal amount of education as their white counterparts. Thus, the United States began the slow road to desegregation. (Williams).

Many of the white citizens of the United States felt angered at the introduction of desegregation, and felt the need to stop the process. White citizens began to act out upon African-Americans, and continued segregation in every way possible. However, many African-Americans had new courage to stand up for themselves as they saw hope for change. While being beaten and battered by their white counterparts, African-Americans

kept the Civil Rights Movement non-violent. Instead they arranged sit-ins, boycotts, and marches to protest the unjust treatment of their race. An example of this is Rosa Park's initiation of the bus boycott.

"On December 1, 1955, Rosa Parks, the 'mother of the Civil Rights Movement,' refused to get up out of her seat on a public bus to make room for a white passenger. Parks was arrested, tried, and convicted for disorderly conduct and violating a local ordinance. After word of this incident reached the black community, 50 African-American leaders gathered and organized the Montgomery Bus Boycott to protest the segregation of blacks and whites on public buses. The boycott lasted for 381 days until the local ordinance segregating African-Americans and whites on public buses was lifted" (Williams). It is amazing that the African-Americans were so strong that they would walk miles to work, instead of riding the bus, to prove that the way they were treated on the buses was wrong. Without using violence, African-Americans were able to make a difference by decreasing the bus revenue by 60 percent!

African-Americans became more prevalent, sitting-in on restaurants that refused to serve them, not leaving no matter what the owner threatened. They were also brave enough to attend schools where they were allowed, but not welcomed. Each step without violence. On August 28, 1963 the African-American peoples arranged a march on Washington, DC. It was during this time that Dr. Martin Luther King, Jr., delivered his famous "I Have a Dream" speech. (Williams). This was undoubtedly the height of the Civil Rights Movement. Finally, in 1964 a law was passed banning discrimination in work places, public accommodations, and schools. This was followed in 1965 with the Voting Rights Act, which allowed African Americans to vote in the United States.

Although there was so much change going on in the black community during this time, it is interesting to note that, "In Art History specifically, there has been little investigation into the Civil Rights Era. There is even less evaluation of art works created by black artists during this period, and of how the politics of the period influenced their art forms… The voices of African-American artists who were creating during the fifties and sixties were effectively muzzled" (Jamie-Horry 3). It is unfortunate that at such an innovative period, revolving around new freedoms, new emotions, yet continued resentment is not properly researched and documented. There is definitely not an abundance of accessible African-American art from this era; however, the subject of the artworks that are available is very clear.

Artists such as Joe Overstreet were affected by the ideas of segregation and racism that blacks were experiencing during the 1960's, and it was reflected in their artwork. Overstreet was enthusiastic to be an artist. He was exploring opportunities such as applying at Disney Studios in California in 1953. Overstreet believed that he was not given a fair opportunity, and was turned away because of his color. "From his experiences at Disney Studios, he began to realize the difficulty of his goal to become a painter. Racism was present not only in the animated film industry, but also in the fine arts world. Overstreet recalls meeting with Mark Rothko, Franz Kline, Jackson Pollock, and William DeKooning in New York City bars and realizing that the art world would never open up to him, or any other black artist. Many black artists experienced restriction and rejection during the fifties and sixties" (Jamie-Horry 16).

Overstreet did not give up on art just because he was rejected by the white community. Instead, he created pieces revolving around racism, and life issues that he has encountered. In his piece, *The New Jemima*, 1964 (Fig. 11) shows the character of Aunt Jemima, who Americans are used to seeing as the lady who cooks, cleans, serves, and acts in a motherly role for the children, in a different light. The piece is done in black and white, which creates a very somber mood. Jemima, a lady who the artist depicts as being filled with black pride, is holding a very large gun, and has a look of satisfaction on her face. This shows that Overstreet felt that some sort of revenge should take place for all of the hurt and sorrow that existed in his, and his family's past. Although the piece is very serious, Overstreet is able to ad a humorous touch by showing Aunt Jemima's pancakes flying through the air in this tense situation.

Inspired by the Civil Rights Movement, Feminism began to flourish in the United States. Women began to realize that just as African Americans were being suppressed, women were also given the notion that they were inferior to males. From the mid 1960's to the late 1980's women fought to change society's views on male superiority. During this time women challenged the stereotypes that held them back, and began to realize that they could achieve more than staying home to be a wife and a mother. Women's rights were even included in the Civil Rights Act of 1964. As stated by this law, "It shall be unlawful employment practice for an employer to fail or refuse to hire or to discharge any individual or otherwise to discriminate against any individual with respect to his compensation, terms, conditions, or privileges of employment, because of such individual's race, color, religion, sex, or national origin" ('Title IV'). Aside from the work force, women also focused their efforts on topics such as freedom of choice, which included a spread of contraceptives, abortion, and divorce. The idea of "Women's Liberation" became widespread.

The Feminist movement seems as though it should have been an exciting time for African American women artists, however, it was not. The feminist movement was focused mainly on European American women, who snobbed African American women in their efforts. Betye Saar, an African American woman artist of the time, recalls, "It was as if we were invisible again, the white women did not support us" (Farrington 148). This left the African American women with a tough choice. They must choose between joining the feminist movement, where they were not properly represented, but were able to progress, or staying with the black American movement, which had already proven to be successful. Betye Saar chose to stay with the black liberation movement.

Saar's artwork is very meaningful to the black liberation movement because her pieces are filled with relics from the past. The majority of her work is created by assembling remnants from when the Jim Crowe laws were enforced. The items that she uses in her pieces are able to show the demeaning nature of segregation.

Similar to Joe Overstreet, Betye Saar also dealt with the stereotype of Aunt Jemima. Her mixed media work, *The Liberation of Aunt Jemima* (Fig.12), holds many symbolic references. In the background stands a strong black woman. In one hand she holds a broom, signifying the past. In the other hand is a rifle, symbol of the new strength that this woman has, and her ability to fight back if she is mistreated, or possibly the defense against the reoccurring racism that feminism brought about. In front of the statuesque

figure is a painting of a black woman holding a baby. According to Frances K. Pohl, author of *Framing America: a Social History of American Art*, the baby is a mulatto baby, it is "an indication of the sexual enslavement of black women" (478). In the very foreground of the artwork is a black fist, the undeniable symbol for black pride. This piece truly shows the great struggle that African Americans have experienced, yet also holds a sense of pride.

In the 1970's, new ideas of cultural pride, starting new, and improving life quality of the African Americans took root, extinguishing ideas of revenge and sorrow.

An artist who portrays the idea of cultural pride is Charles Searles. His artwork revolves around "life experiences, therefore emphasizing education, self-respect, and concentration on the solution in his art forms. These, Searles has come to believe, are the necessary factors for improvement of the position of the African-American" (Jamie-Horry 12).

Searles' artwork is very vibrant and alive with rich, energizing colors. The mood is very happy. His piece *Celebration* from 1975 (Fig. 13) shows a group of people who are proud of their heritage and overcome with joy. With bright yellows, oranges, reds, and blues Searles depicts a cheerful gathering. In the back of the artwork is a set of bongo drums, supplying a rhythm for the piece. With the dancers depicted in the foreground, the viewer can just imagine what the music might sound like. It is amazing to think that someone who has overcome such hardship and unjust treatment in his life could make something so beautiful and cheerful. Searles must have experienced this abundance of joy at some point in his life because he feels that, "artists cannot create works that are not influenced by occurrences faced during their lifetime. 'All [of] your experiences make you what you are'" (Jamie-Horry 12).

Another artist who believed in portraying a sense of culture was Ed Wilson Jr. His piece *Jazz Musicians* from 1984 (Fig.14) shows the progression of the African American culture. This bronze relief shows lively musicians playing various instruments - drums, saxophone, trumpet; all instruments which are traditional to jazz music. Wilson was inspired by jazz music because "He sees black jazz musician as evolving, relaying individual experiences and the history of a people. These artists have developed, modifying musical-melodic structure and rhythm in order to musically document various black social experiences. For example, the migration from the South to the Northern cities introduces some change in music" (Jamie-Horry 14). For Wilson, jazz music is a large part of his culture, and a great influence on his art, along with the ideas of freedom and movement. During the Civil Rights Movement Wilson was involved in organizing protests and sit-ins and challenging segregation and legal racism. It is amazing to see how these factors just contributed to his sense of cultural pride instead of resentment of whites through his artwork. Wilson states that in order to move forward, " The American Negro, whether he is an artist or not, has to get over his self-consciousness of being black. He has to forget the put-down of the 'Tarzan' pictures and see the real potential of African and other black people. Also one's self-image has to be expanded before one can accommodate an outside image intelligently. I feel that the education of the American artist, whether he is black or white, should include exposure to African art, American jazz and the psycho-social dynamics of the American scene. There is a strange vitality

fermenting under this racial tension in America and I want to see it erupt" (Wilson). This was an innovative, intelligent way to look at the situation.

With evolving times, the artwork of many African American artists continues to focus on political and social injustice. Although the focus is no longer solely on racism, there continues to be discrimination in the United States against interracial couples, as well as a deep intolerance for homosexuality. An artist who explores these issues is Renee Cox. According to Farrington, author of *Creating Their Own Image, "The People's Project* propels Cox beyond the era of conceptualism and black consciousness into a contemporary age of eclecticism and broader concepts of human identity. Comprised of Asians, Caucasians, and African-Americans, multiracial and same sex couples, the series offers redefinition of the Other that includes virtually everyone in a reappraisal of race" (227). It is interesting that Cox is striving for equality among everyone in the United States, not just a particular social group to which she belongs.

Renee Cox's piece *Untitled #9* from *The People's Project*, 2000 (Fig. 15) is very striking. An African American woman stands in the foreground of the piece, with her arms intertwined with a Caucasian male who stands behind her. The piece is not only socially valuable because of its representation of the interracial couples, but it also contains beautiful aesthetics. The contrast of the woman's dark skin adjacent to the pale white skin of the male complement one another. The shadows on the figures blend into the dark background, so the viewer cannot tell where one stops and the other begins. The two figures seem to stand as one.

Today African Americans continue to create new, exciting work. It is amazing to think that it has been less than 50 years since the end of the Civil Rights Movement, and many of the people who have experienced that are still alive and making art today. Their life experiences and childhood memories are so valuable. It was such a hurtful, unjust past, but joyous outlook for equality in the future. As Dr. Martin Luther King Jr. continues, "We cannot walk alone. And as we walk we must make the pledge that we shall march ahead. We cannot turn back" (King 361).

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Attitudes Toward Counterfeit Fashion Products: A South Dakota State University Case Study

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ABSTRACT

Ethically, morally, and legally people know it is wrong to produce and use counterfeit money, but why do we not think twice when it is a fashion product? The business of counterfeiting fashions is a growing problem with no end in sight. Over the past few decades, the problem has been increasing to an ultimate high. Purchasing a counterfeit product reflects on a person's ethics and morals. There is a difference between a knock-off version of a designer's product and a counterfeit product; the terms will be defined and evaluated. The ethical and legal dilemma that consumers are in will also be discussed. After a review of the current literature, I look into the attitudes and beliefs of students at South Dakota State University and interpret what the data from the case study reflects about the counterfeit fashion industry.
Key words: counterfeit, fashion, attitudes, beliefs

INTRODUCTION

Ethically, morally, and legally, people know it is wrong to produce and use counterfeit money or copy music CDs and video DVDs, but why do we not think twice when it is a fashion product? Spotting counterfeit items can be a designer's worst nightmare. Designers work hard to create the merchandise they sell. On the other hand, some consumers cannot afford the merchandise of designers.

The purpose of this paper is to review current literature that examines the difference between knock-off and counterfeit merchandise, to look at the counterfeit fashion business, the effects counterfeits have on society, how to spot counterfeit items, and the ethical dilemma with counterfeit fashion purchases. I also look at a case study of attitudes and beliefs of apparel merchandising students at South Dakota State University (SDSU).

For the purpose of this paper, a counterfeit product is defined as a product that has been illegally duplicated to appear identical to the genuine product (Ha & Lennon, 2006). Knock-off products are defined as products that are similar, but not identical to, the original designer version of the product and made with cheap materials, then sold at a lower price point (Calasibetta & Tortora, 2003). Both counterfeit and knock-off products may have similar appearances to the original, such as packaging, trademarks, and labeling

(Ha & Lennon, 2006). When performing a web search for counterfeit fashion, almost one million pages come up for review. Most of those pages use the terms "knock-off" and "counterfeit" loosely but mean the same thing when using both words. Most sites just mean that a product is not the original, authentic designer's version of a product but a reproduction of the original.

It is important to analyze the topic of counterfeit fashion products because the range of items being counterfeited is infinite: anything from dresses, shoes and purses, to watches and jewelry. Designers find it difficult to protect their merchandise because U.S. patent laws require designers to prove their work is "original and novel" while copyright laws do not protect the apparel industry (Marcketti & Parsons, 2006). The trend toward counterfeit merchandise has grown throughout history and predictably will continue to increase.

After a review of the literature that provides a comprehensive understanding of the background and current state of counterfeit designer merchandise, I look at attitudes and beliefs of 60 SDSU students. Through a student survey of 48 SDSU apparel merchandising majors and 12 non-majors, I have been able to interpret the attitudes toward counterfeit fashion among a small group of students at SDSU. The survey contains basic definitions for the terminology used for the study, as well as an introduction of my research objectives. Five of the eight questions discuss knowledge and beliefs about counterfeit fashion products, and the remaining three questions were used to establish student demographics (Frerichs, 2008a; see Appendix A: Student Survey and Appendix B: Demographics of Research Participants).

With 21 of the 60 total students who participated in the survey, I also conducted additional research with small focus group discussions (Frerichs, 2008b; see Appendix C: Focus Group Discussion Questions). They were asked four main questions with some additional sub-questions. Each session was recorded on paper and a digital tape recorder. Each participant granted permission to me to record the discussions anonymously (see Appendix D: Form Used for Obtaining Permission for Audio Recording). The findings discussed in this paper emerged after thorough deliberation of the attitudes and beliefs of SDSU apparel merchandising students.

LITERATURE REVIEW

The Growing Problem

Counterfeit fashion products and merchandise are not new to anyone. The $600 billion annual industry (Dimet, 2006; Nanda, 2007) continues to grow every year and increases as the most serious threat facing the national economy. Philips (2005) reported that the counterfeit business as a whole would be the world's largest business if it were recognized as a business. In 1985, about $60 billion was spent on counterfeit merchandise; in 1994, sales were about $200 billion and in 2002 about $376.2 billion (Ha & Lennon, 2006). The Organization for Security and Cooperation in Europe (OSCE) found that 7% to 10% of the total world trade ($450 billion) is from counterfeit goods (Dimet, 2006; Sforza, 2006; Thomas, 2006c). Both the International Anti-Counterfeiting Coalition (IACC) and OSCE agree that much of the counterfeit industry is made up of fashion

items. About 18% of the $98 million worth of counterfeit products detained by the U.S. customs in 2002 were apparel, sunglasses, watches, handbags, and headwear. Much of the counterfeit fashion industry comes from foreign countries. About 70% comes from Asian countries, including China, Korea, and Taiwan with top counterfeit production and sales, respectively (Nellis, 2003).

Counterfeit purchases deprive the U.S. of more than $200 billion each year in tax revenue (Hathcote, Crosby, & Rees, 2005; Kelleher, 2006; Nellis, 2003). That money could be used, instead, for programming in such places as schools, hospitals, and communities. Less revenue equals less money, which in turn means fewer resources for Americans. Selling counterfeit products is a cash, tax-free business. Ordinary citizens are required to pay taxes but dealers fill their pockets with the tax dollars instead of paying the government. According to Ha and Lennon (2006), counterfeiters contribute to the "economic black market" because governments lose money with no tax revenue.

Serious threats and terrorist acts have been linked to the counterfeit industry. For example, handbags can be lined with illegal drugs and used for smuggling. Groups such as Al-Qaeda, the Mafia, the Irish Republican Army, and Chinese Triad profit from selling counterfeit goods. There is evidence to show links between terrorism and counterfeit goods (Ha & Lennon, 2006). Evidence from the Federal Bureau of Investigation (FBI), other federal officials, and anti-counterfeit investigators shows the bombing of the World Trade Center in 1993 was funded by the sale of counterfeit fashion goods (Ha & Lennon, 2006; Henry, 2003; Kelleher, 2006; Nanda, 2007; Nellis, 2003). Counterfeiting businesses are threatening society; every time someone purchases a counterfeit product, he/she supports illegal activities of some kind, somewhere in the world (Kelleher, 2006).

Not only has the counterfeit business reduced the amount of tax revenue and posed serious threats to security, but also the business has eliminated numerous jobs for people around the world. The Counterfeiting Intelligence Bureau studied the number of jobs lost in recent years due to counterfeiting and discovered between 1988 and 1997 over 200,000 jobs have been lost worldwide; over 100,000 jobs were lost in European countries alone, and 30,000 fashion and apparel related jobs have been lost worldwide (Fighting Counterfeit, 2007; Ha & Lennon, 2006; Sforza, 2006).

Some research has been done to track the number of purchases of authentic products versus counterfeit products from particular designers. Ledbury (2006) conducted a study on brands that consumers purchase most in the UK. The study compared the percent of genuine product purchases to the percent of counterfeit product purchases and found that Louis Vuitton, Gucci, Prada, and Tiffany have nearly the same amount of consumers purchasing the genuine product as consumers purchasing the counterfeit version. On the other hand, Yves Saint Laurent, Chanel, and Burberry have more consumers purchasing the genuine products than the counterfeits.

Spotting the Counterfeit Fashion Product

Counterfeit fashion products are nearly identical to the designer version in aspects of appearance, packaging, trademarks, and labeling (Ha & Lennon, 2006), but the difference lies in the price and quality (Kelleher, 2006). The purpose of selling counterfeit goods is to deceive buyers into purchasing something that they think is authentic. Over 5,000

websites have been created to sell counterfeit purses (Kelleher, 2006) and thousands of other sites sell counterfeit sunglasses, accessories, or apparel. Every website claims they are selling "genuine" and "authentic" products, but there is no way to be sure the customer is getting the real deal without extensive research on the company and its website.

Designers work hard to release the trendiest fashions for the fashion-savvy individual. Researching a company to find out which specific aspects make the particular designer unique is the most beneficial way for consumers to educate themselves before making a purchase. Certificates of authenticity or identification cards are included with every designer product purchase. Authentic designer merchandise will only be sold at authentic dealers for the designer and official retailers such as Nordstrom, Neiman Marcus, Bloomingdales, or Saks Fifth Avenue (Nellis, 2003; Thomas, 2006a).

The fabric quality of a designer bag will be exceptional. Designers do not use low quality fabrics and materials in the production of their products. Bags and purses should stand up under their own weight. Neither the handles nor the bag itself should collapse when the bag sits empty on a table (Thomas, 2006a). The logo will never run into the seams of a bag. The pattern of the fabric is intricately designed and placed so it is aesthetically pleasing (Thomas, 2006a). For example, logo fabrics such as Louis Vuitton, will never run into the seams and letters will not be misplaced. The fabric or leather should not pucker at the seams. Stitches on designer products are small and precise. Poor quality leather and fabrics as well as shoddy stitching, are indicators of a fake (Kelleher, 2006).

The details on the bag should be of the highest quality and have designer name imprints. The zipper pulls will have the name of the designer imprinted on them as well. The handles, buckles, and other trimmings will be of excellent quality. A bag with kinks in the straps, flimsy trimmings or cheap, generic zipper pulls and metal studs are indicators of a fake (Kelleher, 2006; Nellis, 2003; Thomas, 2006a).

Overall construction of a product plays a large role; designers are meticulous and precise. Leather is always of the highest quality and all zippers, buckles, and other decorations will match the product. Designers usually have small color runs of a particular design. Counterfeiters often sell products in more colors than the designer actually makes. The logo is often the most important part of the product; it will never be misspelled, smudged, or misplaced (Thomas, 2006a).

The price is the first and easiest factor to determine if a product is counterfeit. If the price is "too good to be true," it probably is. Designers do not typically discount their merchandise; for example, if a seller on EBay lists an "authentic" bag for $9.99, it is likely to be fake. On the other hand, a product with a high price tag is not necessarily genuine. Consumers need to look at all aspects of a product before committing to a purchase. There is no guarantee that a product found on the Internet and the attached description and picture will actually turn out to be the real item (Fighting Counterfeit, 2007).

Finding a genuine designer bag can be a hard task, especially if customers are trying to order one on the Internet. With thousands of websites available, everyone claims to have authentic designer merchandise. Some sites will tell shoppers that the items sold on the site are "look-alikes" or "knock-offs," both of which are not the original designer products. Many websites on the other hand will not tell shoppers if the products are fake. One way to guarantee that the product is real is to buy directly from the designer's

website. Other websites such as Overstock.com and Bluefly.com also sell designer merchandise at practical prices (Tew, 2007). These sites include a certificate of authenticity, style numbers, and a detailed description of the designer merchandise. Bluefly.com has a strict return policy of no returns unless the security tag is still attached; Overstock.com's return policy is less strict.

BuySAFE.com is another website that guarantees the authenticity of products on their site. Its goal is for every online transaction to be problem-free. BuySAFE verifies the seller's identity, financial stability, and ability to honor the sales terms and conditions. BuySAFE also guarantees a full replacement or refund of up to $25,000 if the purchase is not satisfactory. The service of BuySAFE is completely free to consumers.

Mall kiosks, purse parties, street vendors, and specialty mall shops are other examples of places to purchase knock-off and/or counterfeit designer merchandise. One kiosk in a mall in Omaha, Nebraska, actually promotes fake Chanel bags and trains its employees to sell the bags to customers by telling them to cut off an extra tab on the logo. The bag appears to look the same as the authentic designer's version with the exception of the cut-off tab. Other people encourage women to take part in purse parties and buy discounted designer merchandise. The party host is not at risk, but the person selling the merchandise is buying the items from people supporting serious criminal activities as previously discussed (Dimet, 2006; Kelleher, 2006).

Canal Street in Manhattan, Xiangyang Road in Shanghai, and Silk Alley in Beijing are all examples of major locations of serious counterfeit sales (Thomas, 2006c). In December 2005, Burberry, Gucci, Louis Vuitton, Prada, and Chanel filed a lawsuit against the Xiushui Haosen Clothing Market in Beijing because of the massive amount of "made in China" counterfeit products (Sforza, 2006). The company knew the goods were pirated, but did not stop venders from selling them. They were sued by five designer companies for copyright violation and selling counterfeit merchandise (Western Brands, 2006; Xinhua News, 2005). The designer companies won the lawsuit. According to Xinhua News (2005), the property owner and vendors who sold the merchandise were ordered by the court to stop selling the merchandise and pay nearly $13,000 in compensation to the designers. This lawsuit was the first of its kind to be filed in China.

Ironically, in 2004 commerce officials in Beijing posted signs on a building standing next to the entrance of the Xiushui Market. Trademark protection was the message of the signs and warned violators that they could face fines, seizure of merchandise, and/or lawsuits (Plafker, 2004). On the other hand, in November 2007, California's seizures of counterfeit goods increased 24%, compared to November 2006, at the largest U.S. port, Los Angeles-Long Beach (Casabona, 2007).

Of all goods sold globally, over 10% are illegally copied or counterfeited (Fighting Counterfeit, 2007). About 20% of the sales of knock-off merchandise come from street vendors, flea markets, and auctions. Internet sites sell approximately 14% of the fake merchandise (Dimet, 2006). The statistics prove it is a difficult process but with knowledge, all consumers can beat the growing business of counterfeit and fake goods. Finding the perfect real designer handbag can be a difficult process, but consumers will be highly rewarded with their purchase and the hard work will pay off (Thomas, 2006b).

As mentioned previously, much of the counterfeit goods arrive from China, Korea, and Taiwan, primarily because of easy access to labor. Sweatshop labor in China is cheap (Sforza, 2006) and over 50% of the counterfeit goods imported in the first half of 2005 were traced back to Chinese factories (Kelleher, 2006). The Chinese factories consist of nearly 20% child workers, some as young as age 12. Factory employees are forced to work long hours at less than the minimum wage pay of the United States (Kelleher, 2006). By purchasing counterfeit goods, consumers are promoting child labor and cheap labor in foreign countries.

An Ethical and Legal Dilemma

Ethical decisions deal with an individual's choice in deciding between something morally right or wrong. Making ethical decisions is a common daily occurrence for all individuals. When people are faced with an ethical problem and need to make a decision, they go through three stages: recognizing an ethical issue, making an ethical judgment, and formulating behavioral intentions according to the Hunt-Vitell Theory (Ha & Lennon, 2006). When faced with an ethical decision, people acknowledge the problem, determine alternatives and solutions, and then choose the best option. Consumers are free to make decisions and must deal with the consequences of whatever decision they make.

Ethically, everyone knows manufacturing, using, and dispersing counterfeit money is illegal. Many people also agree it is also unethical to manufacture, use, or distribute counterfeit prescription drugs and airplane or cars parts, but this happens more frequently than consumers would expect. About 2% (or 520,000 pieces) of all airline parts installed each year are counterfeit, according to the Federal Aviation Administration (International, 2007). According to Heather McDonald, an anti-counterfeiting specialist at a law firm in New York, "there have been counterfeit perfumes tested by laboratories that have found that a major component was feline urine" (Thomas, 2008). Many consumers do not think it is a big problem to purchase a counterfeit fashion product, but if a consumer purchased a pair of counterfeit sunglasses, the lenses could shatter, or eyes could develop vision problems due to little or no UV protection. There are numerous examples of instances where consumers could be hurt by the counterfeit products they purchase, such as a garment that is flammable or allergenic, toys that contain hazardous material or parts that break easily, car and airline parts could malfunction and/or cause accidents, electronics could short-circuit, and medications could kill. If consumers knowingly purchase counterfeit products, they are responsible for the consequences (Fighting Counterfeit, 2007).

There is not a difference between using or purchasing counterfeit money, car or airplane parts, prescription drugs, or fashion merchandise. Why do people think it is ok to sell a counterfeit purse when they know making counterfeit money will get them into a lot of trouble? The consequences are different, but the concept is the same: it's counterfeit. Money counterfeiters, if caught, could be fined up to $15,000, spend up to 15 years in prison, or both (United States, 2007). On the other hand, counterfeit fashion laws are not as stringent. Patent and copyright laws are firmly in place in the United States, but fashion designers find it hard to prosecute counterfeiters on the terms of copyright and patent violation (Marcketti & Parsons, 2006).

Research shows that people who purchase fashion items do not believe that counterfeit goods are an alternative to purchasing the genuine product. Fashion purchasers also feel guiltier about buying a counterfeit than non-fashion buyers (Lee, Cheng, & Breseman, 2003). They believe the counterfeit fashion products are poorer quality, and therefore have a negative attitude toward counterfeit products (Shim & Lee, 2005).

METHODOLOGY

After reviewing current literature, I began to wonder: What are the attitudes and beliefs about counterfeit fashion of students at SDSU? According to Janesick (1994),

> Qualitative researchers design a study with real individuals in mind, and with the intent of living in the social setting over time. They study a social setting to understand the meaning of participants' lives in the participants' own terms. (p. 210)

In my attempt to understand the attitudes and beliefs toward counterfeit fashion products at SDSU, I began an interpretive analysis of the research. Rather than setting specific parameters for analysis, I was interested in exploring themes that would emerge from the surveys and focus group discussions. The preliminary study of the surveys and focus group discussions revealed similar feelings among most of the students. The interpretation presented here is structured around the themes and is based on an interpretive approach to textual data that focuses on understanding the meaning assigned to experiences of everyday life (Taylor & Bogdan, 1984; van Manen, 1990).

Demographics and Data Collection

A student survey was handed out in three apparel merchandising classes at SDSU during the spring 2008 semester. Sixty students answered the survey; 45 of the students were apparel merchandising majors, three students were apparel merchandising minors, and 12 were non-majors. The survey included basic definitions for counterfeit products, knock-off products and original designer products (see Appendix A: Student Survey). There were eight total questions on the survey; five questions focused on specific details pertaining to counterfeit fashion and three questions asked for student demographic information. The entire survey took about five minutes to complete.

Of the apparel merchandising students surveyed, 16 were freshmen, 17 were sophomores, seven were juniors, and eight were seniors. Of the non-majors surveyed, one was a freshman, four were sophomores, four were juniors, and three were seniors. All students were females over the age of 18.

Due to the complexity of the subject matter and confusion that could be caused by numerous controversial words, definitions for counterfeit, knock-off, and designer products were given at the top of the survey. For the purpose of the survey, *counterfeit products* were defined as illegally made replicas of designer products portrayed to be the exact designer product, while *knock-off products* were defined as a legally made products similar to the designer's but not portrayed as the exact designer product. In contrast,

original designer products were defined as designer products made and distributed by the designer. In addition to the survey, I also conducted small focus group discussions with 21 of the 60 students surveyed.

DATA ANALYSIS

For the interpretive analysis of this qualitative research, three themes surfaced from the survey and focus group discussions. These themes reflect the opinions and beliefs of students at SDSU: identifying the difference, making the purchase, and ethics/acceptability. The responses were reinforced by experiences and personal feelings from the focus group discussions.

Two points must be kept in mind when reading the themes and supporting materials. Each statement made by the students is coded with a number corresponding to the person as well as survey (S) or focus group (F) to indicate where the data came from (see Appendix B: Demographics of Research Participants). The themes are not written in any order of importance, but rather stated as they emerged from the data collected. No theme is more important than other themes.

Identifying the Difference

When I asked students if they knew the difference between counterfeit, knock-off and designer products, 54% strongly agreed they knew the difference while 46% agreed they knew the difference. General definitions for counterfeit, knock-off, and designer products were given at the top of the survey, but this question was meant to find out if students understood the difference, rather than if they could read the definitions.

While all of the students in the focus group discussions were apparel merchandising students, they all knew what they were purchasing when they bought the counterfeit item. These students have been educated on counterfeits and know what to look for to determine if it is counterfeit, but many have bought items they knew were fakes. In response to a discussion on why consumers, other than themselves or other apparel merchandising students, purchase counterfeits one student said,

- 1F: How can you not know the difference [between counterfeits and genuine products]?

She did not understand that many people who do not study fashion do not know the difference between a real Louis Vuitton purse and a counterfeit.

When students commented on their personal feelings for counterfeit fashion merchandise in general some called it “ugly,” “pointless,” “obviously fake,” and “gross.” One student said when a fake and a real item sit next to each other it is easy to see the difference. Others commented that some people might not know the difference between a knock-off, counterfeit, and a genuine item if they have never seen a designer product.

• 2F: People just don't understand…

Many apparel merchandising students said they get upset and mad when high school students and other people buy the fake purses to "look cool," when the apparel merchandising students have the real designer purse. Individuals also get upset when strangers walk up and ask, "Is that real?" Apparel merchandising students at SDSU have felt the sting of those insulting words.

Making the Purchase

To find out personal opinions and motivations, one question on the survey asked students if they had ever purchased a counterfeit product. Twenty-seven percent of the apparel merchandising students admitted they had purchased a counterfeit product. Eleven of the 13 women who had purchased a counterfeit product have only purchased a product one to three times. The remaining people who have purchased a counterfeit product did not answer how many times they had made a counterfeit purchase. On the other hand 73% said they have never purchased a counterfeit product. When looking at the ages of the students, most who said they had purchased a counterfeit product were juniors and seniors. In contrast, most of the students who said they have never purchased a counterfeit product were freshmen and sophomores. Age and experience may play a part in consumers' lives relating to counterfeit purchases.

During the focus group discussions, almost all students said they had visited a large city and encountered the vendors on the street persuading them to purchase a counterfeit product. Some students felt uncomfortable and "creeped out," while others felt bad for the people who were selling the merchandise. With their own feelings in mind, many of the students also said they followed the vendors and salespeople:

• 3F: I walked down the dark alley and up to their apartment to purchase a counterfeit item.

Some students bought purses while others purchased earrings. Even though several students made the purchases, they knew that it was not real and that they were promoting a bad cause. One student even stated that she felt bad immediately after her purchase and no longer wanted the items she bought:

• 7F: After she slipped the earrings in my purse, I immediately had a bad feeling in my stomach and didn't want the earrings I just bought.

The survey revealed that the group of students questioned do not often receive gifts of counterfeit merchandise. Only 8% of the apparel merchandising students surveyed had received a counterfeit product from someone else in the last year. The remaining 92% have never received a gift of a counterfeit product. One individual did not answer the question.

Shoppers want the status that comes with certain items and if that means they have to buy a cheap counterfeit purse in order to appear to have status that is want they will do, according to one group of students. Some consumers feel they can trick other people:

• 4F: They want the status of people who don't know the difference.

One student brought up her recent trip to China and talked about what it means to carry a counterfeit purse in China:

• 5F: There are fakes all over in China, but no one from China would be caught with a fake. They just don't buy them there. They save for the real one.

Ethics and Acceptability

When I asked students about their own personal feelings regarding ethics of the counterfeit business, most students agree that the business and purchase of counterfeits is unethical and morally unacceptable. Twenty-three percent of the apparel merchandising students felt strongly that purchasing a counterfeit product is ethically and morally unacceptable, while 63% felt the business was unacceptable. In contrast, one person strongly agreed that it was ethically and morally acceptable, and the other 13% felt the purchase of a counterfeit product is acceptable.

• 5S: I hadn't learned some facts about it [counterfeit fashion business] until recently.

Students were also questioned about their peer groups' views. Fifty-six percent of the apparel merchandising students surveyed said that their respective peer group views the purchase of counterfeit products as unacceptable, while 42% said their peer group would view purchasing counterfeit products as acceptable. One student did not answer the question.

Students in the focus group discussions emphasized that people want to appear to have a high status by carrying a designer product. Some individuals cannot afford to purchase a designer purse, so having a counterfeit purse is the equivalent in their minds. People want to have the high status, no matter what it takes to get it.

• 6F: People want to feel confident and carrying a Chanel purse is one way that a woman feels confident.

Some individuals agreed that selling and purchasing counterfeit products is degrading to designers. They felt that by participating in the act they were putting down the designers and is not fair to them. For that reason, those students have not purchased counterfeit products.

Looking the part and having the "image" is also part of the trend. Numerous individuals from separate focus groups said the purse or bag has to go with the person. For example, the bag is likely a fake if the person who owns it is wearing ragged clothes and does not care about the rest of her appearance. Someone who owns a genuine designer handbag will likely hold herself to a higher standard and dress in a more chic and sophisticated style. Another individual brought up a story about a middle school aged girl carrying a Louis Vuitton handbag. She said she knew the girl was carrying a fake because no one at that age could afford a real Louis Vuitton. Someone else said she may

have received it as a gift, but others in the group concluded that it was not likely that someone so young would be carrying a designer purse. The interpretation of this scenario was provided after a thorough look at the comments made during the focus group discussions.

DISCUSSION AND CONCLUSIONS

The research that I conducted suggests implications and ways to further the understanding of the counterfeit fashion business. This research study does not represent the population at large, but only apparel merchandising students at SDSU in 2008. In order to understand the population at large, additional research would be required.

Counterfeit fashion merchandise has been an increasing problem over the past decade. The business of selling counterfeits in general, which in turn costs taxpayers money, is not a new problem. At this time, the problem is not decreasing but the number of counterfeit bags has increased 368% during 2003 and 2004 (Betts, 2004). The counterfeit fashion business is a serious problem in today's society, resulting in numerous research studies. The problem is not decreasing, so researchers are studying the business to find out more information that could potentially change the future. If counterfeit products are available anywhere in the world, people are going to purchase them (Lee & Workman, 2007; Kim & Karpova, 2007).

Many people claim to know the difference between counterfeit, knock-off, and genuine designer products. Even though people know what they are buying, they continue to purchase fakes. This leads me to believe that people do not care that they are purchasing a counterfeit. Individuals who travel to large cities and purchase a counterfeit product just buy it to buy something that connotes status, not thinking whether it is right or wrong.

Many individuals surveyed and questioned feel that if everyone could see a genuine designer bag next to a fake bag, whether counterfeit or knock-off, they would be able to tell the difference between real and counterfeit. As a result people may realize the differences in quality and choose not to purchase the fake bag.

Educating consumers on the differences between a genuine and a fake product is a practical first step toward shaping attitudes. Education should be as basic as possible, and consumers should evaluate the design, fabric, details, workmanship, and price to see if the product might be a counterfeit or genuine (Kelleher, 2006; Thomas, 2006a).

Education and knowledge play a large role in the psychology of why people purchase the products they do, but after thorough analysis of the data, it seems that travel experiences and geographic location also have an impact on the number of counterfeit products purchased. For example, an individual who has lived in the Midwest and has never traveled beyond the bordering states probably will not have had the opportunity to see many counterfeit products being sold, and therefore, probably will not own a counterfeit product. On the other hand, an individual who lives in New York is exposed to the counterfeit industry on a regular basis. Therefore, a New Yorker is more likely to own a counterfeit product.

Age and experiences may also play a role in consumers' lives relating to counterfeit fashion purchases. Young girls want to look like the people they see on television, so they

will do anything to get that "look." Not many 15 year old girls have $1,000 to spend on a handbag to look like her favorite celebrity, so she might pay $20 for the cheap knock-off at the mall kiosk or the misspelled counterfeit on the street.

Apparel merchandising students at SDSU feel they know the difference between counterfeit, knock-off, and genuine designer products, but 13 out of the 48 people surveyed have purchased a counterfeit product one to three times. It is hard to figure out why people buy the things they do, but when the opportunity presented itself and the salespeople were trying to convince the students to purchase something, the students ignored their knowledge and education, and bought a counterfeit product just to say they bought something. Numerous students admitted they only did it to have the experience and to tell their peers they participated in the counterfeit fashion business. The thrill of doing something illegal seemed to be intriguing enough for students to engage in such a transaction.

People face ethical decisions everyday, but a socially responsible shopper will think more seriously about the consequences of purchasing a counterfeit. Some shoppers may feel pressure from their peers who do not approve of counterfeits. Other shoppers will be faced with an ethical decision if they want to purchase a counterfeit, but are aware of the consequences (Ha & Lennon, 2006). Socially responsible shoppers know the result of counterfeit purchases; they have done their research and know the problems the world faces because of the growing industry.

When attempting to educate consumers in general, college-aged consumers should be targeted. One ethical study on college students showed that students agreed that counterfeit money is illegal, but thought purchasing counterfeit purses, shoes, and watches was ethical and did not hurt themselves in any way (Ha & Lennon, 2006). The study also stated that college students should know that designer names are not the only thing that can be counterfeited. School logos, mascots, slogans, and advertising campaigns can also be counterfeited (Ha & Lennon, 2006). Any product containing the school's logo, mascot, or slogan is generating revenue for the school. If the goods are counterfeited by another company or individual and sold for a cheaper price, the revenue is not going to the school, but into someone's pocket. It is important to give the revenue to the school to be used on school-funded events, buildings, and other supporting efforts.

Exploring the attitudes of students is just the beginning of understanding the basics of the counterfeit fashion industry. This study in no way is a complete explanation of the business. Additional research is needed to explore why people purchase counterfeits, how the business can be stopped, and whether legislation to decrease the effects of the counterfeit fashion business is likely to be successfully implemented. This is a growing problem that will not be easily fixed. It is an industry that is spinning out of control.

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APPENDIX A: STUDENT SURVEY

Purpose Statement

As the author, I will explore the thoughts and choices of South Dakota State University Apparel Merchandising students. The goal of the original research conducted is to find out what students believe about counterfeit fashion and how it relates to each person individually. The research will suggest implications and ways to further the understanding of counterfeit fashion.

Definitions

Counterfeit products – An illegally made replica of a designer product that is portrayed to be the exact designer product

Knock-off products – A legally made product similar to the designer's that is not portrayed as the exact designer product

Original designer products – A designer product made and distributed by the designer

Questions for Student Survey

1. I know the difference between counterfeit, knock-off, and original designer products.
   Strongly agree Agree Disagree Strongly disagree

2. I have purchased a counterfeit product.
   Yes 1-3 times 4-6 times 7 or more times No

3. Someone else has given me a counterfeit product in the last 12 months.
   Yes 1-3 times 4-6 times 7 or more times No

4. I believe that purchasing a counterfeit product is ethically and morally acceptable.
   Strongly agree Agree Disagree Strongly disagree

5. My peer group views the purchase of counterfeit products as an acceptable practice.
   Strongly agree Agree Disagree Strongly disagree

6. Year in school
   Freshman Sophomore Junior Senior

7. Age
   16-18 19-20 21-22 23-24 25 +

8. Is apparel merchandising your major or minor at South Dakota State University?
   Major Minor

APPENDIX B: DEMOGRAPHICS OF RESEARCH PARTICIPANTS

Student Survey Participants-60

Students 1-30: Apparel Merchandising Majors
Students 31-48: Apparel Merchandising Minors
Students 49-60: Non-Apparel Students

Focus Group Participants-21

1. Apparel Merchandising Student
2. Apparel Merchandising Student
3. Apparel Merchandising Student
4. Apparel Merchandising Student
5. Apparel Merchandising Student
6. Apparel Merchandising Student
7. Apparel Merchandising Student
8. Apparel Merchandising Student
9. Apparel Merchandising Student
10. Apparel Merchandising Student
11. Apparel Merchandising Student
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18. Apparel Merchandising Student
19. Apparel Merchandising Student
20. Apparel Merchandising Student
21. Apparel Merchandising Student

APPENDIX C: FOCUS GROUP DISCUSSION QUESTIONS

Focus Group Questions

1. How many people have gone to a large city (such as New York City, Los Angeles, Chicago, or a foreign city, etc) and experienced nagging by the vendors on the streets trying to selling products?
   [If yes:]
   - How did you feel about it?
   - What did you do?
   - What was your reaction?

2. Why do people purchase counterfeit products? What is the motivation behind the purchase of a counterfeit product?
3. Why would you choose *to* purchase or choose *not* to purchase a counterfeit product? Have you ever purchased a counterfeit product?
4. What types of thoughts run through your mind when you are shopping?
   - What worries or concerns do you have when shopping?
   - Is your purchase in impulse buy?
   - Do you consider "needs" versus "wants"?
5. Do you have anything other comments you would like to add?

APPENDIX D: FORM USED FOR OBTAINING PERMISSION FOR AUDIO RECORDING

Focus Group Discussions Audio Recording Permission

I, _____ understand that my responses will be anonymously recorded and used for a research study conducted by Amy Frerichs, South Dakota State University student. Anything I say may be used in the final paper.

_____ _____

Signature Date

George D. Green: Influences Behind His Work

Author: Dustin Klein
Faculty Sponsor: Dr. Leda Cempellin
Department: Visual Arts

NOTE: This paper is part of a collective project that is published online in the Michigan-based *Undergraduate Research Journal for the Human Sciences*, 2008 Special Edition: "Eye Deceptions: The Evolution of George Green's Painting from the Late 1970's to the Present" (http://www.kon.org/urc/v7/v7a/george-d-green-painting-evolution.html). Our sincere gratitude to Dr. Dorothy I. Mitstifer, Executive Director of the *Undergraduate Research Journal for the Human Sciences*, the Honors Society Kappa Omicron Nu and the Association of College Honor Societies, for authorizing the separate publication of this paper, as individual contribution, in the 2008 SDSU *Journal of Undergraduate Research*. All the reproduced images of paintings by George D. Green are courtesy the artist.

LATE 1970's AND EARLY 1980's

In *Untitled 9* (Figure 1), Green created a composition consisting of banners. He created a rich texture by draping them one on top of the other and giving each banner its own shadow to make them pop off of the canvas. There are breaks in the overlapping and we see the white of the canvas showing through. Green applies a gradient to most of the banners and disperses another texture throughout them, in order to give the impression of a different material. The positioning of the banners makes them coalesce in the center of the composition, forming a triangular form, which points downward. The addition of the orange banner emphasizes the directional force. There are additions, to the painting, that stand out from the banner elements. Pieces of white masking tape rest behind the banners.

George Green's use of tape can be traced back to Wallerant Vaillant's *Letter Rack*, 1658 (Figure 27). Here, on a wooden board, Vaillant has positioned letters that are kept in place by nailed down strips of tape. The strapping is perceived to fasten the letters, while Green's pieces of tape apparently fasten some of the banners.

In Green's painting (Figure 1), what appears to be a clipping of a completely different painting has been adhered to a banner using the same white masking tape. Another clipping can be found near the left side of the painting, beneath a banner that seems to be folding itself up to reveal what is underneath it. Cornelius Gijsbrects' *Studio Wall*, 1665 (Figure 28), also contains a folded piece of fabric that reveals the canvas supports underneath.

The clipping in Green's painting contains smeared paint that later becomes a regular element. Throughout his works of this period, Green added paint streaks that are similar to smears on a painter's palette. There seems to be dimension to the paint streaks, appearing to be built up by layers. Their role becomes more that of an object and less that of simply texture, but the viewer is not sure if this is an actual dimension, or just another illusion.

Green's painting *Bare Narious Ojay*, 1979 (Figure 2) echoes the banner forms found in *Untitled 9* (Figure 1). They have been given a playful, pastel tone. Green plays with proportion by enlarging some of the banners. Unlike the previous work, this one contains no breaks to reveal the white underneath, just another banner underlying another. Green's style, like that of Frank Stella, consists of overlapping similar shapes to create a cohesive meshing effect, and at the same instance it creates the illusion of depth between the elements (Stella 154).

Similar to George Green's *Fox Trot*, 1981 (Figure 3) is Stella's *Raqqa II*, 1970 (Figure 34). *Raqqa II* includes overlapping semicircles that seem to mesh together yet remain separated by the use of various hues. Where each semicircle overlaps and touches another, new forms and directional forces are created. This effect makes it difficult for the viewer's eyes to find a start or a stop in activity.

Directional forces keep the viewer's eye continuously moving, searching for a focal point to rest upon. Green's textural solution consists of making the gestural strokes and the banners one, not simply paint applied to the banners. More pieces of masking tape have been added to the composition but have been given color. Perhaps they were used to mask out areas of the painting and later placed throughout the composition.

The masking tape's shadows (Figure 3) are placed a distance away, suggesting that the masking tape is much closer to the viewer than the rest of the painting. The shadows also allow them to freely float above the banners. In this way, the banners appear heavier and act as a backdrop, while the pieces of tape rise up and leap towards the viewer. One piece has found its way outside of the composition and overlaps with white frame. In *Podge-Wade*, 1981 (Figure 4), Green begins combining two or more banners to form new shapes. He has also combined the pieces of tape to form lightning bolt shapes.

THE 1980's: SHAPED CANVASES

When studying George Green's shaped canvas period, the influence of Elizabeth Murray upon his work is apparent. Like Green, she used shaped canvases and pop color palettes. Murray's *Tempest* (Figure 38) and Green's *Holy Rollers* (Figure 5) contain both similarities. *Holy Rollers* contains a chaotic lightning bolt element that weaves in and around the angular shapes, while the yellow lightning bolt in *Tempest* weaves in and around the voluminous shapes. "...the fine yellow line that connects and penetrates the figures seems almost narrative and at the same time like the emblematic signs used by cartoonists to indicate motion, surprise, or an aside that is not meant to be seen within the narrative frame" (Fineberg 440).

Both artists used the lightning bolt to create eye movement, leading the viewer throughout the painting. The influence of Wassily Kandinsky is evident: it is as if both Murray and Green took Kandinsky's flat, two-dimensional compositions and brought them into the realm of three dimensions.

In Green's *The Eccentric Beauty* (Figure 9), 1988, we notice the abstract elements exploding from the center of the composition, and our eye is drawn to the pink and red lightning bolt shape. A direct correlation can be found in Kandinsky's *Quiet Impulse*, 1939 (Figure 32). Here, Kandinsky uses the lightning bolt shape to express energy and to

create a strong directional force (Whitford 186). Green takes the element to the next level by giving it dimension.

Both lightning bolt shapes appear to be moving from the right to the left of the canvas, originating from a point on the right and stopping with a hard line on the left. "Movement towards the left according to Kandinsky is movement 'into the distance' or 'going outside' (i.e. as we 'read' a picture from left to right we encounter a movement in the opposite direction). This movement, Kandinsky says, is more 'adventurous' than left-to-right movement and seems to have greater intensity and speed. Movement to the right is movement 'towards home', 'centered inwardly': 'This movement is combined with a certain fatigue, and its goal is rest. The nearer the right, the more languid and slow this movement becomes – so that the tensions of the forms moving to the right become ever weaker, and the possibility of movement becomes increasingly limited'" (Overy 132).

The lightning bolt, found in Kandinsky's *Quiet Impulse*, appears to have origination points on the right and on the left side of the canvas. According to Kandinsky's theory, the lightning bolt should be both energized and relaxed, or be an activity level in between.

Green, however, positions his lightning bolt shape in both *Boogie Woogie Country Man* (Figure 6) and *The Eccentric Beauty* (Figure 9) on the left side of the canvas and allows it to travel towards the right side. The lightning bolt acts to tone down the movement created by the other shapes in the composition.

Although Kandinsky's canvas kept the traditional rectangular proportions, the compositions therein are viewed as having an overall outer shape (Overy 118). Green's shaped canvases from the 1980's allow the composition to break away from the binding square and rectangle format. This gives his work an evident energy and turns the painting into an object.

Other examples of correlation exist when comparing Green's *Minding Dog Rag*, 1987 (Figure 7) and Kandinsky's *Small Worlds 9*, 1922 (Figure 29). Both artists used flat planes to keep the piece from flying away. "Forms that overlap others tend to remain solid" (Overy 117). The planes anchor the composition and emphasize the free, organic shapes elsewhere in the piece. The overlapping of planes can be found in Kandinsky's *Dream Motion*, 1923 (Figure 30). Here, he has overlapped circles, squares, and triangles of complementary colors to create a base for freer elements to be attached. Green applied a similar idea in *Invisible Clarities Breezing Asleep*, 1987 (Figure 8). Bound planes act as the anchor, from which organic shapes burst.

In the 1960's, Frank Stella began his first works using shaped canvases. Instead of creating a work using the traditional rectangle or square shaped canvas, he took advantage of triangular forms like "V" and "L" shapes. In the work *Valparaiso*, 1963 (Figure 33), Stella combined an "A" and a "V" shapes, in order to create a canvas shaped like a parallelogram. Both shapes include the pinstripe pattern, which conforms to the shapes outside line, and in doing so it creates the illusion of depth (Turvey 364).

Stella's *Jarmolince III*, 1973 (Figure 36) is part of a series of shaped collage reliefs, in which Stella started to move away from the flat surface and towards a three-dimensional space. In this work, Stella took advantage of the power of the viewer's eye to pick out negative shapes that surround the elevated portions of the relief. For every form, we see at least another counter-form. The negative shapes can become just as powerful, in terms of visual hierarchy, as the positive shape, which creates a push-pull effect. The negative shape

mirrors the positive yet fights for dominance. However, if not for the positive shapes, the negative ones would not exist and vice versa.

In *Holy Rollers* (Figure 5), Green's style is similar to that of Stella's *Jarmolince III*. Green created the illusion of actual three dimensions by implementing shadows, overlapping of shapes, gradients and textures. Green again overlaps flat planes like those seen in *Podge-Wade* (Figure 4). However, the idea is pushed further when Green adjoins three similar paintings together to form one large painting. The viewer becomes confused when attempting to discern what is real and unreal, which area is paint and which one is not paint, and what is an actual dimension and what is simply illusion. Every shape has a shadow and every shape is overlapped by another shape, which creates the overall meshing appearance of the piece. Everything is held together or supported by another piece. The meshing keeps the eye grounded and prevents the piece from floating.

Lightning bolt elements (or possibly one single lightning bolt), weave themselves in and out of shapes and even find themselves outside of the canvas. This organic addition unifies the entire painting and its lively nature keeps the work from feeling too heavy. It also seems to be a living element that has the ability to snake itself anywhere in the dimension Green has created. The work does not feel too light or too heavy, because there are instances of both extremes throughout. Paint smears can be found on the majority of *Holy Rollers* (Figure 5), and this texture unifies the painting. The paint texture also complements the flat areas.

Boogie Woogie Country Man (Figure 6) contains similar ideas and elements as in *Holy Rollers* (Figure 5), but takes them in another direction. The layering of shapes and shadows is used to make the shapes cohesive, but the piece as a whole has a whimsical, floating feel. Organic and geometrical elements flow in and out of other shapes keeping the piece from floating away. Green is again using a lightning bolt element to hold the piece together, but this time he enlarges the element and gives it dimension. The pink lightning bolt acts as the main support of the entire work and as the focal point, drawing the eye from close to the viewer to out of the viewer and vice versa. It is one of the strongest directional forces seen in the period.

Green smeared yellow and red paint on it, so that the result seems flat with no dimension. In essence, he created an impossible scenario, where a three-dimensional object has perspective, but its texture is two-dimensional. He is mixing the third dimension and second dimension in the same object. This impossible scenario is a trademark of abstract realists like Green and best defines the trompe-l'oeil abstractionism.

Even though the shapes do not depict objects in the natural world, they are done in an extremely realistic way that makes them seem to actually exist.

Also, the organic French curve elements help to create a lightening effect for the piece. Acting as directional forces, the lighter three-dimensional elements meander in and out of the heavier, flatter elements. Green has also included the paint smears not only on the flatter areas, but also on elements that have dimension and visually travel away from the eye. The texture he adds to three-dimensional elements does not take on a third dimension quality, but remains two-dimensional.

THE EXUBERANT PHASE: 1989-1991

Green's work from 1989 through 1991 is characterized by the three-dimensional shaped canvases, but instead of using solely free floating elements, Green implements the cloud-like, gestural strokes as support. Acting earlier as texture, the paint smears seem to hold up the three-dimensional shape and the overall composition's weight. The relationship between the smears and the geometric blocks becomes a symbiotic one, as the smears emphasize the vibrant colors and hard edges of the blocks, while the geometric blocks emphasize the smears fluffy, organic appearance and pastel colors.

In *Neskowin North Coast Blues #6*, 1989 (Figure 10), Green stacks four voluminous shapes in an awkward, unbalanced composition surrounded by a melting pot of colored paint smears. In *Neskowin North Coast Blues #7*, 1989 (Figure 11) and *Neskowin North Coast Blues #8*, 1989 (Figure 12), Green balances the shapes as awkwardly as in *Neskowin North Coast Blues #6*, but he cuts out a section of the paint smear background to reveal more overlapping of flat planes. This setup gives the impression that the viewer is peering through this painting into a previous one done in the late 1970's and early 1980's. Green creates a sort of timeline and shows us that he is moving in a new direction with his compositions, away from the flatness and into more voluminous forms.

In *Tropical Island Country & Western Suite #3*, 1990 (Figure 13), we see a composition of vibrant, voluminous shapes framing a gradient from white to violet. On further inspection, we find that the gradient, which we thought was a view into the distance, is in fact a side of another geometric shape. Following the yellow staircase to the right of the gradient, we notice that the bottom step is part of another separate shape. This is an impossible situation and becomes the focal point of the work.

Green's illusion of depth has never been greater than that of *Gateway Star*, 1991 (Figure 14). The artist has basically built a four-sided runway for our eyes to follow and shoot off into the infinite horizon. A good traditional example, of giving the viewer the illusion of infinite space, is the *Ceiling Fresco* in the Palazzo Ducale created by Andrea Mantegna from 1461 to 1474 (Figure 25), where the artist has created an illusionary scene of angels looking down through an opening in the ceiling. The angels surround the circular opening under a blue sky with puffy clouds. The eye is led to the "opening" though the use of concentric circles, like a bull's eye.

THE LATE 1990's

The art of trompe-l'oeil can be seen from as far back as the Pompeian frescoes. "...Even in ancient times, artists who set out to paint a cycle of pictures giving the illusion of reality have tried to overcome the flat surface of the wall. In some cases they did away with the background wall by opening up a new space which extended that of the spectator by increasing the depth. In other cases the background wall is left in place, and the third dimension is obtained through the invasion of the spectator's space by the picture space. There are of course examples in which both solutions are found side by side" (Milman 14).

George Green added major elements of trompe-l'oeil into his compositions with *Jockey of Artemisium*, 1997 (Figure 15). Green painted wood carved elements with

delicate, stained wood grains, adding highlights and shadows to represent depth and fool the viewer into believing that they are looking at actual alcoves and niches. A central element is the wooden sphere enclosed by a geometric framework consisting of fitted, beveled layers that act as hallways. The sphere appears to rest within this hallway. Similar to *Jockey of Artemisium* is the illusion created by Baccio Pontelli in *Studiolo*, 1476 (Figure 26), located in the Palazzo Ducale. *Studiolo* "consists of a series of trompe-l'oeil panels in which thousands of pieces of wood to create the illusion of half-open, latticed cabinets. Depicted are the accoutrements from the duke's life: armor and insignia, musical and scientific instruments, and books" (Milman 51).

In *Jockey of Artemisium* (Figure 15), Green has included two of these sphere/square elements that seem to differ in scale; however, at further inspection it is clear that the smaller of the two spheres is at further distance from the viewer than the larger, closer sphere. Four wooden alcoves lie beneath the larger sphere, and within them sit three bicolor swatches and one horse and rider figurine done in trompe-l'oeil style.

The horse figurine found in *Jockey of Artemisium* can be traced back to a work done earlier by the hyperrealist artist Ben Schonzeit. In *Horse and Rider*, 1974 (Figure 37), Schonzeit renders a photorealistic chrome hood ornament of a jockey atop a racing horse in full stride. Green substitutes the chrome with a bronze coating. Placing the figurine in the alcove may be Green's attempt to show that this is what has been done in the past, now he is doing it again and then he is stashing this idea away in this alcove never to be used again. Green may have added the figurine to pay homage to Schonzeit or to show respect to the trompe-l'oeil artists that came before him.

We see the illusion of dimension in prior paintings, but this is the first time Green has used representational elements. The wood carved elements allow Green to imitate the actual dimension more convincingly than in any of his other works.

Another addition to Green's compositions (Figure 15) is scenery. In the upper-left hand corner he painted a peaceful cloudy scene, where puffy and wispy clouds intermix. A hurricane-like twirl of delicate clouds acts as the focal point in the cloud scene. Again Green uses the trompe-l'oeil style to represent the clouds. He is not necessarily attempting to trick the viewer into thinking that they are seeing actual clouds, but more so that they are seeing a photograph or a smaller painting within a larger painting. The cloud scene could pass for a cropping from another painting that Green has placed into his composition.

The usual paint smears, which we have seen in previous works, make another appearance here. They themselves appear cloud-like and seem to correlate with the cloud scene. By adding the cloud scene and paint smears, Green has created a mixed media type work, which strictly uses nothing but paint.

In the work *Gravityspool*, 1997 (Figure 16), Green has taken the beveled alcove elements to the next level by increasing their numbers from four smaller ones to eight larger ones. Within six of the alcoves, Green paints along a common theme: Greek and/or Roman art. Whereas *Jockey of Artemisium* (Figure 15) contains only one element pointing to another actual artwork, *Gravityspool* (Figure 16) contains six. The remaining two alcoves contain non-representation color compositions, like those we see in the previous painting. Instead of increasing the number of the sphere/square elements, Green has added only one to this work. However, Green has pushed the wood grain even further in

this painting. A large majority of the work contains the wood grain. In turn, more wood grain translates into more intricate wood carvings.

Green also pushes the cloud scene images from one image to three. While the scene in *Jockey of Artemisium* is frameless, two of the three scenes are now enclosed in beveled frames. The frameless cloud scene does not seem to rest solitarily, as we see in the previous painting, but now is held into place by wood paneling, which produces a stair-stepped type shape. Again, Green downplays the use of the paint smears, but gives them an even more cloud-like look. He uses a creamy white hue over a sky blue.

In *Untitled*, 1997 (Figure 17), Green not only inserts more wood grain elements, but he also visually composes them into more intricate "architectural" pieces. Green brought the wood elements off the surface of the canvas and has created a sort of garden, an Escher-like environment. He has added other new wood pieces. A wooden pediment is held up by a wooden rounded column on one side, and on another is held up by what appears to be a piece of floor trim. Green has also created a floor on which these pieces stand. He has now increased the number of the sphere/square elements to three. He has also created a new element by framing a pyramid instead of a sphere. *Untitled* contains one cloud scene, which is not framed like previously, but is held in place by an actual wooden staircase. Green has moved from framing images with flat two-dimensional stair casing panels, to a three-dimensional staircase.

Both evasion and invasion of the viewer's space can be found in many of Green's paintings from the late 1990's. *Horizon*, 1999 (Figure 18) contains wooden elements that move out toward the viewer, and also openings for the eye to travel away from the viewer. The shapes jutting towards the viewer make the recesses more impressive and vice versa. Adding both extremes of space creates a push-pull effect. Green set up an environment where we can choose where our eye can focus, near or far.

In *Horizon*, Green has created wooden forms in a trompe-l'oeil style. We find two cloud scenes bordered by picture frames, intermixed with the wooden forms. The cloud scenes appear to be paintings within a painting. This aspect of trompe-l'oeil can be traced to the Surrealist work of René Magritte. In *The Human Condition*, 1934 (Figure 31), Magritte has created a situation where the viewer is facing a window and is peering out onto a generic landscape. He has placed an easel in front of the window, blocking the view. On the easel rests a canvas that depicts the exact landscape scene behind it.

"I placed a painting representing exactly that portion of the landscape covered by the painting. Thus, the tree in the picture hid the tree behind it outside the room. For the spectator, it was both inside the room within the painting and outside in the real landscape. This is how we see the world. We see it outside ourselves, and at the same time we only have a representation of it in ourselves" (qtd. in Torczyner 156).

It is as if the viewer is allowed to see the making of a trompe-l'oeil painting within in a trompe-l'oeil painting. Not only are we fooled once, but even a second time, on further inspection of the scene.

THE LATEST PHASE, AT THE BEGINNING OF THE THIRD MILLENNIUM

Green's works from 2000 onward contain an illusionary wooden frame. A similar use of frame has been made by Jan van Eyck when he painted *The Annunciation Diptych* (Figure 24). Jan van Eyck allowed the figure, he was painting, to reach outside the border of the frame. Green does something similar in *Pictures from the Monroe: Sphere*, 2001 (Figure 19), where he allows the abstract shapes to travel into the illusionary frame and outside of it.

In an *Untitled* work of 2003 (Figure 22) Green has painted a frame with a near absence of a painting. A photograph, tape and scraps of paper are the only elements held within the frame. Cornelis Norbertus Gijsbrechts created the illusion of the backside of a canvas with "nothing more than a white tag applied to the surface" (Grootenboer 167).

With *Pictures from the Monroe: Sphere*, Green has created a composition with two of the strongest elements found in his work from the late 1990's: the sphere/square element, and the seascape/cloud scene. The piece would be entirely representational, except for the cluster of abstract shapes he has painted in the upper-right hand corner. *Untitled*, 2001 (Figure 20) has similar attributes. If not for the playful, interactive abstractive shapes, it too would be solely representational.

In *Palm Forest*, 2002 (Figure 21), Green joined three croppings from what appears to be three different ocean scenes and surrounded them by a very convincingly depicted frame. He did not include any playful shapes or abstractions.

Other borrowed objects can be traced back to other works by Ben Schonzeit. In *After the Hurricane*, 1971 (Figure 35), Schonzeit placed sugar packets, featuring landmarks from Chicago, Washington and Dallas, onto a photorealistic rendering of a generic city street. A similar composition can be seen in *Green's Mendocino to Gold Beach*, 2005 (Figure 23), where the artist created a photorealistic image and placed, on top of it, the illusion of photographs from different locations. In Schonzeit's work, the sugar packets act as a roadmap that tells the viewer where he has been and where he is now. He painted the present location with the help of past experiences. Green did something similar, in that he painted a new location by picking and choosing from past locations he has visited. Both artists used souvenirs as references to better capture a new environment, or at the least allowing the viewer to see the process of creating art.

An offshoot of Magritte's idea of the painting within a painting is the photograph within a painting. Green painted photographs over a convincing ocean scene. The photographs are also ocean scenes and therefore create a situation found in *The Human Condition* (Figure 31), where the artist is allowing the viewer a glimpse at the making of a painting. The photographs act as the research an artist would work from in creating a trompe-l'oeil work and is evidence of past events that lead up to creating new ones: in this case, a painting.

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LIST OF ILLUSTRATIONS

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Figure 1. George D. Green, *Untitled #9*, 1976

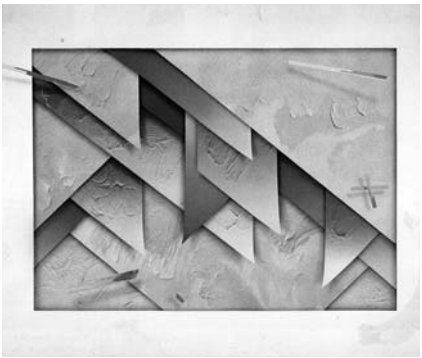

Figure 2. George D. Green, *Bare Narious Ojay*, 1979

Figure 3. George D. Green, *Fox Trot*, 1981

Figure 4. George D. Green, *Podge-Wade*, 1981

Figure 5. George D. Green, *Holy Rollers*, 1982

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Figure 7. George D. Green, *Minding Dog Rag*, 1987

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Figure 10. George D. Green, *Neskowin North Coast Blues #6*, 1989

Figure 11. George D. Green, *Neskowin North Coast Blues #7*, 1989

Figure 12. George D. Green, *Neskowin North Coast Blues #8*, 1989

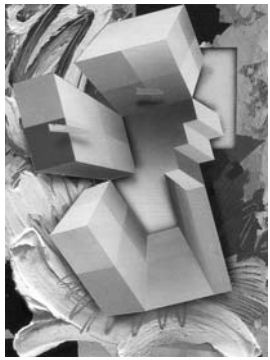

Figure 13. George D. Green, *Tropical Island Country & Western Suite #3*, 1990

Figure 14. George D. Green, *Gateway Star*, 1991

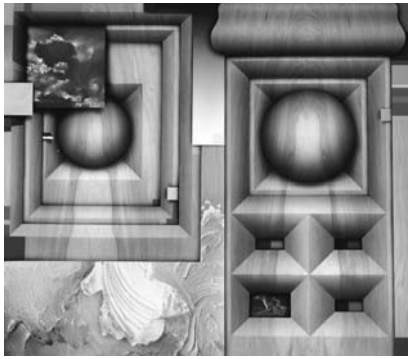

Figure 15. George D. Green, *Jockey of Artemisium*, 1997

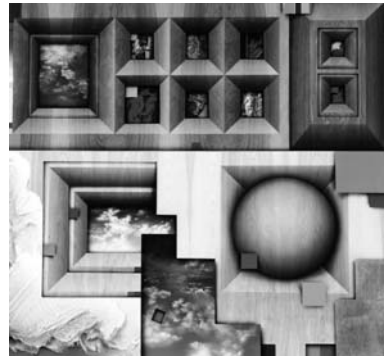

Figure 16. George D. Green, *Gravityspool*, 1997

Figure 17. George D. Green, *Untitled*, 1997

Figure 18. George D. Green, *Horizon*, 1999

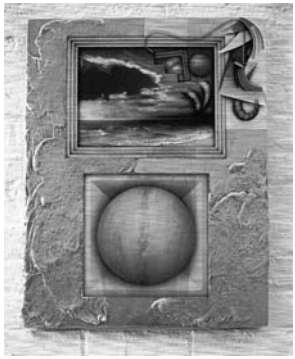

Figure 19. George D. Green, *Pictures from the Monroe: Sphere*, 2001

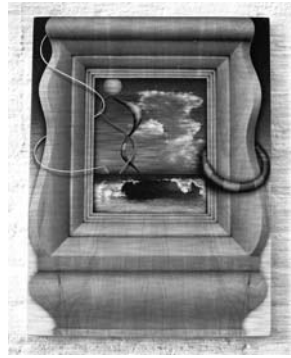

Figure 20. George D. Green, *Untitled*, 2001

Figure 21. George D. Green, *Palm Forest*, 2002

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Figure 23. George D. Green, *Mendocino to Gold Beach*, 2005

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http://www.benschonzeit.com/content/seventies/seventies/1_horse_ryder.html
Figure 38. Elizabeth Murray, *Tempest*, 1979
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EROSION FUNCTION APPARATUS

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ABSTRACT

The Erosion Function Apparatus (EFA) test uses site-specific soil samples acquired via thin-walled tubes to generate the erosion rate and shear stress which is plotted to create an erosion plot. The information produced by the test can help an engineer accurately determine the depth of scour as a function of time for bridge design, and thereby determine the depth a foundation system should be constructed.

During EFA testing, a data acquisition system records the velocity and amount of soil eroded. This data is used to calculate the Reynolds Number, friction factor, erosion rate, and shear stress. Once the data has been reduced to erosion rate and shear stress, it is plotted to form an EFA plot.

The EFA test contains significant uncertainties in selecting the roughness values and timing of the test. Selecting incorrect roughness values can produce a misleading EFA plot by incorrectly calculating the shear stresses, which will not be representative of the erodibility of the soil. Incorrectly timing the test will also lead to an inaccurate representation of the erodibility of the soil by improperly calculating the erosion rate.

INTRODUCTION

Soil scour around a bridge pier is a major design consideration for bridge design. A major cost of constructing a bridge results from the depth of the foundations needed to resist soil scour resulting from water turbulence as water flows around a pier. The deeper the foundation, the more expensive the bridge; therefore, if scour depth is determined by conservative methods and is used as the design depth for the foundation, the bridge may be over-designed. The maximum scour depth may never develop during the lifetime of a bridge if the in-situ soil is clay or silt (Ting et. al. 2001); therefore, it is appropriate to accurately predict the scour rate for the foundation's depth.

Scour rate in coarse-grained soils is well understood and easy to calculate since one major flood event can cause the maximum scour depth. A coarse-grained soil will erode very evenly and quickly because the only force that resists erosion is the friction between the grains. Since the soil will erode quickly and the maximum scour depth will likely be reached during the lifetime of the bridge, an engineer can use the maximum scour depth as the design depth.

Fine-grained soils present a much more difficult analysis due to the forces that develop between the individual particles (Briaud et. al. 2001). Isomorphous substitution and defects in the particle crystals cause clays to have a negative surface charge. The

negative charge attracts water molecules to the surface of the particle until it has a thin layer of water surrounding it. Each fine-grained particle has this same attraction to water molecules, and the water molecules in turn are attracted to each other forming a weak hydrogen bond. Due to the hydrogen bonding, the engineering behavior is much different for fine-grained soils. They erode very irregularly and slower than coarse-grained soils; therefore, a bridge may never experience the maximum scour depth within its design life. Because of this slower erosion rate, it is essential to understand and predict the scour rate for fine-grained soils in order to determine an appropriate design depth for foundations. The EFA was created as a means to determine the erosion rate in fine-grained soils.

Each soil will have a unique initial stress where the soil begins to erode, termed the critical shear stress and erosion rate, which are essential to predicting the scour depth. Shear stress is directly proportional to the fluid velocity at the soil/water interface. The EFA allows for the determination of the critical shear stress and the erosion rates at several other shear stresses by increasing the flow velocity and timing how quickly the soil erodes.

The result from the EFA test is used as input into a newly developed method of determining the scour depth around a pier over time. This new method and the developmental process is discussed in detail in engineering journals (Briaud et. al. 1999, 2001 a, b, 2004, and Ting et. al. 2001).

METHOD

The EFA device utilizes site-specific, thin-walled tube samples to acquire an erosion plot. Samples are extracted as close to the foundations as possible. A borehole is drilled to the desired depth, and thin-walled tubes are pushed into the soil. The tube is extracted with the soil sample inside.

The tubes are placed into the device and one millimeter of soil is extruded into a water tunnel. Water enters the tunnel at an initial velocity (generally less than 1.0 m/s), and the operator increases it until soil erosion is observed. A fine-grained soil will generally start to erode at a high velocity (i.e. 3 m/s). It is important to record the critical velocity where the soil begins to erode, since this velocity marks the critical shear stress of the soil.

The velocity is increased incrementally above the critical velocity. At each increment, the sample erodes for a period of time. The amount of erosion and test duration are recorded and are used to calculate the erosion rate.

Between test velocities, the sample is removed from the tunnel, and the soil is trimmed to the top of the tube. As stated before, fine-grained soils (clays and silts) erode very irregularly; the sample must be trimmed in order to accurately determine when 1 mm has eroded for the next desired velocity.

RESULTS

The data from the EFA test is reduced to erosion rate (mm/hr) and shear stress (Pa). The erosion rate is calculated by dividing the amount of soil eroded by the duration of the test. The shear stress is calculated by first calculating the Reynolds Number, $\mathrm{Re} = \frac{v \cdot D}{\nu}$ where v=average flow velocity; D=pipe diameter; and ν=kinematic viscosity, and friction factor, $\frac{1}{\sqrt{f}} = -2.0 \log\left(\frac{\frac{\varepsilon}{D}}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$ where *f*=friction factor and ε=mean height of roughness of pipe. Using Re and *f*, the shear stress is calculated by $\tau = \frac{1}{8} \cdot \rho \cdot f \cdot v^2$ where τ=shear stress and ρ=density of fluid. The critical shear stress and the other shear stresses are plotted against the erosion rates to create the erosion plot.

Figure 1 represents the erosion plot for a soil sample obtained from a bridge abutment near Big Sioux River, Flandreau, SD. The shear stress was calculated with a constant roughness value of 1 mm. Seven shear stresses above the critical shear stress were calculated from the test velocities.

Figure 2 represents the erosion plot for a soil sample obtained from a bridge abutment near Split-Rock Creek, Brandon, SD. The shear stress was calculated with a constant roughness value of 1 mm. Multiple shear stresses were calculated below the critical shear stress, but only three were calculated above the critical shear stress because of the limited velocity of the apparatus (approximately 6 m/s).

Figure 3 represents the erosion plot for a soil sample obtained from a bridge abutment near White River, Presho, SD. The shear stress was calculated with a constant roughness value of 1 mm. Three shear stresses above the critical shear stress were calculated from the test velocities.

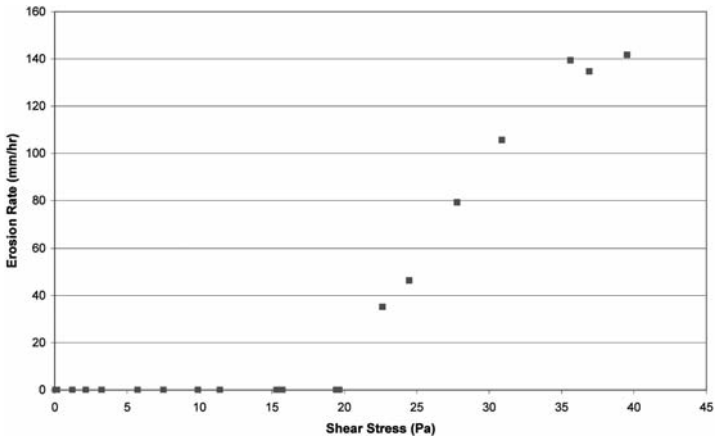

Figure 1. Erosion plot for soil obtained from a bridge abutment near Big Sioux River, Flandreau, SD.

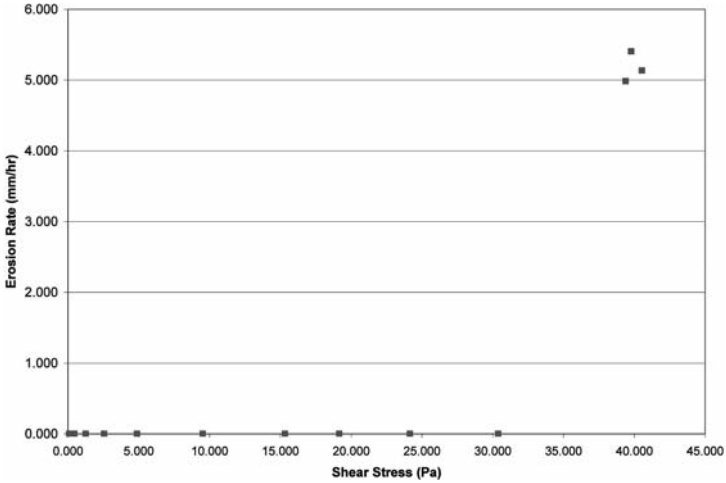

Figure 2. Erosion plot for soil obtained from a bridge abutment near Split-Rock Creek, Brandon, SD.

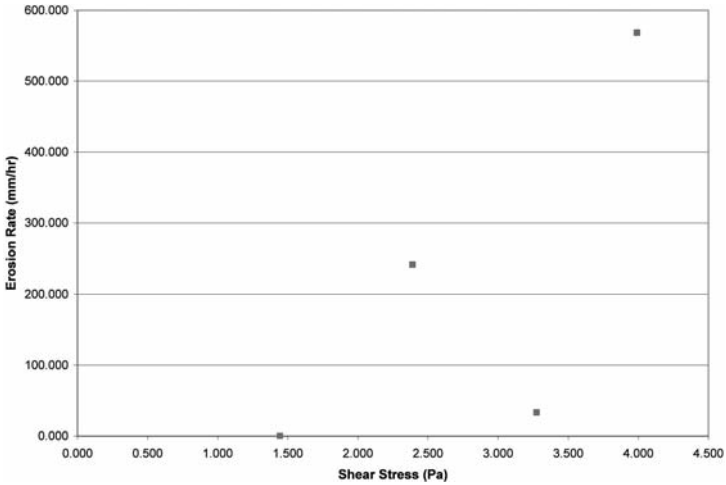

Figure 3. Erosion plot for soil obtained a from bridge abutment near White River, Presho, SD.

DISCUSSION

A site-specific sample is the main advantage of using the EFA method to acquire the erosion plot. Comparing the different erosion plots for the three sites, it is apparent that

the erosion of soils can vary greatly from one location to another. The shear stresses and erosion rates ranged from 40 Pa with a corresponding erosion rate of 5.5 mm/hr to 4.0 Pa with a corresponding erosion rate of 570 mm/hr. Because of this wide variability in soils, a site-specific soil sample is a great asset to acquire an understanding of the erodibility of the site-specific soils.

A large uncertainty is introduced throughout the testing procedure. In order to calculate the shear stresses from the velocity, a friction factor, *f*, must first be calculated. The Colebrook formula, $\frac{1}{\sqrt{f}} = -2.0 \log\left(\frac{\frac{\varepsilon}{D}}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$, uses a roughness value, ε, to calculate the friction factor. A constant roughness can be estimated (i.e. 1 mm) or the operator can estimate the roughness of the sample at each test velocity by looking at the soil sample. Because fine-grained soils typically erode very irregularly, a large uncertainty is introduced if the roughness is estimated for each test velocity. A similar uncertainty is introduced if the roughness remains constant for each test, since the chosen roughness may be incorrect for the sample at some test velocities. Estimating a different ε value results in a different shear stress, which changes the computed erodibility of the soil at certain shear stresses. Figure 4 shows how the shear stress can change as different roughness values are estimated. With an ε value of 0 mm, the critical shear stress is near 7 Pa; however, with an ε value of 1 mm, the critical shear stress is near 19 Pa.

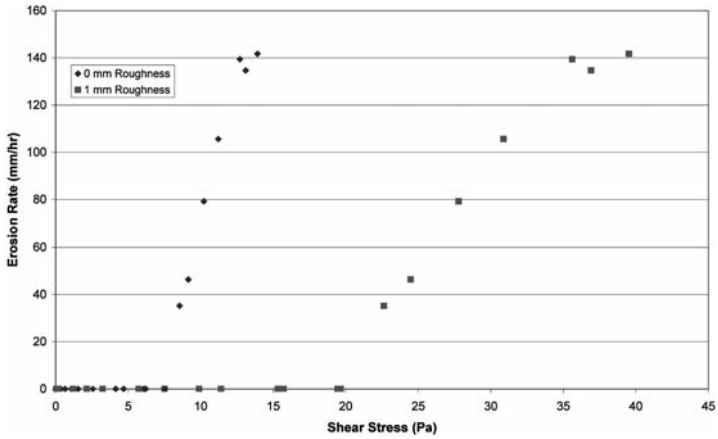

Figure 4. Roughness comparison - Erosion plot for soil obtained from a bridge abutment near Big Sioux River, Flandreau, SD.

Uncertainty is also introduced through the timing of the soil erosion. The operator visually estimates when 1 mm of soil has eroded, but different operators may have different estimates of when the soil has eroded 1 mm because fine-grained soils erode irregularly. If the operator estimates 550 seconds to erode 1 mm of soil, the erosion rate

would be 6.55 mm/hr; however, if the operator estimates 400 seconds to erode 1 mm of soil, the erosion rate would be 9.00 mm/hr. The difference in erosion rates changes the resulting erosion plot.

CONCLUSIONS

In conclusion, the EFA can be a very useful tool as input for designing bridges. It is a simple method for calculating the critical shear stress and EFA plot by using a relatively undisturbed, site-specific soil sample, but the uncertainties are present in the current testing procedure. The unknown roughness value is a critical value that must be determined accurately in order to get a representative critical shear stress and EFA plot for the soil sample.

Because the roughness value is unknown, an estimate must be used for the value in order to calculate the friction factor, *f*. Figure 4 shows the effects of different roughness value estimates, ε, on the critical shear stress and the EFA plot. By varying the ε value, a wide variety of plots can be produced.

Further research is needed to find an effective procedure to calculate the roughness value and correct for the uncertainties.

ACKNOWLEDGEMENTS

This study was funded by the South Dakota Department of Transportation (SDDOT) and the Mountain-Plains Consortium (MPC). The support of SDDOT and MPC is gratefully acknowledged.

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Fatigue Analysis of an Inline Skate Axel

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Department: Mechanical Engineering

ABSTRACT

In this paper, an inline skate axel is analyzed based on fatigue and economic principles for four different materials. The loading scenario on the axel of the inline skate is derived and broken down to a maximum shear stress that must be less than the maximum fatigue stress of the axel material. A fatigue analysis using Goodman line diagrams is applied to axels made of aluminum, titanium, nylon, and PVC. The material strengths are then compared to the loading requirements and determined whether they would be sufficient for an axel material. Finally, the prices are compared to verify the selection of the cheapest and structurally stable axel material.

INTRODUCTION

Inline skates are a common piece of equipment seen everyday when the summer months roll around. Manufacturers produce thousands of pairs of inline skates a year and are always looking for ways to generate cost savings. Within each pair of inline skates there contains four sets of axels which are mainly constructed of an aluminum-based alloy. If a replacement material could be found that provides enough strength to withstand the system loading and is cheaper, such cost savings could be generated. Material strength properties are extremely important because if any of the axels were to fail during the use of the product, the manufacturers would be at fault and the operator may sustain injuries.

The first thing that needs to be performed is breaking down the whole inline skate to just the single axel and the loading that is present on the component. Figure 1 shows how the initial maximum force gets evenly divided onto all four axels. Since the loading is predominately shearing, a shearing analysis is the appropriate method to determine maximum loading scenarios. Once this analysis is completed material selection can commence.

Figure 1. Reaction Forces of an Inline Skate

When selecting materials as a substitute for the current application the Goodman line diagram is a very useful visual to help determine how much stress a material can take for a given dynamical loading. The Goodman line diagram uses the yielding line, the fatigue line, and the application line to produce an intersection point which represents the point of operation under peak loading conditions. Clearly, different materials are capable of producing different maximum operating stresses. These maximum operating points will be found for aluminum, titanium, nylon, and PVC. After the materials are compared to the maximum loading scenario, a selection will be made based first on structural integrity (being able to withstand the loading) and second by an economic standpoint (being able to produce cost savings from the current setup).

METHODS

The main point of analysis on the axel is the area of fatigue. This is due to the wheels going through a high number of cyclic loadings. The method used to analyze the fatigue on the axel is the fatigue theory with Goodman Line Diagram. To construct a Goodman Line Diagram we need to know specific information about both the material and the loading situation to which the object will be subjected.

First, we take a look at the loading situation. In the use of an inline skate, the average repeated maximum force on the axel would be the weight of the user when the user is on one blade, and the minimum force would be zero. A maximum weight that is set for the inline skate at F = 400lbs and a safety factor of 1.5 is selected [1]. Since each skate has four axels and the force is transmitted to the axel through the outsides of the

blade, a reasonable assumption was made that one axel could be modeled with amplitude of F/4 or 100lbs.

The main point of analysis is in the axel of the inline skate. A three dimensional model of the axel is drawn in Pro-E™ as shown in Figure 2.

Figure 2. Pro-E™ Model of the Axel

Based on the model in Figure 2, its simplified model is shown in Figure 3. The axel of the inline skate can be simplified as a cylinder since diameter difference is small. The load is distributed as shown in the same figure.

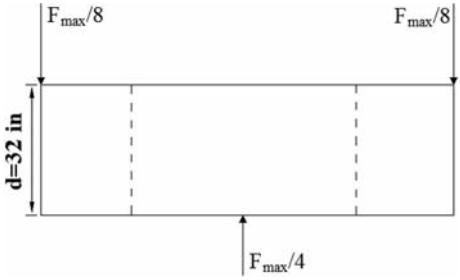

Figure 3. Load Distribution on the Simplified Model

With the loading and the simplified model of the axel, the stresses on the axel are calculated. The stress on the axel can be found by using the basic definition of shearing stresses with consideration of safety factor. The equation for shearing stress is shown in equations 1 and 2.

$$SF = \frac{design \quad overload}{normal \quad load} \qquad (1)$$

and

$$\sigma = SF\frac{F}{A} \qquad (2)$$

where,

σ = Stress for design overload
SF = Safety factor
F = Force
A = Cross-sectional area

Using a cross-sectional area of 0.0804in^2 and the values for the force $\frac{F_{max}}{8}$ and SF = 1.5 a stress of 0.993 ksi is obtained. This is the stress that any material used to make this

part will meet under the maximum force. With the minimum force being zero the minimum stress will also be zero. From these two known stresses, a sine wave can be used to model the cyclic loading scenario of the axel as shown in Figure 4.

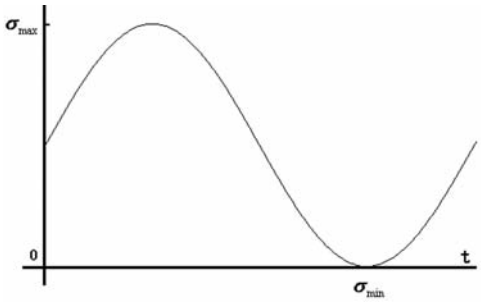

Figure 4. Cyclic Loading Diagram of the Axel

Material properties that need to be known are the yielding strength and the ultimate strength. These properties can be found in a number of references. The values used in this paper are from reference **[1]**. The Goodman Line diagram is highly dependent on a value called the endurance limit or fatigue strength, $S_{n,}$, of the selected material. The calculation of the endurance limit depends on several correction factors such as the surface condition, size, loading situation, temperature, and the expected reliability. The following equation shows their relationship:

$$S_n = S_n^{'} C_L C_G C_S C_T C_R \qquad (3)$$

where

S_n = fatigue strength of materials
$S_n^{'}$ = standard fatigue strength
C_L = load factor
C_G = gradient factor
C_S = surface factor
C_T = temperature factor
C_R = reliability factor.

The criteria and values for these correction factors can be found in [1]. Before the equation (3) could be used, the Standard Fatigue Strength $S_n^{'}$ has to be calculated as follows:

$$S_n^{'} = 0.5 S_u \qquad (4)$$

where

S_u = ultimate strength of materials.

The standard life calculation is for a life span of 10^6 cycles. This is a very high number of cycles that can be considered to be infinite for the life of the inline skate.

Next based on fatigue theory and the loads applied on the shaft, the mean stress, σ_m, and the alternating stress, σ_a, will be calculated for the Goodman Line diagram. Since the

loading for the system is from zero to a maximum load the alternating stress and the mean stress are equal. Both are expressed as follows:

$$\sigma_a = \frac{(\sigma_{MAX} - \sigma_{MIN})}{2} \quad (5)$$

and

$$\sigma_m = \frac{(\sigma_{MAX} + \sigma_{MIN})}{2} \quad (6)$$

where,

σ_a = Alternating stress
σ_m = Mean stress
σ_{max} = Maximum stress
σ_{min} = minimum stress.

Since all the variables are known, the Goodman Line diagram can be constructed. A Goodman line diagram consists of two axes where the horizontal axis represents σ_m, and the vertical axis σ_a with the unit ksi for both. On the horizontal axis the values of the yield strength and the ultimate strength are plotted, then on the vertical axis the yield strength is plotted again as well as the endurance limit. A line is then drawn connecting the yield strength points on the vertical and horizontal axis. This line is called the yielding line. Next a line is drawn from the ultimate strength point on the horizontal axis to the endurance limit point on the vertical axis, which is called the Goodman line for the infinite life cycles. Further, the load line is drawn from the zero point outward with a slope that is equal to the alternating stress divided by the mean stress for the design application. Since the alternating stress equals the mean stress, the load line goes from the zero point at an angle of 45 degrees. The Goodman Line diagram can be seen in Figure 5.

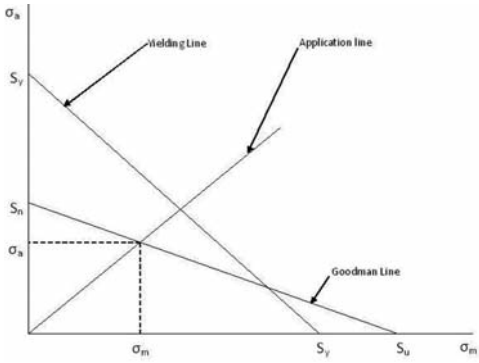

Figure 5. General Setup of Goodman Line Diagram

Now that the Goodman Line diagram is made it must be interpreted. The interpretation starts with finding where the load line intersects the Goodman line and the yielding line. If the load line intersects the yielding line first, then yielding of the material is the main

concern. If the load line intersects the Goodman line before the yielding line, then fatigue is the main area of concern. From the point that the load line intersects the Goodman line we can find the maximum stress that can be handled by the material for the 10^6 life. Since our load line is at 45 degrees it does not matter which axis you take the reading for value of stress because they will be equal. The value that is read off the graph is the maximum fatigue stress that can be put on this material and expect that the material satisfies the fatigue requirements.

Most raw materials are priced on a per pound basis. This requires that the volume of the axel must be found and then the weight of the axel must be found for proper analysis of the cost benefits. From the model of the axel we can figure that the volume is 0.108 in3. The equation used for calculating the weight from the volume and material density can be shown in the following:

$$W = V\rho \qquad (7)$$

where

W = weight (lbs)
V = volume (in^3)
ρ = density (lbs/in^3)

RESULTS

Using the Goodman Line diagramming method described previously, aluminum is the first material to be considered since the current material for the inline skate axels are mainly made of an aluminum alloy. This will give a base comparison point for the other three materials. Figure 6 below is the graphical representation of the Goodman Line diagram for aluminum. The operating point for aluminum under our zero-max loading is where the application line intersects the Goodman line. Reading to one of the axis (σ_m or σ_a) on the graph, the maximum stress of the material for the application is found. For aluminum this value turned out to be 15.5 ksi. Because this value is above the max loading scenario stress, a validation for using this material has been achieved but at a cost of around $2.00/pound (material price may fluctuate).

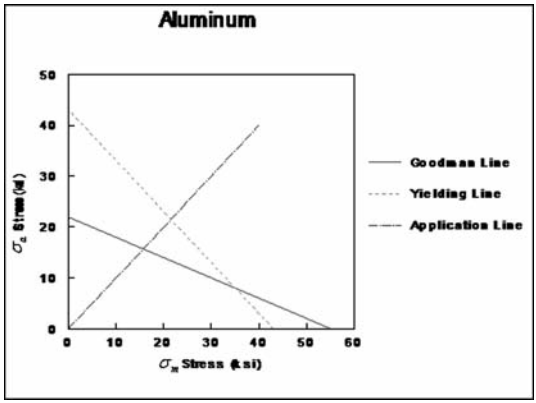

Figure 6. Goodman Line Diagram for Aluminum

Once again using the Goodman Line diagram for titanium, Figure 7 shows that the material stress is around 34 ksi. This is well over the requirement of around 1.0 ksi and thus could be a viable material to use. However; the cost of titanium is approximately $25.50/pound, so producing the axels out of this material is not a wise choice especially in the case of trying to generate cost savings.

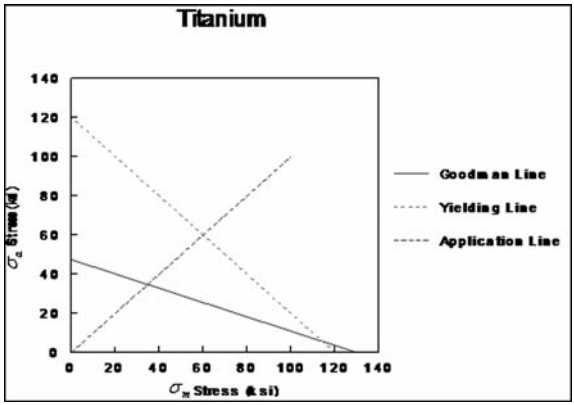

Figure 7. Goodman Line Diagram for Titanium

Using the Goodman Line diagram as shown in Figure 8 for nylon shows that the material stress is far less then that of the previous two materials. The nylon stress was calculated to be 4 ksi. Once again this is large enough to withstand the loading situation

and it also provides cost savings since the price of nylon is only $1.64/pound of material. Comparing this to aluminum, that's a saving of around 36 cents per pound of material used on the inline skates.

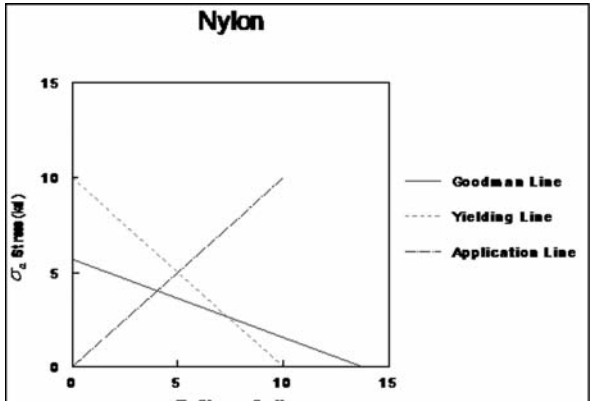

Figure 8. Goodman Line Diagram for Nylon

Finally there is PVC to consider. Running the Goodman Line analysis on this material provides some promising data. Figure 9 below shows that like the other three materials selected, it can withstand the loading stresses, too. PVC is calculated to have a material strength of around 2.1 ksi which is still a little more than double of the required strength for the loading. The cost of PVC per pound is only about 41 cents. This equates to a cost savings of around $1.59/pound when compared to aluminum.

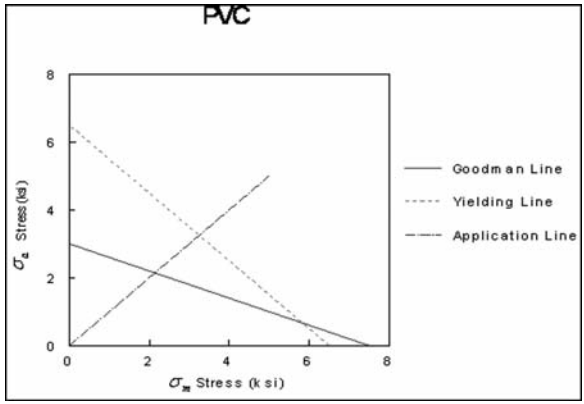

Figure 9. Goodman Line Diagram for PVC

DISCUSSION

As you can see all of the materials that are used in this analysis would work. The values calculated are shown in Table 1.

Table 1. A Comparison of Load Capacity and Costs of Four Materials

Material	Nylon	PVC	Aluminum	Titanium
Infinite Life (ksi)	4	2.1	15.5	34
Price per lbs ($/lbs)	1.64	0.41	2.00	25.49
Density (lbs/in^3)	0.001268	0.001501	0.1	0.16
Cost of Part Material ($)	0.000225	0.000066	0.021600	0.440467

Assuming that the axels can be manufactured in the same way, it can be reasoned that the PVC axel would be the best choice for cost saving. The material cost savings of the PVC over aluminum is around 327%. The savings per pair of inline skate would be about $0.172. This may not seem like a lot but if the company only produced 100,000 pairs of inline skates with PVC axels they would save $17,200 over the aluminum axels.

The previous values are assuming that the manufacturing for the plastics are the same as the metals but the plastics that were selected could both be used in injection molding techniques. Since injection molding normally makes a very high amount of parts relatively quickly, it can be assumed that time as well as material cost could be saved with the use of plastic.

LIMITATIONS

There are some limitations on the numbers attained above. The raw material costs are just a snapshot in time and all prices could fluctuate. So what might be cheaper now might not be cheaper later.

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Characterization and Analysis of Hailstorms in the Northern Great Plains

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ABSTRACT

Hail is a meteorological occurrence that appears frequently during spring and summer across the Northern Great Plains. This paper first characterizes patterns associated with reported hail events occurring within a five-state region (North Dakota, Minnesota, South Dakota, Iowa, and Nebraska) from 2000-2006 using records taken from the National Climatic Data Center (NCDC) Severe Storms database. Patterns of interest include the seasonality of hail activity for each state and across the region, observational bias in the reporting of hailstone size, and temporal trends in the number of hail reports across the region and in each state. This paper then explores a possible link between the solar cycle and regional hail activity. Daily observations of solar radio flux (at 10.7 cm) and National Weather Service hail reports dating from 1956-2006 were compared. A chi-squared goodness of fit analyses showed possible associations exhibiting weaker significance in Solar Cycles (S.C.) 21 and 22, and higher significance during S.C. 23. The recent appearance of a significant linkage may be due to changes in reporting effort, weather patterns, or both. Further study is required to distinguish observational artifacts from geophysical effects. Because hail activity is common to the Northern Great Plains, a deeper understanding of the effects of the solar cycle on hail and also the spatial and temporal patterns associated with regional hail may prove beneficial for climate prediction, weather forecasting, and underwriting of crop-hail insurance.

INTRODUCTION

Hail is a natural, though unusual, form of precipitation that routinely occurs only in certain regions of the planet. It can have a range of effects on people and property. For the city dwellers, hail may be, with exceptions, no more than a minor annoyance inflicting minimal damage. However, for farmers and ranchers, hail can have severe impacts and even disrupt the local agricultural economy through substantial crop or forage damage and even loss of livestock. Hail damage to crops is complex function contingent on several variables: frequency, intensity, hailstone size, crop phenology, prevailing windspeed and direction during the hailfall, and the growing conditions in the days after the event (Parker et al. 2005).

In this paper, patterns associated with the National Weather Service (NWS) reports of hail recorded from 2000 to 2006 in the Northern Great Plains region (North Dakota, Minnesota, South Dakota, Iowa, and Nebraska) are characterized. The first aim of the paper is to summarize the seasonal pattern of hail reports and illustrate an apparent bias in reporting of hailstone size. The second aim is to investigate possible linkages between the phase of the solar cycle and hail occurrence across the region. Interest in this linkage arose upon reading a recent publication suggesting linkages between solar activity and climate mode effects (Kryjov & Park 2007).

METHODS

Hail reports were accessed through the Severe Storms database maintained by the National Climatic Data Center (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms). The database allows access to NWS storm reports filtered by state, date range, or event type. Only hail events with hailstone size of at least three-quarters of an inch (~19 mm) are recorded in the database. Hail reports recorded within the five-state region during 2000 through 2006 (7 years) were imported to spreadsheets for analysis. Patterns of interest included (a) hail report frequency by month for the region and each state, (b) frequency distribution of hailstone size reports; (c) interannual variability of reports; and (d) temporal trends in hail reports across state and region. Mann-Kendall nonparametric trend analysis (de Beurs & Henebry 2004) was performed using a Visual Basic/Excel implementation (Grimvall & Libiseller 2003).

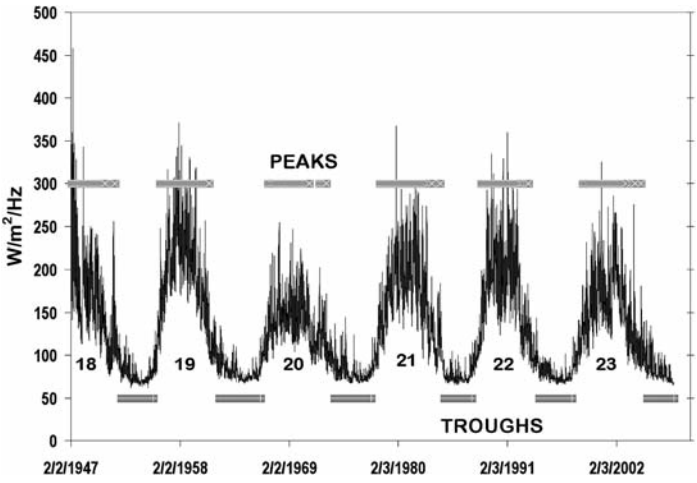

Figure 1. Daily solar flux at 10.7 cm. Periods determined to be high, or greater than 150 Wm²/Hz, and periods determined to be low, or less than 85 Wm²/Hz, are highlighted by the gray symbols above and below the respective time periods. Solar cycle numbers indicated.

Daily observations of solar flux at wavelength 10.7 cm are available through the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC) website, SPIDR (Space Physics Interactive Data Resource; (http://spidr.ngdc.noaa.gov/spidr/). The observations were divided into different phases of the solar cycle by two schemes (Figure 1). Extended periods of flux activity greater than 150 W/m²/Hz were classified as "Peak" periods; extended periods of flux activity lower than 85 W/m²/Hz were classified as "Trough" periods; "Rising Limb" and "Falling Limb" periods were those observations falling after the Trough and Peak periods, respectively (Table 1).

Table 1. Hail reports from 1956 through 2006 allocated to phases of the solar cycle.

	Trough	Rising Limb	Peak	Falling Limb	RL + FL	Total	Reports/day
Total # of observation days	5893	2492	6808	3733	5865	18567	N/A
Total hail reports in region	14153	4433	13606	7837	12270	40029	2.156
Hail reports in NE	4345	1498	3857	2227	3725	11927	0.642
Hail reports in MN	3225	999	2598	1253	2252	8075	0.435
Hail reports in IA	2409	821	2544	1866	2687	7640	0.411
Hail reports in SD	2457	594	2630	1677	2271	7358	0.396
Hail reports in ND	1717	521	1977	814	1335	5029	0.271

In addition to this four-class scheme, counts during each limb period were summed to make a three-class scheme. A Chi-Squared goodness of fit test (Zar 1984) was used to evaluate whether there was a disproportionate number of hail reports occurring during particular phases of the solar cycle. Tests were applied to each state and to the five-state region using both the four-class and three-class schemes for the entire record of observations from 1956 through 2006 (Table 2) as well as by solar cycle (Tables 3, 4).

Table 2. Chi-squared analyses to evaluate disproportionate association of hail reports with particular phases of the solar cycle over the period 1956 through 2006.Region

	χ^2 statistic (four-class)	p-values for *d.f.*=3	χ^2 statistic (three-class)	p-values for *d.f.*=2
Region	3.00	>0.10	0.72	>0.10
Nebraska	1.29	>0.10	1.18	>0.10
Iowa	1.27	>0.10	1.21	>0.10
Minnesota	3.13	>0.10	3.10	>0.10
South Dakota	3.42	>0.10	0.13	>0.10
North Dakota	1.13	>0.10	0.63	>0.10

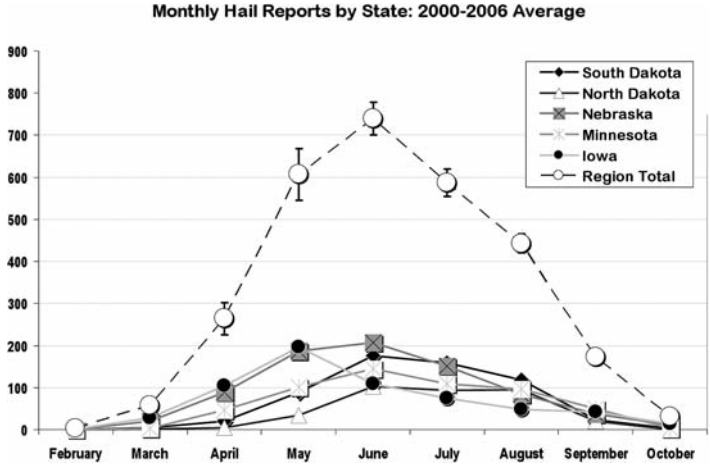

Figure 2. Seasonality of hail reports in the Northern Great Plains. Note the divergence in peak timing across the region and the high interannual variability of reports in May.

RESULTS

Figure 2 illustrates the seasonality of hail report activity for each state and across the region from 2000 through 2006. On average across the region, the highest number of hail reports occurs in the May-June time period. However, in the Dakotas, the average peak period for hail reports occurs later, during June-July time frame. Also, an interesting point is that Iowa's average peak was during May and then drops below the average of the four other states through the rest of the growing season. There is also a distinct pattern of higher interannual variability during May than the rest of the year, as shown by the errors bars in Figure 2. The variability is not symmetrical on either side of the June peak: interannual variability for July is much lower than for May.

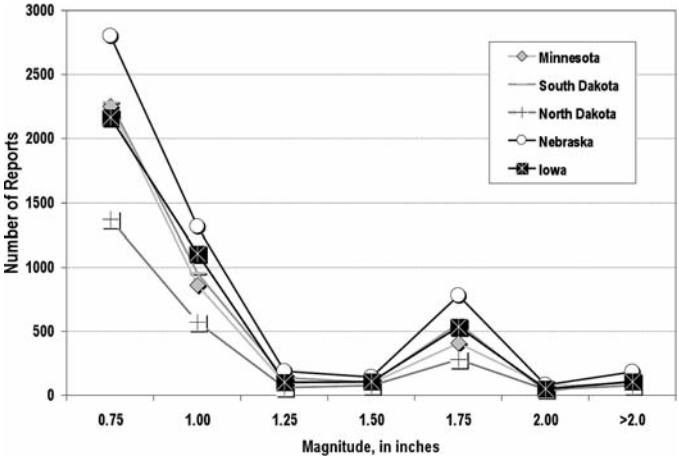

Figure 3. Frequency distribution of hailstone size reports. Note the anomalous spike in reports at 1.75 inches. This appears to be observational bias.

Figure 3 reveals an observational bias in the reporting of hailstone size. The minimum reporting size for hail events is three-quarters of an inch with the most common increment being one-quarter of an inch (6.35 mm). There is a clear spike in the number of reports at 1.75", contrary to expectation.

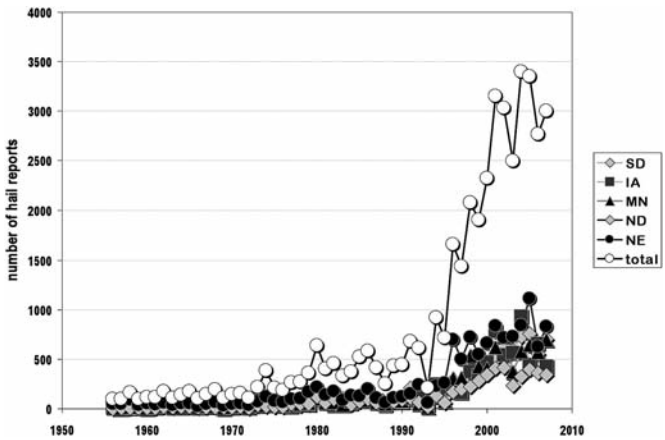

Figure 4. Total amount of hail events recorded in the Northern Great Plains region from 1956-2007, as well as for each state in the region. Note the significant increase in reports in the mid-1990s.

Figure 4 shows strong temporal trends in the number of reports in the region and in each state. There is a remarkable increase in reports in the mid-1990s and this increase is fairly consistent across states. Figure 5 captures the proportional contribution of each state to the regional total. An 11-year retrospective moving average filter was applied to the proportional reports to reduce the possible effects of the solar cycle. It is clear that there has been a decreasing trend of reports in Nebraska (Mann-Kendall test = -4.02, $p<0.001$) and increasing trends in both South Dakota (Mann-Kendall test = 1.70, $p<0.1$) and North Dakota (Mann-Kendall test = 2.95, $p<0.01$). Trends in Iowa and Minnesota were not significant at $p<0.1$.

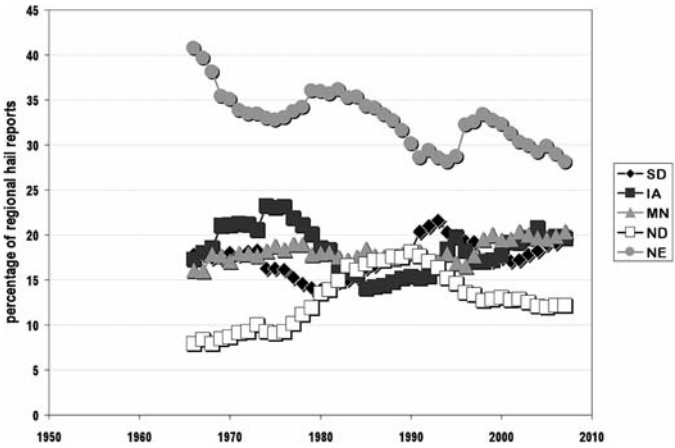

Figure 5. Trends in percentage of total region-wide hail reports by state filtered by an 11-year moving average. Nebraska is significantly decreasing while the Dakotas are significantly increasing.

Average daily rate of hail report occurrence during the entire observational record was just over 2.2 across the region, with rate in Nebraska more than twice that of North Dakota (Table 1). The null hypothesis of no linkage between the solar cycle and hail occurrence makes a prediction of an even distribution of hail reports across the phases of the solar cycle. When viewing along the entire observational record, the occurrence of hail reports across the region and in each state was not significantly disproportionate (Table 2). However, Figures 4 and 5 reveal significant changes in reporting effort during the observational record that could obscure more subtle associations between the solar cycle and hail reports. Table 3 shows the results of the chi-squared analyses for the five-state region applied at the level of solar cycle. (In 2008, we are at the very end of Solar Cycle 23.) There is no association in Solar Cycle (S.C.) 20 and weak association in S.C. 21 and 22; by S.C. 23, the association is highly significant for both the four-class and three-class schemes. Table 4 extends the analysis to each state. Only in Nebraska is there

not a highly significant association in S.C. 23. In the Dakotas the association is highly significant starting as early as S.C. 21.

Table 3. Chi-squared analyses to evaluate disproportionate association of hail reports across the five-state region with particular phases of the solar cycle for solar cycles (SC) 20 through 23.

SC	Variable	Trough	Rising Limb (RL)	Peak	Falling Limb (FL)	RL + FL	Total	χ^2 statistic (four-class)	p-values for *d.f.*=3	χ^2 statistic (three-class)	p-values for *d.f.*=2
20	Total Days	1310	1142	632	931	2073	4015				
20	Hail Reports	437	436	243	454	890	1570	2.140	>0.10	1.204	>0.10
20	Reports/Day	0.334	0.382	0.385	0.488	0.429	0.391				
21	Total Days	1476	415	1645	484	899	4020				
21	Hail Reports	1060	288	1830	678	966	3856	6.705	**<0.10**	3.687	>0.10
21	Reports/Day	0.718	0.694	1.112	1.401	1.075	0.959				
22	Total Days	1134	316	1433	663	979	3546				
22	Hail Reports	1547	213	1980	536	749	4276	5.175	>0.10	5.100	**<0.10**
22	Reports/Day	1.364	0.674	1.382	0.808	0.765	1.206				
23	Total Days	1279	619	1327	698	1317	3923				
23	Hail Reports	4632	3496	8987	5895	9391	23010	9.045	***<0.05***	7.142	***<0.05***
23	Reports/Day	3.62	5.648	6.772	8.446	7.131	5.865				

DISCUSSION & CONCLUSION

The quality of the hail report data is suspect in several respects. There is apparent observational bias (Figure 3). The temporal trends in number of reports (Figure 4) and proportional contribution of each state to the regional total (Figure 5) suggest a systematic change in reporting effort in the mid-1990s. There are likely also to be effects arising from changes in population density, observer mobility, weather awareness, and, possibly climate change. Resolution of these effects must be left to another study.

The linkage between solar cycle and hail occurrence appears stronger in the most recent solar cycles than earlier. The recent appearance of a significant linkage may be due to changes in reporting effort or to weather patterns. More data and analyses will be required to distinguish observational artifacts from geophysical effects.

Table 4. Chi-squared analyses to evaluate disproportionate association of state-level hail reports with particular phases of the solar cycle for solar cycles 20 through 23.

	χ^2 statistic (four-class)	p-values for *d.f.*=3	χ^2 statistic (three-class)	p-values for *d.f.*=2
Nebraska				
S.C. 20	1.87	>0.10	0.89	>0.10
S.C. 21	6.62	**<0.10**	5.37	**<0.10**
S.C. 22	3.19	>0.10	2.23	>0.10
S.C. 23	3.85	>0.10	3.55	>0.10
Minnesota				
S.C. 20	6.52	**<0.10**	6.46	***<0.05***
S.C. 21	3.60	>0.10	1.04	>0.10
S.C. 22	10.86	***<0.05***	10.35	***<0.01***
S.C. 23	8.03	***<0.05***	8.00	***<0.05***
Iowa				
S.C. 20	4.42	>0.10	1.18	>0.10
S.C. 21	1.51	>0.10	0.56	>0.10
S.C. 22	3.42	>0.10	2.83	>0.10
S.C. 23	20.31	***<0.01***	13.80	***<0.01***
South Dakota				
S.C. 20	4.42	>0.10	4.42	>0.10
S.C. 21	19.59	***<0.01***	9.44	***<0.01***
S.C. 22	8.06	***<0.05***	7.48	***<0.05***
S.C. 23	19.25	***<0.01***	9.30	***<0.01***
North Dakota				
S.C. 20	6.22	>0.10	0.89	>0.10
S.C. 21	21.90	***<0.01***	15.16	***<0.01***
S.C. 22	11.34	***<0.05***	9.80	***<0.01***
S.C. 23	9.66	***<0.05***	9.15	***<0.05***

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Is Hypnosis an Appropriate Conjunctive Treatment for Dental Phobia?

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ABSTRACT

This paper was written to explore the use of hypnosis as a conjunctive treatment. A brief history of hypnosis from ancient times to modern practice is presented as well as public views, mechanisms, effects, uses, evidence, and dentistry-specific case studies. Hypnosis has been both widely accepted and rejected, and its methods and uses have evolved over time. Current research has found neurophysiological evidence to support the use of hypnosis, and it has been successfully used in various fields of practice. No single indicator can prove the phenomenon and its effectiveness is the result of a complex set of procedures. Hypnosis as it is known today can serve as an alternative conjunctive treatment for certain individuals under certain conditions.

IS HYPNOSIS AN APPROPRIATE CONJUNCTIVE TREATMENT FOR DENTAL PHOBIA?

Many people find it very difficult to visit doctors, especially dentists. Often negative previous experiences coupled with low pain tolerances and fear can lead to avoidance and phobias. Dental procedures are important beyond the concept of maintaining clean and straight teeth. Dentists and hygienists may detect cancers and other disorders of the tissue in and around the mouth. Dental decay can lead to blood infections, bad breath and a whole host of negative symptoms.

If a patient has developed a phobia of dental procedures, convincing him or her to undergo treatment may be next to impossible. In most modern cases patients with such phobias are sedated by some chemical form, usually a nitrous oxide gas. The use of sedatives can be costly, invasive, and may carry a risk of interactions and side effects. Concerns of drug side effects may lead many patients and physicians to consider alternative treatments.

Throughout history, hypnosis has been used for various effects ranging from hysteria to memory recall, but overall it has been shown to be an effective relaxation mechanism. For certain patients hypnosis may offer an inexpensive, noninvasive supplemental procedure to reduce the anxiety associated with dental visits.

The purpose of this paper was to explore hypnosis and its role in society and specifically the medical setting. Can hypnosis truly offer an alternative to chemical

sedation at a level safe and efficient enough to mandate widespread use? Also, the views on hypnosis theories and hypnosis itself have been investigated in an attempt to gather foresight of medical hypnosis compliance.

HISTORY

Hypnosis is by no means a recent discovery. Hypnosis has been practiced, researched, investigated and debated for centuries. It has evolved from beliefs of mystical and divine intervention to theories of magnetic force and, most recently, theories of suggestibility, psychophysiology and diversion. Both support and criticisms for the use of hypnosis as a form of treatment have occurred since ancient times. In order to gain perspective on the procedure and its feasible applications, hypnosis' past should first be examined.

In 1843 James Braid coined the term hypnosis, but the practice of hypnosis has been around since antiquity. Principles of hypnosis have been traced back as far as the Ancient Egyptians who used a form of it in dream temples (Waterfield, 2004). A stele, which is an upright inscribed stone slab, was discovered in 1972 by Charles Muses. It depicted a scene of a trance induction that occurred during the rule of Ramses II (Lockert, 2001). Even Socrates and some of his followers alluded to the healing power of words (Muses & Young, 1972). Evidence indicating the use of hypnosis or hypno-related procedures dates back over a thousand years BC.

One of the more familiar names in hypnotism is Franz Anton Mesmer. Mesmer gained notoriety for his elaborate hypnotic practices, but several physicians, priests, and alchemists developed principles of hypnotism prior to his birth. Two hundred years before Mesmer, in 1529, a Swiss alchemist and physician, Paracelsus, suggested that a heavenly, magnetic fluid played a role in disease and healing (Gezundhajt, 2007). A few years later, a man by the name of Girolamo Cardano published material related to hypnosis. Most researchers account Cardano, a medieval Italian mathematician who lived from 1501 to 1576, with the first reported case of self-hypnosis. In 1551, Cardano printed *De Subtilitate Rerum* in which he described feelings of trance and out of body experience (Gezundhajt, 2007). The early 1500's marked a period of discovery and theorizing of hypnosis before it was even known by that term.

Another predecessor to Mesmer was Father Johann Joseph Gassner (1729-1779). Gassner is considered the real precursor to modern hypnotherapy (Burkhard, 2005). Gassner practiced exorcisms by intentionally provoking the symptoms, then "curing" the symptoms via verbalization with the patient. Although his actions are not what a lay person would associate with hypnosis, Gassner's methods of treatment demonstrated the potential power of words over psychological and physical detriments.

Mesmer (1734-1815), whose name is the root of the English word mesmerize, was born into a strongly Catholic family. He initially entered a Jesuit college, but later left the church to study medicine. He graduated from the University of Vienna as a Doctor of Medicine. Later, with influence from Father Maximillian Hell, Mesmer formulated the idea of mineral and animal magnetism (Lockert, 2001). In 1774, Mesmer observed Father Hell as he put magnets on patients to treat physical symptoms. In 1775, Mesmer

expounded on Hell's methodology. Mesmer wrote a document claiming the magnets could be replaced with nearly any inanimate object (Crabtree, 1993). In 1777, Mesmer met Johann Gassner and observed the priest's ability to cure without magnets. Subsequently, Mesmer discarded the belief that the magnets held supernatural powers and instead switched his theories to nature-based principles (Forrest, 1974).

A few years later in 1784, Marquis de Puysegur stumbled across what we modernly consider a hypnotic state. While attempting to enter a young peasant into a trance state in order to treat him for fever and congestion, Puysegur did not observe the convulsive state that was common with the Mesmerian practices of the time. Puysegur instead observed that the young man had entered a deep state of relaxation that resembled somnambulism (Crabtree, 1993). Puysegur's observations were contrary to what was commonly observed with trance induction of the time, but resembled the more modern idea of a hypnotic state.

Beyond the ideas of magnetism stood an Indo-Portuguese monk by the name of Abbe Jose Custodio de Faria (1746-1819). De Faria hypothesized that a magnetizer's will has no effect on the patient and the presence (or lack of) magnetic fluid also had no effect. De Faria hypothesized the hypnotic trance was created by a fascination that a subject felt towards the inducer and the persuasion and coercion that had been implemented (Gezundhajt, 2007). De Faria was an early theorist on the strength of rapport. His theories and practice attempted to disprove the need for physical objects in order to induce a trance.

A few years later, a Scottish surgeon named James Esdaile (1808-1859) was in charge of a hospital in India and began to utilize the methods of hypnosis. Just prior to the discovery of chloroform, Esdaile used Mesmeric analgesia very successfully in a number of procedures and presented his results to the government. After the release of his results, Esdaile was placed in charge of a small hospital in Calcutta where he performed thousands of procedures using Mesmeric analgesia (Gezundhajt, 2007). The Indian natives flocked to Esdaile out of respect and admiration of his treatments. James Esdaile is one of many pioneers who brought hypnosis into medical hospitals.

James Braide, also a Scottish surgeon, helped push hypnosis into more modern procedures. Although he also dabbled in phrenology, he is most credited as the "father of hypnotism." He derived the term hypnosis from the Greek word for sleep. It was Braid's belief that hypnosis did not require any direct action by the hypnotist on the subject, and catalepsy would occur in hypnotized subjects. Braide felt that hypnosis should only be used in the medical and dental professions as an addition that could help cure several ailments (Gezundhajt, 2007). Braide not only coined the term hypnosis but also postulated that hypnosis could be induced without any physical contact between the hypnotist and the patient.

One of the theorists on the idea of suggestibility was a Frenchman, Auguste Ambroise Liebeault (1823-1904). He was a country doctor who used information from the famed brain specialist Paul Broca. Liebeault believed that about ninety-five percent of people are hypnotizable and that magnetic medicine is simply the power of the imagination (Bernheim, 1889). Today, much of the research on hypnosis has focused on who is hypnotizable and what characteristics may distinguish those who are hypnotizable from those who are not.

More recently, Sigmund Freud (1856-1939) practiced hypnosis in Vienna. Initially Freud felt hypnosis was simply ordinary sleep (Gravitz, 2004). However, as Freud continued his practice he came to believe that hypnosis was nothing like nocturnal sleep or drug induced sleep. According to Freud, during hypnosis changes can occur and a person is capable of mental functions that they are incapable of during normal sleep (Freud, 1905). The idea that hypnotized subjects are capable of performing tasks outside their normal range of capabilities has been scrutinized ever since.

Freud used hypnosis to help treat neurotics, but he became frustrated after he found it impossible to induce everyone. Freud is quoted by Chertok (1979) from Freud's *Five Lectures on Psychoanalysis* (1910) as saying:

> I soon came to dislike hypnosis, for it was a temperamental and, one might almost say, a mystical ally. When I found that in spite of all my efforts, I could not succeed in bringing more than a fraction of my patients into a hypnotic state, I determined to give up hypnosis ……. Since I was not able at will to alter the mental state of the majority of my patients, I set about working with them in their normal state.

Over the course of the last few thousand years man has investigated the nature of hypnosis. Hypnosis has been theorized to occur due to things such as divine intervention, supernatural powers, magic rituals, natural powers of objects, subject fascination, and suggestion. Certainly many more physicians, alchemists, therapists and others have practiced and contributed to hypnosis than those listed previously.Throughout time hypnosis has experienced changes in both title and theory, and its practicality as a treatment procedure is still being explored today.

PUBLIC AND SCIENTIFIC VIEWS

Throughout history hypnosis has been praised and spurned by everyone from kings to peasants. Public opinion and scientific insights have varied from culture to culture, year to year, and individual to individual. Still today opinions on hypnosis vary to both ends of the spectrum. The past has shown that hypnosis and those who practice it have been subject to a plethora of public action from admiration to defamation and banishment. The nature and very existence of hypnosis has been debated for centuries and will continue to be debated for years to come.

During the Middle Ages in Europe, trances were rejected by the many rulers of the time and its proclaimed power to heal or spiritually enlighten was completely disregarded. Several hypnotists were discredited and/or banished due to their hypnotic practices. Anton Mesmer was banned from the Medical Family of Vienna in 1777 after temporarily treating a woman's blindness (Forrest, 1974). Later, Mesmer was the subject of two royal investigations. The first was by the Academie des Sciences and the Academie de Medecine which included the American Benjamin Franklin. The second was conducted by the Societe Royale. Both investigations discredited Mesmer's idea of the existence of an internal fluid that could be manipulated in order to cure (Darnton, 1968). Even Mesmer, one of the most documented hypnotists today, came under scrutiny of the public and scientific community.

In the mid 1800's an English physician by the name of John Elliotson was banned from practicing at University Hospital in London after using magnetic sleep as an analgesic during major surgeries. Elliotson was a professor of medicine and was one of the first physicians to advocate the use of the stethoscope (Gezundhajt, 2007). In a similar fashion, John Esdaile was also eventually looked down upon by both the medical community and the church because the use of chloroform had become an accepted medical practice (Gezundhajt, 2007). Once practitioners were able to empirically prove the effects of chemically induced analgesia, the seemingly non-provable method of hypnosis was disregarded as substandard practice.

Beyond the medical realm, the use of hypnosis for public entertainment, or stage hypnosis, has resulted in some governmental regulation, at least in the United Kingdom. In the United Kingdom stage hypnotists must apply for a special license which is granted by a local council (Heap, 2000).

Heap (2000) cites two cases in which participants were negatively afflicted by stage hypnosis. The first case occurred in 1995. A young man sued a hypnotist after falling off a stage while running from imaginary mice. He later claimed to have developed a phobia of mice. The second case involved the death of a healthy young woman one night after she took part in stage hypnosis. The mother of the deceased felt the stage hypnosis was directly related to her death. The news of these trials was publicized and at least two more cases arose. The sudden influx in stage hypnosis related court cases prompted the United Kingdom Home Office to establish a panel of experts to explore the dangers of hypnosis. In October 1995 the panel reported that no significant risks to mental health were posed by stage hypnosis; therefore, prohibition was not warranted (Home Office, 1996). Even with the panel's suggestion, many medical practitioners worry about the efficacy and safety of hypnotic procedures (Cangus & Wagstaff, 2000).

Although stage and clinical hypnosis are quite different, several common misconceptions have skewed the general public's view of hypnosis. For example, some fear involves the thought that a hypnotist may fail to cancel a suggestion entirely, and a compulsion may develop. Such a case was reported by Heap (2000). A man claimed to have an intense desire to have sexual relations with household furniture and appliances post-hypnosis. Heap reports such reactions are highly unjustifiable as modern research indicates hypnotic suggestion is inhibited by six factors:

1. The suggested response must be within the subject's repertoire of abilities.
2. The response must be acceptable to the subject and compatible with the context it is given.
3. Although the suggestion may be experienced by the subject as having a compulsive quality, it involves cognitive effort on the subject's part.
4. The influence of suggestion is easily overridden by existing competing habits.
5. The subject's impulse to respond to the suggestion usually dissipates with time.
6. The influence of the suggestion is determined by the explicit and implicit demands of the context and when those demands are perceived as no longer operative, the subject stops responding.

In Spain and the surrounding countries there has been a surge of interest in hypnosis (Capafons, 1999). Spanish researchers discovered that post-hypnotic amnesia only

occurred in exceptional cases and the amnesia was easily reversed. The same researchers claim that when patients are told they will be hypnotized it evokes attitudes and expectations that interfere with the therapeutic process. Thus, these researchers feel that the term hypnosis should be scrapped in favor of a more fitting title (Caycedo, Pons & Sarro, 1969). Spain has been somewhat of a recent hot spot for hypnosis research.

Furthermore, Spanish policies show that hypnosis is not yet fully accepted as a justifiable procedure there. Psychoanalysis and hypnosis are excluded from publicly financed health services in Spain based on the belief that there is a lack of scientific evidence on its safety and efficiency (Royal Decree 63/1995). Current research in Spain is focusing on ideas that reject hypnosis as a special state and attempts to prove its effectiveness (Cangas & Wagstaff, 2000).

Hypnosis certainly has a past colored with periods of high acceptance and times of total disregard. Its use in hospitals, stage performances, and therapeutic treatments has brought attention from the general public and scientists alike. Scrutiny of its use has led to legislation and new focuses in research. Such scrutiny may lead to disbelief and doubt which may in turn lead to research that may unlock some of the mysteries associated with hypnotism.

MECHANISM

The inductions of trances and hypnosis have varied just as their theories have. Similar to the theories on the nature of hypnosis, theories and methods of induction have largely been shaped by skepticism and investigation. Inductions have been as complicated as to involve elaborate mechanisms and machines and as simple as using a mere visual focus. Modern advances in neuroimaging have allowed for research on the physiological effects of the induction. Another area of modern research has been conducted on the presence and effects of susceptibility. Inductions have gone through major changes in order to stay up to date with the associated theories.

Early mechanisms for entering trances varied greatly, but one that is especially documented is Mesmer's use of the *baquet*. The *baquet*, as described by Crabtree (1993), is an oaken tub specially designed to store and transmit magnetic fluid. It is four to five feet in diameter and one foot deep. It had a lid, and along the bottom were bottles arranged in concentric circles. Some of the bottles were empty and pointing towards the center. Others were filled with magnetized water and pointed towards the outside. The tub was filled with water containing iron filings and powdered glass. Iron rods were positioned in the lid, and as such they could be placed against the pained area of the subject's body. Procedures inside the *baquet* were done in large rooms with huge mirrors. Meanwhile, Mesmer would dress in a cloak and play a glass harmonica. His assistants sat in the corners to help control convulsing subjects because convulsions were very common. Mesmer's induction process was complex and highly ritualistic.

Most modern forms of inductions are not a random assortment of procedures that the subject is told to follow. Rather, an induction follows a sequence with neurophysiological logic. The induction involves initially activating the anterior left sided attention

mechanisms which are later inhibited to allow for selective inhibition of frontal functions. This selective inhibition creates the possibility for hypnotic experiences such as automaticity and involuntariness (Gruzelier, 2000).

Inducting a trance or hypnotic state does not ensure that the hypnotist will be able to impose any sort of effect on the subject. Ideas can be suggested into actualization by three mechanisms (Bierman, 1995). Bierman states rapport, linkage, and authority reign over hypnosis. Rapport is used to create a feeling that the patient and therapist are of similar mind. The hypnotist's ideas and state of mind are the same as the patient's. Rapport is often created through a series of meetings in which a relationship of trust is built. Next, linkage is the creation of a feeling that the therapist's words are the patient's experience. Linkage allows the hypnotist to not only describe current behavior but also future experiences. Linkage is, according to Bierman, what is considered the classic induction. Linkage is the idea that the hypnotist has the ability to predict or produce future experiences. Finally, Bierman states authority as the idea that the therapist's ideas are now the client's reality. Authority is correlated to the instruction of the young by the old and is an inevitable consequence of mammalian child rearing. Hypnotic induction actually could be considered the entire process from rapport to formal induction, as every step is crucial to developing the hypnotic state.

Much of the recent hypnotic research has been related in some way to the idea of susceptibility. Susceptibility refers to the ability of the participant to be hypnotized. Participants are most often defined as being either high or low in susceptibility. Different theories have proposed that highly susceptible patients are not only hypnotized easier, but experience stronger effects than those not as high in susceptibility (Gruzelier, 2000).

In a medical setting, many low susceptible patients adamantly wish to experience hypnosis and therefore comply heartily with instructions (Gruzelier & Brow, 1985). Research in susceptibility may lead to an ability to train subjects who are otherwise not susceptible to hypnosis to be hypnotized. The attention of highly susceptible patients responding to instructions of hypnosis is different than when the instructions come from a story. Attention under hypnosis also differs from patients who were deeply relaxed or in a hypnosis simulation, and different from the attention of low susceptibles (Gruzelier & Brow, 1985). Susceptibility may also be increased by dispelling of misconceptions and worries (Gruzelier, 2000). In opposition to that, negative hypnotic experiences can lead to decreased susceptibility.

Hypnotic induction involves several components. Feelings of rapport, linkage and authority are crucial to the hypnotic experience. Hypnotic susceptibility may also play a key role in hypnosis as highly susceptible patients have exhibited differences in focused attention and susceptibility which can be influenced by misconceptions. Evidence has shown that several key elements need to be established in order for there to be a hypnotic effect.

EFFECTS AND POTENTIAL USES

Hypnotism has experienced a multitude of critics and skeptics. The effects of hypnosis have been credited with many detrimental and dangerous results as well as

many beneficial ones. Advocates of hypnotism and those in opposition to its practice have long disputed the true effects of hypnosis. Treatment possibilities, side effects, potential dangers, and even the derivation of the word hypnosis have been researched.

In modern practice the derivation of the word hypnosis opposes many practitioners' theories. Hypnosis is derived from the Greek word for sleep and the association between hypnosis and sleep has for the most part been abandoned. Also, the idea of a trance is more accurately defined in modern times as a state of mental abstraction from external things, absorption, exaltation, and ecstasy (Gruzelier, 2000). Many titles have been proposed and discussed in an attempt to find a suitable name for the experience currently known as hypnosis, but for the vast majority of the population, hypnosis is what it is regardless of the derivation of the word.

Misconceptions with hypnosis have been commonplace throughout the history of its practice. Jean Sylvain Bailly wrote to the French King Louis XVI concerned that Mesmer's magnetism practices on women were more effective because women were more prone to enter a trance than men. He based his belief on thoughts that women had more responsive nerves, their imaginations are livelier, and that they are more excitable (Bailly et al., 1784). Bailly worried that Mesmer was using women's frailty to seduce them. Years later Sigmund Freud also became worried when a woman threw her arms around him confessing an undying love after exiting a hypnotic state. Hypnosis has been attributed with the idea that subjects of hypnotism may develop intense feelings for the practitioner.

Sivec and Lynn (2000) studied participants of hypnosis, progressive relaxation, and non-hypnotic interviews. The participants were asked to recall their earliest childhood memory. After hypnosis and progressive relaxation, participants reported a higher perceptual-kinaesthetic experience that was not reported in the interview group. This study and others like it have provided evidence that hypnotic procedures may increase patients' self-awareness beyond that of their non-hypnotized state.

Earlier, it was mentioned that susceptibility has been a large focal point for current research. A large amount of evidence has been gathered indicating low and high susceptible subjects differ not only in their neurophysiology but also in the effects of their hypnotic induction (Miltner et al., 2000). The Stroop interference effect, which is a measure of reaction time, is greatly reduced in those who are highly susceptible when compared to those who exhibit low susceptibility (Rubichi, Ruicci, Padovani & Scaglietti, 2005). Accordingly, high susceptible participants perform much better on tasks of sustained and focused attention such as the Necker cube illusion and the auto-kinetic movement illusion (Crawford, Brown & Moon, 1993). These studies exhibit evidence that those who are highly hypnotizable experience different effects than those who are not.

One would be inclined to believe that if highly susceptible subjects are better at focusing attention, they should be able to more effectively use distraction to moderate pain even when they are not hypnotized. Research in this area has achieved various results. In one study, participants of both susceptibility categories showed no significant pain management prior to hypnotism; however, following hypnotism the highly susceptible group reported pain levels significantly lower. Most susceptibility research has resulted in mixed results, making it difficult to generalize findings. (Miller, Barabasz & Barabasz, (1991).

Other effects of hypnosis have also been studied. Some studies have found that telling participants they were hypnotized can have an effect on their reported changes, responsiveness, results, etc. For example, Gandhi and Oakley (2005) had two groups listen to identical relaxation scripts with the only difference being the title of the script. One was titled relaxation and the other was titled hypnosis. Those who listened to the script labeled hypnosis demonstrated higher responsiveness to suggestion than the group who listened to the script titled relaxation.

Hylands-White and Derbyshire (2007) conducted two interesting studies. In the first they assessed the relationship between pain reduction during a task and hypnotizability. They discovered that highly susceptible subjects were no more capable of decreasing perceived experienced pain than those of lower susceptibility. The second study, similar in nature to Gandhi and Oackley (2005), tested the influence of labeling a procedure relaxation versus hypnosis. Identical procedures were administered with different titles. The group who received the procedure titled hypnosis reported being almost five-fold more hypnotized. Hylands-White and Derbyshire (2007) combined data from the two trials and concluded their findings by stating it is better that the participant believes he or she could be hypnotized rather than being highly hypnotizable. Also, analgesic benefits do not increase with hypnotic suggestibility. However, labeling the procedure hypnosis rather than relaxation did show increased analgesic effects.

A minority of patients experience negative post hypnotic symptoms. One study published results stating that 8-49% of post hypnotic participants experience negative effects such as headaches, dizziness, nausea and stiff necks while 62-85% of post hypnotic participants report positive experiences such as relaxation (Lynn, Martin & Frauman, 1996). Brentar, Lynn, Carlson and Kurzhals (1972) developed an instrument to measure post hypnotic experience. They named the scale the Posthypnotic Experience Questionnaire and administered it to three groups. One group was hypnotized, the second was asked to sit with their eyes closed and were instructed they would be tested on body awareness, and the third group, the control, sat quietly in a room for 20 minutes with no special instructions. Hypnotized participants did not report positive experiences at a higher frequency than either of the other two groups. The frequency of reported negative experience was comparable for all groups (Brentar, et al., 1992). This study suggests that hypnotism does not cause more negative effects than sitting quietly in a room.

Most all treatments of any kind come with some form of potential harmful effects, and hypnosis is no exception. Safeguards must be in place to assure that the least amount of harm or discomfort is induced. Subjects should be screened for psychopathology prior to hypnotic induction (Orne, 1965). In addition, before subjects are brought out of a hypnotic state they should be informed they will feel refreshed and alert in order to avoid feelings of headache, confusion, and decreased arousal (Guzelier, 2000).

Even if negative symptoms are not common, measures should be taken to avoid as many negative effects as possible. Some important steps to avoiding transient experiences during hypnosis were outlined by Crawford, Hilgard, and MacDonald (1982). First the development of positive rapport should begin during the very first session between the subject and the hypnotist. The hypnotist should maintain constant vigilance towards the subject's reactions. The end of the hypnosis should be clearly defined so that the patient

is completely de-hypnotized before leaving. Also, anyone wishing to use hypnotic treatment should be trained for sensitivity towards and proper treatments for transient experiences that may occur. Crawford et al. continue by stating, obviously, if further medical or psychological treatment is warranted, a qualified practitioner should be made available to the subject.

Hypnosis has been found to alter attentional abilities on certain tasks and decrease feelings of pain. However, telling someone they have been hypnotized also seems to have similar effects. Those who are more easily hypnotized seemingly experience more profound effects from hypnosis. In a few cases hypnosis has been reported to have caused some negative after-effects. A full understanding of exactly who can be hypnotized and the exact effect hypnosis will have on participants is not known. The uncertainties surrounding the effects of hypnosis make it very important to follow proper procedures to ensure the safety and efficiency of the procedure.

EVIDENCE

Solid evidence of hypnosis may be difficult to come by and some scientists believe the quest for neurobiological evidence should be abandoned. Similar to schizophrenia, no simple brain wave, neurochemical or other single neurobiological marker is likely to define hypnosis. Hypnosis is best defined as a complex system involving alterations of brain systems that are determined by social context and the influence of the hypnotist (Gruzelier, 2000).

Frontal brain lobe activity can alter personality and character without altering intellectual functions which was made evident by the famous case of Phineas Gage. With such evidence, it is not unlikely to believe that hypnosis can alter character so that patients are guided only by immediate prospects and can be guided in the absence of anticipatory responses (Gruzelier, 2000).

Wagstaff (1998) states neurophysiological evidence would definitely offer more acceptable evidence than simply lay opinions and would also have the greatest chance of promoting a scientific understanding. EEG and other neuro-imaging technology have provided evidence linking left anterior brain inhibition with hypnosis. However, a marker common with left frontal inhibition, left frontal theta, cannot by itself define a hypnotic state (Spiegel, 1998).

Researchers have discovered electroencephalographic gamma oscillations recorded over the orbital frontal cortex of a non-hypnotized subject correlate positively with reported pain. During hypnosis the location of oscillations shifted away from the frontal region (Croft, Williams, & Gruzelier, 2000). Other research (Gruzelier, 1998) found neurophysiological links to the induction of hypnosis. As hypnotic induction is begun with fixation and focusing, left anterior selective attention processes are engaged. As induction continues into the suggestion of tiredness, selective anterior inhibition is initiated. Finally guided imagery provokes posterior involvement which includes more involvement from the right than the left hemisphere of the brain. Neurophysiological research utilizing imaging technology has found indications of specific cranial region

involvement in hypnosis, but a true cause/effect relationship has yet to be discovered. Further research conducted on the relaxation associated with hypnosis has shown relaxation in hypnosis is different from other forms of relaxation. Gruzelier (2000) provides a summarization of these differences:

1. Electrodermal orienting responses were found to differentiate hypnosis from a relaxation control without differences in tonic arousal.
2. Hypnotic relaxation exhibits a left to right hemispheric shift that normal relaxation does not.
3. A lateral shift with a haptic task during hypnosis was different from that of participants of deep relaxation in a flotation tank.
4. Alpha and theta activity also varies between hypnosis and relaxation even after de-hypnosis.

Furthermore, it was found that subjects deemed highly susceptible showed a higher sensitivity in the right hemisphere of the brain and medium susceptibles showed a bilateral improvement in sensitivity (McCormack & Gruzelier, 1993).

Although no single cause of hypnosis is currently known, and some say one does not exist, researchers have unveiled many clues to how hypnosis affects brain functioning. Hypnosis appears to correlate with fairly distinct changes in neural activity especially in the left frontal region of the brain. Susceptibility and cranial hemispheric sensitivity have also been shown to be correlated. Current research has provided evidence towards fundamental causes of a hypnotic state, but certainly future research is needed if a cause and effect relationship is to be established without confounding variables.

HYPNODONTIA

Truly anxious patients often are incapable of tolerating in-depth dental procedures without drug treatment, sedation, or general anesthesia. These treatments are costly, time-consuming and invasive. One proposed alternative is medical hypnosis which can be used as a relaxant or sedative for essentially minimal monetary cost.

Dental procedures may create a mental state of anxiety in some. Psychosomatic dental fear may lead to several detrimental physical manifestations such as treatment avoidance and neurophysiological reactions before, during, and after dental procedures (Eitner; Schultze-Mosgan, Heckman, Wichmenn, & Hotst, 2006). Psychosomatic reactions can be triggered by things like sounds, smells, feeling of impending pain, and feelings of subjectivity (ter Horst & de Wit, 1993). A common method of measuring dental anxiety is Corah's Dental Anxiety Scale (DAS). The DAS is a four question scale that asks patients to rate feelings on a range from 1 (no anxiety) to 5 (extreme anxiety). A score from 4-12 indicates little anxiety. A score equal to or greater than 15 means high anxiety and possible phobia (Eitner et al., 2006).

Eitner et al. (2006) released a case report of a 54-year-old patient in need of molar implants on both her left and right mandibles. Her score on the DAS was 13. The patient showed no symptoms of obvious fear of physicians, psychological disorders, or general fears. She reported only fearing dental procedures. The thought alone induced sweating,

an elevated heart rate, an elevated respiratory rate, and nausea. She received hypnotic treatment prior to the procedure on the left mandible but not on the right. The vital parameters of heart rate and blood pressure were monitored during both procedures. During the non-hypnosis procedure the heart rate and blood pressure elevated above the levels that were observed during the hypnosis treatment side. According to Eitner, the patient showed similar vital and stress parameters under hypnosis as someone who had received drug sedation via Midazolam. In addition, the patient post-operatively reported a 'loss of sense of time', considered the procedure a positive experience, and stated optimism for future procedures.

Similarly, a 31 year old female with throbbing pain in her left third molar which kept her from sleeping the previous two nights visited a dentist. The following is from Gow's (2006a) case report. She reported extreme anxiety towards dental procedures. 'Jan' showed increased respiration and perspiration at the mention of a tooth extraction. Immediately she stated she felt it would be impossible for her to tolerate such a procedure. Jan reported anxiety and low tolerance for pain. Also, she feared the anesthetic would not work, and the dentist would continue even though the tooth was not numb. She scored high on the DAS (16) and had a history of avoiding dental appointments. Jan was scheduled for a series of sessions in which rapport would be established and the processes of hypnosis explained to her.

However, one week prior to her third scheduled session Jan experienced tremendous pain. She revisited Gow, and he determined an immediate surgical extraction was warranted. Jan was induced into a hypnotic state via eye fixation and reverse counting. The upper third molar was removed with a pair of forceps. Before ending the hypnotic state, Jan was reinforced that she had overcome irrational fears of dental treatment and she would now experience less anxiety at the dentist. Jan was brought out of hypnosis via reverse counting. Her post-operative DAS score had lowered to a 7. She stated, "Hypnosis definitely helped. I can now use these techniques with my new dentist."

Gow (2006b) also recounts the case of a 55 year old female with dental phobia in need of periodontal treatment and an extraction. 'Jo' presented an interesting case as she was blind from birth. Jo self reported extreme anxiety. Her DAS score was 20 which also indicated dental phobia. When asked about previous dental experience she reported her pain as 9 out of 10 with 10 being the most pain imaginable. Furthermore, when asked to rate the pain she anticipated on further treatment, she reported an 8/10.

Gow reported that a diagnosis of dental phobia was applicable to Jo considering her extremely high DAS score and her tendency to avoid dental appointments. Jo also stated she felt she had a low pain tolerance threshold. Both her son and daughter also feared dental treatment. Interestingly, Shaw (1975) discovered parents who had children suffering from dental anxiety were more likely to be more anxious themselves. Similarly to Jan, Jo reported that her biggest fear was the belief the dentist would perform a Gow assured her the tissues would indeed be numb. He also offered hypnosis as a complementary pain management procedure. Jan then told Gow she had no previous experience with hypnosis but felt it may help her control her fear.

A series of rapport building sessions followed in which Jo's fears and misconceptions of hypnosis were discussed. During the third rapport building session, Jo was induced

into hypnosis by vivid description of all five senses. Jo was told to find a very special place and go there. Her hypnosis was deepened by encouragement to use her four intact senses of hearing, touch, smell and taste. Jo imagined her special place to be a garden and she reported hearing birds, feeling the wind, smelling flowers, and petting her dog. Jo was given a post-hypnotic suggestion that when she returned for the procedure she would become more relaxed and more quickly. Jo's hypnosis was ended by a reverse counting from seven to one. After termination of hypnosis, Jo stated her experience was difficult to describe. She went on to say she was able to imagine every suggestion but did not feel like she was actually experiencing them. Jo's experience demonstrates an ability to mentally distance oneself from an immediate physical environment.

One week later Jo's dental procedure was carried out while she was under hypnosis. To induce the hypnosis, Gow instructed Jo to close her eyes and picture herself back in the garden at the count of seven. Jo was treated for periodontal disease and the hypnosis was terminated once again via reverse counting from seven to one. Jo returned twice more for teeth cleaning and scaling, and she asked to again be hypnotized both times. A few months later Jo needed a tooth extraction which was also conducted under hypnosis. After the extraction Jo again took the DAS and her score was a 10. When asked about fear for pain in future procedures, she now rated it as a 3/10.

Hypnosis has been practiced in professions beyond general dentistry. Another field in which hypnosis has been notably used and researched is maxillofacial surgery. A three year study was conducted in Germany at the University Hospital Schleswig-Holstein in Luebeck, Germany. Hermes, Hakim, and Sieg (2006) examined patients who showed interest in a combined method of treatment that included local anesthetic paired with hypnosis. These patients received an in-depth explanation of both the procedure they would receive and hypnosis. Every patient received a standardized hypnosis CD and was instructed to listen to the CD two times before the day of their operation. On the day of the operation, hypnosis was inducted via headphones from a portable Sony CD player. Surgery in complete absence from pharmacological anesthetics was not deemed appropriate or ethical, so all patients received a local anesthetic.

Fifty patients scheduled for elective oral surgery were used for a prospective study. Twenty-five patients received only local anesthesia. The other twenty-five received both anesthesia and tape recorded hypnosis. Both groups showed increased preoperative anxiety, but those who received hypnosis returned to baseline anxiety levels intra-operatively. The non-hypnotized group remained at the heightened anxiety state. The results from the prospective study warranted further research.

During the three years of the study, 340 procedures on 295 patients were completed using tape-recorded hypnosis. Procedures included oral surgery (n=371), septic surgery (n=12), plastic and reconstructive surgery (n=39), oncological surgery (n=22) and traumatological surgery (n=20). The patients reported feelings of relaxation, anxiolysis and mental distance from the procedure during post-operative interviews. 78 percent of the participants felt hypnosis was an enrichment of medical therapy. 86.5 percent felt further research on the medical use of hypnosis is warranted. The researchers reported sedation, anxiolysis, inhibited motor skills, and increased tolerance for procedures as positive intra-operative effects of hypnosis. The surgeons reported hypnosis allowed

patients with a history of severe anxiety to be operated on with only local anesthesia instead of general anesthesia. Eight patients reported no benefit from the combined treatment and four more patients with high anxiety reported no relief of anxiety. In conclusion the German researchers propose that hypnosis could never serve as a full-on substitute for pharmacological sedation or general anesthesia, but it may be a very effective conjunctive treatment for anxiety and sedation (Hermes et al., 2006).

DISCUSSION

Elements of hypnosis have been practiced since ancient times and are still practiced today. One of the major contributor's to hypnosis whose name is commonly associated with hypnosis, is Franz Mesmer. There are also lesser known contributors such as James Esdaile. Historically hypnosis has survived mixed investigations and public opinions. It has evolved from a supernatural ritual into a more scientifically influenced procedure. Early hypnotists challenged each others' ideas which, in turn, furthered the understanding of what was actually necessary to create a hypnotic state. The public's perception of hypnosis changed along with the theories and was often met with criticism and skepticism. Many hypnotists were discredited and/or barred from practice based on misconceptions. Public and scientific opinions have traditionally had an impact on hypnosis practice and research.

Hypnosis has been used and tested for several ailments. Historical methods often utilized complex and involved equipment and procedures. Today simpler, less involved methods have been developed. Furthermore, EEG evidence has shown that specific brain regions may be involved in hypnosis, and certain sequences of activation and inhibition of cranial lobes may be related to suggestibility. Hypnotism has also been shown to increase one's ability to focus attention. Experiments have been conducted comparing hypnosis to normal relaxation and somewhat distinct differences have been found. Researchers have also found that some patients are more easily hypnotized than others, and the more susceptible patients may experience stronger effects.

Hypnosis has been specifically used in dentistry and other medical fields to effectively manage anxiety and fear. Patients who would otherwise be incapable of tolerating medical and dental visit have undergone dental and maxillofacial procedures. Patients report lower scores on Corah's Dental Anxiety Scale after undergoing a procedure while under hypnosis and report decreased anxiety for future appointments. Side effects from hypnosis are very rare and in the majority of the cases were easily reversed. Negative effects have been significantly controlled by making sure proper safeguards are in place.

Hypnosis is monetarily inexpensive and has very low risk of side effects. It has been found effective in anxiety reduction and relaxation. Hypnosis may very well be an inexpensive and relatively safe alternative to general anesthesia for patients experiencing phobia or extreme anxiety. Alternative treatments for anxiety such as hypnosis may allow people who would otherwise be unable to tolerate procedures to receive dental and/or medical care. Hypnosis, whether it can be scientifically explained or not, has been shown

to manage anxiety and has allowed patients to handle stressful situations. In some patients it has decreased pain perception and created a feeling of mental distance from the procedures.

Research on hypnosis has shown it to be a feasible alternative treatment to willing patients. Currently, no single mechanism or method of hypnosis has been proven effective beyond a reasonable doubt of confounds, but to be fair, the same might be said about some medications currently prescribed. It is the opinion of this author that hypnosis may in fact be warranted in some cases, if, and only if, the patient is willing to try it as a conjunctive therapy.

Evidence has not shown hypnosis capable of being used in solitude for general anesthesia, only as a supplement to local anesthesia or as a sedative. If being hypnotized or being told he or she were hypnotized increases a person's ability to tolerate procedures, it may be against the Hippocratic Oath not to allow them such a treatment. Hypnosis cannot be proven to exist without doubt, nor can it be disproven beyond reasonable doubt. Can hypnosis be used effectively as a treatment method for dental anxiety? Probably, especially in those patients willing to try an alternative procedure and especially in conjunction with local anesthetic. Should hypnosis be a mandated practice? No. One should be familiar with hypnotic inductions and dangers before considering implementation of hypnosis into a treatment plan. Use of hypnosis should be determined strictly at the patient/physician level and be based on both parties' comfort and the practitioner's knowledge of the procedure. Future research may someday prove or disprove the effects of hypnosis, but as it is known today, hypnosis has the potential, in certain cases, to decrease anxiety, fear, and cost associated with medical and dental procedures.

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Particle Motion On A Plane Slope Under Spilling Breaking Waves

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Faculty Sponsor: Dr. Francis Ting
Department: Civil and Environmental Engineering

ABSTRACT

The experiments discussed in this paper involve the motion of discrete solid particles on a plane slope under spilling breaking wave conditions. Particle Image Velocimetry was used to capture images of seeder particles in water so the motion of the fluid particles and solid particles could be traced. The images produced from the experiments have two phases. Since the behavior of the water and the sediment particles must be studied individually, the two phases of the image must be separated. A series of functions in MATLAB allows the two-phase image to be separated into two images—one containing only the sediment particles and one with the background seeder particles which represent the fluid phase. The ultimate goal of this study was to determine how the sediment particles behave under spilling breaker wave conditions. MATLAB was used to fit a fourth order polynomial to seven data points from which the sediment particle velocities and accelerations could be found. Three situations of interest were investigated: (1) no large-scale turbulence in the field of view, (2) a turbulence burst landing shoreward of a sediment particle, and (3) a turbulence burst occurring seaward of a sediment particle. It was found that regardless of which of the above three situations occurred, the net transport of the sediment particles over one wave cycle was offshore for the spilling breaker case. The intensity and location of the downbursts determined only the magnitude of the net offshore transport.

INTRODUCTION

Organized flow structures occurring intermittently in space and time characterize the turbulent flow field under breaking waves. These structures are imperative to sediment suspension in the surf zone (Ting, 2006). The behavior of sediment particle motion in fluid under various breaking wave conditions is a complex problem. In order to study a complex problem, it is essential to start with a simple situation before looking at all of the variables together. The experiments discussed in this paper involve the study of discrete particle motion on a plane slope under spilling breaking wave conditions. Preliminary conclusions have been drawn as a result of these experiments.

Particle Image Velocimetry, or PIV, is a technique used to study fluid motion by capturing images of seeder particles in fluid. In such studies, seeders are stirred into the water to allow the fluid motion to be traced, and glass spheres are placed to represent

sediment particles. Because of this, the images that are produced have two phases. The motion of the water and of the sediment particles must be studied individually so the two phase images must be separated. MATLAB software was used to accomplish this.

Methods

The experiments were conducted in a wave flume tilted to a slope of three percent. The two-phase PIV measurements were taken in a plane parallel to the bottom of the flume at a height of approximately one millimeter above the bottom. The measurements captured the fluid and particle motion just shoreward of the wave breaking point. The field of view of the measurements was approximately 400 millimeters in the longitudinal direction and 200 millimeters in the transverse direction. Figure 1 illustrates the experimental setup.

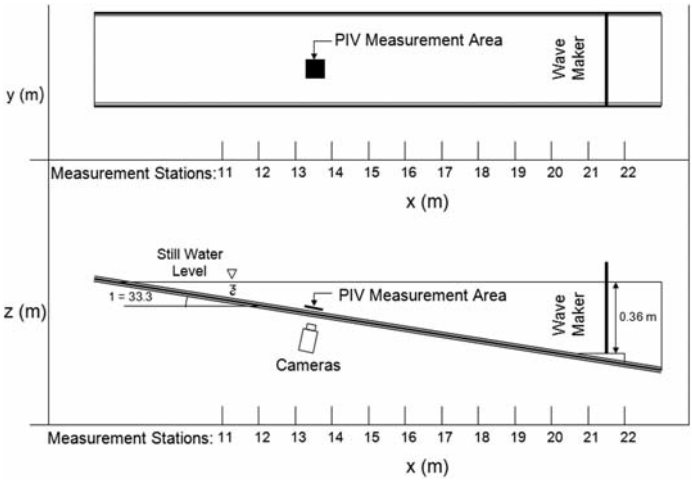

Figure 1. Experimental Setup

The spilling breaker has a wave period of two seconds in the experiments. The measured wave height and still water depth at the center of the measurement area were 0.08 and 0.146 meters, respectively. A total of 30 test runs were completed in which 200 straddled frames were captured with a sampling rate of 15 frames per second. Precision glass spheres with a specific gravity of 2.5 and diameters of 1.0 and 1.58 millimeters were used to represent sediment particles.

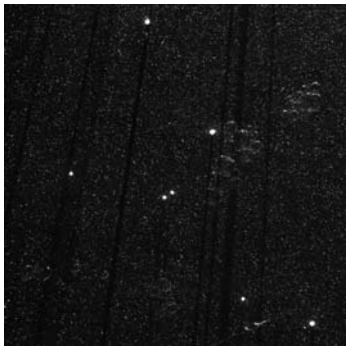

Figure 2. Original image

Figure 2 shows an original image captured by the cameras in the PIV measurements. The image shows the 1.58 and 1.0 millimeter particles, the seeder particles, and entrained air bubbles. A series of functions in MATLAB allows the two-phase image to be separated into two images—one containing only the sediment particles and one with the background seeder particles. The images are made up of pixels with gray levels ranging from 0 to 255 in MATLAB. Pixels values of 0 are shown as black and values of 255 are shown as white.

The first step in this process is to morphologically open the image with a disk structuring element of radius three pixels. Morphological opening of an image by a structuring element is erosion of the image by the structuring element followed by dilation of the result by the structuring element (Gonzalez et al., 2004). Dilation adds pixels to the boundaries of objects in an image and erosion deletes pixels on the boundaries of objects. The result of this operation blends the seeder particles into the background allowing the sediment particles to stand out.

The next step was to separate the sediment particles from the background. The goal in this process was to keep the shape of the particles as round as possible while retaining their sizes. All pixels that had gray levels less than 80 were set to 0 and all others were set to 255. Next the particles edges were smoothed with a filtering function to make the particles nearly round. The particles were then eroded back to their original sizes. The background image without the sediment particles is shown in Figure 3. The image with only the sediment particles is shown in Figure 4.

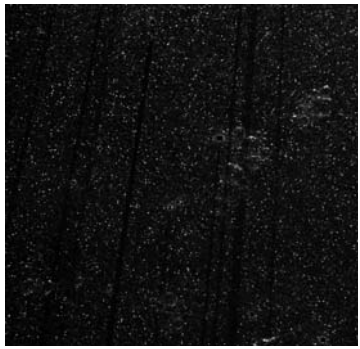

Figure 3. Background

Figure 4. Sediment Particles

After separating the sediment particles, the coordinates of the centroid of each particle were exported into Excel. The coordinates were then converted from pixels to millimeters. The particles' information from each frame was then manually copied into a separate table for further analysis.

The ultimate goal of this study was to determine how the sediment particles move under breaking wave conditions. The particles' velocities and accelerations are two important parameters in studying their behaviors. The velocities and accelerations were found through basic calculus of taking the derivatives and second derivatives of the positions with respect to time. Because the plots of the particles' positions versus times were so irregular, only seven positions were analyzed at one time.

An algorithm in MATLAB was developed to fit a fourth order polynomial to seven adjacent data points. The center data point was the position of interest, and a for loop was used to advance to subsequent points. The polynomial, its derivative, and its second derivative were evaluated at the position of interest to give the instantaneous velocity and acceleration at that point.

RESULTS

The effect of different turbulence conditions on the motion of sediment particles have been observed in this experiment. The offshore, onshore, and net movement of the sediment particle changes with respect to the location of turbulence bursts. Three situations of interest were investigated: (1) no large-scale turbulence in the field of view, (2) a turbulence burst landing shoreward of a sediment particle, and (3) a turbulence burst occurring seaward of a sediment particle.

The position with respect to time of a 1.0 millimeter particle when there is no large-scale turbulence in the field of view is shown in Figure 5. The graph shows that the sediment particle moves about 120 millimeters offshore and 80 millimeters onshore. This creates a net offshore transport of about 40 millimeters over one wave cycle.

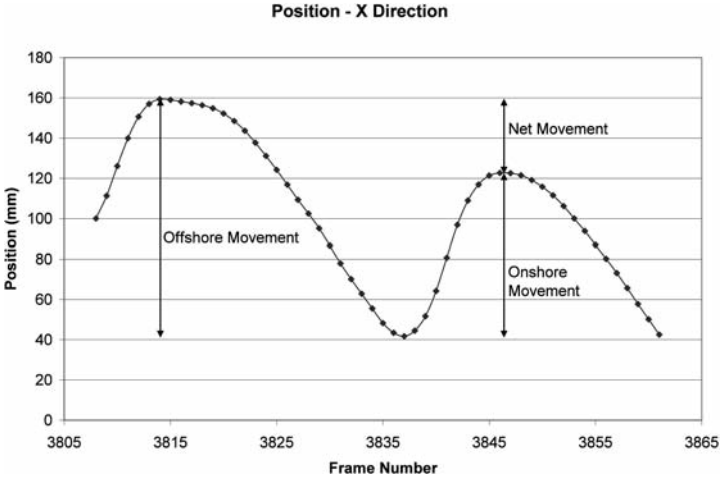

Figure 5. Weak Turbulence

A situation where a downburst of turbulence impinges on the bed in front of the 1.0 millimeter sediment particle is shown in Figure 6. In this case, the sediment particle still moves about 120 millimeters offshore but only 32 millimeters onshore. The onshore movement is significantly smaller than the previous case creating a net offshore transport of about 85 millimeters over one wave cycle.

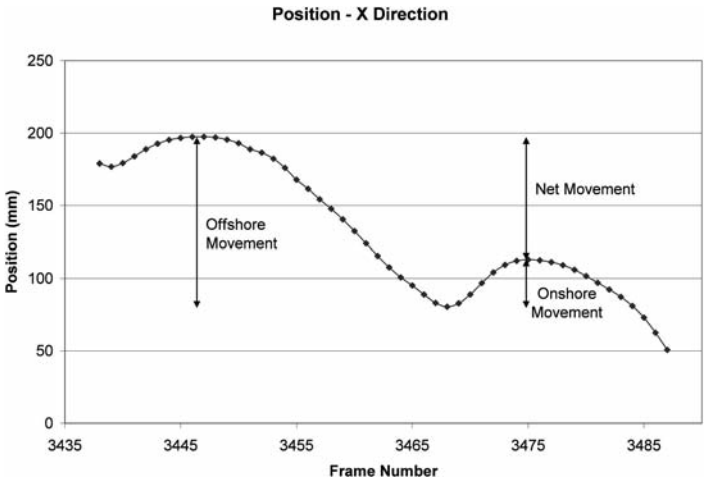

Figure 6. Turbulence Burst Onshore

The opposite situation is shown in Figure 7. The graph shows the situation where a downburst of turbulence impinges on the bed behind the 1.0 millimeter sediment particle. In this case, the offshore movement of the sediment is about 90 millimeters which is much less than the previous cases. The onshore movement is about 70 millimeters leading to a reduction in the net offshore transport of only about 20 millimeters.

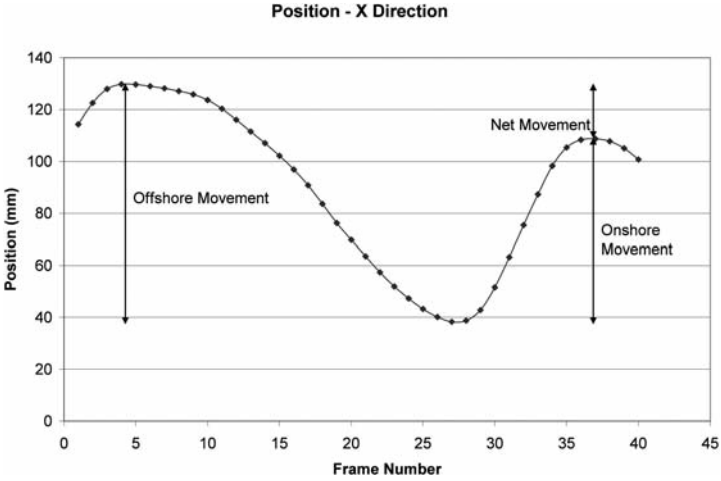

Figure 7. Turbulence Burst Offshore

CONCLUSIONS

The techniques discussed in this report would allow one to analyze the motion of particles under breaking wave conditions. Important parameters to study include the displacement of different sized particles as the wave passes, evidence of particles trapped in a vortex, outward displacement of particles from a center which may indicate a downburst of turbulence, and any indications of particle suspensions.

The three different scenarios described in the results section show how turbulence downbursts in the wave can affect the movement of the sediment particle. However, regardless of which of the three situations occurs, the net transport of the sediment particles over one wave cycle is offshore for the spilling breaker case. The intensity and location of the downbursts affect only the magnitude of the net offshore transport.

ACKNOWLEDGEMENTS

This study was funded by National Science Foundation (NSF) Grant OCE-0525676 and the Research Experience for Undergraduate (REU) program. I am grateful for the

support from NSF. I would also like to acknowledge Dr. Francis Ting for this research opportunity from which I have gained many valuable experiences.

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Analysis of Wind Turbine Transverse Vibration

Authors: Matt Hein, Whitney Karpen
Faculty Sponsor: Shawn Duan
Department: Mechanical Engineering

ABSTRACT

Large wind turbines have become an appealing choice for renewable electrical energy production throughout the world. The United States Midwest contains massive potential for wind energy development and is therefore being primed for large wind turbines to harvest this resource and bring it to market. Because of this, safety concerns have arisen in regard to their ability to withstand the harsh climate of the region. Analysis of the transverse vibration caused by severe weather will be preformed. A simplified model will allow for an analytical solution and displacement graphs produced with MATLAB code. This information will allow for an unbiased conclusion about large wind turbine safety.

INTRODUCTION

Wind power is the process through which wind is used to generate electricity. A wind turbine as shown in Figure 1 plays a key role for this kind of energy conversion. The wind pushes against the surface of the slanted blades that move as the air molecules slide against it. The kinetic energy of the wind is converted into mechanical power, and subsequently electricity. Though a wind turbine is an effective device for wind energy conversion, vibration as a critical issue is born with it.

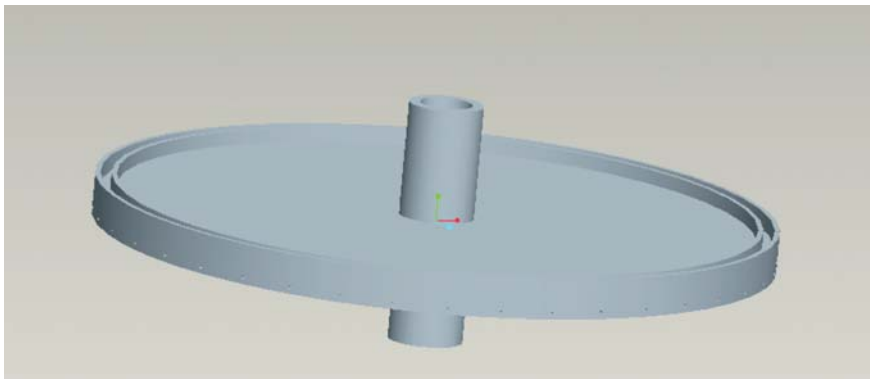


Figure 1. A wind turbine on prairie

In this paper, the wind turbine will be approximated as a cantilever beam that is fixed at the ground. The nacelle and blades will be combined and approximated as one mass. The supporting beam will be modeled as a spring. The model will be undamped with one degree of freedom, accounting for translational motion. The model of the system (wind turbine) can be simplified because it is a large machine and small variables will have little effect on the vibrational analysis as a whole as shown in Figure 2. The flow induced vibration of the wind turbine tower will be neglected from this analysis because it is a marginally small effect compared to the translational wind force transferred from the blades to the towers maximum height.

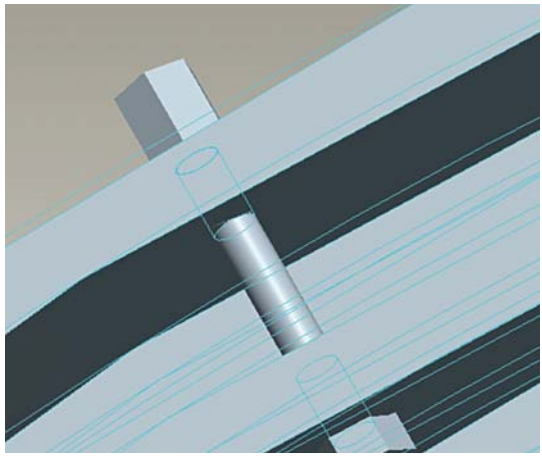


Figure 2. Simplification of the wind turbine to a one-degree of freedom system [1]

Equations of Motion will be developed for the model to determine if the structure can withstand severe weather of the northern United States. According to the National Weather Service website record storms in South Dakota have had wind speeds as high as 40 to 50mph. If these wind speeds were present the turbine would break its rotor at a wind speed of 25 mph a pitch its blades to reduce drag and lift. For our scenario we will consider the possibility of the pitch motors failing so that a maximum cross-sectional area is directly exposed to the highest wind speed of 50 mph.

The data being used is for a GE 1.5MW wind turbine which is one of the most widely used models in the United States.

METHODS

Total Translational Force Determination

A blade of GE 1.5 MW wind turbine is represented in Figure 3. The total translational force acting on the blade can be expressed by the following equations:

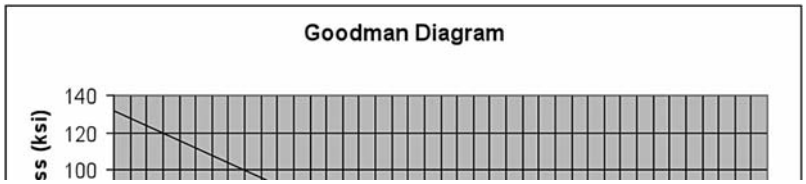


Figure 3. Picture of largest acting forces on blade due to wind.

wind speed: $v = 50mph = 22.35m/s$ (1)
blade weight: $W = 7tons = 6.35kN$ (2)
blade length: $l = 37.8m$ (3)
drag coefficient: $C_D = .015$ (4)
lift coefficient: $C_L = 1.3$ (5)
Note: *drag and lift coefficients from the reference [2]*
average air density: $\rho = 1.024kg/m^3$ (6)
average blade diameter: $D = 1.8m$ (7)

The area of the blade tangential to the wind is approximated by taking the product of the blade diameter and length.

blade area: $A = D * l = 1.8m * 37.8m = 68.0m^2$ (8)

drag force: $F_D = C_D \rho A \frac{v^2}{2} = .015(1.024\frac{kg}{m^3})(68.0m^2)\frac{(22.35m/s)^2}{2} = 260.9N$ (9)

lift force: $F_L = C_L \rho A \frac{v^2}{2} = 1.3(1.024\frac{kg}{m^3})(68.0m^2)\frac{(22.35m/s)^2}{2} = 22.6kN$ (10)

total translational force:

$$F_T = \sqrt{(F_L)^2 + (F_D)^2} = \sqrt{(22600N)^2 + (260.9N)^2} = 22.602kN \quad (11)$$

Equivalent Tower Stiffness Determination

Tower height to hub: $l = 64.7m$
Tower material: assuming tower is constructed of Structural A36 Steel Alloy and the Modulus of Elasticity
Outside diameter, thickness of tower: 4.5m outside diameter with a 15mm thickness

$$k = \frac{3EI}{l^3} = \frac{3E \cdot [\pi/64(d_o^4 - d_i^4)]}{l^3} = \frac{3 \cdot 200GPa \cdot [\pi/64(4.5^4 - 4.47^4)]}{64.7^3} = 7.849 \times 10^5 Ns/m \quad (12)$$

Equivalent Mass Determination

mass of individual blade: $m_{blade} = 647.3kg$ [3] (13)
mass of nacelle and internal components: $m_{nacelle} = 91{,}060\,kg$ (14)
$m_{eq} = 3m_{blade} + m_{nacelle} = 3(647.3) + 91060 = 96{,}886\,kg$ (15)

Vibrational Equation of Motion of 1-DOF Simplified Model

System equilibrium is selected as the reference for modeling.

$$m_{eq}\ddot{x} + kx = F_T \cos(\omega t) \qquad (16)$$

where: m_{eq}= total equivalent mass of blades, rotor, and nacelle.
k= stiffness of the simplified tower.
F_T= total translational force caused by wind.
ω= frequency of harmonic wind force.

Further we use the following assumed relationship:

$$\omega = 2m_{eq}\omega_n \qquad (17)$$

where

$$\omega_n = \sqrt{\frac{k}{m_{eq}}} = \sqrt{\frac{7.844\times10^5}{96886}} = 2.85 rad \qquad (18)$$

and

$$\omega = 2\cdot 96886\cdot 2.85 = 552250 rad/s \qquad (19)$$

The total solution of the system is the sum of the transient and steady-state solutions.

$$x(t) = x_h(t) + x_p(t) \qquad (20)$$

where

$$x_h(t) = C_1\cos(\omega_n t) + C_2\sin(\omega_n t) \qquad (21)$$

and

$$x_p(t) = \mathrm{X}\cos(\omega t) \qquad (22)$$

In equation (22), the magnitude X can be expressed as follows:

$$\mathrm{X} = \frac{F_T}{k - m_{eq}\omega^2} \qquad (23)$$

If the initial conditions are represented by $x_0(mm)$ and $\dot{x}_0(m/s)$, then we have

$$C_1 = x_0 - \frac{F_T}{k - m_{eq}\omega^2} \qquad (24)$$

and

$$C_2 = \frac{\dot{x}_0}{\omega_n} \qquad (25)$$

Substituting (24) and (25) into (23), we have

$$x(t) = (x_0 - \frac{F_T}{k - m_{eq}\omega^2})\cos(\omega_n t) + (\frac{\dot{x}_0}{\omega_n})\sin(\omega_n t) + (\frac{F_T}{k - m_{eq}\omega^2})\cos(\omega t) \qquad (26)$$

Entering the necessary information with assuming zero initial conditions, we have:

$$x(t) = (0 - \frac{22600}{7.844\times10^5 - 96886\cdot(552250)^2})\cos(2.85\cdot t) + (\frac{0}{2.85})\sin(2.85\cdot t) + (\frac{22600}{7.844\times10^5 - 96886\cdot(552250)^2})\cos(552250\cdot t) \qquad (27)$$

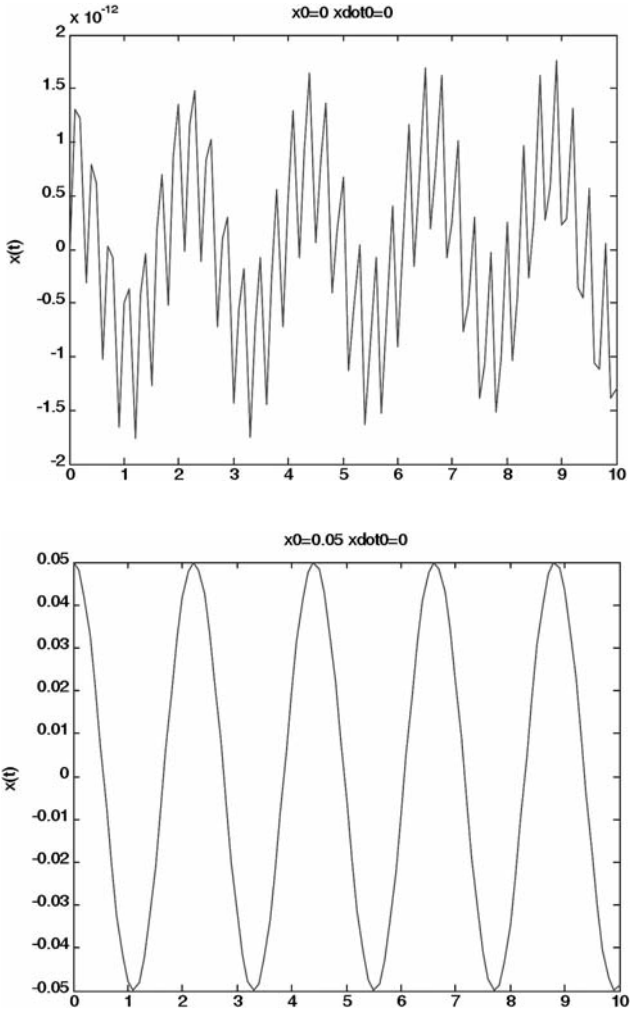
Simplifying equation (27), we have the following equation:

$$x(t) = 7.648\times10^{-13}\cos(2.58\cdot t) - 7.648\times10^{-13}\cos(552250\cdot t) \quad (28)$$

The resulting equation of motion is graphed in figure 4 using MATLAB

RESULTS

Figure 4 shows the vibration responses of equation (26) with four different initial conditions for and in time domain. The associated Matlab codes are given in the appendix.



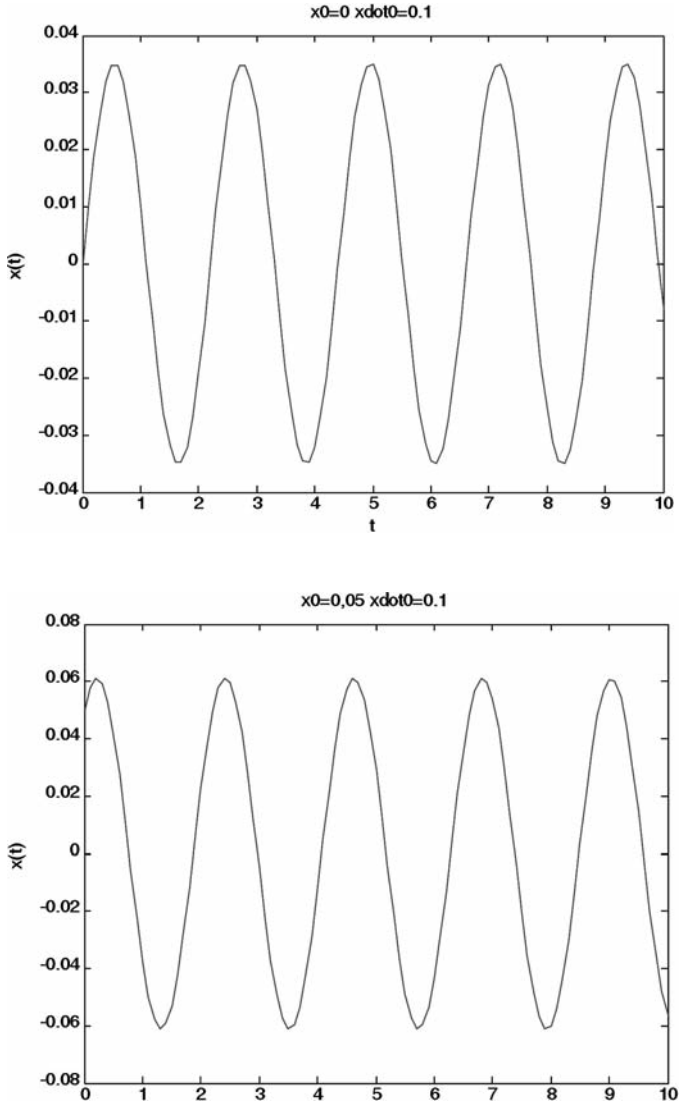


Figure 4. MATLAB graphical output of vibration responses.

DISCUSSION

The solution for this vibrational system gives some preliminary data in the design of large wind turbine towers. With the wind being modeled as strong (50 mph) and gusting the movement was limited to less than 8x10-13 meters. For a system this large that amount of movement would be nearly impossible to detect. It may be possible for the induced movement to increase if the wind is “optimized” so that the frequency nearly matches the natural frequency of the wind turbine but the purpose of this discussion does not include that analysis.

LIMITATIONS

The simplified model of the wind turbine and weather conditions account for the greatest forces in the system but do not accurately represent the directional and intensity changes for wind of severe weather. Thickness of the tower wall is a critical dimension but can only be approximated because of the competitive advantage this value represents in reducing production costs.

ACKNOWLEDGEMENTS

Thank members of wind energy industry for providing information on physical characteristics of wind turbine. Thank Dr. Duan for guidance in analysis of the system and the production of this article. Thank Mechanical Engineering Department for providing the educational curriculum that makes this research possible

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[3] GE spec sheet

APPENDIX

```
% Matlab Codes for Wind Turbine Tower Vibration
p=1.204;        %average air density (kg/m^3)
v=22.35;              %Wind Speed (m/s)
dblade=1.8;                 %average blade diameter
lblade=37.8;                        %length (m)
ablade=lblade*dblade;         %blade area
cdrag=0.015;                        %drag coefficient
```

```
clift=1.3;                    %lift coefficient

%Force Calculations
fdrag=cdrag*p*ablade*v^2/2;          %drag force (N)
flift=clift*p*ablade*v^2/2;          %lift force (N)
F0=((flift)^2+(fdrag)^2)^.5;         %total force (N)

wn = 2.85;          %rad/s
m = 96886;          %kg
w = 552250;         %rad/s

xa0 = 0;
xa0_dot = 0;
xb0 = .05;
xb0_dot = 0;
xc0 = 0;
xc0_dot = 0.1;
xd0 = .05;
xd0_dot = 0.1;

f_0 = F0/m;
for i = 1: 101
 t(i) = 10 * (i-1)/100;
 x1(i) = xa0_dot*sin(wn*t(i))/wn + (xa0 - f_0/(wn^2-w^2))*cos(wn*t(i))...
 + f_0/(wn^2-w^2)*cos(w*t(i));
 x2(i) = xb0_dot*sin(wn*t(i))/wn + (xb0 - f_0/(wn^2-w^2))*cos(wn*t(i))...
 + f_0/(wn^2-w^2)*cos(w*t(i));
 x3(i) = xc0_dot*sin(wn*t(i))/wn + (xc0 - f_0/(wn^2-w^2))*cos(wn*t(i))...
 + f_0/(wn^2-w^2)*cos(w*t(i));
 x4(i) = xd0_dot*sin(wn*t(i))/wn + (xd0 - f_0/(wn^2-w^2))*cos(wn*t(i))...
 + f_0/(wn^2-w^2)*cos(w*t(i));

xend

figure
plot(t,x1);
ylabel('x(t)');
title('x0=0 xdot0=0');

figure
plot(t,x2);
ylabel('x(t)');
title('x0=0.05 xdot0=0');
```

```
figure
plot(t,x3);
xlabel('t');
ylabel('x(t)');
title('x0=0 xdot0=0.1');

figure
plot(t,x4);
ylabel('x(t)');
title('x0=0,05 xdot0=0.1');
```

Effects of Deuterium on *Chlamydomonas reinhardtii*

Authors: Brett Kollars, Ryan Geraets
Faculty sponsor: Dr. Marie-Laure Sauer, Dr. Fedora Sutton
Department: Plant Science

ABSTRACT

In order to develop software tools to monitor rates of total protein turnover in plants, attempts were made to maximally label all the proteins in vivo. Our study focused on the use of the stable isotope of hydrogen, deuterium, to label proteins of *C. reinhardtii*. The goal of this study was to determine the effect of the label on algal growth. *C. reinhardtii* is a unicellular green algae that is heterotrophic, photoautotrophic and mixotrophic. The results showed that increasing concentrations of deuterium in the algal growth medium had a negative effect on the growth of the algae. These preliminary results indicated that other stable isotopes such as Nitrogen-15 and Carbon-13 should be assayed to see if, contrary to deuterium, they allow normal growth of the algae.

INTRODUCTION

The initial goal of this research is to develop protocols to achieve 100% labeling of total cell proteins so that the turnover rates of the total proteome can be determined. Full labeling of the plant proteome would facilitate the development of software that would make it possible to follow the changing proteome profile in response to environmental stresses. We have chosen to focus on proteins since they have critical roles in many processes including maintaining cell structure as well as serving as components in conveying signals to the nucleus and cytoplasm.

There are various techniques available for monitoring protein turnover including the use of stable isotopes (Pratt et al., 2002; Fedjaev et al., 2007). For this study we chose to use deuterium which is an isotope of hydrogen with a greater atomic mass due to one more neutron in the nucleus. This difference in neutrons allows deuterium-labelled peptides to be separated from unlabeled peptides by mass spectrometry (Burke and Mackay, 2008). Although deuterium is a simple isotope to use as it has no radioactive properties, Unno et al., (2003) reported that deuterium has a negative effect on yeast cell's growth. They reported that yeast cell lines grown in a deuterium medium had an increased expression of Hsp70 indicating higher stress levels than yeast cells grown in media prepared with water. Hsp70 is a chaperone protein that facilitates the maintenance and the folding of other proteins. For example, during heat stress, Hsp70 protects the cell by restoring the complex dynamitin/p50, which in turn prevents errors of replication during mitosis (Hut et al., 2005).

For this study we decided to look at the effects of deuterium on *Chlamydomonas reinhardtii* (Goodenough, 1992). If *C. reinhardtii* can grow in 100% deuterium without showing signs of stress then it would be easy to label and monitor protein turnover. *C. reinhardtii* is a motile, unicellular green algal cell with two flagella. It is a very useful organism in that it is photoautotrophic, heterotrophic, and mixotrophic; thus able to grow in different media and under different conditions. These characteristics of this model organism along with the fact that its genome was sequenced make *C. reinhardtii* ideal for our study. Growth of algae in medium prepared with heavy water resulted in reduced growth rate: the higher the deuterium concentration in the media, the less the algae grew. Thus we propose that deuterium is not a good label for our system as we are looking for a label that does not affect the organism.

MATERIALS AND METHODS

The strain of *C. reinhardtii* used in this study was CC-1266. The algae were grown in TAP medium (Tris Acetate Phosphate) (Harris, 1989) containing different concentrations of deuterium including 30%, 60%, and 90%. The deuterium was added by simply replacing the water used in the medium with the specific amount of deuterium. Algae were also grown in regular TAP medium in which none of the water was replaced for a control.

Different tubes containing 6 mL or 50 mL of media were shaken continuously under fluorescent light with a 16/8 hour photoperiod (Figure 1).

To measure algal growth absorbency readings were made once a day during lag phase and twice a day during the log phase. These readings were made using a spectrophotometer at a wavelength of 600 nm. To start the cultures, 1 mL of *C. reinhardtii* CC-1266 was added to 5 mL of medium, or in the case of the 50 mL cultures, 5 mL was added to 45 mL of medium.

RESULTS AND DICUSSIONS

As the concentration of deuterium was increased in the growth medium, the growth of the algae declined. This difference in growth is illustrated in Figure 2.

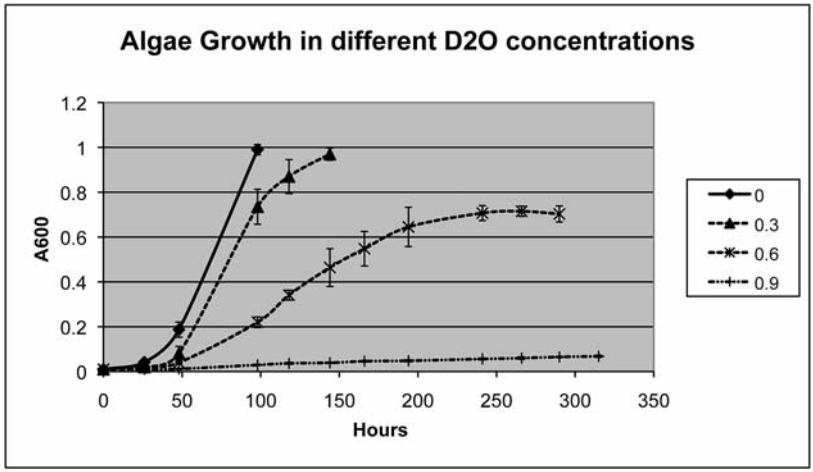

Figure 2. Effect of increasing deuterium concentrations on algal growth. Four different concentrations of deuterium were tested: 0%, 30%, 60%, and 90%. Growth readings were made using a spectrophotometer at 600 nm. Readings were taken once a day during lag phase and twice daily during log phase.

The effect of deuterium on algae can be caused by different factors. For example deuterium has been reported to have a negative effect on mitotic spindles as shown by studies on sea-urchin eggs and grasshopper spermatocytes (Lamprecht et al. 1991). They believed that deuterium blocks mitosis by either increasing or paralyzing the assembly of microtubules which delays the process. Also, Deuterium's heavy nature forces conformational changes in the structure of membrane proteins required for energy production (Vasilescu and Katona, 1986). This results in an imbalance of ADP/ATP and improper ATP production causing the destruction of ATP in the cell. The demand for more energy along with the suppressed ATP production makes for a weakened ATP reservoir and a tiring organism.

Significant morphological differences were also observed between cells grown in TAP and cells grown in TAP-deuterium as show in Figure 3.

Normal *C. reinhardtii* cells have a single big green chloroplast, two flagella, present a motile behavior and do not cluster. Algal cells grown in deuterium showed significant changes in cell characteristics. Those cells appeared less green, they would grow in clumps and didn't have flagellas (Figure 4). The cells that appeared clear had lost their chloroplast and were dead.

Figure 1. Algae cultures grown on a shaking table under fluorescent light. Cells were kept constantly shaking and on a 16/8 photoperiod. Different volumes of cells including 6 mL cultures and 50 mL cultures were grown.

Figure 3. Growth of CC-1266 in TAP media (left) and in TAP medium with 60% deuterium (right). We observed a clear change in color and the algae in deuterium appeared to form irregular clusters.

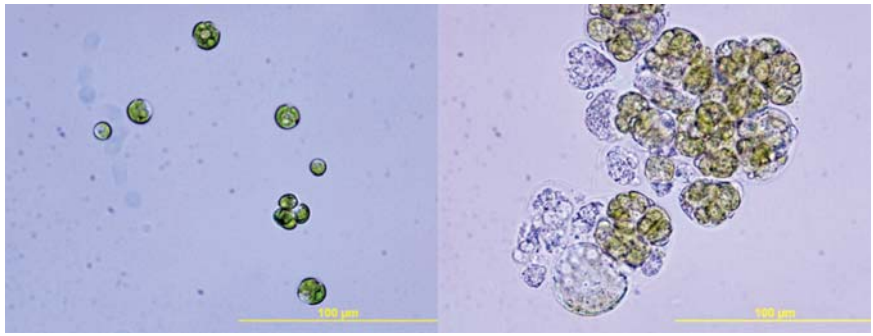

Figure 4. Microscopic evaluation of CC-1266 cells grown in TAP (left) and in TAP with 60% deuterium (right). Normal *C. reinhardtii* cells: green in color, motile, and two flagella. Deuterated *C. reinhardtii* cells: loss of color, irregular clusters, loss of flagella, and dead cells.

For many of these reasons we can conclude that using the stable isotope deuterium to label plant proteins cannot be our label of choice because we have shown that it significantly affects the growth and development of the algae. These preliminary results directed our research to using other stable isotopes including nitrogen-15 and carbon-13 to monitor protein turnover.

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