

Inquiry: The University of Arkansas Undergraduate Research Journal

Volume 5

Article 1

Fall 2004

Inquiry: The University of Arkansas Undergraduate Research Journal - Volume 5 - Fall 2004

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Editors, Inquiry (2004) "Inquiry: The University of Arkansas Undergraduate Research Journal - Volume 5 - Fall 2004," *Inquiry: The University of Arkansas Undergraduate Research Journal*: Vol. 5 , Article 1.

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THE UNIVERSITY OF ARKANSAS
UNDERGRADUATE RESEARCH JOURNAL

INQUIRY

Volume 5

Fall 2004



University of Arkansas
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Received on: 12-14-04
Inquiry : the University of
Arkansas undergraduate
research journal

Published by ScholarWorks@UARK, 2004

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INQUIRY

Undergraduate Research Journal of the

UNIVERSITY OF ARKANSAS, FAYETTEVILLE

Volume 5 - 2004

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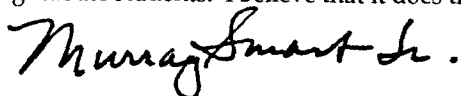
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Foreword:

This journal, the fifth in an annual series, is a project of the Teaching Academy of the University of Arkansas and is testimony to the Academy's belief that a function of good teaching is to encourage good research and creative thinking on the part of the students.

This issue of *Inquiry* records the individual research exploration of eleven U of A student/faculty mentor pairs during the 2003/2004 academic year. The projects included here are drawn from disciplines from all six of the university's undergraduate colleges and schools—the Dale Bumpers College of Agricultural, Food and Life Sciences, the School of Architecture, the J. William Fulbright College of Arts and Sciences, the Sam M. Walton College of Business Administration, the College of Education and Health Professions, and the College of Engineering—and are representative of the quality of research done by the honor students in the various disciplines represented on campus. The breadth of subject matter included here is testimony to the commitment made throughout the university to honors study and research at the undergraduate as well as the graduate level. These eleven articles were chosen by *Inquiry's* publication board from abstracts received as a result of a call for papers. They vary in subject, in writing style, and in the manner in which they reference their research sources; but they are uniformly excellent in content. In most cases, the paper published herein is a digest of the student's larger research product. However, in some cases, the students' honors theses are published in their entirety. This year for the second time the journal is paired with a website, <http://advancement.uark.edu/pubs/inquiry/>, on which a number of papers appear that were recommended for publication but excluded because of space and cost limitations. We hope interested readers will peruse both the articles in hard copy in the journal and those published on the website as well.

The intent of the journal is to record the depth and breadth of the scholarly activities of the university's best undergraduate students. I believe that it does this.



Murray Smart, Jr., Editor, University Professor of Architecture, Emeritus

Inquiry Publication Board, 2003-2004 Academic Year

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SECTION I: ARTS AND HUMANITIES

ARCHITECTURAL THEORY, ETHNOMUSICOLOGY

TOWARD AN UNDERSTANDING OF NORWEGIAN DWELLING

By Amber R. Murray
Department of Architecture

Faculty Mentor: Dr. Ethel Goodstein
Department of Architecture

Abstract:

Neither traditional nor modern Norwegian artifacts have received significant critical attention or appreciation in mainstream histories of western art or architecture. This lack of cultural exportation has to do with the fact that surveys of art and architecture history, as well as close studies of the modern period, have tended to focus on canonical works, and, often as a result, the artifacts of Norway have been excluded from this mainstream history. In response to this paucity of scholarship, this study investigates the intersections between Norway's art and culture through a synthesis of phenomenal readings of the country's built landscape, formal analysis of selected works, and research of Norwegian culture and society in regional and cultural studies literature. The research questions that will guide the project developed, in large part, from situations I observed during a 2001 study tour. This experience made clear that understanding aesthetics in Norway also demanded understanding how memory, dwelling, perception, and expression of national identity operate in the environment. Drawing from the frameworks of human-environment relations, the psychology of aesthetics, and phenomenology as well as traditional formal analysis, the study will engage interdisciplinary methods to analyze Norway's art and the cultural landscape of which it is part.

Introduction:

By existing in a given place, one cannot help but be influenced by it. The natural surroundings, history, art, culture, and built form all come together and influence a specific phenomena, which then has the potential to impact the human psyche. Because the connection between surroundings and humans is inherently reciprocal, much can be learned about both if parallels are drawn between them; and thus a definition of how one dwells emerges. For dwelling not only talks about the actual place that is lived in, but a complete human reality. Lighting, space, smells, and materiality by themselves create an incomplete portrait until the constant dialog of human thoughts, memories, perceptions, and expressions are factored in. One dwells in the world not only with the body, but with the mind as well. Or as Christian Norberg-Schulz has defined it, "Man dwells when he is able to concretize the world in buildings and things".¹ In other words, when one engages in the surroundings by creating tools

to work it, structures to be protected from it, or art to react to it, dwelling takes place. Understanding of the immediate world develops through a continuous dialog between mind, surrounding, and manmade objects. The definition of that dialog then becomes synonymous to the definition of dwelling, for it describes a complete reality. My desire is that through this particular format I am presenting, a thorough description of that dialog can be approached.

My choice for examining specifically how the Norwegians dwell came from questions formulated after a lone journey taken there in the summer of 2001. It was the first time I completely immersed myself in a culture that was distinctly different from my own. There I felt no one was concerned with me. Even the clouds seemed to have an agenda concerned only with themselves. They casually graze along the tips of the fjords, changing the atmosphere from hour to hour, moving with a self-contained cloud conviction not typically seen. I was surprisingly comfortable with my newfound position, and have since then wanted to understand how and why simply being in a different place could so profoundly affect the way I was experiencing the surroundings I came in contact with.

That personal reading of Norway is where I begin to see relationships between the people and its environment, which I will attempt to further define by the following combination of methods of inquiry: phenomenology through writings of Christian Norberg-Schulz² and psychology through writings of Rudolph Arnheim³. By using the foundation of knowledge cultivated by these two men, I will propose relationships that run through Norwegian landscapes and painting. I have chosen these particular methods of analysis because of their potential to further elaborate upon defining the phenomena of a place, which I will explain below.

I was first exposed to Christian Norberg-Schulz when I read *Nightlands: Nordic Building* sometime after I returned from Norway. To my advantage, I found that he articulated some of my initial observations. Through his particular method of defining the Nordic phenomena, he creates a portrait of place by focusing on the structure of it. That is, he looks at all things that are man made and natural and describes them in length to understand the "spirit of the place"⁴ or "genius loci."⁵ His approach is a romantic

idea based upon seeing and “recognizing something as something”⁶, in other words seeing direct relationships between culture and place in order to develop the identity of that place. He employs this method because he believes that with it one does not become “detached from life,”⁷ as he claims can occur when analyzing by using psychological and sociological methods. I believe this is not entirely true however. Due to the fact that he is Norwegian, it was at one time easy for me to be assured that Norberg-Schultz’s observations were valid by association, but after further reading and intellectual growth, I am no longer entirely satisfied with his approach to phenomenology⁸. For him the logic of psychology moves too far from the actual place itself, but the definition of phenomenology is: *A philosophy or method of inquiry based on the premise that reality consists of objects and events as they are perceived or understood in human consciousness and not of anything independent of human consciousness*⁹. This suggests to me a more multifarious approach that includes the inquiry of not only the objects and events of reality, but how a conscious human interprets those objects and events. Rudolf Arnheim reveals in *Toward A Psychology of Art* and that art can be approached by using psychological methods without losing sight of “life.” I appreciate Arnheim’s methods because although they are scientific in nature, they still stress the importance of artistic endeavors being necessary for human life, which should be embraced by the human spirit. He believes that maybe with the understanding of art, the mind can be better understood as well, for wisdom’s sake, not scientific probing. More simply stated, through these interdisciplinary approaches, I hope to develop conclusive observations that further articulate the Norwegian phenomenon of dwelling by adding a layer of psychological analysis to the work of Christian Norberg-Schulz. First, not unlike Norberg-Schulz himself, I will describe the landscape as I experienced it in addition to providing images that correlate with the text. Then I will analyze specific works by Edvard Munch using the methodologies of Rudolf Arnheim to relate the paintings and the painter to influences coming from the Norwegian landscape. Although I have only chosen a few examples to elaborate upon, it is assumed that other paintings, buildings, and manmade objects could fall under the same scrutiny. As alluded to before, by looking at the landscape and then finding parallels between it and manmade objects through psychological methods, I hope to approach an understanding of Norwegian dwelling that has the capability to include frameworks of human consciousness, perceptions, and expressions. For that seems to be only way that a complete phenomena can reveal itself.

Defining Landscape:

To understand how Norwegians dwell, first a brief catalog of the landscape will be made. As mentioned in the introduction, for humans to dwell they must react to the landscape, so to make any conclusions about manmade objects such as art, the context from which they came from must first be thoroughly defined.

For organizational clarity, specific aspects of natural Norwegian phenomena are broken up into six categories: sequence, closeness of sky, understanding geologic time, harsh climate, light, and remoteness. Although many other aspects are involved in describing a Norwegian experience, these have specifically become apparent contributors to the aesthetic ideals of Norwegian culture. I will expound further how such a conclusion was made further in the study by reintroducing these physical features in the context of specific moves made in painting. It seems imperative however to first describe them without being associated with anything else so that an initial appreciation of the landscape itself can be formed.

Sequence:



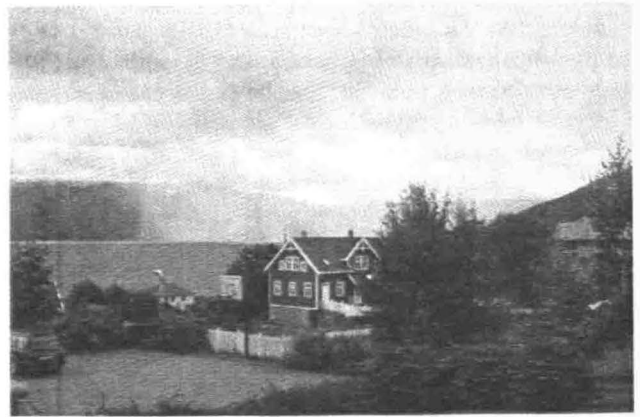
Not unlike a labyrinth, the Norwegian landscape reveals itself in a sequential manner. Its topography was formed, and is still in the process of being formed, by slow moving glaciers carving away land as they proceed out into the sea. Through this process the fjords are made along the perimeters. Mountain faces plunge steeply into cold turquoise water, creating limited opportunities for habitation. On the tops of the mountains the weather is intense. The Norwegian’s must carry out their days in the valleys, moving between walls of rock, “hence it is the Norwegian dream to reach “over the high mountains.”¹⁰ There are no expansive views; one must move through landscape to experience it, but even then twists, turns, fog, rain, clouds, and indirect sun inhibit complete or universal understanding. Each has their own interpretation based on individual encounters.

Closeness of Sky:

Due to Norway's proximity to the earth's axis, the sun's small angle reflects the sky in such a way that it appears to be closer to the earth. The added pressure can be felt, creating an intimate relationship between the earth and the sky.

Understanding Geologic Time:

At a few vantagepoints, glaciers make themselves apparent. By seeing them in relation to the heavily carved land one becomes aware of how the place was formed. It has no regard for human time or scale. For thousand of years before humans were on this earth and for many more after they leave it, the glaciers steadily move along with forces so strong they are almost inconceivable.

Harsh Climate:

The climate defines how the days will be carried out. Therefore, if one wants to live one must adhere to the rules of the season, which influences how cultural rituals will develop, and buildings will be put together.

Light:

A low sun creates long shadows, endless days in the summer, eternal nights in the winter, and distinct colors in the transitional stages. At any point no object has the opportunity to face the sun and be defined by it. The shadows and darkness create ambiguity in the surroundings

Remoteness:



Being physically disconnected from Europe and having a landscape that has the capacity to separate individuals, towns, and cities renders a culture of remoteness

On Painting:

Paintings, and most art in general, have the ability to reveal particular relationships between man and his surroundings. The desire behind pure aesthetic expression comes from human mental needs, which are hard to define due to the intangibility of them, yet closely associated with to the human psyche. For that reason it becomes advantageous for this study to first draw conclusions from Norwegian painting, to identify patterns of spatial and chromatic relationships, before coming to conclusions about dwelling.

When questioning the reasoning behind artistic motivation, many have come to the conclusion that artists express themselves in order to communicate to others. This logic fails to consider however not only why we produce art, but as Arnheim states, "many artists either ignore this motive or explicitly reject it."¹¹ For me, the fact that mythology, science, history, and other such pursuits are all credited as important and valid to most individuals seems to provide the assumption that humans seek explanations about the world they interact with. And for aspects dealing with human consciousness that language, mathematics, and reasoning may not be able to approach due to their individual mediums, art has the potential to elaborate upon. It makes sense really. We don't typically learn about the immediate world solely through written or spoken ideas, but through deciphering the interaction between shapes, lines, materials, and colors in addition to all the

other forms of experience. Composition engages us in the everyday and therefore a visual means of communication to further define that everyday world, becomes necessary. Words can be too far removed from an actual visual experience to map out a particular human feeling, and since we thrive off such sensations, to be able to make them stay and be pondered in a concise visual moment seems logical due to our fixation on understanding.

These observations lead to the next assumption: that using the Gestalt theory of expression as a source of validity would be appropriate for executing this study. The theory states that there is a relationship between the expressive nature of objects both animate and inanimate, and the perception of them. For instance, trees, an arrangement of rocks, a cloudy sky, a human body, in addition to art, all have expressive qualities. Even though they themselves may not carry emotion, it is our ability to perceive the compositions of such objects that allows us to come to conclusions as to what emotions they provoke. For example Arnheim states:

"To be aware of a fire as merely a set of hues and shapes in motion instead of experiencing the exciting violence of the flames presupposes a very specific, rare, and artificial attitude."¹²

The same can be said for art. Mark Rothko, for example, is a painter who creates very simple compositions by layering different colored squares and rectangles, yet that description would not satisfy anyone who actually has experienced the work of Rothko. One of art's objectives is to project a certain perception; thus viewers are inclined to be aware of their reaction to it. When standing in front of a series of Rothko's canvases, which is how they are intended to be viewed, the saturation of color becomes overwhelming and the ghostly simplicity has the ability to place you in another realm. The perceived feeling is strong and spiritual, yet the paintings are literally just rectangles.

In his own words, Rothko comments on the use of shapes in his paintings:

"On shapes: They are unique elements in a unique situation. They are organisms with volition and a passion for self-assertion. They move with internal freedom, and without need to conform with or to violate what is probable in the familiar world. They have no direct association with any particular visible experience, but in them one recognizes the principle and passion of organisms. The presentation of this drama in the familiar world was never possible, unless everyday acts belonged to a ritual accepted as referring to a transcendent realm."¹³

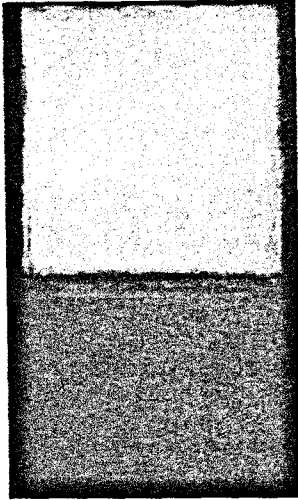


Fig. 1. Mark Rothko, Untitled, 1963, oil on canvas, private collection.

Although it would not be advantageous to concentrate much more on the work of Rothko, he serves as a good example of showing that the human mind does not just look at things; it digests them. Rothko wanted to crystallize a particular tone of emotion. Therefore, he developed a painterly method that relies on the power of simple geometric form and, as intended, he guides the viewer's perception to produce a specific reaction. Expression and perception are in a constant dance with one other be it concerning a canvas of shapes, the Sonjefjorden in the winter, or both in relation to one another. For these reasons, making connections between natural conditions and artistic expression with a psychological framework rationally makes sense. When the surroundings are perceived by a mind, then that mind develops a certain mental position, and then that position crystallizes itself in a tangible manner through some medium, a level of understanding between humans and the surroundings coalesces. Although the medium could be a bodily expression, dance, or musical composition, I will only talk about painting due to its static and descriptive nature, which is similar to architecture in that way. If I could access the mind directly, I may not have to follow this route, but obviously that is not a possibility. I will have to make assumptions on the actual psyche by looking at the input and output, natural phenomena and manmade objects.

The specific paintings I will look at come from the body of work of Norway's most canonical painter Edvard Munch. Several factors that have influenced this choice are, first, that most Norwegians know of Edvard Munch and appreciate his artistic contributions. Finding a painter whom the majority of Norway identifies with becomes very important when considering that generalizations about an entire nation are being made, which then explains why an early twentieth century painter was chosen. For the art to have resonance with the people, they must be known. Munch's paintings have been exhibited for many years in the national museums and have been absorbed by the cultural heritage. In addition, Munch has heavily investigated his personal

expression through themes concerning natural conditions found in Norway. Instead of identifying artists who correlate temporally with each chosen piece of architecture, the findings found in these paintings are intended to transcend aesthetic periods. They are based on geologic time, or the clock that nature adheres to, which moves much slower in relation to human concepts of time and therefore creates relationships that will cover all periods of art and architecture. In each situation however, particular historical references will be made due to their importance for as Arnheim states below:

"While there is no evidence to support the hypothesis that the central phenomenon of expression is based on learning, it is worth noting that in most cases the interpretation of the perceived expression is influenced by what is known about the person or object in question and about the context in which it appears."¹⁴



Fig. 2. Edvard Munch, Amor and Psyche, 1907, oil on canvas, Munch-Museet, Oslo.

To start the analysis of Edvard Munch, I will look at *Amor and Psyche* (fig.2) using the methods of Arnheim. Although, as far as my studies have taken me, Arnheim does not make associations with the natural context from which the painting was done in, he does make historical associations, which leads me to believe that making further correlations are completely feasible. He does this however, only after a thorough description of the actual painting itself, as suggested in the following statement.

"The examination takes the form of a descriptive inventory. We cling as closely as possible to what is directly presented to the eyes, on the assumption that in a successful painting the essential meaning is directly exposed in the properties of visual form."¹⁵

Munch's painting is composed of three layers: front, middle, and back. The front and most dominant layer is the male figure. The middle is the smaller and lighter female figure. The back is a nondescript backdrop that changes in tone from dark to light moving from the bottom and right. Due to the two main figural

objects standing, facing one another on either side of the painting, the composition is split along the central vertical axis. It is then split again in the horizontal center by the tonal change in the background. The male figure however is not restricted by the demarcation set by the rest of the painting. He pushes through the vertical axis with his form and through the horizontal with his contrastingly fully dark body (fig.3). The dark swath along the right side balances him. The female figure's body is much lighter in tone than the males, yet her head is dark and more intricate than the rest of the painting, making it appear heavy. The brush strokes are very strong in both color and vertical direction. Where the strokes deviate from the path, the figures assert themselves. By using the solid brush strokes, one becomes much more aware of the chosen color palette. Furthermore, the placement of the two is very close, and the lack of depth in the background brings them ever closer together. An air of tension is created since he is looking right at her, as the viewer is, but her stare is off into the distance. One feels a certain level of empathy with the man, due to him standing in the same position as ourselves; yet he is also in our way, keeping us from her, while she remains trapped.



Fig. 3. Diagram of Amor and Psyche

To further understand the context of the painting, and thus Munch's interpretation of the theme, the story of Psyche and Amor should be known:

"Psyche is a princess so beautiful that the goddess Venus becomes jealous. In revenge, she instructs her son Cupid to make her fall in love with a hideous monster; but instead he falls in love with her himself. He becomes her unseen husband, visiting her only at night. Psyche disobeys his orders not to attempt to look at him, and in doing so she loses him. In her search for him she undertakes a series of cruel and difficult tasks set by Venus in the hope of winning him back. Cupid can eventually no longer bear to witness her suffering or to be apart from her and pleads their cause to the gods. Psyche becomes an immortal and the lovers are married in heaven."¹⁶



Fig. 4. Bertel Thorvaldsen, Cupid and Psyche Reunited in Heaven, 1807, original model, Thorvaldsen's Museum, Copenhagen.

For centuries many artists have depicted this heart-warming love story. They however usually chose the moment at which Psyche and their love become eternal (fig. 4). Munch on the other hand seems to portray the first awkward moment when Psyche is approached by her new husband when, not only does she suspect him to be a monster, but when he is about to lose her virginity to a stranger in the dark. The portrayal becomes even more interesting if the association is made that the woman looks very much like Tulla Larsen, a former lover of Munch. Apparently at the end of the century she wanted to marry him very much, but he was reluctant. One night in a heated argument about their wedding Munch shot himself in the hand. Shortly after the melodrama Larsen married another artist and Munch developed a deep hatred for women.¹⁷ Knowing this, the scene seems to illuminate his uncomfortable relationship with women and the subsequent intimacy that occurs in them. In addition to *Amor and Psyche*, Munch produced many highly charged scenes concerning women such as *Death of Marat*, (fig. 5) where Munch uses another historical reference to facilitate his expression. This tactic was not uncommon for Munch. He would often experiment with ambiguity in subject titles and matter in a long series to work toward a desired painting and, in addition, create participation with the viewer. An observation which implies a parallel between the specific lighting conditions of Norway and Munch's reliance on ambiguity. Below Christian Norberg-Schulz describes how the low sun angles of the northern countries illuminate the surroundings.

"Here in the North, the sun does not rise to the zenith but grazes things obliquely and dissolves in an

interplay of light and shadow. The land consists not of clear massings and distinct spaces; it disperses as fragment and repetition in the boundless. The vegetation is not characterized by particular species, such as stone pine and cypress, but instead a network and thicket. And the buildings lose much of their figural effect; houses lie scattered and hidden."¹⁸

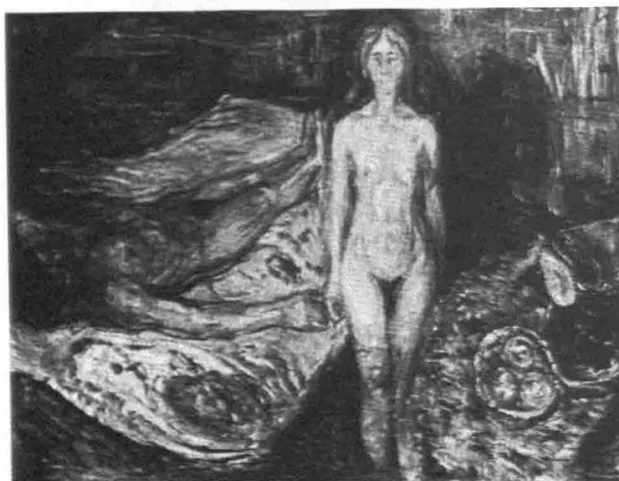


Fig. 5. Edvard Munch, *Death of Marat*, 1907, oil on canvas, 59x78 inches, Munch-Museet, Oslo.

It comes as no surprise then that Munch would in turn paint the world in an ambiguous manner, for it that was in fact the way it was seen. For example, *Psyche and Amor* do not seem like gods in Munch's depiction. The only reason that the viewer would reach that conclusion is because of the title. Viewers can associate with the figures due to their common situation; the historical reference gives us added information, while the painting technique takes it away, thus forming ambiguity and added engagement. If it were all laid, the observer would not be prompted to question it, to dwell in it. Which leads to yet another association with the Norwegian landscape. Similar to the way in which landscapes are perceived, Munch's paintings unfold through participation over time. Either through a series that reference each other, or by looking at each ambiguous one individually, he would dwell in his own work, and leave it open for others to dwell in also. In fact it is stated that, "He felt so strongly about the unfinished and indefinite aspects of his works that he always had to have them around him."¹⁹ In the images of him working in his studios, this statement holds true. He is always photographed with many canvases surrounding him, of which he would then change or be inspired by while he worked (fig. 6). In a way, he was defining his own world through painting. A journey through life, illustrated. The paintings became synonymous to memories for reflection, but since they were tangible objects, he had to keep them to influence the next step. In this way there is interplay between the fragment of each piece and the complete lifework because the boundaries between each individual work were erased. As Franz Servaes stated, which happens to be very appropriate for this

study, Munch's "artistic goal seems to be a pictorial phenomenology of the Soul."²⁰



Fig. 6. Munch in the Outdoor Studio at Ekley, ca. 1925

Although through painting, Munch remained very engaged with the world, he was very detached as well. Much more than most artists, Munch explored themes of being isolated. I cannot help but to assume that this could have something to do with the composition of the Norwegian landscape. The features and climate both have the ability to make it very difficult to interact with other people throughout the year. Sometimes Munch could express the feeling of being alone by simply arranging a grouping of trees. In fact, his most seminal painting *The Scream* comes from a series of paintings that focus on his social anxieties (fig. 7, 8, 9). Specifically in *Amor and Psyche* the male figure, which can be assumed to be Munch himself, struggles to engage with the woman. By having him play an overbearing role and her standing statically with her eyes closed with no indication of acceptance, he conveys himself as being ostracized.



Fig. 7. Edvard Munch, *Anxiety*, 1884, oil on canvas, 39x30 inches, Munch-Museet Oslo.

Fig. 8. Edvard Munch, *Despair*, 1892, oil on canvas, 36x26 inches, Thielska Galleriet, Stockholm.

Fig. 9. Edvard Munch, *The Scream*, 1893, oil on canvas, 35x29 inches, Nasjonalgalleriet, Oslo.

For Munch, "Everything is movement and light: God is in us and we are in God, God is in everything. Everything is in us. In us are whole worlds."²¹ This pantheistic view is not uncommon in Norway.²² His contemporary and fellow artist Harald Sohlberg wrote once that "the mountains in the winter make one silent, overwhelmed; one has something of the same feeling underneath

the mighty vault of a cathedral, only a thousand times stronger.”²³ To experience an awesome force, one only has to step outside, so seeing “God” in everything would be a common phenomenon. A few particularly strong forces in the Norwegian Landscape are the glacial movements, climatic periods, and the closeness of the sky. As mentioned in the previous chapter, the active glacial movements confront the inhabitants of Norway by revealing its process of being. In most other places, the land has not changed dramatically in years, so the relationship between its formation and form may not be obvious to the average person. This open honesty can be seen in Munch’s work as well. Munch dwelled in his own shortcomings, regret, and fear, as he expresses in *Amor and Psyche*, but he did not keep those feelings to himself. Instead he chose to make himself vulnerable through his expressive art. “He had the courage to soberly display his own life for observation, renouncing all self-pity; a display of temperament that, profoundly speaking, became his life philosophy ... In the Jungian sense, he ‘crystallized’ the archetypal images and symbols for man’s deepest emotional experiences.”²⁴ Pola Gauguin even pointed out once that: He “sought after life’s primal force, which all classical emotion builds upon. It was natural for him to see right through all civilization and bourgeois social convention; to discover that nature itself, in all its fundamental life function, had not changed greatly.”²⁵ Such intensity in Munch’s work may have also been influenced by the previously mentioned features: pressure of the sky and the climate. While being exposed to an active landscape would be inspiring, the other two features have the ability to confront you ever further. For example, since the sky seems much closer in Nordic counties, one’s relationship with the earth becomes much more prevalent by the compression. In addition, the harsh climate forces inhabitants to be very aware of where they are on the land in order to use it to their advantage. For instance in some months, if you don’t build on the south side of the mountains, your home would be in cut off from all sunlight. Maybe even more important, if you could not access a fjord, you would be cut off from all communication because any other route was impossible.²⁶ This intensity of life and emotion can very easily be seen in the way Munch painted. His vivid color pallet in addition to his wild marks in addition to many other less obvious tactics, convey a sense of vibrant emotion that some painters aren’t concerned with.

To end the discussion on painting, I leave you with the following statement from Munch. It comments on his specific position with the relationship between art and nature, which asserts that even though the observations I have made may not be completely correct, that there is indeed a strong connection between Munch and his environment.

“Art is the opposite of nature.

A work of art can come only from the interior of man.

Art is the form of the image formed from the nerves, heart, brain and eye of man.

Art is the compulsion of man toward crystallization.

Nature is the unique great realm upon which art feeds.

Nature is not only what is visible to the eye—it also shows the inner images of the soul—the images on the back side of the eyes.”²⁷

Image Notes:

-All images in the “Defining Landscape” chapter were taken by the author.

-Fig 1. Mark Rothko: the works on canvas: a catalogue raisonné

-Fig 2. Postcard from Munch-Museet, Oslo

-Fig 3. Diagram made by the author

-Fig 4. Postcard from Thorvaldsen’s Museum, Copenhagen

-Fig 5. After the Scream: The Late Paintings of Edvard Munch

-Fig 6. After the Scream: The Late Paintings of Edvard Munch

-Fig 7. After the Scream: The Late Paintings of Edvard Munch

-Fig 8. After the Scream: The Late Paintings of Edvard Munch

-Fig 9. After the Scream: The Late Paintings of Edvard Munch

Endnotes:

¹ Christian Norberg-Schulz *Genius Loci*. Page 23

² Christian Norberg-Schulz (1926-2000) Architectural historian and architect. Born in Oslo. After World War II he studied in Switzerland at the Eidgenössische Technische Hochschule, Zurich, graduating in 1949. He spent the years 1950-51 in the Norwegian army. He joined the faculty of the school of Architecture in Oslo in 1951, where he was appointed assistant professor. In 1963 he received his Ph.D. from the Technical University in Trondheim. He was promoted to professor of architecture in 1966. During the academic year 1973-74 he was visiting professor at the Massachusetts Institute of Technology and the University of Dallas, TX, in 1978, He was Dean of the Oslo School of Architecture. In the early 1970s he authored two volumes in the *History of World Architecture* series on Baroque Architecture which looked at the buildings both structurally and as works of art. An expert in the modern architecture, his seminal book for architects was *Intentions in Architecture* (1963, US 1968). His writing is greatly influenced by the Gestalt and phenomenological theories he read as a student. Bibliography: *Nightlands: Nordic Building*. Cambridge: MIT Press, 1996; *Late Baroque and Rococo Architecture*. New York: Rizzoli, 1985; *Baroque Architecture*. New York: Rizzoli, 1986; *Genius Loci: Towards a Phenomenology of Architecture*. New York: Rizzoli, 1980; *Architecture: Meaning and Place: selected essays*. New York: Rizzoli International Publications, 1988; *Architecture: Presence, Language, Place*. London: Thames & Hudson, 2000; *Intentions in Architecture*. Cambridge, MA: M.I.T. Press, 1968.

³ Rudolf Arnheim (1904-) Arnheim was trained as a psychologist, and considered himself to be a psychologist. But with the exception of his dissertation (Arnheim, 1928) and one or two other writings, he never published an experiment. He was born in Berlin, 15 July 1904. In 1923 he entered the University of Berlin where he “minored” in art and music history, but most important was his eventual training and adherence to Gestalt psychology. He now lives in Ann Arbor, Michigan. Bibliography: *Art and Visual Perception: A Psychology of the Creative Eye*. Berkeley: University of California Press, 1954; *Film as Art*. Berkeley: University of California Press, 1957; *Toward a Psychology of Art*. Berkeley: University of California Press, 1966; *Visual Thinking*. Berkeley: University of California Press, 1969; *Entropy and Art*. Berkeley: University of California Press, 1971; *The Dynamics of Architectural Form*. Berkeley: University of California Press, 1971; *The Power of the Center: A Study of Composition in the Visual Arts*. Berkeley: University of California Press, 1982; *New Essays on the Psychology of Art*. Berkeley: University of California Press, 1986; *Parables of Sun Light: Observations on Psychology, the Arts, and the Rest*. Berkeley: University of California Press, 1989; *Thoughts on Art Education*. Los Angeles: Getty Center for Education, 1990; *To the Rescue of Art*. Berkeley: University of California Press, 1992; *The Split and the Structure*. Berkeley: Univer-

sity of California Press, 1996; *Film Essays and Criticism*. Madison: University of Wisconsin Press, 1997.

⁴ Christian Norberg-Schulz *Nightlands: Nordic Building* viii

⁵ Christian Norberg-Schulz *Genius Loci*

⁶ Christian Norberg-Schulz *Nightlands: Nordic Building* viii

⁷ Christian Norberg-Schulz *Nightlands: Nordic Building* viii

⁸ This statement seems harsh so I must state that I still admire his approach and body of work very much. If it were not for him, the architectural history of Norway would be in dire need.

⁹ According to the *American Heritage Dictionary of the English Language, Fourth Edition*. Houghton Mifflin Company, 2000.

¹⁰ Christian Norberg-Schulz *Nightlands: Nordic Building* pg 32

¹¹ Rudolf Arnheim *Toward a Psychology of Art* pg 19

¹² Rudolf Arnheim *Toward a Psychology of Art* pg 63

¹³ Mark Rothko, *The Romantics Were Prompted* from Herschel B. Chipp's *Theories of Modern Art* pg 548

¹⁴ Rudolf Arnheim *Toward a Psychology of Art* pg 66

¹⁵ Rudolf Arnheim *Toward a Psychology of Art* pg 258

¹⁶ abbreviated story found at http://www.plotinus.com/myth_cupid_psyche.htm, no author listed

¹⁷ Elizabeth Perlinger *After the Scream: The Late Paintings of Edvard Munch* pg 27

¹⁸ Christian Norberg-Schulz *Nightlands: Nordic Building* pg 1

¹⁹ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 24

²⁰ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 45

²¹ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 21

²² An assumption I am making based on 1) the fact that 6.8 percent of Norway's population today are members of some type of religious affiliation according to *Statistics Norway*, 2) having been there myself to witness the intensity of the place, and 3) similar comments to Munch's made by fellow artist Harald Sohlberg.

²³ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 64

²⁴ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 45

²⁵ Oivind Storm Bjerke *Edvard Munch and Harald Sohlberg: Landscapes of the Mind* pg 45

²⁶ Jerri Holan *Norwegian Wood: A Tradition of Building* pg 45

²⁷ Edvard Munch *Waremunde, 1907-1908* from *Theories of Modern Art* pg 114

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Faculty Comments:

Professor Goodstein made no comment on this paper.

JOSEPH COOPER WALKER, ESQ. (C. 1761-1810), A FORGOTTEN IRISH BARD: A DISSECTION OF HIS ADVERTISEMENT AS A MAP TO HIS MELODIES.

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Abstract:

In conducting preliminary research for my undergraduate honors thesis, I discovered a two-volume publication in Mullins Library at the University of Arkansas, The Historical Memoirs of the Irish Bards (1818) by Joseph Cooper Walker, Esq. (c. 1761-1810). It held a variety of information on the music and poetry of ancient Ireland. What interested me most was the collection of melodies at the end of the first volume. Looking at overviews of Irish music collection, I saw little mention of Walker and his Irish Bards. Upon further investigation, I found that the first edition of his book (1786) contained only fifteen melodies. It was then that I based my thesis around Walker, his book, and the world in which he lived. This article features a segment of that thesis, focusing on Walker's preface (which he calls an Advertisement) to the original fifteen melodies. This Advertisement is a primary document that marks Walker as a pioneer Irish ethnomusicologist. My study also investigates possible explanations for why Walker was overlooked or underestimated for his ground breaking work in the study of Irish music.

Introduction:

Last year, while conducting preliminary research for an undergraduate honors thesis, I ran across a two-volume publication in Mullins Library at the University of Arkansas, *Historical Memoirs of Irish Bards* by Joseph Cooper Walker, Esq. (c 1761-1810).¹ It held a variety of information on ancient Ireland, but the section that interested me most was a relatively small number of tunes, only forty-three, collected in an appendix to Volume One. This particular work was published as a second edition in 1818, but a first edition was dated 1786. I began my research from there, which included other resources of Mullins library and its very helpful Interlibrary Loan Department. I also spent a week at Boston College at the Irish Music Center,

O'Neill Library, and the Burns Library of Rare and Collectable Books (which houses an impressive Irish music archive).

I found quickly that, ten years after the first edition was published, a man named Edward Bunting began collecting and publishing large amounts of Irish tunes and melodies.² When one first glances at modern writings about ancient Irish collections, Bunting is usually one of the first names one sees. However, it still stands true that, although Walker was not the first person to collect Irish traditional music, he was earlier than Bunting and many others. However, Walker is rarely mentioned, if at all, in the overviews of Irish collections that I had seen in my preliminary research; it seemed to me then that he had been overshadowed by the ambitious collectors who followed him.

Delving deeper, I found that there were only fifteen melodies in Walker's first edition, and that the second edition was published eight years after his death. Though there is no indication as to who added the additional twenty-eight melodies, or why, Walker at least wrote a preface to his original fifteen tunes, which he called an *Advertisement*.³ The *Advertisement* described his motivations and methods. This preface constitutes a valuable primary document for those studying the birth of ethnography and ethnomusicology in Ireland (which began in the late eighteenth century), for it was written by a pioneer in the field. Though Walker's *Advertisement* features as only a segment of my thesis on Walker and his book, I present it here as a valuable discovery in the field of historical Irish ethnomusicology.

Eighteenth Century Ireland and the Birth of Irish Ethnography:

Many events of the eighteenth century contributed to creating an environment ripe for Irish ethnography. Though they are too numerous to give in detail here, there are a few that cannot avoid being mentioned. The penal laws, which had oppressed Irish Catholics throughout the earlier half of the century, began to lax over time. In Dublin, several events occurred that

contributed to Irish pride: Handel's *Messiah* premiered in Dublin in 1742; the Bartholomew Mosse of the Rotunda Hospital, the first maternity hospital in the world, was built in 1750 (as a reaction to the alarming number of still births in the population); and the Guinness Brewery at St. James' Gate opened in 1759.⁴ Rebel secret societies, such as the White Boys (created in 1760), began an agrarian revolt throughout the Irish countryside, regulating the British landlords and fighting for justice for the common Irish person. The American Revolutionary War played a part as well. Not only did the American Revolution inspire the Irish, but it also required many British soldiers stationed in Ireland to go and fight, weakening Britain's strong hold on Ireland. Groups such as the Irish Volunteers and the United Irishmen were created by Irishmen to protect the island from other foreign invaders in the absence of their current British ones. With Britain's hold on Ireland weakened, the Irish took the opportunity to gain concessions from the Crown. Ireland gained her constitution in 1782. Although it affected a minority of the Irish population, it was still a step in the right direction. Walker, by this time, was around twenty-two years old.

It seems that, after 1782, the growing sense of Irish nationalism began to manifest itself in an intellectual manner. Previously, the Irish were forced to be concerned primarily with mere survival. Now that they had a little more freedom, they could portion that energy elsewhere. Irish intellectuals began to actively combat the view that their culture was a primitive bastardized version of British culture and held Irish culture up as a field worthy of study in its own right.

Throughout the eighteenth century secret societies in Ireland were used to defend those who could not help themselves. Philanthropic societies aided those who could not aid themselves. However, the founding of the Royal Irish Academy in 1785 marked the beginning of one of Ireland's first lasting intellectual societies.⁵ The RIA's aims (as stated in the charter) were the "promotion and investigation of the sciences, polite literature, and antiquities, as well as the encouragement of discussion and debate between scholars of diverse backgrounds and interests."⁶ Walker, as well as many of his colleagues, was a member of the RIA.

Walker's *Historical Memoirs of Irish Bards*:

Walker published his *Historical Memoirs of the Irish Bards* in 1786, around the age of twenty-six, while working as a treasury clerk in Dublin Castle. The aim of his book was to outline the history of the poetry and music of the Irish from as far back in history as possible to the present, the eighteenth century. The preface of Walker's *Irish Bards* tells the reader much about Walker's intentions in writing this book. The opening lines state, "I trust I am offering to my Countrymen an acceptable present: the gift has novelty, at least, to recommend it. Though Ireland has been long famed for its Poetry and Music, these subjects have never yet been treated historically."⁷ Walker understood that

what he was writing, although done similarly in other countries, had not yet been fully addressed in Ireland.

Historical Memoirs of Irish Bards is an account of Irish bards, including of their poetry and music. A brief look at the contents of this book will quickly reflect how and why this book was significant for Irish ethnography and musicology. The content of the book itself covers the traditions and practices, including musical practices, of the Irish bards from ancient times, and how they evolved through history. The book ends with Walker's observations on the state of music in Ireland during the seventeenth and eighteenth centuries. In this closing, Walker made a significant statement that can be directly tied to the goals of some ethnomusicologists today. Walker noted that England was influenced by Italian music, and that this influence eventually made its way to Irish soil. As this music gained popularity among the Irish, Irish traditional music and the people who played it fell to the way side, because it wasn't as refined. He lamented that:

... in proportion as our musical taste is rectified, the pleasure we derive from pure melody is lessened. This refinement may be said to remove the ear so far from the heart, that the essence of music (an appellation by which melody deserves to be distinguished) cannot reach it. Nor is it necessary in this age, that the ear and heart should be closely connected. For modern music is calculated only to display the brilliant execution of the performer, and to occasion a gentle titillation in the organ of hearing.⁸

The manner in which he approached Irish culture, history, poetry and music in his book, as well as his final argument for the study of traditional music, would not have been written like this before his time, nor would it have been accepted earlier by the general public or even within intellectual circles.

As if Walker's book were not enough to elevate interest in the rich history of Ireland's ancient arts, he added nine appendices, which further explored the subject. The appendices consisted of short essays written by Walker and his colleagues. In the few twentieth century works that mention Walker, the "Memoirs of Cormac Common" and the "Life of Turlough O'Carolan" (both blind Irish harpers) tend to be noted as the most interesting and noteworthy of Walker's appendices. However, while each of the appendices is a valuable contribution to the elevation of Irish studies, it is the "Select Irish Melodies" (the Ninth Appendix in Walker's book) that marks Walker as a pioneer ethnomusicologist. The fifteen tunes, which range from bagpipe laments to Gaelic song airs to harp tunes, make up one of the earliest sources of written Irish traditional music (see Table 1 for tune titles). When one looks at the tunes, their notation suggests that they were taken from performers who had learned them aurally. In addition, there is evidence that the transcriptions were written as close to the actual performance as possible. Furthermore, Walker's *Advertisement* is an invaluable map to understanding these Irish

melodies. Without it, we would know little about some of the tunes at all.

Walker's *Advertisement* as a Map to His Melodies:

In the period in which Walker's book was written, the word "advertisement" often referred to a statement, often written, used to call attention to something, as a notice.⁹ Walker's *Advertisement* is written in four sections (see Figure 1.1 for original document, Figure 1.2 for transcription of document), and will be addressed here according to those four sections.

The first section of the *Advertisement* states the purpose of the inclusion of the tunes in the book. Walker describes his treatment of Irish music in his book as "occasional." (Walker's mention of things musical throughout his book was hardly occasional.) The stated purpose of the "few" melodies, few being fifteen, is that they are specimens, used to illustrate the parts of his book in which he deals with Irish melodies. That being said, the only tunes about which he specifically refers the reader from the *Advertisement* to a location in the text of the book are (see Table 1): nos. II-V, The Irish Cries; no. X, "Coulin;" no. XIII, "Plough Tune;" no. XIV, "Carolan's Devotion;" and no. XV, "Lord Mayo." The purposes of the inclusion of the other tunes, which do not specifically support Walker's text, are explained as they appear in the *Advertisement*.

The second section of Walker's *Advertisement* is devoted to the first six tunes of the collection; it also gives a rationale for the order in which the melodies are presented. The first six tunes are presented together; the following nine tunes are, for the most part, dealt with on an individual basis. Walker first presents the four Provincial Cries (nos. II-V) enveloped by an introductory tune and a concluding tune, stating that modern musicians had given them collectively a "dramatic form."

The introductory tune is "Cath Eachroma," also known as "The Battle of Aghrim."¹⁰ Walker states that it is a "wild air of their [modern musicians'] own days," which the said musicians used as an introduction to the Provincial Cries. The contrast of a relatively modern tune set with the Cries, which Walker claims come from "remote antiquity," gives evidence that his tunes are diachronically layered.

The Cries that follow this wild air represent each of the four provinces in Ireland: no. II, "Gair Chonnachtach," or "The Lamentation of Connacht" (representing Connacht, the western province); no. III, "Gair Mhuimhneach," or "The Lamentation of Munster" (the southern province); no. IV, "Gair Olltach," or "The Lamentation of Ulster" (the northern province); and no. V, "Gair Laighneach," of "The Lamentation of Leinster" (eastern province). Lamenting in Ireland is also known as "keening," and is a tradition that has been referred to as early as the seventh century in a eulogy for St. Cummain the Tall.¹¹ The practice of keening involved four hired keeners, who would situate themselves around the deceased, who had been laid out at his or

her wake. They would sing lamentations back and forth, throughout the night, as well as sing of the deceased's family, life, successes, etc.

The Provincial Cries in Walker's collection differ little from each other. They essentially follow the same patterns, both melodically and in their phrase sections, though they vary in length at times and some sections are transposed. Their similarities give the inexperienced eye the impression that they are variations of each other, and therefore lend themselves to the pseudo-suite form that the musicians of Walker's time had given them. A possible explanation as to why they are so similar will be investigated momentarily.

Walker's "suite" is completed with an Irish dump (tune no. VI), the title of which is "Gol na mna'san ar." Although Walker's 1818 edition gives the English version of this title as "The Lamentation of the Aged Woman," other sources translate it as "The Lament of the Women in the Battle."¹² Indeed, taken piecemeal, it translates as such as well. The title may be dissected thus: the word gol (of which guil, as in na guil, is a form) means 'crying or weeping'; na mna means 'of women' (mna is the irregular plural for the Irish word bean, meaning 'woman'); and san ar means 'in massacre or slaughter', and once also referred to those slain in battle.¹³ That being said, Walker does give the reader some reference to the tune's potential origins. Walker states that the dump was "said to be sung by the Irish women, while searching for their slaughtered husbands, after a bloody engagement between the Irish and Cromwel's troops."¹⁴ The word 'dump' originally referred to certain instrumental pieces from English sources between 1540 and 1640; the pieces tended to be "solemn and still," "deploring," and "doleful."¹⁵ Though the later Irish dump differs formally from the English dump, the dump in Walker's collection certainly matches the description. The Irish dump has also been defined as simply an Irish lament or sad tune.¹⁶ If, indeed, this dump originated as the cry of women searching for their husbands, this plaintive six-measure-long melody does aurally match the image of such. Incidentally, this use of the word 'dump' shares its origins with the use of the same word in the phrase "in the dumps" or "down in the dumps, a phrase which has been seen in written English as early as the sixteenth century."¹⁷

We will divert our attention from Walker's *Advertisement* for a few moments in order to further investigate the origin of the Irish Cry that Walker showcases. An entire essay by William Beauford,¹⁸ devoted to the origins of the Irish lamentation, was published in the *Transactions of the Royal Irish Academy*, five years after Walker's 1786 edition.¹⁹ In his essay, Beauford discusses the origin and methods of the Caoinan, and gives a musical example of it in several cycles or recitations. The Caoinan consists of choruses that are sung back and forth between the keeners. As a new chorus always begins on the ending note of the preceding chorus, several cycles of the Caoinan result in transposed choruses, which sound the same but

are sung at different intervals from each other. Beauford then informs us, "Each province was supposed to have different Caoinans, and hence the Munster cry, the Ulster cry, etc. but they are only imitations of the different choruses of the same Caoinan independent of provincial distinctions."²⁰ It is for this reason that Walker's Provincial Cries are so similar. Figure 2.1 is extracted from Beauford's musical example, and is the first stanza of the caoine, which would be sung by the head bard in a low and mournful tone. In order to facilitate comparison, this example is immediately followed by Figure 2.2, Walker's sixth tune, the Irish dump "Gol na mna'san ar."

Though not identical, these melodies bear a striking resemblance to each other, particularly in the manner in which they begin and end. Walker's melody is composed of two three-measure phrases that are almost identical to each other. Beauford's is constructed in two four-measure phrases: the first of which might be loosely viewed as a varied expansion of the first two measures of Walker's tune, with the second, again loosely viewed, as an expansion of Walker's complete three-measure phrase. Beauford's melody has a range of a major seventh, whereas Walker's has only a major sixth.

Walker had stated that the dump was said to be sung by women searching for their men in the fields after a battle with Cromwell's troops. Although this may be true, the similarities between "Gol na mna'san ar" and the opening lament of the Caoinan imply that the origins of this melody are much older.

Now that we have seen how the Irish dump corresponds to the opening cry of the Caoinan, we'll look at the bigger picture for a moment. The following graph (Table 2) is drawn up according to each of the four chorus repetitions of the Caoinan (provided by Beauford): the First and Second Semi-Choruses and the Full Chorus of Sighs and Groans (split into Part A and Part B in the graph). Beauford's account stated that each successive chorus began on the same note as the concluding note of the chorus before. As can be seen by this graph, this is almost always the case. Note three particular variations:

1. In the third repetition of the Full Chorus, the A section begins on "(C') B."²¹ This means that the chorus technically begins on a C', but it is a pick-up note, and the first note on a downbeat is B.
2. Also in all but one repetition of the Full Chorus, several measures are omitted from the Walker counterpart. This is due to variants on the melody in the Walker tunes, which do not resemble the Caoine at these points closely enough to be associated.
3. None of the Provincial Cries correspond to Section B of the Full Chorus, and the fourth repetition of the Full Chorus does not even have

a Section B.

From this diagram, we can see how each of Walker's Provincial Cries fits into the overarching Caoinan. Look at Figures 3.1 and 3.2 to see how the first recitation of the First Semi-Chorus matches up to the first four and a half measures of "Gair Chonnachnach." The First Semi-Chorus is also called the Ullaloo because of the sounds that it carries (see Figure 3.1). These "words" do not have a specific meaning, in that they aren't translated (as other verses that are sung in Irish, but translated into English in Beauford). These "words" may be a form of wailing or lamenting. Note that both examples begin on D, the same note that ended the opening cry and the dump. The two examples above are almost identical. This pattern follows in a similar manner throughout the comparison of the Caoinan to Walker's Provincial Cries.

Now that we have investigated the possible origins of Walker's Provincial Cries, we will return to the second section of his *Advertisement*. Walker concludes this section by informing the reader that, in modern performance, the completion of the set is accompanied by shouts from the audience, supposedly because they are so moved by the sorrow of these lamentations. This section of the *Advertisement* provides at least one example of performance practice for its era. In speaking of these tunes, Walker also provides an insight into how it was performed as of 1786. Though it is implied that this suite, in his day, was performed instrumentally (based on the use of words such as "played" and "performed" instead of "sung"), his background information gives evidence that its origins lie in a vocal tradition, which is confirmed by Beauford's article in 1791.

The third section of Walker's *Advertisement* covers the remaining nine tunes in the collection. Section three being about the same length as Section two, less is said about each tune. Walker also uses this section to reinforce the authoritative quality of these tunes as representations of Irish music. Pertaining to some of the tunes, he discusses how and where they were collected from performance. With others, he attaches them to the geographical districts in Ireland with which they are associated.

Of nos. VII, VIII, and IX – "D'eala Mairi liomsa," "Abair a chumain ghil," and "Ailleacan Dubh O!," respectively – Walker says nothing more than that they are "from a period beyond the reach of memory." With these three, it seems including them for their antiquity is an adequate reason for Walker. While looking at various collections in Boston College, I noticed that these three tunes show up in considerably more collections of the surrounding era than do the Provincial Cries. Tunes no. VII – IX, about which Walker says so little, appear frequently in other collections of the time; "D'eala Mairi liomsa" appears as itself and under various similar titles in at least five different collections, "Abair a chumain ghil" appears in at least six, and "Ailleacan Dubh O!" in at least fifteen. Granted, most of the numerous collections in which they appeared came after

Walker's edition. However, it is interesting to note that later collections chose more frequently these tunes, to which Walker had paid such brief attention, and less the Cries, to which Walker had devoted a good deal of space in his *Advertisement*.

In order to discuss the time period of No. X, "Coulin," Walker refers us to the text of his book (p 134). In the text, he recounts the tune's story, provided to him by William Beauford:

In the 28th year of this [King Henry VIII's] reign, an act was made respecting the habits and dress in general of the Irish, whereby all persons were restrained from being shorn or shaven above the ears, and from wearing Glibbes or Coullins (long locks) on their heads, or hair on the upper lip called a Crommeal. On this occasion a song was written by one of our Bards, in which an Irish Virgin is made to give preference to her dear Coulin, (or the youth with the flowing locks), to all strangers, (by which the English were meant) or those who wore their habit. Of this song the air alone has reached us, and is universally admired.

Assuming that Walker was referring to the beginning of Henry's reign in Ireland (as opposed to the beginning of his reign in England), which was in 1519, the Bard would have "composed" it in 1547. As Walker mentioned, however, the words which the air accompanied did not survive.

Following this brief journey to the text of his book to understand "Coulin", Walker redirects his attention in his *Advertisement* to the next two melodies: nos. XI and XII, "Speic Gailleanach" and "Speic Seoach." His introduction to them is a bit confusing. Walker first states, "Several districts of this kingdom have certain appellations for airs which originated in them," wherein the reader is informed of the naming of tunes based on their place of origin, which is not uncommon in traditional music in general. Walker gives the example of "Speic Seoach, the Speic, or 'Humours of Joyce's Country.'" This is the actual title of melody no. XII, but Walker gives the impression that the "Speic," like the Cries, is a particular form. He then writes, "Of these I have given two specimens in Nos. XI. and XII." Granted, these two indeed contain the word "Speic," and their English version titles appear in the 1818 edition as "The Humours of Leinster" and "The Humours of Joyce's Country," the latter of which Walker mentioned in his preface.

Neither of the English titles in the 1818 edition is a very accurate translation. Firstly, the word *speic* does not mean 'humours'. It *can* mean 'peak', as in a mountain.²² It is not clear as to whether there was an obsolete connection between the humour of place and the visual appearance of place. In *Sources of Traditional Irish Music*, these two melodies are the only ones that start with the word *speic*. Also, here it is translated as 'salute', not 'humours'. In addition, tunes that are normally translated as "The Humours of Ö" use the word *pléaráca*, a word associated with revelry.²³ The English version of the word *Gailleanach* is misleading as well. In melody no. IV ("The

Lamentation of Leinster"), we saw that *Gailleanach* means 'Leinster'. Yet here, it appears that *Gailleanach* is meant to refer to Leinster. A possible explanation is that the word *Gailleanach* is associated with the word *gall*, which refers to foreigners.²⁴ As many of the foreign invaders over the years would have entered Ireland through Leinster (the province closest to England), there is a slight possibility that the word *Gailleanach*, at some time, may have been associated with Leinster.

Translation shortcomings aside, Walker does provide the reader with the name of the collector and method of collection, within which is a clue to performance practice, and he also sets an approximate date to the performance. We are told that the two melodies were "pricked from the voice by the Rev. Dr. Young, while on a visit last winter in the county of Roscommon." In Walker's time, the word "prick" was, at times, used to describe the writing down or setting of music by means of 'pricks' or notes.²⁵ The melodies were "pricked from the voice;" therefore it can be known that the tunes were, at least at that particular performance, vocal pieces. Here Walker also refers to his source of collection, the Reverend Dr. Young.²⁶ We also know that, depending on exactly when Walker wrote the *Advertisement*, Young was in Roscommon during either the winter of 1785 or 1784. It is worthwhile here to note that the area referred to as Joyce's Country is a part of Connacht, the western Irish province, of which Roscommon is also part. Walker closes his discussion of these two melodies with the statement, "I will observe, en passant [in passing], that in no part of Ireland do our old melodies so much abound, as in Connaught; that province may be said to be vocal with them." From this we may gather that Walker is making a statement about the frequency of vocal pieces which originated from or were performed in Connacht (as opposed to the other three provinces), two of which he chose to include in his collection.

For melody XIII, "Plough Tune," Walker only refers us to page 132 of his text. Here, he relates that there existed several airs that were sung by the Irish during work. He describes it thus, "Ö Irish ploughman drives his team, and the female peasant milks her cow, they warble a succession of wild notes, which bid defiance to the rules of composition yet are inexpressibly sweet."

Walker closes the third section by stating that nos. XIV and XV ("Carolan's Devotion" and "Tiagharna Mhaighe-eo") are modern, and refers the reader to Appendix No. VI, the "Life of Carolan," specifically to pages 78 and 103. Turlough Carolan (*Coireadach Ó Cearúlláin*, 1670-1738) was born near Nobber, Co. Meath, in eastern Ireland. He was a blind Irish harper who is often attributed as the last of the Irish bards. On page seventy-eight, Walker recounts the story of the origin of "Carolan's Devotion":

The incident which gave birth to Carolan's Devotion, I had from Mr. [Charles] O'Connor: as it is amusing, I will relate it. A Miss Fetherston of the county of

Longford, on her way one Sunday to church in the town of Granard (w) [the "(w)" footnote states this happened in either 1720 or 1721], accidentally met our Bard [Carolan], and began, in the following manner, a conversation with him, which he supported with a "gay impertinence."

Walker then imparts two pages of dialogue between Carolan and Miss Fetherston, wherein he compliments her, and she responds with humility. As they are outside a church, Carolan comments that his devotion would be turned from the divine to herself, if he does not leave her quickly. As he departs, she requests that he visit her home soon, and that in the mean time he pray for her. He agrees, but again refers to his devotion to her, in contrast to devotion to prayer. At the end of this dialogue, Walker states:

Instead of praying for Miss Fetherston, as she requested, he [Carolan] neglected his religious duties to compose a song on her, which, Mr. O'Connor observes, "is a humourously sentimental, but in bad English." In this song he complains, with more gallantry than piety, that the Mass is no longer his devotion, but that now his "devotion is she:" for, amorous from nature, his gallantry did not forsake him even after he had passed that season of life from which Voltaire calls "l'age des passions." The air of this song is pre-eminent amongst his musical compositions: it is, indeed, rich in melody.

On page 103, Walker discusses a controversy over the melody "Tiagharna Mhaighe-eo." The previous page consists of a rather long quotation from a letter written to Walker by Charles O'Connor.²⁷ In this quotation, O'Connor disputes the previous writings of a Dr. Campbell, wherein Campbell had claimed that "Tiagharna Mhaighe-eo" was a composition of Carolan.²⁸ O'Connor relates the "true" story as to how "Tiagharna Mhaighe-eo" came to be, long before Carolan's time. A descendant of the former Lord Mayo apparently composed it in order to stay in his master's favor. O'Connor and Walker both assert that this is the true story, for a descendant of the Mayo family imparted the story to O'Connor. He also imparts that the name of the composer was David Murphy. Walker then presents a translation of the ode, translated by "the elegant translator of Carolan's Monody [. . .] translated by a lady." This anonymous lady was in fact Charlotte Brooke, a poet, translator, and close friend of Walker's. Walker had originally intended to present the original ode in Irish, as well as an English translation, but in a footnote he explains that he could not obtain a copy accurate enough to satisfy him. Also in this footnote, Walker states that Thady Keenan, a friend of Mr. O'Connor, composed the air that accompanies the ode. Unfortunately, Walker does not specify whether or not the transcription of the air "Tiagharna Mhaighe-eo" in his collection of melodies was taken directly from Keenan.

Walker uses the fourth section to close his *Advertisement* with acknowledgements to one of his sources. He states:

I cannot close this advertisement without acknowledging my obligations to Mr. Gore Ousley, second son of my friend R. Ousley, Esq; of Limerick. This young Gentleman exercised his musical skill in committing to notation for my purpose, several of our old melodies; - to him I am indebted for the Provincial Cries.²⁹

In the second section of the *Advertisement*, Walker makes it clear that the Provincial Cries are performed as a set. If Mr. Gore Ousley notated the Cries, and if the Cries had been performed according to the current trend at that time, would he not also have notated the two tunes which envelop them? Though Walker does not specify this, it is highly possible that Ousley *did* transcribe the two enveloping tunes, for Gore was a piper himself and would have been privy to current performance practices as a whole. Also, from the third section, we know that Reverend Dr. Young recorded "Speic Gaillleanach" and "Speic Seoach." Within the text of the "Life of Carolan," Walker makes reference to where he obtained information about "Carolan's Receipt" and "Tiagharna Mhaighe-eo," but he never specifically cites who wrote down the melody for him. Of the other tunes, Walker does not indicate from whom he received them. It appears that Walker himself did not have any aptitude for transcribing melodies; therefore it is reasonable to believe that someone else did. His lack of full annotation and acknowledgement of his sources for the melodies starkly contrasts the heavily annotated text of the book itself, and there is no explanation.

What can be gathered from the *Advertisement* to the Irish melodies is that most of them are old, some of them ancient. The largest question at this time is: why did Walker write so much more about some melodies than others? He states that the Cries are worthy of precedence due to their antiquity. One would speculate, however, that if Walker knew about the overarching Caoinan of which Beauford wrote, he would have mentioned it. It may even be possible that Beauford was inspired by Walker to elaborate on the Provincial Cries, and to set the record straight. It seems that Walker, who would not have read Beauford's article for another five years, found the Cries to be important due to their current performance practice. However, Walker also states that "D'eala Mairi liomsa," "Abair a chumain ghil," and "Ailleacan Dubh O!," are from time immemorial. While they are so old that Walker cannot provide information about their origin, it is surprising that he did not at least state from where he got them. Great attention is paid to the performance practice of the first six as a set; however, Walker gives us little to no information as to the context wherein the other tunes would be performed, although he does acknowledge that some were vocal pieces. One may assume that he only provided information about performance practices of which he knew. It may also be considered that the first six tunes, on which he spends the most time, possibly took away from the time he could have spent discussing the other nine. It is evident in other places in his writing that he simply ran out

of time. Perhaps this was the case with the *Advertisement*, as well. Despite its brevity, we can see that Walker is presenting these tunes as something worth appraising by his readers, some for their historical value, and some for their importance in their day.

Walker's Reception:

If we keep in mind that Walker was a pioneer in his field, it may be possible for us, in hindsight, to forgive him of his shortcomings. However, the literary critics of his day spared him no such mercy. Perhaps the most astounding critique that has survived is the review of Walker's book, by Charles Burney, written for the *Monthly Review* (a British periodical) in December, 1787.

The legacy of Charles Burney (1726-1814) lies in his writings about music. At the time of his review of Walker's *Historical Memoirs of the Irish Bards*, he was sixty-one years old, and was already established in Europe as a definitive authority on Western art-music. This was unfortunate for Walker, as Burney, being British and very knowledgeable in classical music, showed no mercy to an amateur Irishman writing about his native music. Although some of Burney's criticisms are particular and accurate, much of his fourteen-page review consists of generalized, sarcastic, and debasing comments that read now as below the belt. In many of his comments, it seems that Burney is not only criticizing the book, but Walker himself, and even the Irish people in general. Burney does slightly acknowledge his bias by stating:

Mr. W. says, 'it is the fashion of the day to question the antiquity of Irish MSS.;' and we see plainly, in England, that it is the fashion of the day to give them an antiquity and a credence, in Ireland, that we are unable to allow. If the Irish ask too much respect and reverence for these fables, the English will certainly give them too little.³⁰

He is essentially prefacing the review by stating that Walker's work is asking too much of the reader.

Burney also criticizes Walker's sources of information or lack thereof. Walker's work is heavily footnoted, with ample information as to where he obtained information (there are 549 references to 188 authors, one of whom was Burney himself). He may have done this in order to establish some credibility. However, Burney does not see it this way. He criticizes Walker for citing books which would have already been common knowledge to the educated reader, writing:

[...] notwithstanding these innumerable proofs of the Author's acquaintance with books in all the living as well as dead languages, they only remind us that he is a young book-maker, and has not yet read enough to know what has been already often quoted, and what is still worthy of a place in a new book written with taste and elegance.³¹

Walker himself had stated in his book that, as he was delving into the shadows of antiquity, it was sometimes difficult to establish some information as fact. In the cases where Walker does not have substantial evidence for his ideas, and can't cite them, we see that he carefully proposes the ideas, acknowledging that, due to their antiquity, they may or may not be valid, but there was no way to know. Burney quickly criticizes Walker's use of words such as *perhaps*, *probably*, and *we may suppose*, writing:

[...] the Author [Walker] is to be pitied, for he has nothing better to offer on this occasion, except a poor *perhaps*, which in these incredulous times is not current coin. 'Perhaps the Irish Readan, Fideog, or Lonloingean, were flutes; or rather Recorders, which are still more simple in the construction, but extremely soft and sweet.' And perhaps they were *not* – who knows? – or, indeed, who cares?³²

It is important to note that Burney points out that speculation is not "current coin." This may be true for studies of British antiquity, where they had not centuries of occupation inhibiting them from properly recording their native history, and therefore having more solid evidence and ample records. This was not the case with Irish antiquity, as many hindrances, British occupation being one of them, rendered the creation and preservation of writings throughout the ages more difficult.

Burney goes on from there to nitpick at anything and everything that he can find wrong with Walker's book, and Walker himself. He even uses typos of words, both in English and in French, within the Walker's text to belittle Walker and question his understanding of French, in which Walker was fluent.

Near the end of Burney's review, he devotes half a page to the "Select Irish Melodies." Among other criticisms, he writes, "... the first five ["Cath Eachroma" and the Provincial Cries] are so rude and similar, that they afforded us little amusement."³³ Of course, Burney would have had to wait four more years to read Beauford's article,³⁴ in order to understand the reason why they were so similar. Nonetheless, if he had read Walker's *Advertisement* more carefully, he might at least have gathered that they were called Cries for a reason; the Cries were not for amusement, they were originally for funerals! Burney also claims that several of the melodies sounded more Scottish than Irish. Due to the close proximity of Scotland to Ireland, it is natural that they would have melodies that were the same or similar. These tunes were later collected by other Irish collectors, and still considered "Irish," despite Burney's accusations. Finally, Burney states of Walker and his tunes, "... it is to be feared, [...] that the national melody of our neighbouring island will not be adopted at the opera, so soon as he thinks it ought." Ironically, one of Walker's tunes had already been adopted at the opera, a *British* opera which had premiered five years previously. Walker's melody no. IX, "Ailleacan Dubh O!" was first published as the melody for the song "Sleep on, sleep on" in the *British*

comic opera, *Poor Soldier*, by John O'Keefe and William Shield. Overall, it appears that Burney's goal was not to review Walker's book, but to demolish any credibility that Walker might have had.

Walker's colleagues were on his side, however. In a letter from Charles O'Connor, we see O'Connor attempting to console Walker:

Be by no means concerned [with] the *critique* of the critical reviewers on your book. They are n[ot] just in censuring your quotations from ancient and modern writers. Without such authorities how could you support many of your facts? Would they not censure you for omitting them? Why did I not commend you for the lights you have cast on a subject never att[empted] before you by an antiquary of our island? In many instances it [should] be shown that the reviewers of France, England, and Germany have been hurtful to true knowledge by giving but too often a wrong direction to the public judgments.³⁵

This letter was dated in 1786, and therefore preceded Burney's review. It seems that Burney was not the first to criticize Walker harshly. Oddly, it seems that Walker's reception was friendlier in Rome than his own country, for two other letters from O'Connor state:

My grandson in Rome assures me that your *Memoirs* on our *Irish Bards* is much approved of. The literate of that capital do you justice, and they will do more on the next edition of your book. [Ö] your book has had a good reception from such Roman readers as understand our language, and one gentleman in particular wants a copy of your *Bards*, which I could wish that you forwarded to Rome by the first opportunity.³⁶

It is possible that those in England and Ireland who criticized Walker were too close to the trees to see the forest, and it was only at a cultural distance that one could appreciate the steps Walker was taking to forge a path in Irish ethnography.

As was mentioned earlier, despite its unfriendly reception, there was a second edition. Enlarged to two volumes, the first volume consisted of the original book and its appendices; the second volume consisted of a preface written by Walker, several of his essays, and twenty-two appendices written by himself and his colleagues on matters of Irish interest. It was published eight years after Walker's death, with no indication as to who put forth the effort to publish it. There is some evidence that whoever got Walker's book published tampered with at least one point in the text. Walker cites O'Connor's *Dissertations on the History of Ireland* several times within his essays. The footnote cites the "3rd Ed.," and edition which was not published until 1812 (two years past Walker's death). However, he also cites Ledwich's *Antiques of Ireland*, a book which was in second edition by 1804,

but no one changed that citation to make it more up to date. It is feasible that Walker was working on it at some point during his life. However, as some of the essays are in the form of a letter to Walker from the author, it appears that not much was done to the manuscript that would become the 1818 edition past 1788, as there are no dates on letters or in the text indicating that anything was being written after that year. If Walker had intended a second edition, which is likely, for O'Connor referred to a second edition in his letter, Walker certainly had most if not all of the materials compiled by 1790. Currently, the most likely explanation for his lack of publishing at that time was his downfall due to Burney and other critics, and the overshadowing by the likes of Edward Bunting, whose renowned collections of Irish were mentioned in the introduction to this essay.

Edward Bunting (1773-1843) was an Irish music collector who published three large collections in his lifetime: *A General Collection of the Ancient Irish Music* (1796), *A General Collection of the Ancient Music of Ireland* (1809), and *The Ancient Music of Ireland* (1840). The fault of Bunting is that he altered the music he recorded so that it could be played on a piano, therefore making it more profitable. Bunting's collections may give us the notes that were played by harpers of the day, but were transposed from their original key to keys that harpers couldn't play. Whereas a proper ethnomusicologist would have made careful note of the technique of the melody being played by both hands of the harper, Bunting loses any indication of this by rearranging the music so that the melody is in the right hand and the accompaniment is in the left hand. Though we owe Bunting credit for the sheer quantity of melodies he collected, we may now wish that he had also published the original versions of his tunes.³⁷ Walker's aim was to publish the music just as it was; Bunting's aim was to publish the music so that it was accessible to the classical ear, and playable in the parlor.

Conclusion:

Between the likes of criticisms of Burney and the quantity of Bunting, Walker seems to have been kept from receiving the credit he was due as a pioneer ethnomusicologist. Over the last two centuries, critics of Walker have dismissed him as an amateur, and therefore not worthy of attention. Finally, in 1965, the Irish historian R. A. Breathnach, though admitting Walker's dilettantism, granted Walker this much, writing, "The author of *Historical Memoirs of the Irish Bards* deserves to be remembered for his enthusiastic advocacy of Irish learning when perhaps such advocacy was of greater importance than scholarly competence."³⁸

Joseph Cooper Walker himself admitted that he was an amateur, in the sense that there could not be, at this time, such a thing as a professional in this field. In the preface to his book he wrote:

I do not pretend to have done completely, what has lain so long undone: no doubt many sources of information still remain unopened, and many

documents unconsulted. However, I have marked out a path which may facilitate the pursuit of those who shall hereafter follow me.

Walker, influenced by the love of his culture and his country, wrote of its bardic past, its poetry, and its music. He provided one of the earliest written records of Irish music. Several of the melodies in his 1786 collection had never been previously published anywhere else. In fact, two of the melodies, "Gair Mhuimhneach" and "Gair Olltach," do not appear in any other collections at all, before or after Walker.³⁹ The rest of the Provincial Cries appear in two other collections. For this alone he should be remembered. What makes Walker such an important figure in Irish ethnography and ethnomusicology is not that he was the best in his field, but that he was one of the first in his field. In his own words above, he stated, "However, I have marked out a path which may facilitate the pursuit of those who shall hereafter follow me." Any one who walks today on the path of Irish ethnography must surely acknowledge that that path was forged for them by those who walked it previously, including Joseph Cooper Walker.

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Endnotes:

¹ Joseph Walker. *Historical Memoirs of the Irish Bards* (1786; 2d ed. Dublin: J. Christie, 1818).

² A General Collection of the Ancient Irish Music (1796), A General Collection of the Ancient Music of Ireland (1809), and The Ancient Music of Ireland (1840).

³ See Figure 1.1 (p 7) for facsimile of the Advertisement, and Figure 1.2 (p 8) for a transcription of the Advertisement.

⁴ Pat Boran, *A Short History of Dublin* (Dublin: Mercier Press, 2000), 61.

⁵ There did previously exist, founded in 1731, the Dublin Society for

the Improvement of Husbandry, Manufacturing, and Other Useful Arts. However, its only tangible contribution up to the 1780s consisted solely of a school of art in 1740. The Dublin Society later came under the patronage of George IV in 1820, and became the Royal Dublin Society. Brian Lalor, Ed. *The Encyclopedia of Ireland*, s.v. "Royal Dublin Society," by Dervilla Donnelly (New Haven: Yale University Press, 2003).

⁶ *Encyclopedia of Ireland*, s.v. "Royal Irish Academy," by Peter Harbison.

⁷ Joseph Walker, *Historical Memoirs of Irish Bards* (1786; facsimile, New York: Garland Publishing, Inc., 1971), v.

⁸ Walker, *Irish Bards* (1786), 158-159.

⁹ *Oxford English Dictionary Online*, s.v. "1. advertisement," http://dictionary.oed.com/cgi/findword?query_type=word&queryword=advertisement (accessed March 26, 2004).

¹⁰ For Scanning purposes, the 1971 facsimile of Walker's Irish bards was used for Figures 1.1, 2.2 and 3.2

¹¹ The actual Battle of Aghrim took place on 12 July 1691, in which Godard van Reede, a Dutch soldier who had previously been appointed lieutenant general of the English cavalry in Ireland by King William III, defeated Irish Jacobites after recently capturing the town of Athlone. Athlone is located on the eastern edge of Roscommon, a county located in the northeast.

¹² "Lament, ß Europe." *Grove Music Online* ed. L. Macy (Accessed 26 March 2004), <<http://www.grovemusic.com>> Publications, 1993), 12.

¹³ Such as: Thomas O Canain, *Traditional Music of Ireland* (Cork: Ossian Publications, 1993), 12.

¹⁴ John O'Brien, *An English-Irish Dictionary* (1767; 2d ed. Dublin: Printed for Hodges and Smith, 1832), s.v. "na" and "guilim."

¹⁵ Cromwell first became Governor of Ireland in August 1649.

¹⁶ Alan Brown, "Dump," *The New Grove Dictionary of Music and Musicians*, ed. S. Sadie and J. Tyrrell (London: Macmillan, 2001), 7, 702-703.

¹⁷ O Canainn, *Traditional Music*, 12.

¹⁸ *Oxford English Dictionary Online*, s.v. "dump, n1," http://dictionary.oed.com/cgi/findword?query_type=word&queryword=dump (accessed March 26, 2004).

¹⁹ Beauford was a friend and colleague of Walker, and a member of the RIA.

²⁰ William Beauford, "Caoinan: or some Account of the Antient Irish Lamentations," *Transactions of the Royal Irish Academy* IV (1791), 83, 41-54.

²¹ Beauford "Caoinan" *Transactions*, 43-44.

²² For those with little to no musical background: A capital letter (note) by itself refers to that note within the range of middle C to the octave above middle C. A letter with a prime mark represents the note in the octave above that. For example, G is simply called "G", and is the G above middle C. G' is called "G prime" and is the G an octave above G above middle C.

²³ Rev. Patrick S. Dineen, *Foclóir gaedhíle agus bÉarla: An Irish-English Dictionary* (Dublin: Irish Texts Society, 1996), s.v. "speic."

²⁴ Dineen, *Irish-English Dictionary*, s.v. "pléarásca"; Seamus Connelly, Director of Irish Studies Music Program, Boston College, conversation with the author, February 25, 2004.

²⁵ Breen "Conchubhair, Assistant Professor of Irish Studies, Boston College, conversation with the author, February 25, 2004.

²⁶ This usage is now obsolete. *Oxford English Dictionary Online*, s.v. "prick, v.," http://dictionary.oed.com/cgi/findword?query_type=word&queryword=prick (accessed March 26, 2004).

²⁷ Rev. Dr. Young was a fellow of Trinity College Dublin, a member of the RIA, and a friend of Walker's.

²⁸ Charles O'Connor, a Catholic historian and friend of Walker, was a senior figure and learned member of the RIA; he was a highly respected and valuable resource of information to Walker and his colleagues.

²⁹ Thomas Campbell, *A Philosophical Survey of the South of Ireland: in a series of letters to John Watkinson*, M.D. (Dublin: Printed for W. Whitestone, W. Sleater, etc., 1778), Letter 44.

³⁰ Ralph Ousley, Esq., was also a member of the RIA.

³¹ Charles Burney, "Review of Walker's Irish Bards," *Monthly Review* (December 1787), 425-6.

³² Burney, "Review of Bards," *Monthly Review*, 426.

³³ *Ibid.*, 429.

³⁴ Burney, "Review of Bards," *Monthly Review*, 438.

³⁵ Refer to page 12.

³⁶ Robert Ward, etc. Eds. *Letters of Charles O'Connor of Belanagare: A Catholic Voice in Eighteenth-Century Ireland* (Washington, D.C.: The Catholic University of America Press), 476.

³⁷ *Ibid.*, 481, 485.

³⁸ As Bunting's papers are held in an archive in the Queen's University Belfast, it is possible that some of the original manuscripts do exist here, and may be more true to performance practice than his published works. It is my intention, during my graduate study in Ireland, to see these manuscripts.

³⁹ R. A. Breathnach, "Two Eighteenth-century Irish Scholars: Joseph Cooper Walker and Charlotte Brooke," *Studia Hibernica* 5 (1965), 97.

⁴⁰ Aloys Fleischmann and Mícheál "O Súilleabhain, *Sources of Irish Traditional Music, c. 1600-1855*. (New York: Garland, 1997).

Table 1: Titles of Walker's Irish Melodies, 1786 Edition

I	Cath Eachroma
II	Gair Chonnachtach
III	Gair Mhuimhneach
IV	Gair Olltach
V	Gair Laighneach
VI	Gol na mna'san ar
VII	D'eala Mairi liomsa
VIII	Abair a chumain ghil
IX	Ailleacan Dubh O!
X	Coulin
XI	Speic Gailleanach
XII	Speic Seoach
XIII	Plough Tune
XIV	Carolan's Devotion
XV	Tiagharna Mhaighe-eo

Table 2: The Segmented Caoinan, with the corresponding sections in Walker

	Caoinan Section	First	Last	Walker Titles	Section	First	Last
	Opening Cry	F	D	Gol na mna'san ar	Entire	F	D
1st	First Semi-Chorus	D	E	Gair Chonnachtach	Pick-up measure to m4 b3	D	E
	Second Semi-Chorus	E	G	" "	m4 b4 - m8 b2	E	E
	Full Chorus A	G	G	" "	m8 b3 - m15; m22 - 26 (end)	G	G
	Full Chorus B	G	D'	not present	not present	n/a	n/a
2nd	First Semi-Chorus	D'	E'	Gair Mhuimhneach	Pick-up measure to m4 b3	D'	E'
	Second Semi-Chorus	E'	E'	" "	m4 b4 - m8	E'	E'
	Full Chorus A	G'	G	" "	m9 - 17; m28 - 32 (end)	G'	G
	Full Chorus B	G	D	not present	not present	n/a	n/a
3rd	First Semi-Chorus	D	E	Gair Olltach	Pick-up measure to m4 b3	D	E
	Second Semi-Chorus	E	B	" "	m4 b4 - m6 b3	E	B
	Full Chorus A	(C') B	G	" "	m6 b3.5 - m14; m19 - 24 (end)	(C') B	G
	Full Chorus B	G	G	not present	not present	n/a	n/a
4th	First Semi-Chorus	G	B	Gair Laighneach	Pick-up measure to m4 b3	G	B
	Second Semi-Chorus	B	D'	" "	m4 b4 - m9 b3	B	D'
	Full Chorus A (end)	D	G	" "	m9 b4 - m19 (end)	D	G
	Full Chorus B	n/a	n/a	not present	not present	n/a	n/a

Figure 1.1: Facsimile of Walker's 1786 Advertisement¹⁰

A D V E R T I S E M E N T.

HAVING occasionally treated of Irish Music in the Historical Memoirs of the Irish Bards, I will here subjoin a few specimens of it, for the purpose of illustrating that part of my subject.

The remote antiquity of NA GUIL (a), or Irish Cries, entitle them to precedence; but modern Musicians having determined to give this extraordinary piece of Music a dramatic form, united it with a wild air of their own days called CATH EACHROMA, or Battle of Aghrim, which serves as a kind of prologue to The Cries. I have therefore given the Cath Eachroma the first place in this little collection. After this air is played, the Provincial Cries (Nos. II, III, IV, and V.) are performed in succession: then (No. VI.) a melancholy tune, or dump (which is said to have been sung by the Irish women, while searching for their slaughtered husbands, after a bloody engagement between the Irish and Cromwell's troops) follows; and the whole is supposed to conclude with a loud shout of the auditors, meliorated by affliction.

Nos. VII, VIII, and IX. are melodies of a period beyond the reach of memory.—The era of No. X. I have already determined. (b)——Several districts of this kingdom have certain appellations for airs which originated in them, as Speic Scoach, the SPEIC, or Humours of Joyce's Country. Of these I have given two specimens in Nos. XI. and XII. which were pricked from the voice by the Rev. Dr. Young, while on a visit last winter in the county of Roscommon. I will here observe, en passant, that in no part of Ireland do our old melodies so much abound, as in Connaught; that province may be said to be vocal with them.—No. XIII. is noticed in page 132 of the Hist. Mem. of the Irish Bards.—Nos. XIV. and XV. are modern, and mentioned in the Life of Carolan; see pag. 78 and 103.

I cannot close this advertisement without acknowledging my obligations to Mr. Gore Ousley, second son of my friend R. Ousley, Esq; of Limerick. This young Gentleman exercised his musical skill in committing to notation for my purpose, several of our old melodies;—to him I am indebted for the Provincial Cries.

(a) Hist. Mem. of the Irish Bards, p. 67.

(b) Ibid. p. 134.

¹⁰ For scanning purposes, the 1971 Facsimile of Walker's *Irish Bards* was used for this Figures 1.1, 2.2, and 3.2.

Figure 1.2: Transcription of Walker's 1786 Advertisement.

ADVERTISEMENT

HAVING occasionally treated of Irish Music in the Historical Memoirs of the Irish Bards, I will here subjoin a few specimens of it, for the purpose of illustrating that part of my subject.

The remote antiquity of Na Guil (a), or Irish Cries, entitle them to precedence; but modern Musicians having determined to give this extraordinary piece of Music a dramatic form, united it with a wild air of their own days called Cath Eachroma, or Battle of Aghrim, which serves as a kind of prologue to The Cries. I have therefore given the Cath Eachroma the first place in this little collection. After this air is played, the Provincial Cries (Nos. II, III, IV, and V.) are performed in succession: then (No. VI.) a melancholy tune, or dump (which is said to have been sung by the Irish women, while searching for their slaughtered husbands, after a bloody engagement between the Irish and Cromwel's troops) follows; and the whole is supposed to conclude with a loud shout of the auditors, meliorated by affliction.

Nos. VII, VIII, and IX. are melodies of a period beyond the reach of memory. — The era of No. X I have already determined. (b) — Several districts of this kingdom have certain appellations for airs which originated in them, as Speic Seoach, the Speic, or Humours of Joyce's Country. Of these I have given two specimens in Nos. XI and XII. which were pricked from the voice by the Rev. Dr. Young, while on a visit last winter in the county of Roscommon. I will here observe, en passant, that in no part of Ireland do our old melodies so much about, as in Connaught; that province may be said to be vocal with them. — Nos. XIV and XV. are modern, and mentioned in the Life of Carolan; see pag. 78 and 103.

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(a) Hist. Mem. of the Irish Bards, p. 67.

(b) Ibid. p. 134.

Figure 2.1: Opening cry in the Irish Caoinan, from Beauford

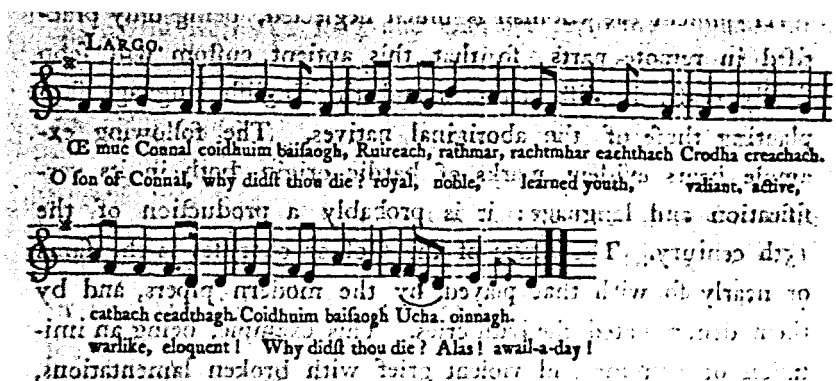


Figure 2.2 “Gol na mna’san ar” from Walker’s 1786 Edition²²

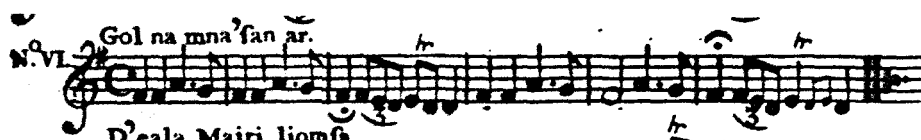


Figure 3.1: First Semi-Chorus, or Ullaloo in Beauford.



Figure 3.2: Opening Measures of “Gair Chonnachtach” from Walker’s 1786 Edition.



Faculty Comment:

Dr. Rembrandt Wolpert, Ms. Morris's mentor made very interesting observations about his student's work in his letter nominating this study for publication. He said:

Hilary's love of and deep commitment to things Irish found an outlet here when she discovered on the open shelves in Mullins Library a copy of what turned out to be the second edition of Joseph Cooper Walker's two-volume *Historical Memoirs of the Irish Bards*, published in Dublin in 1818. She set her heart on finding out about the forty-three "Select Irish Melodies" included as an Appendix to Volume One: a task in historical ethnomusicology which she knew from the outset would have to be conducted primarily via inter-library loan and a well prepared research visit to the Irish Music Archives of Boston College.

Walker soon emerged as Hilary's "Forgotten Irish Bard". The first edition of his work was published in 1786, included only fifteen tunes, but pre-dates by ten years the first of the large, well-known collections of Edward Bunting, *A General Collection of the Ancient Irish Music* (1796). Indeed, Walker's predating Bunting places his fifteen initial tunes right at the beginning of systematic collecting of traditional Irish melody. The deeper Hilary delved into writings of the time and since, however, the clearer it became to her that Walker is at best strangely under-represented, at worst maligned for dilettantism in the bulk of his work, and belittled for the tunes he chose to offer. And this right up until recent scholarship, despite the evidence from her painstaking combing through catalogs and tune indices that the six tunes classed together as a "Suite of Cries" and placed first in Walker's tune-sets (in the first and the second edition) appear to be remnants of an archaic lamentation ritual that, thanks to his recognition then of their "remote antiquity", make their first — and for two of the "Cries", only — appearance on the vast terrain of Irish Music Collections.

Hilary's research into Walker's early reception threw up an extensive and destructive review of *The Historical Memoirs*, published in 1787, the year immediately following Walker's work, by none other than the English music-scholar Charles Burney himself, perhaps the leading figure in Music criticism of the

day. (Here Hilary highlights the political context for Walker's book and the age old English-Irish rivalry.) Letters to Walker from scholarly friends in the Irish Academy reveal the extent of his personal devastation, but also their unshaken faith in the importance of what he had achieved for the elevation of Irish antiquities. Indeed, presumably sparked off by Walker's study, one of his colleagues in the Academy, William Beauford, published five years later, in 1791, a musical study of the practice of lamenting, or Caoine, that, as Hilary argues, supports and adds to what Walker had provided by publishing "The Cries" and documenting his tune-collection.

This last aspect, Walker's documentation, is Hilary's reason for placing him as a pioneer "ethnomusicologist" among the early Irish ethnographers. Walker prefaces his fifteen "Select Irish Melodies" with a short *Advertisement*, providing the rationale for his presenting the tunes, invaluable information on current performance practice, data about by whom, how, and where some of the tunes were committed to paper, and so on. Hilary treats this *Advertisement* as the primary document it is, minutely dissects it, and follows the threads out into the body of Walker's book and beyond to the collections held at Boston College to build her argument for re-evaluating Walker's contribution. She argues that some of his circumspection on the one hand and daring speculation on the other, both so irritating to Burney, necessarily belong to the special risks that must be taken by the pioneer in a field. She also lays bare the poignancy of the scholar devastated by the more influential reviewer, and hints that this initial reception may have more than temporarily sidelined his contribution to the history of Irish Music.

This has been a fun venture from start to finish. With her Irish background, as a double-major in French and Music, and having already begun study of Irish language and music, Hilary is particularly suited to this sort research. Her love of words and where they come from, coupled with her historical interests translate easily into the sort of nitty-gritty but contextualised work required for working through tune-indices and archival collections, and bodes very well indeed for her planned graduate work also on living traditions in Ireland.

SECTION II: SOCIAL SCIENCES AND BUSINESS

ACCOUNTING, ECONOMICS, AND FINANCE

AN INVESTIGATION OF ELECTRONIC TAX FILING IN ARKANSAS

By Angela LeRae Adams
Department of Accounting

Advisor: Dr. Deborah Thomas
Department of Accounting

Abstract:

As a part of the IRS Restructuring and Reform Act of 1998, Congress set a goal for the IRS to have at least 80 percent of federal tax returns filed electronically by 2007. During the last tax filing season, electronic filing of tax returns increased by around 9 percent, up to 41 percent of individual returns filed, with over 18 million taxpayers filing state and federal returns simultaneously.¹ While the number of electronic returns is increasing, the IRS is unlikely to reach its 80 percent mandate by 2007.

Government taxing agencies are actively pursuing ways to use technology to increase effectiveness and efficiency while decreasing costs. In order to reach more citizens, research is needed to identify who currently e-files and what are the barriers for those that do not. In response, a survey was mailed to Arkansas citizens concerning their use of electronic filing for federal and state tax returns. The goal was to identify demographic characteristics of taxpayers that file electronically versus those that do not. Responses were statistically analyzed for variations. The results provided a basis for research into possible actions the government can take to increase the number of e-filers. The findings will be of interest to the IRS and state tax authorities, tax researchers and the general public. This is due to the fact that government agencies can create cost savings by automating more of their services and transactions, and these benefits accrue to the public through lower taxes or increased public goods.

Introduction:

Although the Internal Revenue Service (IRS) is attempting to increase electronic tax filing compliance, less than half of American taxpayers are filing their returns electronically. Electronic filing is beneficial to taxpayers and tax preparers for many reasons. In addition, there are numerous benefits for the Government and the IRS. Consequently, as part of the IRS Restructuring and Reform Act of 1998, Congress has set specific goals for the IRS regarding electronic tax filing. The purpose is to encourage the IRS to deliver improved service to taxpayers,

while taking advantage of the benefits it can provide. However, for various reasons, which we will explore, it is not likely that the IRS will reach its goals.

The purpose of this paper is to identify possible actions that the IRS can take to increase compliance. While Congress is aiming its goals of increased electronic filing at businesses, as well as individuals, the focus of this research will concentrate on individual tax filing. In order to determine factors that contribute to the decision to file electronically, a survey was mailed to Arkansas citizens about their use of electronic filing for federal and state tax returns. The goal is to identify demographic characteristics of taxpayers that file electronically versus those that do not. In addition, respondents that do not e-file will be asked about the reasons they do not and what changes would be required for them to file electronically in the future. Once this information is obtained, decisions can be made on a course of action to reach the targeted goals. The results will be of interest to the IRS and state tax authorities, tax researchers, tax practitioners and the general public.

Federal Objectives of IRS Restructuring and Reform Act:

In the IRS Restructuring and Reform Act of 1998 (RRA 98), Congress set several goals for the IRS regarding electronic tax filing. The primary objectives that were provided to the IRS include¹:

1. Paperless filing should be the preferred and most convenient means of filing federal tax and information returns,
2. The goal of the Internal Revenue Service to have at least 80% of returns filed electronically by the year 2007; and
3. The Internal Revenue Service should cooperate with and encourage the private sector by encouraging competition to increase electronic filing of returns.

Since the enactment of RRA 98, the IRS has continually searched for ways to improve compliance rates. The use of electronic filing has many advantages for all parties involved.

However, the trends of electronic filing in recent years have been less than satisfactory.

Advantages and Disadvantages of Electronic Tax Filing:

There are numerous advantages of filing electronically. There are potential benefits for the government, return preparers, and individuals alike. Some of the advantages offered by electronic filing include cost savings, reduction of errors, and faster refunds. However, many disadvantages of the current system have been identified as well. One of the most obvious disadvantages is the possibility of security weakness that would threaten taxpayer confidentiality. It is necessary to more closely examine both the advantages and disadvantages of electronic filing in order to discover new methods of recruiting non-electronic filers" (Table 1).

The government has many incentives associated with electronic filing. First of all, the processing costs of electronic filing are significantly lower. The labor costs of manually entering tax data are dramatically cut when the data is submitted electronically. In addition, there is a reduction in entry errors, time for processing, and general burden of entering the returns. Another benefit that has recently gained some recognition is the decrease in number of callers at the IRS call center. This is due to the decrease in errors and faster processing time. As electronic filing grows, more and more cost savings are recognized. Due to the decrease in paper returns, the IRS was able to close its first tax return processing center in Brookhaven in 2003, and there are plans for additional closings in the future. All of the cost savings will allow the government to reallocate funding to areas that may benefit the public sector as well.

As previously stated, return preparers and individual filers are seeing benefits as well. For these groups, the reduction in errors means that they will experience a much simpler process, without the burden of post-filing issues. Increased convenience includes the possibility of free tax filing, electronic payment options, and faster refunds. The timeliness of tax refunds has been a big motivator for those that are due refunds. However, for those that owe the government money, they prefer to postpone payment.

Unfortunately, along with all of the benefits of electronic filing, there are shortcomings as well. There has been concern that security weaknesses may threaten the confidentiality, integrity, and availability of sensitive systems and taxpayer data. The current system is simply not advanced enough to handle the type of overhaul that is needed. Over the past few years Congress has spent a substantial amount of money in business systems modernization. They have fully funded IRS budget requests as well. Another problem is that taxpayers with extremely complicated tax returns simply cannot file electronically. Until these issues are addressed, many filers will probably continue with paper filing.

Table 1: Summary of Electronic Filing Advantages/Disadvantages

Advantages	Disadvantages
Cost Savings	Security weaknesses
Convenience	Complicated returns
Reduction of errors	Possible cost issues
Fast confirmation	
Faster Refunds	

Recent Activities and Trends:

Congress and the IRS have attempted to increase the number of electronic filers through various programs. Of the actions taken thus far, one of the most important may be the Free File Alliance. In 2003, several tax software companies formed an agreement with the federal government to offer free electronic filing to certain taxpayers. The alliance encourages those that would not ordinarily pay someone to prepare their taxes to file online. It is also convenient for residents of the eight states who are now requiring mandatory filing of returns. Previously it was much cheaper for individuals to pay the price of mailing a paper return, rather than paying the fee for electronic filing. Hopefully this alliance will persuade more taxpayers to e-file.

However there are limitations as to who can file for free under the program. Only about 60% of taxpayers are qualified to use Free File. The software companies have various conditions under which the taxpayers must fall in order to qualify. Eligibility is based on factors such as income, age, state of residence, and type of form being filed.

The IRS has considered developing its own software or providing direct filing via its Web Site. However, private sector businesses that earn a substantial amount income from electronic filing would be devastated should this occur. They would lose the majority of their business, which would require the government to address the issue of unfair competition. Furthermore, as stated by Jason Mahler, general counsel for the Computer & Communications Industry Association, "We don't think it's the proper role for the IRS to be sitting side by side with the consumer determining how much money they owe the government."ⁱⁱ

However, the IRS website does make it possible for taxpayers to make payments online through the Electronic Federal Tax Payment System (EFTPS). Through the EFTPS, taxpayers may make tax payments through the Internet or by phone. In addition, taxpayers may elect to instruct their financial institution to electronically place the funds in the Treasury's account. Should taxpayers choose to use the EFTPS, the benefits include convenience, accuracy, flexibility, ease of use, and fast and economical payment.

Another attempt that Congress has made to increase the incentives for electronic filing is a bill that would extend the April 15th deadline to April 30th for those who file and pay taxes electronically. The Taxpayer Protection and IRS Accountability Act of 2003, H.R. 1528, was passed in the House of Representatives on June 19, 2003. However, it still awaits decision by the Senate. This would be a big incentive for the approximately 30% of taxpayers who owe the government money each year, as it would allow them an extra 15 days to pay up. This issue has also been addressed in President Bush's 2005 Budget Proposal. In his proposal, returns would have to be filed and paid electronically by April 30th. Paper filers would still be required to pay by April 15

The practitioner community, including the American Institute for Certified Public Accounting (AICPA), have raised various concerns over the proposed due date change, citing the following reasons²:

- Taxpayer confusion over inconsistent due dates
- Paper extensions would still be required on April 15
- Estimated tax calculations on April 15 would not be avoided
- Added burden on practitioners
- Confusion due to non-conforming state and local Departments of Revenue
- Illusory incentive to file electronically
- Move away from "National Tax Day" of April 15

Several states are enacting various mandates that are aiding in federal initiatives. Many are requiring that tax preparers file individual returns electronically. The guidelines differ from state to state, but generally only require that practitioners who

file a certain number of returns comply. These practitioners may face penalties, such as fines, for non-compliance.

So, what has all of this done for e-file compliance? During the 2003 filing season, electronic filing of tax returns increased by 12.5 percent, up to 42.1 percent of individual returns filed, with over 18 million taxpayers filing state and federal returns simultaneously. However, this is down from the previous year's increase of 16.4%. According to the IRS, the 2004 filing season million returns, of which 45.8 million were filed electronically. If this is a good representation of the remainder of the filing period, approximately 62% of taxpayers will file electronically. While the number of electronic returns is increasing, if the current trends continue (Table 2)³, the IRS is unlikely to reach its 80 percent mandate by 2007. In the five years after RRA 98 was enacted, less than half of filers have been motivated to file electronically. If trends continue at these rates, the IRS could expect a very disappointing number of taxpayers to be filing online by the deadline. And even more importantly, it will likely be much harder to motivate the remaining paper filers to change. For these reasons, the IRS is aggressively searching for ways to reach the targets. Therefore, it is necessary to find different ways to encourage these taxpayers to convert to electronic tax filing.

Survey of Arkansas Taxpayers:

In order to understand better the reasons that taxpayers continue to file paper returns, a survey was conducted among a sample of Arkansas residents (see Appendix A). This information will serve as an aid in determining the motivators of filing electronically, as well as things that can be done to further motivate those that have not yet converted to electronic filing. The residents were asked to respond to questions concerning tax filing for the 2002 taxable year. These questions examined the following three groups of characteristics of the filers:

Table 2: Growth of Electronic Filing for Individual Tax Returns (millions)

Year	Total Returns	On-line returns ¹	Practitioner returns	Telefile returns	Total electronic returns	Percent returns e-filed	Percent growth of e-filed returns
2003 ²	124.1	11.8	36.4	4.0	52.2	42.1	12.5
2002	131.7	9.4	33.1	4.2	46.7	35.5	16.4
2001	131.0	6.8	28.8	4.4	40.1	30.6	13.3
2000	128.4	5.0	25.2	5.2	35.4	27.6	20.8
1999	126.0	2.4	21.2	5.7	29.3	23.3	20.1

Taken from IRS Oversight Board Electronic Filing Annual Report to Congress (November 2003)

Table 3:

Demographics	Filing History	Motivations
Gender	Access to Internet	Motivators for electronic filing
Race	Knowledge of electronic filing	Reasons for not filing electronically
Age	Type of form filed	Other incentives to file electronically
Income	Extra schedules that were filed	
Marital Status	Expectations of refund	
Number residing in household	Use of refund	
Level of schooling	Use of CPA	
Size of community		

Survey Response:

The survey was mailed to a random sample of 1000 Arkansas residents. The names and addresses were obtained from a sampling agency, Survey Sampling, Inc. Of the 1000 surveys that were mailed out, 191 usable surveys were included in the analysis. Representing a 19.1 % response rate. Not included in the useable surveys were 38 surveys that were returned undeliverable, and 7 surveys that were returned indicating that the respondent was not able to complete the survey due to the fact that they were deceased or did not file a return. This left a possible sample of 955 residents, which produces a response rate of about 20%.

Table 4:

Surveys Mailed:	1000
Returned Undeliverable	(38)
Delivered	962
Total Responses	198
Unusable/Incomplete	(7)
Usable Responses	191
Response rate	19.85%

Descriptive Statistics:

In order to determine what differentiates electronic filers from paper filers, it must be determined which if any forms the respondents filed electronically in the last filing year. According to the results of the survey, approximately 37% of taxpayers filed at least one of their returns electronically, while the remaining 63% filed both their state and federal forms by a paper method. In addition, the majority of taxpayers chose to file both electronically, if they were going to file any in that manner. This is consistent with current IRS statistics of e-filing compliance.

The respondents also exhibited certain demographic characteristics that would be worthwhile to note. Based on the responses from all who participated in the survey, 92% of them were Caucasian. The remaining respondents were African American, Asian, or Native American, representing 6%, 1%, and 1%, respectively. In addition, 62% were male while only 38% were female, 77% were 40 years old or over, 86% had a least some college education, and 73% were married. Refer to Appendix B for a detailed list of response statistics.

Current Motivations and Additional Incentives:

Electronic filers were asked to identify their motivations for filing electronically. They were asked to indicate all factors that contributed to their decision. Figure 1 shows the response results.

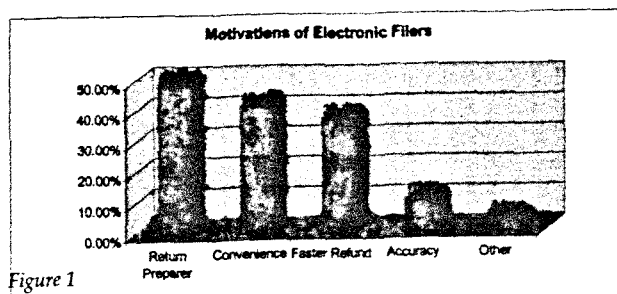


Figure 1

The above graph illustrates that the most commonly identified motivators are the advice of a return preparer, convenience of e-filing and the idea of a faster refund. Therefore the IRS should make it a priority that each of these motivators is exploited to the greatest extent possible. Possible actions to achieve this will be identified in a later section. Of the 4% of respondents that answered "other", their reasons included advice from others and free filing with tax software packages.

It is also beneficial to identify reasons that those that continue to file paper returns have not converted to electronic

filing. Again, this group of respondents was asked to indicate all of the factors that contributed to their decision. The options included: distrust of computer security, owed taxes and wanted to postpone payment, not comfortable with computers, habit, and the cost of online filing. Figure 2 shows the results.

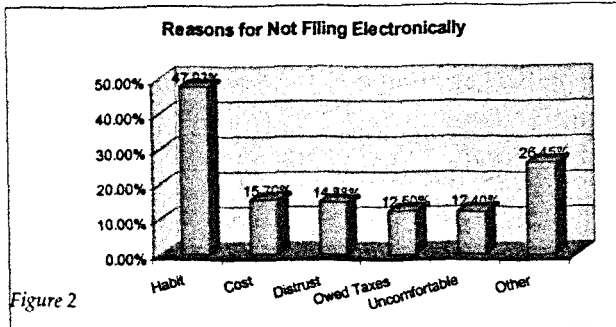


Figure 2

As one can see, the majority of respondents do not file electronically because they have always filed by mail and they just aren't interested in doing it any other way. Another popular answer was that their CPA did not file electronically. This accounted for about 57% of those that indicated "other" as a reason. Other reasons included difficulty of forms and technical difficulties.

Paper filers were also questioned about possible actions that could be taken to encourage them to file electronically. Possible motivators that were identified included: free or lower filing costs, confidence in computer security, better access to a computer, better personal computer skills, and assistance with electronic filing. They were given the option to provide their own answers as well. The results are illustrated in Figure 3.

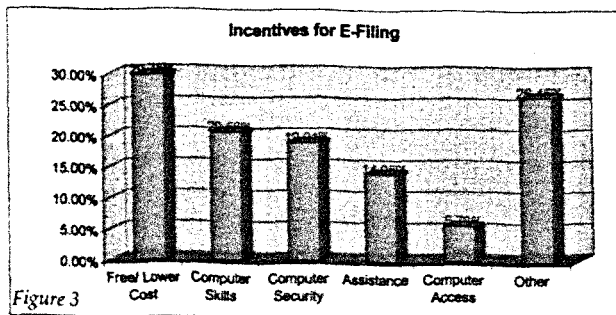


Figure 3

As the results indicate, taxpayers view free or lower filing costs as the biggest incentive to file electronically. The "other" category also had a significant percentage of respondents. The majority of these respondents indicated that they would file electronically if their CPA required them to do so. In addition, many answered that nothing would encourage them to change.

Characteristics of Electronic Filers:

In order to determine other factors that may affect decisions to file electronically, the respondents were broken into two

groups: electronic filers and non-electronic filers. These groups were then compared based on a number of different factors. T-tests were performed on the data to determine whether there were significant differences in certain areas. The following table illustrates the results of the tests.

When interpreting the results of a t-test, the p-value can determine whether or not the difference in two sets of data is significant. If the p-value falls below the desired level of significance, it can be determined that the means of the two groups are statistically different. The standard level of significance is .05, therefore, if the p-value for the two groups is under .05, there is reason to believe that there is a significant difference in that particular characteristic for electronic filers and those that do not file electronically.

Table 4 indicates that there are some differences in the two groups. The biggest difference between the groups was related to whether or not the taxpayer was due a refund. Those taxpayers who chose not to file electronically were mostly those who were not receiving a refund. This can be attributed to the fact that taxpayers who file electronically tend to receive their refund more quickly.

E-filers also appear to be younger than Non E-Filers. Older filers may not choose to file electronically because they do not own a computer or they are not comfortable using it. In addition, younger filers are most likely attracted to the convenience and speed that electronic filing offers. This may also be the reason why electronic filers tended to have more people in the household. With an increased number of family members, convenience may be a big incentive. Another reason for this difference may lie in the fact that older filers tend to have fewer people living in the household, since the majority of their children reside outside the home. This would further support evidence that older filers are less likely to file electronically.

Further Analysis of Refund Expectation:

As Table 6 indicates, taxpayers who expect a refund are more likely to file electronically. Last year, almost 13% of taxpayers did not file electronically because they owed taxes. This is because they want to wait as long as possible to hand their money over. In order to confirm this, Table 3 shows the filing preferences of those that were due a refund compared to those that were not.

The results further confirm that those who are due a refund are more likely to file electronically than those who are not. Almost 37% of respondents who were due a refund filed electronically, while only 14% who were not due a refund filed electronically. In addition, those who were not due a refund were almost twice as likely to file neither return electronically, than those who were.

Table 5: Variation of Means between E-Filers and Non E-Filers

	Mean		
	E-Filers	Non E-Filers	Total
Refund	1.5797	2.3417	2.0576
Type of Return	1.5362	1.3667	1.4241
Preparer	0.5507	0.5417	0.5497
Community	2.1884	2.3750	2.3037
Education	3.6087	3.4000	3.4869
Race	1.2029	1.0500	1.1047
Gender	0.3913	0.4667	0.4346
Income	3.4493	3.4833	3.4921
Marital Status	1.4783	1.4917	1.4817
Number in Household	2.7246	2.2500	2.4346
Age	4.1014	4.9917	4.6649
			P-Value

Table 6: % of E-Filers Based on Refund Status

	Refund Due	No Refund
Both	36.88%	14.29%
Federal	5.67%	2.04%
State	1.42%	0.00%
Neither	56.03%	83.67%

Characteristics of Older Taxpayers:

Since age is a significant factor in determining whether or not an individual will file their return electronically, it is useful to examine characteristics of different age groups. Most importantly, it is necessary to determine why older filers do not file electronically. In addition, it would be helpful to know the factors that would influence them to convert to electronic filing.

The age group that was least likely to file electronically was that were between the ages of 60-69. Figure 4 shows the reasons that this group indicated for not filing electronically.

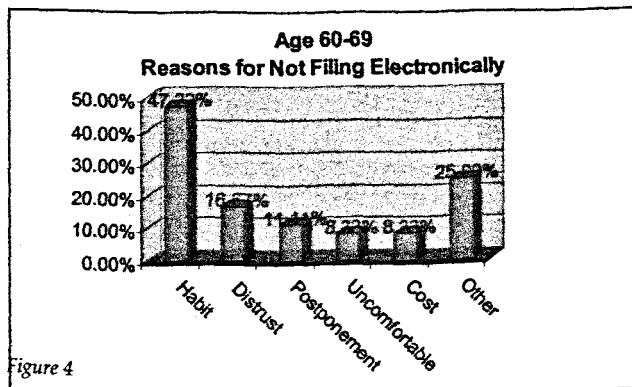


Figure 4

The above figure illustrates that the main reason given for paper filing was habit. The main response for "Other" was that their CPA made the decision for them. Distrust of computer security was another significant factor.

In addition to knowing why older filers don't file electronically, it is important to know the factors that would influence them to change their mind. Figure 5 shows the responses for the 60-69 age group.

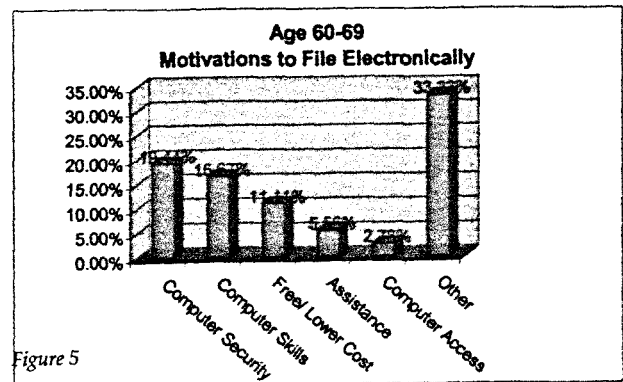
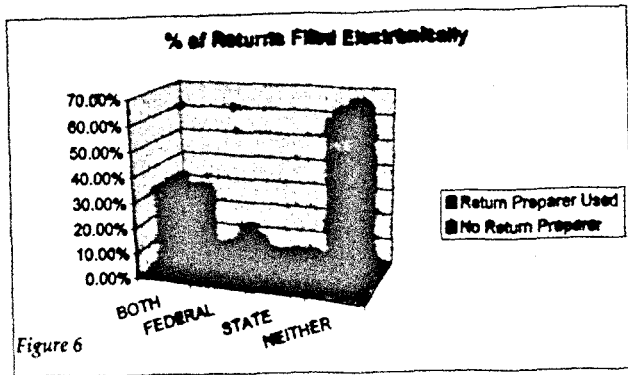


Figure 5

This figure indicates that greater security and increased computer skills would convince these taxpayers to file electronically. Those that indicated other reasons expressed that they would allow their CPA to make the decision.

Characteristics of CPA Prepared Returns:

Due to the large number of responses regarding the CPA's role in electronic filing, the responses were separated based on whether or not a return preparer was used. Figure 6 compares electronic filing percentages for those that used a return preparer versus those that did not. It indicates that those returns filed by return preparers had a slightly higher likelihood of being filed electronically. In addition, the return preparers usually filed both the state and federal forms electronically or did not file either in this manner. However, there did not appear to be a significant difference in these categories based on the variance analysis.



Biases:

The results did appear to contain some response biases. There was a greater response from members of certain demographic segments. These biases must be remembered when evaluating the responses. These biases include gender, education, race, and age differences. Perhaps the greatest bias was the race of the respondents. Caucasians accounted for 92% of the results. In addition, there were a greater number of male responses than female, representing approximately 62% and 38%, respectively. They also tended to be fairly well educated, with 85% having at least some college education. Finally, 78% were over the age of 40. Refer to Appendix B for more detailed statistics on response rates.

Results and Implications:

The results of the survey can be used to determine which demographic groups are more likely to file electronically. The IRS can then decide which of the demographic groups should continue to be targeted, as well as the groups that are not being reached with current incentives. It would likely be more effective for the IRS to use different methods to target the different demographic groups, since these groups may respond differently to certain tactics.

The information obtained from the survey also provides useful insight into reasons that some taxpayers do file electronically. The results indicate specific incentives that the IRS may be able to use in the future to increase the number of electronic filers. This information can be used to develop new methods of recruiting greater percentages of electronic filers.

The survey also identified specific reasons that paper filers choose not to file electronically. Due to the fact that there were a significant amount of responses to each of the given reasons, the IRS should search for ways to eliminate these concerns. If these concerns can be eliminated, or at least lessened, these taxpayers may decide that the benefits of filing electronically outweigh the disadvantages.

Perhaps the most important finding is that the older filers are less likely to file electronically. This is one particular

demographic group that the IRS needs to target. In order to encourage older filers to convert to electronic filing, the IRS should address the concerns of these groups. They should also examine incentives that create benefits for the older filers.

Another important finding is that taxpayers who receive refunds are more likely to file electronically. The IRS needs to develop a plan that would encourage taxpayers who are not receiving refunds to file electronically. They are likely to dramatically increase the number of electronic filers by creating incentives that are attractive to those who are still filing by paper.

Recommendations:

The implications of the survey suggest various methods that the IRS could use to attract more electronic filers. One of the most important steps that should be taken is to find ways to target older taxpayers. These taxpayers did indicate that a better understanding of computers and more confidence in computer security would influence their decision. Actions that the IRS could take include giving taxpayers assistance and instructions for electronic filing. In addition, simplifying the process would make it easier for older filers to understand.

Another action that the IRS could take is requiring all tax preparers to file electronically. This would increase the number of electronic filers in older age groups, as well as others. Many states are already requiring tax preparers to file electronically, if they prepare over a certain amount of tax returns. However, this is currently not a federal requirement. Due to the large amount of responses that indicated the decisions of CPA's had a great influence on the decision, this would likely be a sure way to increase electronic filing compliance rates. However, as previously stated many preparers are opposed to this requirement.

The cost of electronic filing was another reason that taxpayers did not file electronically. Although the free file alliance has allowed some filers to submit their returns at no cost, many taxpayers do not meet the qualifications to file for free. Therefore, the IRS needs to examine ways to make electronic filing free or cheaper for all filers. One possibility would be to expand the qualifications for free filing. However, they must be careful not to infringe upon private sector businesses.

Another action that has been suggested involves issuing tax credits to those who file electronically. This would allow businesses to still charge for filing, by shifting the cost to the government. The taxpayers would pay the business, but would later receive a credit from the government. Depending on the amount of the credit, this would reduce or eliminate the out-of-pocket expense for taxpayers. In addition, it would encourage filers who do not receive refunds to file electronically.

Finally, there have been discussions concerning the extension of the April 15th due date. This would be an incentive for many taxpayers to convert to electronic filing. Since paper

returns only have to be post marked on April 15th, it is disadvantageous to file electronically by the same date. When filing electronically, the government can process your return much faster, therefore taking the money out of the bank sooner. In addition, those filers who waited a little too long to file their taxes, and did not file an extension, would be forced to file electronically in order to avoid penalties. Although, it does seem to be a good idea, this does lead to some confusion and other disadvantages as well.

After reviewing the advantages and disadvantages of a number of alternative actions, it appears that some actions would be more advantageous than others. One action would be to offer a tax credit for electronic filers. Some of the cost savings realized by the IRS would be reduced, but the reduction in effort and errors would likely make up the difference. In addition, requiring tax preparers who meet certain criteria to file electronically would definitely increase electronic filing compliance. However, the IRS should be sure address preparer concerns about electronic filing.

Conclusions:

The IRS is working hard to achieve the goal set forth in the IRS Restructuring and Reform Act of 1998. Even with their efforts, studies have shown that they are not likely to reach 80% compliance by 2007. However, plans are in place to increase the marketing budget for electronic filing. In addition, the IRS plans to mail post cards encouraging electronic filing to taxpayers and preparers. Through these efforts, along with others, electronic filing will continue to grow in popularity. Although, 80% will not be reached by 2007, it may be reached soon after. As younger generations start their careers, and older generations begin to retire on minimal income, electronic filing will become the standard in tax filing.

Endnotes:

¹ Joint Committee of Taxation report to Congress on IRS modernization (May 19, 2003).

² IRS Oversight Board Electronic Filing Annual Report to Congress Adaptation (November 2003)

³ E-Filing.com. Advantages of E-Filing Pandit, Ganesh and Allen J. Rubenfield. *The CPA and The Computer "E-Filing: The Ups and Downs"*. Sept. 2003

⁴ Block, Sandra, SmartPros "E-filers My Get Later Deadline to File Taxes" Feb. 4, 2002 <http://www.smartpros.com/x32824.xml>

⁵ IRS ETAAC Report to Congress 2003, [http://www.irs.gov/TaxationTeam/Proposal to Extend Due Date for E-Filed Returns](http://www.irs.gov/TaxationTeam/Proposal%20to%20Extend%20Due%20Date%20for%20E-Filed%20Returns), <http://aicpa.org>

⁶ Taken from IRS Oversight Board Electronic Filing Annual Report to Congress (November 2003)

Faculty Comments:

Ms. Adams', thesis advisor, Dr. Deborah Thomas, made the following comments about her student's work:

As thesis advisor for Angela Adams, I am writing to endorse her work on electronic filing of tax returns. Her research paper is meritorious for the following reasons:

Universal Topic: Angela's work investigates something that affects every American - the annual filing of individual income tax returns.

Practical Topic: Electronic filing is a cheaper and more efficient alternative to paper tax returns, for both the taxpayer and the government.

Timely Topic: In 1998, Congress set a goal that 80% of all tax returns be filed electronically by 2007. The IRS is making progress toward that goal, with increased e-filing during the 2004 tax season. But as of April 9, 2004, only 57% of 2003 individual returns were filed electronically.

Unique Database: Angela built her data from an original mailed survey of 1,000 Arkansas residents. Her response rate of close to 20% was high for this sort of research.

Meaningful Results: The IRS must find ways to encourage taxpayers to use e-filing to meet the 2007 Congressional mandate. Angela's research identifies some of the roadblocks to and avenues for increasing the use of electronic filing that could assist the IRS in meeting its goal.

Quality paper: I believe you will find Angela's paper to be well-written and insightful.

Appendix A- Survey Instrument

Electronic Tax Filing

Please answer the following questions using a pencil, and return the survey in the provided Business Reply Envelope.

1. Where do you have Internet access? (Fill in all that apply)
 - ☐ Home
 - ☐ Workplace
 - ☐ Other _____
 - ☐ School
 - ☐ Library
2. Are you aware that you can file your tax returns via the internet?
 - ☐ Yes
 - ☐ No
3. Which tax return(s) did you file electronically last year?
 - ☐ Both federal and state
 - ☐ Federal only
 - ☐ State only
 - ☐ Neither
4. If you did, what motivated you to file electronically? Was it: (Fill in all that apply)
 - ☐ Convenience
 - ☐ Accuracy
 - ☐ Faster refund
 - ☐ Return preparer did it for me
 - ☐ Other _____
5. If you didn't, why didn't you file electronically? Was it: (Fill in all that apply)
 - ☐ Distrust of computer security
 - ☐ Owed taxes, so want to postpone payment
 - ☐ Not comfortable with computers
 - ☐ Habit - I've always filed by mail/just not interested
 - ☐ Cost of online-filing
 - ☐ Other _____
6. If you didn't, have you investigated the cost of filing electronically?
 - ☐ Yes
 - ☐ No
7. If you didn't, what would make you more likely to file electronically? (Fill in all that apply)
 - ☐ Free or lower filing cost
 - ☐ Confidence in computer security
 - ☐ Better access to a computer
 - ☐ Better personal computer skills
 - ☐ Assistance with electronic filing
 - ☐ Other _____
8. Were you due a tax refund last year?
 - ☐ Yes, both federal and state
 - ☐ Yes, federal only
 - ☐ Yes, state only
 - ☐ No
9. If yes, what did you do with your tax refund? (Fill in all that apply)
 - ☐ Used it to pay groceries/bills/necessities
 - ☐ Used it for recreation/vacation/luxuries
 - ☐ Saved it
10. Which Federal return did you file in 2002?
 - ☐ 1040
 - ☐ 1040EZ
 - ☐ 1040A
 - ☐ Other _____
11. If you filed 1040 in 2002, which schedules did you file? (Fill in all that apply)
 - ☐ Schedule A itemized deductions
 - ☐ Schedule C small business/self-employed
 - ☐ Schedule D capital gains
 - ☐ Schedule E income/rental property/partnership
12. Did you pay someone to do your 2002 tax return for you?
 - ☐ Yes
 - ☐ No
13. In what type of area/community do you live?
 - ☐ City
 - ☐ Suburb
 - ☐ Small town/community
 - ☐ Rural area/farm
14. Which best describes your level of schooling?
 - ☐ Didn't graduate from high school
 - ☐ High school graduate or equivalent
 - ☐ Some college including business or trade schools
 - ☐ College graduate
 - ☐ Graduate or professional degree
15. Which best describes your racial or ethnic group?
 - ☐ White
 - ☐ African-American
 - ☐ Hispanic
 - ☐ Asian
 - ☐ Native American
 - ☐ Multi-ethnic
16. Are you male or female?
 - ☐ Male
 - ☐ Female
17. Which best describes your total 2002 household income?
 - ☐ \$15,000 or less
 - ☐ \$15,001 to \$25,000
 - ☐ \$25,001 to \$50,000
 - ☐ \$50,001 to \$75,000
 - ☐ \$75,001 to \$125,000
 - ☐ \$125,001 to \$500,000
 - ☐ \$500,001 or over
18. Which best describes your present marital status?
 - ☐ Married
 - ☐ Separated or divorced
 - ☐ Widowed
 - ☐ Single
19. How many people, including yourself, live in your household?
 - ☐ 1
 - ☐ 2
 - ☐ 3
 - ☐ 4
 - ☐ 5
 - ☐ 6
 - ☐ 7
 - ☐ 8
 - ☐ 9
 - ☐ 10+
20. What is your current age?
 - ☐ Under 20 years
 - ☐ 20-29 years
 - ☐ 30-39 years
 - ☐ 40-49 years
 - ☐ 50-59 years
 - ☐ 60-69 years
 - ☐ 70 or more years

Please give any additional comments about electronic tax filing on the back of this form.

Appendix B- Summary of Survey Repsonses

1	YES	NO	SUM	% YES	% NO
Home	141	50	191	73.82%	26.18%
Work	97	94	191	50.79%	49.21%
School	11	180	191	5.76%	94.24%
Library	29	162	191	15.18%	84.82%
Other	10	181	191	5.24%	94.76%

2	YES	NO	SUM
#	183	8	191
%	95.81%	4.19%	100.00%

3	BOTH	FEDERAL	STATE	NEITHER	SUM
#	59	9	2	121	191
%	30.89%	4.71%	1.05%	63.35%	100.00%

4	YES	NO	SUM	% YES	% NO
Convenience	30	161	191	15.71%	84.29%
Faster Refund	27	164	191	14.14%	85.86%
Accuracy	7	184	191	3.66%	96.34%
Return Preparer	38	153	191	19.90%	80.10%
Other	5	186	191	2.62%	97.38%

5	YES	NO	SUM	% YES	% NO
Distrust	18	173	191	9.42%	90.58%
Postponement	15	175	190	7.89%	92.11%
Uncomfortable	16	175	191	8.38%	91.62%
Habit	59	132	191	30.89%	69.11%
Cost	20	171	191	10.47%	89.53%
Other	35	156	191	18.32%	81.68%

6	YES	NO	SUM
#	33	158	191
%	17.28%	82.72%	100.00%

7	YES	NO	SUM	% YES	% NO
Free/Lower Cost	43	148	191	22.51%	77.49%
Computer Security	25	166	191	13.09%	86.91%
Computer Access	7	184	191	3.66%	96.34%
Computer Skills	25	166	191	13.09%	86.91%
Assistance	19	172	191	9.95%	90.05%
Other	34	157	191	17.80%	82.20%

8	BOTH	FEDERAL	STATE	NEITHER	SUM
#	98	30	13	49	190
%	51.58%	15.79%	6.84%	25.79%	100.00%

81	110	191	42.41%	57.59%
25	166	191	13.09%	86.91%
46	145	191	24.08%	75.92%

116	42	14	7	181
65.19%	23.20%	7.73%	3.87%	100.00%

114	77	191	59.69%	40.31%
34	157	191	17.80%	82.20%
53	138	191	27.75%	72.25%
30	161	191	15.71%	84.29%

101	88	189
53.44%	46.56%	100.00%

73	21	59	37	190
38.42%	11.05%	31.05%	19.47%	100.00%

2	26	59	70	31	188
1.06%	13.83%	31.38%	37.23%	16.49%	100.00%

174	12	0	2	1	0	189
92.06%	6.35%	0.00%	1.06%	0.53%	0.00%	100.00%

115	71	186
61.83%	38.17%	100.00%

15	16	49	50	37	14	0	10
8.20%	9.84%	26.78%	27.32%	20.22%	7.85%	0.00%	100.00%

137	19	20	12	188
72.87%	10.11%	10.64%	6.38%	100.00%

34	73	33	35	8	1	0	0	0	0	184
18.48%	39.67%	17.93%	19.02%	4.35%	0.54%	0.00%	0.00%	0.00%	0.00%	100.00%

20	20 or under	20-29	30-39	40-49	50-59	60-69	70 or more	Total
#	1	13	28	43	42	36	26	189
%	0.53%	6.88%	14.81%	22.75%	22.22%	19.05%	13.76%	100.00%

MUSICAL COPYRIGHT INFRINGEMENT AND POLICY IMPLEMENTATION AT HIGHER EDUCATION INSTITUTIONS

By Henry Haruaki Wendel
Department of Economics

Faculty Mentor: Professor John Norwood
Department of Economics

Abstract:

Copyright infringement through campus networks has become an increasingly troubling problem for higher education institutions across the nation for two reasons. First, the network infrastructure is being abused to the extent that high percentages of the traffic to and from the university are of illegal material. Second, much of these materials are illegal, so administrators must follow procedures and implement policies, which will indemnify the university when a member of the university violates the law.

Throughout the nation, university administrators are taking different approaches to combat this new issue on campuses. In this study, the policies of the one hundred seventeen Division I Football institutions were critiqued. Some schools are taking a very relaxed approach and simply have a cursory statement in their policies mentioning students, faculty, and staff must follow all laws and policies. Others have taken a more active approach. The University of Arizona has the most comprehensive policies. They have included information on the Copyright Act, links to federal regulations, and a link to the university's policies on the use of Peer-to-Peer (P2P) programs. A great number of institutions are also complying with the Recording Industry Association of America (RIAA) and disconnecting suspected violators from the campus network. However, this seems to be contradictory to our nation's Constitution which states individuals are "innocent until proven guilty." In the current system, which is common across the nation, it would seem as if users are "guilty until proven innocent."

The availability of these P2P networks has resulted in a tremendous amount of legislation and trials to occur to protect the owners of the copyrights. New legislation or large numbers of suits are filed seemingly every week. Since last August, there have been almost 2,000 suits filed against individuals and several court cases against companies across the nation. In December, federal court of appeals ruled that service providers do not have to give copyright owners the personal information of people suspected of possessing copyrighted materials. This

was a huge blow to owners as this was the primary means in which they were able to fight this growing issue.

New issues that will face administrators will be very prevalent. One such process that students are beginning to use is called stream ripping. This allows users to tune into several Internet radio stations at once and while doing so, a program converts the songs into a music file and stores it on the host computer. What is so different about this program is that it uses legal streams of music and then stores the songs. There is no sharing that takes place and network administrators cannot tell that there is anything illegal taking place.

This problem is one that will not be solved soon. The emergence of new technologies and the increasing ability of students to find ways to break protectionist measure implemented by the copyright owners will continue to grow. While this thesis has been a comprehensive study of the legal history, institutional policies, and what might be in store in the near future, there would be aspects of this issue that could not be predicted. This is a very timely issue that will surely see much more spotlight.

Introduction:

In the last few years, there have been thousands of lawsuits against people illegally downloading copyrighted music through the Internet. The recording industry has been fighting this growing trend since 1999. Artists are holding file sharing largely responsible for a 25 percent decline in sales of CD's since 1999, when Napster, the first popular file-swapping software, was released (Harmon). While the various recording labels do not attribute all this loss to illegal downloads, they do feel it is a substantial portion, with as much as \$700 Million in sales lost to these downloads (Suing Music Downloaders). Today, there are various means by which college students can download illegal materials. The most prolific sources are Peer-to-Peer (P2P) programs that connect various users to each other as a means of exchanging files. There are literally hundreds of P2P networks that students can use; however, Kazaa, Limewire, and Morpheus are the predominant utilities used by college students to acquire legal and illegal materials as defined by the 1998 Digital

Millennium Copyright Act (DMCA) and subsequent legislation. With the proliferation of high-speed Internet in collegiate residence halls across the nation, students are able to spend less time downloading and are able to access much more illegal content than in previous years. At any given moment in time, there are hundreds of thousands of users on Kazaa alone who have terabytes of information shared. These factors have forced the Recording Industry Association of America (RIAA) to battle to decrease these illegal downloads to help slow the drastic drop in record sales.

In a recent CBS/New York Times poll (See Appendix B) there was a clear distinction in the ideas held by those between the age groups 18-29 years and 30 and older years. The younger group tended to pay closer attention to the latest occurrences dealing with sharing music and felt it was more acceptable to share music files. Sixty-nine percent of the younger bracket thought it was at least somewhat acceptable to share music files compared to the fifty-five percent among the older group. The staggering difference between the two groups came in the extreme answers to the question with twenty-nine percent of the younger group thinking it was always acceptable compared to nine percent of the older group. In contrast the same ratio of younger to older individuals showed only thirty percent thought it was never acceptable compared to forty percent.

In August of 2003, the RIAA initiated a plan to start a stringent campaign against individuals who were violating copyright law by downloading music. The RIAA has teamed with college administrators in determining which students were abusing the facilities, but also worked to educate all students on the law and the consequences of violating such law. Subsequently, the RIAA followed through on its plan, and on September 8, 2003, filed 261 lawsuits against people found in violation of the DMCA, promising to file thousands more soon (Harmon). Many people have been appalled at the RIAA for some of the people who have been sued. For instance, one of the defendants is a 12-year-old named Brianna Lahara (Suing Music Downloaders).

The major problem the RIAA has faced has been eliminating the file-sharing programs that are prevalent today. Unlike Napster, Kazaa and the other programs today do not store any files on their servers; instead, users connect to each other directly using Kazaa as a medium for this connection. Therefore, Kazaa is not in violation of any copyright law. Furthermore, there is a substantial amount of legal material available through these channels, which gives justification for allowing these companies to stay in existence. This has forced the recording industry to ask Internet providers such as Verizon and AOL, as well as college administrators to release information about their customers who are downloading these files. Colleges and Universities are also facing problems from these illegal downloads. This is a two-part problem: first, the colleges are providers of the means by which the students are able to download the copyrighted materials (Hamilton). Universities could be held partially liable for this

action; however, the RIAA has tended to try to work with Universities as long as they are giving information on their users. Second, the universities are having hardware issues from these downloads. Due to the high demand on the university's infrastructure from downloading and streaming (the act of listening to the material without downloading it), colleges are limiting bandwidth to the residence halls in order to compensate for this problem. This allows the scholarly research in the different academic buildings to continue with as little delay as possible.

Statutory Framework and Case History:

The authority of Congress to pass legislation protecting the works of authors is provided for in Article One, Section Eight of the Constitution. In carrying out this mission Congress has stated that:

Copyright protection subsists, in accordance with this Title, in original works of authorship fixed in any tangible medium of expression... Works of authorship include the following categories: (1) literary works; (2) musical works, including any accompanying words; (3) dramatic works, including any accompanying music; (4) pantomimes and choreographic works; (5) pictorial, graphic, and sculptural works; (6) motion pictures; (7) sound recordings; and (8) architectural works." (17 USC 102)

Currently, the broadest legislation passed concerning this topic is the Copyright Act of 1976. Under Section 102(a) of this Act, copyright owners are required to have the following characteristics in order to gain protection: 1) the work must be original, 2) creative, and 3) fixed (able to be reproduced and sold) (Hawke, 3). Section 106 of the Act provides several rights to the owner of the copyright:

- 1) To reproduce the copyrighted work in copies or phonorecords
- 2) To prepare derivative works based on the copyrighted work
- 3) To distribute copies or phonorecords of the copyrighted work to the public by sale or other transfer of ownership, or by rental, lease, or lending
- 4) In the case of literary, musical, dramatic, and choreographic works, pantomimes, and motion pictures, and other audiovisual works, to perform or display the copyrighted work publicly
- 5) In the case of sound recordings, to perform the copyrighted work publicly by means of a digital audio transmission. (Hawke, 4)

Extended in 1998 by the Copyright Term Extension Act of 1998, copyrights are valid on any work for the span of the creator's life plus 70 years (17 U.S.C., Section 302). The most important aspect one must remember concerning copyright is that it is a strict liability tort, which means no intent is required to be found in violation (Background ... University Networks). Under the Act, there are three forms of infringement that a user can be found to be responsible for: direct, contributory, and vicarious.

Direct: According to Title 17 of the U.S.C. Section 501(a), "anyone who violates any of the exclusive rights of the copyright owner as provided by sections 106 through 122..., or who imports copies or phonorecords into the United States in violation of section 602, is an infringer of a copyright..." Keeping this in mind, virtually anyone found in violation of sharing protected music can be found directly infringing copyright law.

Contributory: As defined by case law, contributory infringement could be claimed if "one who, with knowledge of the infringing activity, induces, causes, or materially contributes to the infringing conduct of another..." (Gershwin Publishing Corp v. Columbia Artists Management, Inc., 443 F. 2d 1159, 1162 (2nd Cir. 1971)). Intuitively, this would require the direct infringement of copyright law by another party, not involved in the contributory infringement. There are two parts that are important when considering liability: 1) knowledge; and 2) inducing, causation, or material contribution (Background ... University Networks). According to the Joint Committee of the Higher Education and Entertainment Communities, students who knowingly leave their computers connected to a P2P program allowing for users to download from them could be found contributing to copyright violation.

Vicarious: Vicarious liability, on the other hand, can be imposed on persons who do not "induce" or "cause" direct infringement or, for that matter are not even aware that another party is involved in infringing activity when their economic interests are intertwined with the direct infringers (Background ... University Networks). Napster has already been found liable because of contributory and vicarious infringement; however, there have not been any students who have been sued because of vicarious infringement. Theoretically, a student could be found liable if he or she was operating a P2P network and uploaded or downloaded files, deliberately enabled others the access to files, had the right to manage the activity of the networks users and gained financially from the activity (Background ... University Networks).

The most important legislation passed in regard to this issue in recent years is the Digital Millennium Copyright Act of 1998 (DMCA) that amends the aforementioned Copyright Act. This legislation is very broad and set the standard on copyright infringement through the Internet. It also makes it illegal to break an electronic encryption, or to distribute information allowing

someone to break the encryption. Also, it is perpetual in nature. Thus, even if the copyright has expired, the encryption can continue, and it is illegal to break it. Educational institutions have a very important section of the DMCA to consider when instituting policies for their networks and users. As defined in the University of Houston's Acceptable Use of Computing Resources, the DMCA "is a federal statute that limits an online service provider's liability for copyright infringement claims based solely on the online service provider's automated, copying, storing and dissemination functions." The good news for college and university administrators is that the DMCA restricts liability for service providers that engage in: 1) transitory (mere conduit) digital network communications; 2) system caching; 3) information residing on systems or networks at the direction of users; and 4) information location tools. (17 U.S.C. Section 512). In order to be eligible for safe harbor (which indemnifies the university from any legal recourse), colleges and universities must implement policies that agree to disconnect egregious offenders and also designate someone to take notices from the Copyright office.

While the DMCA does provide protection for colleges and universities, students must be acutely aware that this protection is not an overarching one that covers them as well. As described later in this paper, during a recent decision in a case brought against Verizon Internet Services, Inc., there has been a subpoena process initiated under the DMCA to detect which person is in violation by tracing a specific Internet Protocol address (IP address). Id. At Section 512(h).

Copyright Infringement Act - This federal law explicitly states that Internet service providers are not responsible for monetary remission to copyright owners if the provider is complying with the copyright owner to effectively target violators seeking commercial advantage or financial gain. Complying may include but is not limited to terminating the Internet service to the user permanently or temporarily; complying could also include turning over identifying information to the copyright owner. (17 USC 512)

No Electronic Theft Act - This federal law defines financial gain as stated in the Copyright Infringement Act and sets the minimum gain at \$1000 during any 180-day period, of one or more copies or phonorecords or 1 or more copyrighted works. Under the NET Act, fines, imprisonment (up to five years), forfeiture, destruction, or disposition of the illegal material can all be sanctions placed on violators. (17 USC 506)

Other actions courts have taken against violators include injunctions and restitution of costs and attorney's fees. Injunctions have typically been the immediate action taken against violators as prescribed by sections 502 and 503 of the Act, which allow for restraining orders, preliminary injunctions, impoundment, and disposition orders. Therefore, students found in violation of the Act could have their computers seized by authorities. In order to

comply with authorities, immediate actions taken by universities tend to lean towards disconnecting students from the campus network. While the DMCA does provide protection for colleges and universities, students must be acutely aware that this protection is not an overarching one that covers them as well.

RIAA:

The Recording Industry Association of America (RIAA) is the organization which represents a majority of the major record labels responsible for producing much of the music heard today. The stance taken by the RIAA is very obvious: the organization wholeheartedly opposes the illegal copying of copyrighted music. With the passage of the Digital Millennium Copyright Act in 1998, the RIAA realized a great shift in managing their anti-piracy campaign. In a press release on March 5, 1998, the organization is quoted as saying "anti-piracy statistics indicate that while cassette piracy has dropped 80% over the last five years and cassette street vendors are dissipating, music piracy is rapidly moving towards the Internet and CD piracy" (RIAA Press Release, March 5, 1998). At the time of this press release, the cost to the average consumer to pirate a song was much higher than today. At that time, prices for CD burners started around \$400 and Internet prices hovered around \$20 a month for a 56k connection; the phenomenon had not reached its full potential.

In 2000, RIAA's battle against the online providers such as MP3.com and Napster started in full force. In their first victory, a federal judge ruled in favor of RIAA against MP3.com and ordered the company to cease and desist from all their illegal practices. However, much more publicized was the case that would eventually bring Napster to its knees. On May 5, 2000, a California district judge ruled against Napster, Inc., citing violation of copyright laws. (114 F. Supp.2d 896, Cal. D.C. 2000) At the heart of these two firms being found responsible for copyright violations was the method in which they provided their music. Both supplied users with a means to download music from a central storage server, which was owned by the respective company. However, copyright laws prohibit this from taking place, because only the individuals who purchase the music have the right to possess the Mp3s. This was a huge victory for the RIAA. At the time, Napster was the largest source for free online music. However, Napster would not take this as the final word, and later that year, Napster appealed the decision of the lower court. On February 13, 2001, music producers, song writers, and artists won a major victory when the Ninth Circuit Court of Appeals upheld the decision of the District Court and ruled in favor of the respondents on all counts. (239 F.3d 1004, 9th Cir. 2001) In their decision the court stated, "Napster by its conduct knowingly encourages and assists the infringement of plaintiffs' copyrights." (239 F.3d 1004, 9th Cir. 2001) Along with the ruling that copyright laws were violated, the court ruled that the preliminary injunction against Napster was too broad and ordered the District Court to redefine their injunction in a narrower

manner. After all the subsequent motions were filed by Napster and all eventually struck by the courts, Napster finally realized they had lost the battle.

Since the Napster ruling, many other companies have been shut down as well. However, the RIAA has lost several battles to other online content "providers." These other providers are called Peer-to-Peer networks, which serve as a medium that allows users to connect to other users to download material on the user's hard drive. In several cases since 2001, courts have consistently ruled that these providers are not in violation of copyright laws because they do not actually ever possess the illegal materials. This has caused a lot of turmoil for the music industry, and in October of 2002, the "creative content industries" asked thousands of higher education institutions to monitor, educate, and reprimand students on violations of copyright laws in relation to the DMCA. Subsequently, six leading higher education associations representing virtually every college and university in the United States also sent letters to support the RIAA's request. Knowing that this could reduce liability on the part of the institution and also helps in diminishing the demand strain on the campus networking, colleges and universities have been complying with this request. (Press Room, Content Community, College Groups Outline Threat of P2P, Ask for Action)

The last major case, which has set a major precedent in the file-sharing controversy, was the lawsuit between the RIAA and Verizon. The issue of this case was whether or not the RIAA could sue Internet service providers to force them to provide information pertaining to suspect copyright infringers. The argument Verizon made was that this information was private and that corporations cannot sue for this information, even if it is against Verizon's Acceptable Use Policy (AUP). According to Verizon's AUP, rule 4 states, "You may not store material on, or disseminate material over, Verizon Online's systems or servers in any manner that constitutes an infringement of third party intellectual property rights, including rights granted under the US Copyright laws." However, even though Verizon knew they had users in violation of the DMCA, they did not feel they could be compelled to turn over this private information. In their decision, the trial court sided with the RIAA which stated that with sufficient proof, Internet service providers were required to provide the identity of the person accused of infringement (In re Verizon Internet Services, Inc. 240 F. Supp.2d 24, D.D.C., 2003). "It is also clear that the First Amendment does not protect copyright infringement ... Nor is this an instance where the anonymity of an Internet user merits free speech and privacy protections (31-32, District Court Opinion.)" This statement from the District Court's Opinion was one of the fundamental reasons it came to its decision. Furthermore, the court also said the following, "Verizon has provided no sound reason why Congress would enable a copyright owner to obtain identifying information from a service provider storing the infringing material

on its system, but would not enable a copyright owner to obtain identifying information from a service provider transmitting the material over its system." (18, District Court Opinion). In effect, this decision would force service providers to turn over the names of their users who have repeatedly downloaded copyrighted material. The process to identify an individual offender is quite extensive. First, the copyright owner or designee detects which IP address is receiving or sending illegal material. Once this happens, the owner would file a John Doe suit using the IP address to identify the person. Once there is a preponderance of evidence, service providers are required to turn over the identifying information to the copyright owner. This decision was later overturned in December of 2003, when the U.S. Court of Appeals issued a decision which said Verizon and other service providers could not be compelled to turn over private information of their users (351 F.3d 1229, D.C. Cir. 2003). This was a tremendous setback for copyright since now they would have to depend on firms to do so voluntarily.

The RIAA has also brought thousands of suits against individuals for their violation of copyright laws. Hundreds of these suits were brought against college students at institutions around the country. Among the first to be subpoenaed were two students at Rensselaer Polytechnic Institute, one at Michigan Technological University, and one at Princeton University. The RIAA brought these suits against the students threatening penalties up to \$150,000 per song that was illegally stored on their computers (Goldstein, *The Dartmouth*). These students were all accused of not only sharing their music, but also publicizing their collections to the public with libraries containing anywhere from 27,000 to 1 million music files (Goldstein, *The Dartmouth*). Each of these suits was settled out of court, and even though each of the four students denied the allegations, the students settled by agreeing to pay between \$12,000 and \$17,500 and disabling their file-sharing services (Carlson, *Record Companies*). About a month after this first round of suits, the RIAA sent warning letters (See Appendix Q to approximately 2 million users of file-sharing services to educate them about copyright law (Carlson, *Record Industry*). To date, approximately 2,000 suits have been brought against individuals with hundreds of those people being college students across the nation.

Today, the RIAA spends millions upon millions of dollars attempting to catch intellectual property right violators. One might ask why the RIAA does not share files on programs like Kazaa to catch these individuals; however, due to U.S. law, this could be considered entrapment and could tarnish their reputation in the eyes of the consumer. Therefore, independent firms are hired to find individuals who are sharing these copyrighted materials. Of course, once these sharers found out that the RIAA and other copyright owners were doing this, they began changing file names to make it increasingly difficult for these firms to find the illegal materials. Now, these firms have to run comparisons to find the likelihood that the songs downloaded are copies of those that are trademarked.

Colleges and Universities:

Colleges and universities across the nation have been forced to deal with this epidemic that is plaguing networks. There is a very important message that needs to be conveyed to all users of the campus network infrastructure, which is that access to the network is a privilege, not a right. Those found in violation of any policies set forth by the institution shall be punished accordingly. This establishes a standard to all users that lets them know that this type of behavior will not be tolerated and the institution is very serious in these terms. The excessive downloading by students in residence halls across the country has caused tremendous strain for the infrastructure in place, and limits the amount of web traffic that can be used for the primary purpose of academics. Since 2001, network administrators have been struggling with providing enough bandwidth to everyone who is in "need" of it. For example, Mr. Dewitt Latimer of the University of Tennessee said that downloads from Kazaa alone constituted more than 50 percent of the traffic on residential networks; moreover, about 75 percent of the outgoing traffic was directly attributable to outside users downloading materials from students within the residence halls at the University (Chronicle, September 28, 2001). Also in 2001, Justin Sipher, Director of Computing and Technology Services at the State University of New York at Potsdam, said that SUNY-Potsdam had doubled bandwidth capacity in the last year and would double again within a month. To inhibit students from abusing their network accessibility, administrators are taking a few different approaches. The most prevalent form of restricting access is to purchase hardware that allows administrators to perform "Bandwidth-shaping." Managers can tell these devices to restrict the speed at which certain types of downloads are allowed to be transferred (Carlson, *Napster was Just the Start*). Some hardware controllers are also able to prioritize certain Internet ports that could have higher priority and actually disconnect others if the network becomes too crowded.

One may ask why administrators do not just monitor the files being transmitted through their networks in order to identify the users who are sharing the illegal files. First of all, the cost to hire people to monitor the network traffic would be exorbitant and more than likely unfeasible. However more importantly, under the regulations set forth by the DMCA, if network administrators were to monitor file traffic, they could be held responsible for not sanctioning their users if transmitting the files. While many institutions do write into their policies that they maintain the right to search through the files on the network, the hypothesis of the actual implementation of this policy would be to monitor the transmittal of viruses and not whether a file is legal or not.

Furthermore, administrators are pushing for educational programs to inform students of their legal and ethical restrictions in downloading material from legal and illegal sources. For instance, the University of Delaware has required students to

become educated on these issues and subsequently pass a test before gaining access to the campus network (Chronicle, Sept. 28). Then, if these students violate the policy, their network connections are disabled and students are instructed on the legal issues (Chronicle, Sept. 28). Other institutions require egregious offenders to write educational papers or create educational programs before being allowed to reconnect to the network. One other form of protection at least one institution has tried was to actually seize the computers suspected of containing illegal materials. In November 2002, the US Naval Academy confiscated approximately 100 computers (Baker, Knight Rider Tribune Business News). In other cases, some network administrators are banning the use of file-sharing programs on the campus network. For instance, in April 2003, the New Jersey Institute of Technology decided to prohibit the use of any file-sharing programs through the network (Carlson, New Jersey Institute).

Campus network administrators are also affected by any new legislation or judgment handed down in regards to file sharing. In 2000, Metallica sued Yale University, Indiana University and the University of Southern California along with Napster for allowing their users to use Napster to download their songs. Metallica felt these institutions had done nothing to positively enforce the DMCA and, therefore, used these three universities as examples for the rest of the country. These three suits were later dropped when the institutions agreed to ban the use of Napster on their networks (Chronicle, Appeals Court Rules). Administrators in several departments at all residential campuses have been faced with the issue of how to enforce these policies and to what extent they would be working in conjunction with the RIAA to fully comply with the law.

One aspect that bypasses P2P networks completely is using other file transfer options for sharing music within an intranet on the campus. This allows friends within an institution to send files to each other without ever connecting to a P2P network. Users could then copy CDs to their computers or download MP3 files and then transmit these illegal copies to their friends. To add to the complex issue, students can also now send files through instant messaging clients such as MSN Messenger and AOL Instant Messenger. These present grave challenges to administrators because unlike the P2P networks, they cannot just block a certain IP address to disallow access. Essentially, network administrators would have to monitor the files being transferred to determine if they were legal files. This however poses the aforementioned problem of having network administrators monitoring files; it opens the university up for liability.

The latest technique that students across the nation are using is a process called Stream Ripping. Applications use an Internet radio source to provide the songs, which are then converted into MP3 files and stored on the local computer's hard drive. This brings two very problematic issues to administrators. First, with the current infrastructure in place, it will be difficult to distinguish whether a student is listening to the Internet radio

stations or if they are using these stations to provide music. Also, since the firms are using shared directories to catch copyright violators, there is no surveillance technique that can be used within the program. With these conditions in place, it is almost impossible to determine whether students are violating federal copyright laws.

Preventative Measures Taken:

Administrators have taken several steps to prevent the possibility of having to comply with any lawsuits filed by the RIAA against their students. Colleges and universities from around the nation have taken proactive stances to alleviate this problem. One of the most interesting methods which administrators are using to prevent lawsuits is to actually create a blanket subscription that students can take part in to legally download music from online sources. In November 2003, Penn State University became the first to sign such an agreement with Napster. Napster was of course the first file-trading software company that was sued for their part in violating intellectual property rights. After Napster was found liable, the company was bought out and started a pay service that is now what is being used by Penn State. Normally, users would pay \$9.95 per person per month for this service (which only applies to Windows 2000 and XP users), but Penn State has been provided a discounted rate for the service (Chronicle, Young). Right now, a mandatory information technology fee (Chronicle, Read) is paying for this service. Following in their footsteps was the University of Rochester who signed a similar deal four months later. Both institutions use the service, which allows the students at both universities the opportunity to download the songs to their computers, listen to streaming music, and find out information about the artists they are listening to. However, if students wish to burn these songs to a CD or upload them to portable MP3 players, students will have to pay an additional \$0.99 per song transferred. Charles Phelps who serves as Provost at Rochester said colleges have a "responsibility to help students understand the law and what is proper legal and moral behavior." With this in mind, Rochester has also started to create public forums updating students on the laws revolving around copyrights. Furthermore, Phelps said the university is planning to offer a course on "the legality of file sharing (Chronicle, Young)." Officials at Penn State have said that if this service is successful, there is a possibility that the service could extend to off-campus students, Macintosh users, faculty, staff, and even alumni in the future (Chronicle, Read). In response to these deals, Mike Bebel, President and COO of Napster said, "We want to encourage a new generation to try using legitimate services. (Chronicle, Read)."

There has been some opposition to this new trend in offering these services to students. Fred von Lohmann, an attorney with Electronic Frontier Foundation said, "This is a classic example of trying to force students to take what the record labels are willing to give. Consider what Napster offers compared

to what you can get with peer-to-peer file sharing. Napster mostly excludes independent artists." Many students will agree with Mr. von Lohmann. What incentive do students have to pay per song if they are still able to download the songs for free from these P2P sources? For many students, it is not only in their rooms that they listen to the music. A vast majority of the students bum these songs to CDs and take them to their car to listen to during their travels to work, home, or play. The only motivation students would have to follow these avenues would be to stay legal in all their actions. However, this is assuming every student knows that downloading music from other users is illegal and unethical.

Another form of prevention that the RIAA has is a program called Audible Magic, which can identify copyrighted songs in the midst of their transfer from computer to computer (Schwartz, NY Times.com). Once these transfers are detected, they are blocked. According to the article, Audible Magic executives say that the program can be installed on network devices as well as integrated into P2P programs like Kazaa. Legally, this provides even more assistance to administrators who can use this sort of program to decrease their liability. Already, Charles Phelps, Provost at the University of Rochester has said he was impressed with the new program. If all expectations hold true, this may be the best solution in solving this extremely complex situation.

Another form of preventative policy is to limit the amount of content a user can download during a specified time period. For instance, the University of Vermont has added a limit of one gigabyte per student per day, which would still allow for a tremendous amount of information to be downloaded (Chronicle, September 28, 2001). Other institutions have similar policies in place that might allow for a set amount each week. Moreover, some schools use programs that will require some users to logon to the network in order to have full access to the Internet. For instance, the University of Arkansas uses a program called ResNet, which forces students to logon for certain time sessions (within the residence halls it is a 24-hour session and in the general access areas, it is a 3-hour session). This allows for two critical issues to be controlled while users have access. First and foremost it tracks which person is actually assigned to the IP address that may be in violation. For instance, if a student goes to a public access port and connects, the user must login; therefore, being able to monitor which user is connected at what time. Also valuable, since the sessions expire at most every twenty-four hours, users are not able to download the extremely large files that take several days to acquire.

Methodology of Researching University Policies:

The Acceptable Use Policies of all the Division I institutions (See Appendix D) were collected by searching each of the 117 schools' websites and printing a hard copy of their policies concerning acceptable use. The hopes were that using the websites of each institution would provide the most current version of the

policies. This however may not be the case if the newest version had not been uploaded for viewing at the time of the search. Also to be considered is the type of schools that are part of the NCAA's Division I for football. A vast majority of these institutions are very large public schools that may hold different standards as compared to their smaller counterparts. The reason this manner of selection was chosen is because of an already well-established grouping of institutions that tend to be institutions at the heart of most new occurrences. For a listing of all the institutions studied, please follow the link:

<http://web1.ncaa.org/ssLists/sportByInst.do?sport=MFB&division=1>.

Policy Critique:

During the research for this thesis, the computing policies of each Division I institution were collected to compare and contrast how effective these regulations are in both insulating the institution from legal recourse by the RIAA and in informing students, faculty, and staff of their responsibilities in ethical behaviors while using the campus computer infrastructure. The challenge in gathering each of these policies was that there was no one name that was consistently used by every school in naming their policies. Among the names found were: Acceptable Use Policies, Code of Computing Ethics, and Computing Policies (for the purpose of this paper, the term Acceptable Use Policy is used). A vast majority of the institutions studied had policies in place as required by the DMCA. Many state laws (such as Arkansas's Act 1287 of 2001) require state agencies to create acceptable use policies.

There are two primary means by which universities have enabled themselves to limit the amount of illegal downloading that occurs at their respective campuses. First and foremost is that almost every school includes a sentence in their policies that requires all users to follow all university policies, as well as local, state, and federal regulations. Obviously, this requires any users on the campus networks to abide by the aforementioned laws. Many institutions have started to include some additional resources in their Acceptable Use Policies. Copies of the DMCA, state and local laws, and special notices about copyright violations have become increasingly prevalent in policies. The second restriction that schools place on their users is that they may not partake in activities, which tie up the resources of the infrastructure and hinder the academic pursuits of the faculty and students. With the increased number of files being downloaded or streamed, the students in the residence halls have monopolized much of the bandwidth. However, if this problem becomes excessive, schools would then be able to sanction them based on this rule without knowing if they had illegal materials.

Through the research conducted, there was one university that stood out as having excellent policies in contrast with their peers in regards to their inclusion of copyright information. The

University of Arizona has policies that were very comprehensive without being excessive. Section 7 of the Acceptable Use of Computers and Networks at the University of Arizona is extremely inclusive of what constitutes infringement and also includes links to internal and external sources. The reason this is so beneficial is because students may not be aware of all the legal aspects of possessing or trading these illegal materials. While a majority of the schools studied only state that students must follow all appropriate laws, Arizona has included a specific link to a page devoted to the use of P2P programs and links to the U.S. Copyright Office as well. Also important is the use of being somewhat broad in the policies. Some institutions mention copyright infringement, but only as it relates to the software piracy that is common today. If institutions make this reference, they should be careful and also include references to how users can get into trouble by illegally copying other forms of data files. Otherwise, the users may claim that they "thought only software was illegal because that is all that is mentioned in the policies."

Some institutions have chosen to include examples of violations of the policies which have been set forth. While this is very beneficial to readers, policy makers must be careful and should include a phrase to the extent of, "these example are provided for practical knowledge; however, they are not all inclusive."

A number of schools also take the liberty to add in the punitive sanctions that can be brought against those found in violation of the school's policies. The sanctions are fairly common among the institutions:

- 1) After a charge has been brought against the student, an administrator will meet with or e-mail the student and discuss the violation with the individual.
- 2) The offender's Internet access will be disabled (sometimes immediately) either temporarily, or for repeat offenders, permanently.
- 3) Seizure of equipment that contains the illegal content.
- 4) Censorship of the material if posted on a website within the university's domain.
- 5) Referral to the proper legal authorities.

The trend with institutions today is to limit the violator's access immediately. At the University of Arkansas, a typical educational sanction requires a student found in violation to write a five-page paper concerning the topic of copyright infringement or intellectual property ownership.

Recommendations:

When creating or revising Acceptable Use Policies, institutions must be acutely aware that students are not fully

knowledgeable in the most current legal proceedings. Children have never had the accessibility to computers and the Internet as they do now, and many start downloading music when they are in elementary or junior high school. Since this is almost a part of everyday life now, the challenge for collegiate institutions will be to educate their students and staff about the legal ramifications of this activity. Therefore, the inclusion of a section specifically dedicated to intellectual property rights is crucial. Also, much like some of the institutions currently have in place, computing policies should include links to the more crucial information that is outside of the university's policy which students may not have direct interaction with. Information such as the DMCA, NET Act, the Educase website, and any local or state regulations would be very advantageous in the education of students. Also, the consolidation of all relevant documents into one comprehensive policy would be very beneficial. Lastly, inclusion of a code of ethics can be greatly helpful. One such code is the EDUCOM Code of Software and Intellectual Rights (See Appendix E). This Code can be easily adapted to any institution and could also be part of a document that each user signs in agreement to abide by all relevant policies and laws. Once this policy is created, students, faculty, and staff should have easy access to this document. The ultimate link would be off of the homepage of each institution's website. If each institution could include the link at the bottom of the homepage with their privacy policies and other disclaimers, users would not be able to use that as an excuse for being ignorant of the policies.

In evaluating the sanctions handed out by the institutions, the vast majority of the sanctions are understandable. However, the troubling one is the immediate restriction on the use of the network's services. For instance, at the University of Arkansas, when Computing Services is notified that one of their users has been caught downloading or sharing illegal materials, the department immediately disables the Internet port in question (since copyright owners are able to identify the alleged IP address identified as infringing, this allows the department to identify the user). However, this seems to be contradictory to our nation's Constitution which states individuals are "innocent until proven guilty." In the current system, which is common across the nation, it would seem as if users are "guilty until proven innocent."

The Future:

Napster's service seems to be in direct contradiction to what some network administrators are trying to curtail. It is well known that streaming music and video requires much more bandwidth than a simple download of each of these songs that Napster would be providing. This seems to be the opposite of what many administrators have stated is one of their primary goals, which is to reduce the amount of network traffic from these downloads. The campus administrators of institutions which are contracting with Napster may see problems with having students stream so much multimedia content that

bandwidth will be monopolized by these files without any sort of hardware controls. Furthermore, with the proliferation of legal online music sources, Napster has not been as successful. For instance, one of the newest sources for online music downloads is Wal-Mart's website (www.walmart.com). Here shoppers can purchase individual songs without having to have a monthly subscription and each song costs only \$0.88. With approximately the same size library of songs available to download, Wal-Mart also has exclusive rights to certain hit songs. The only problem with Wal-Mart's service is they only offer edited songs, which could eliminate a possible source of sales for the company. With this new entrant, one would predict that other vendors would have to lower costs and/or eliminate any monthly service charge. With almost every other music vendor offering songs at \$0.99, they will have to compete with Wal-Mart's new prices. However, Wal-Mart has an advantage in being able to sustain losses for their initial period while trying to drive out their competitors. This being said, the stamina that programs like Napster show will be quite intriguing. Also, it would seem like that the agreements between Napster and institutions like Penn State will become less prevalent as students who wish to follow legal methods turn to the new low price alternatives.

One interesting combination of the previous two policy recommendations could facilitate legal transfers. That is, if an institution were to block all P2P file-sharing programs except one, the one that the school contracts with, then they could still allow the transfer of these legal files. These files would all be legitimate copies of each file. However, many of the legal sites that offer files available for purchase would not even require a second fee in order to copy to a different media. Therefore, the students' fees that are paid each year could then be applied to these contracts with providers.

There are hundreds of ways in which students at universities violate copyright laws. While downloading material is one manner in which students acquire files, universities must realize that there is no way they can eliminate the exchange of these files. College administrators and the RIAA will continue to face the entrepreneurial spirit of college students. For instance, record labels have started to encrypt CDs that have intermittent sounds that destroy the quality of any copies; however, this encryption problem was short lived as users found ways to bypass this issue. Having this situation at college campuses is quite a unique situation. In one way, administrators hope the encryption is not broken in order to reduce the amount of traffic. On the other hand, our classrooms are the setting where students are learning how to break these encryption codes which allow them to continue in this problem. Once users broke this "problem", it was only a matter of time until the content on the P2P networks again became illegitimate copies. Therefore, our incubators of knowledge are helping to promote the problem at hand.

The future also contains means by which very creative individuals will bypass the entire process of having to worry

about being caught for sending MP3 files. In an interview with Eric Roberts, Associate Director for Technology for University Housing at the University of Arkansas, Mr. Roberts said that a fear is that one day converting MP3 files into a HyperText Transfer Protocol (herein referred to as http) file could become commonplace. This is the same protocol used for creating common web pages. Essentially, this conversion would create an enormous http file that is indistinguishable from other http pages (Roberts). Once this conversion takes place, users could download these files and convert them back into MP3 files. The problem then posed to administrators is being able to discern a standard webpage from the converted music file because the only distinguishing difference would be size that cannot solely be a determinant. As of now, the technology to create these http files is not available, nor is the technology to detect it. Essentially, it seems to be a race to find out if this may one day become a prevalent issue.

Music is not the only source of problems that face campus administrators. Software, video, and academic plagiarism through the campus networks are also issues that are very prevalent today. In fact, this has become such a significant problem that the RIAA has collaborated with the Motion Picture Association of America (MPAA), the Software and Information Industry Association (SIIA), and the Entertainment Software Association (ESA). The video, software, and music industries are all taking a very strong stance on securing their rights in regard to copyrights. As seen in the research, thousands of individuals have been sued, laws have been created, and policies have been set. Most recently, on March 31, 2004 the U.S. House of Representatives passed legislation entitled the "Piracy Deterrence and Education Act of 2004." Within this legislation, Congress recognizes the issue that P2P networks bring to copyright owners and attempt to institute policies that will eliminate this issue by expanding upon the sanctions that are available through the NET Act. The new sanctions for a first violation include up to three years imprisonment for violators with a possible five years available if the user has commercial intentions in violating the copyrights. These sanctions can double for a second or subsequent offense. This Act did not only create criminal penalties for each of these offenses. Also included were programs developed to educate different organizations on the most up-to-date information in regards to enforcing copyrights, as well as a program called the Internet Use Education Program that would try to educate the public on current issues. These programs allow the federal government to reduce the likelihood of a person claiming ignorance

Also, the Federal Bureau of Investigation (FBI) is working with the RIAA, MPAA, SIIA, and the ESA on a new program to create an "Anti-Piracy Warning Initiative." Announced on February 19, 2004 the FBI and the various organizations will spend billions of dollars in this effort. With this program, a new seal will be displayed on future copyrighted materials

(www.fbi.gov). In addition, an "Education Letter" (See Appendix F) has been created for informational purposes.

The aforementioned industries have not been completely successful in their attempts to deter copyright infringement globally. In late March 2004, a Canadian Federal Court Judge ruled that service providers cannot be forced to identify their users to the Canadian Recording Industry Association or other copyright owners (CTA.ca). More than likely to be appealed, this decision is similar to the Verizon case mentioned previously in regard to U.S. law. Citing a lack of evidence to turn over the private information, Judge Konrad von Finckenstein compared the transfer of music to a photocopy machine. Von Finckenstein said, "I cannot see a real difference between a library that places a photocopy machine in a room full of copyrighted material and a computer user that places a personal copy on a shared directory linked to a P2P service."

Conclusion:

It is obvious that the measures taken by the Recording Industry of America have made a tremendous impact on the number of illegal files transmitted from user to user. In fact, after the announcement on June 29, 2003 that they would be targeting individual violators, there was a decrease of approximately two million users of Kazaa in the subsequent three months. Some of the files available to the public on these file-sharing networks expose customers to legal liability. Thousands of users have had to curtail their downloads in fear of having legal action taken against them. Furthermore, administrators of collegiate networks across the world have had to take strict action in order to limit the liability for the universities in which they work. However, the end of this problem is still years away. New technology, creative minds, and the ever-threatening specter of illegal manifestation on collegiate networks are impending, and network administrators must remain vigilant in protecting their infrastructure. Another key aspect is the continued battle of the legal music providers to entice the key market of college students to buy their products. More than likely, the trend to enter into contracts with music providers like Napster is over; however, new ideas are imminent and only time will tell what the future holds for not only the United States, but the global community as a whole.

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Appendices:

Appendix A:

Timeline of Important Events:

May 1999 - Napster Inc. file-sharing service is founded by Shawn Fanning and Sean Parker and explodes in popularity.

Dec. 7, 1999 - Recording Industry Association of America (RIAA) sues Napster in federal court in San Francisco alleging copyright infringement.

April 13, 2000 - Heavy metal rock group Metallica sues Napster for copyright infringement and racketeering. Rapper Dr. Dre files suit two weeks later.

July 2000 - Patel grants the RIAA's request for a preliminary injunction and orders Napster shut down. Soon after, the 9th U.S. Circuit Court of Appeals stays the lower court injunction, ruling that "substantial questions" were raised about the merits and form of Patel's injunction.

Oct. 2001 - The recording and film industries sue the companies behind the Grokster and Morpheus file-swapping services. The company behind the Kazaa file-swapping service is added to the suit later.

Jan. 21, 2003 - U.S. District Judge John D. Bates rules that Internet providers must agree to music industry requests to identify users who illegally download music. The case arose when Verizon Communications Inc. resisted a subpoena from the RIAA to track down several file-swappers.

April 3, 2003 - Hoping to "send a message," the RIAA files lawsuits against four college students who operate computer networks the RIAA says distribute copyrighted songs. One network reportedly distributed over 1 million files; the suit seeks \$150,000 for each copyrighted work that was downloaded.

April 24, 2003 - In a win for the RIAA, Judge Bates rules that Verizon must hand over the names of two customers suspected of illegal file swapping. Verizon appeals the ruling.

April 25, 2003 - Judge Stephen Wilson of U.S. District Court in Los Angeles rules that Grokster and Morpheus do not have direct control over files swapped on their networks and cannot be held liable for copyright infringement committed by their users. The entertainment companies appeal.

April 29, 2003 - As part of its anti-piracy "education initiative" the RIAA, along with other music industry groups, begins sending out instant messages to a planned one million file-swappers using peer-to-peer networks Kazaa and Grokster warning them that exchanging copyrighted songs is illegal.

May 2, 2003 - The RIAA reaches settlements with the four college students it sued for trading copyrighted music files over college campus computer networks. The payouts range from \$12,000 to \$17,500 - substantially less than the initial lawsuits sought.

June 5, 2003 - After losing a court battle, Verizon Communications Inc. surrenders the names of four of its Internet customers to the RIAA, which had accused them of illegally offering song downloads.

June 25, 2003 - Continuing their aggressive strategy, the RIAA announces plans to sue hundreds of individual file-swappers who offer "substantial" collections of mp3s for downloading. Critics accuse the RIAA of resorting to heavy-handed tactics likely to alienate millions of music lovers.

July 14, 2003 - An Internet tracking firm reports the number of people using several Internet file-sharing services has declined by several thousand a week after the music industry's threat to sue online music swappers.

Sept. 8, 2003 - The RIAA files 261 lawsuits against individual music lovers, accusing them of illegally downloading and sharing songs over the Internet. The action, which had been expected, follows subpoenas sent to Internet service providers and others seeking to identify roughly 1,600 users.

October 2003 - Napster comes back online as a pay service with the blessing of all five major music labels. It launches with more than a half-million songs and retains some of the community features that made the old version so popular, such as allowing subscribers to trade songs and play lists.

Jan. 21, 2004 - The RIAA sues 532 "John Doe" defendants identified only by their numeric Internet protocol addresses. It's the industry's first action since an appeals court ruled that subpoenas couldn't be used to force Internet providers to identify music downloaders without filing a lawsuit first.

March 23, 2004 - The recording industry sues 532 people for allegedly sharing digital music files over the Internet. For the first time, individuals using computer networks at universities are among the targets.

Credits: CBS News, Associated Press, Wired Magazine

Appendix B:

CBS NEWSMEW YORK TIMES POLL: ONLINE MUSIC SHARING

September 15-16, 2003

q42 How closely have you followed the issue of people sharing music for free through the Internet? Would you say you've followed it very closely, somewhat closely, not very closely, or not at all?

TOTAL RESPONDENTS

***** Age*****

	Total%	18-29%	30 and older%
Very closely	8	13	7
Somewhat closely	31	39	29
Not very closely	23	19	24
Not at all	37	28	40
DK/NA	1	1	0

q43 When it comes to sharing music over the Internet for free, which comes closest to your view:

1. Sharing music files over the Internet is ALWAYS acceptable, no matter how many copies are made, or by whom, OR

2. Sharing music files over the Internet is SOMETIMES acceptable, if a person shares music from a CD he or she owns with a limited number of friends or acquaintances, OR

3. Sharing music files over the Internet is NEVER acceptable because it deprives musicians and music companies of their income?

THOSE WHO FOLLOW THE ISSUE

***** Age*****

	Total%	18-29%	30 and older%
ALWAYS acceptable	14	29	9
SOMETIMES acceptable	44	46	
NEVER acceptable	37	30	40
DK/NA	5	1	5

q44 Several companies are now letting people purchase individual songs over the Internet for a small price. What do you think would be a fair price to pay for an individual song that you could get on the Internet, listen to, and burn onto your own CD?

Up to 50 cents	15	27	12
51 cents to \$1.00	29	33	28
\$1.01 - \$2.00	13	17	12
\$2.01 - \$5.00	17	15	18
over \$ 5.00	2	0	3
Nothing	1	2	0
DK/NA	23	6	27

UNWEIGHTED WEIGHTED

Total Respondents	675	
Total ages 18-29	101	149
Total ages 30 and over	571	524

The poll was conducted among a nationwide random sample of 675 adults interviewed by telephone September 15-16, 2003. The error due to sampling could be plus or minus four percentage points based on the entire sample. Sampling errors for subgroups may be higher. The error due to sampling on Americans age 18-29 could be plus or minus ten percentage points.

Appendix C:

The text of the warning letter from Napster:

"It appears that you are offering copyrighted music to others from your computer. Distributing or downloading copyrighted music on the Internet without permission from the copyright owner is ILLEGAL. It hurts songwriters who create and musicians who perform the music you love, and all the other people who bring you music.

When you break the law, you risk legal penalties. There is a simple way to avoid that risk: DON'T STEAL MUSIC, either by offering it to others to copy or downloading it on a "file-sharing" system like this.

When you offer music on these systems, you are not anonymous and you can easily be identified. You also may have unlocked and exposed your computer and

your private files to anyone on the Internet. Don't take these chances. Disable the share feature or uninstall your "file-sharing" software. For more information on how, go to http://www.musicunited.net/5_takeoff.html.

This warning comes from artists, songwriters, musicians, music publishers, record labels and hundreds of thousands of people who work at creating and distributing the music you enjoy. We are unable to receive direct replies to this message. For more information about this Copyright Warning, go to <http://www.musicunited.net>."

Appendix D:

Definition of Division I Institution by the NCAA (www.ncaa.org)

Division I member institutions have to sponsor at least seven sports for men and seven for women (or six for men and eight for women) with two team sports for each gender. Each playing season has to be represented by each gender as well. There are contest and participant minimums for each sport, as well as scheduling criteria. For sports other than football and basketball, Div. I schools must play 100% of the minimum number of contests against Div. I opponents — anything over the minimum number of games has to be 50% Div. 1. Men's and women's basketball teams have to play all but two games against Div. 1 teams, for men, they must play 1/3 of all their contests in the home arena. Schools that have football are classified as Div. I-A or I-AA. I-A football schools are usually fairly elaborate programs. Div. I-A teams have to meet minimum attendance requirements (17,000 people in attendance per home game, OR 20,000 average of all football games in the last four years or, 30,000 permanent seats in their stadium and average 17,000 per home game, or 20,000 average of all football games in the last four years, OR be in a member conference in which at least six conference members sponsor football or more than half of football schools meet attendance criterion. Div. I-AA teams do not need to meet minimum attendance requirements. Div. I schools must meet minimum financial aid awards for their athletics program, and there are maximum financial aid awards for each sport that a Div. I school cannot exceed.

Appendix E:

EDUCOM Code - Software and Intellectual Rights

Respect for intellectual labor and creativity is vital to academic discourse and enterprise. This principle applies to works of all authors and publishers in all media. It encompasses respect for the right to acknowledgment, the right to privacy, and the right to determine the form, manner, and terms of publication and distribution.

Because electronic information is volatile and easily reproduced, respect for the work and personal expression of others is especially critical in computer environments. Violations of authorial integrity, including plagiarism, invasion of privacy, authorized access, and trade secret copyright violations, may be grounds for sanctions against members of the academic community.

Appendix F:

Letter from the FBI in their new Anti-piracy Initiative:

To Users of Peer-to-Peer Systems:

The FBI has undertaken a new initiative to educate and warn citizens about certain risks and dangers associated with the use of Peer-to-Peer systems on the Internet. While the FBI supports and encourages the development of new technologies, we also recognize that technology can be misused for illicit and, in some cases, criminal purposes. In an effort to help citizens learn how to protect themselves, this letter is being distributed and is posted on the FBI's web site at www.fbi.gov/cyberinvest/cyberedietter.htm.

Peer-to-Peer networks allow users connected to the Internet to link their computers with other computers around the world. These networks are established for the purpose of sharing files. Typically, users of Peer-to-Peer networks install free software on their computers which allows them (1) to find and download files located on another Peer-to-Peer user's hard drive, and (2) to share with those other users files located on their own computer. Unfortunately sometimes these information-sharing systems have been used to engage in illegal activity. Some of the most common crimes associated with Peer-to-Peer networks are the following:

Copyright Infringement: It is a violation of Federal law to distribute copyrighted music, movies, software, games, and other works without authorization. There are important national economic consequences associated with such theft. The FBI has asked industry associations and companies that are particularly concerned with intellectual property theft to report to the FBI — for possible criminal investigation and prosecution — anyone that they have reason to believe is violating Federal copyright law.

Child Exploitation and Obscenity: The receipt or distribution of child pornography and unlawful obscenity over the Internet also is a serious Federal crime. The FBI cautions parents and guardians that, because there is no age restriction for the use of Peer-to-Peer services, pornography of all types is easily accessible by the many young children whose parents mistakenly believe they are only accessing music or movies. In fact, children may be exposed to pornography — and subsequently lured by sexual

predators — even though they were not searching for pornography, as some network users deliberately mislabel the names of files for this purpose.

Computer Hacking: Peer-to-Peer networks also have been abused by hackers. Because these systems potentially expose your computer and files to millions of other users on the network, they also expose your computer to worms and viruses. In fact, some worms have been specifically written to spread by popular Peer-to-Peer networks. Also, if Peer-to-Peer software is not properly configured, you may be unknowingly opening up the contents of your entire hard drive for others to see and download your private information.

The FBI urges you to learn about the risks and dangers of Peer-to-Peer networks, as well as the legal consequences of copyright infringement, illegal pornography, and computer hacking. For more information about the law, visit www.usdoj.gov/criminal. The FBI takes seriously its mission to enforce the laws against those who use the Internet to commit crime. To report cyber crime, please contact your local FBI Field Office, www.fbi.gov/contact/fo/fo.htm or file a complaint through the Internet Crime Complaint Center at www.IC3.gov.

Faculty Comments:

Professor John Norwood, Director of the Walton College Honors Program, made the following remarks about Mr. Wendel's research:

This paper deals with a current and important topic: the policies of institutions of higher education toward copyright infringement by students. This proposal was accepted by SURF for an undergraduate research grant: clearly they believed that the topic was timely and important. Now that the project has been completed, I can say that their confidence was well founded.

Henry has done a tremendous amount of background work on this topic. He was in contact with more than 110 universities from across the country, and examined each of their copyright policies. He then assembled this information into a coherent whole that is both interesting and informative.

I believe that Henry's work will be used as a guide by a number of universities, including the University of Arkansas. He has been very thorough and diligent in his work, and the result is a piece of work that is truly outstanding.

In summary, I believe that this project has resulted in an outstanding research paper.

DOES THE ADOPTION OF "ECONOMIC VALUE ADDED" IMPROVE CORPORATE PERFORMANCE?

By Matthew Louis Bell
Department of Finance

Advisor: Dr. Tomas Jandik
Department of Finance

Abstract:

Determining how to properly measure corporate performance is one of the most important problems in contemporary corporate finance. Without a sound mechanism to evaluate managerial performance, a corporation's management has no adequate standard to be judged by. This can destroy the firm's value very quickly through poor managerial decisions. For this reason, managers need to be evaluated and compensated based on a performance measure that truly demonstrates the changes in a company's value.

The interests of executives and shareholders do not always coincide, as can be seen through many of the current corporate scandals. Thus, it is almost universally argued that the best way to align these interests is through incentive-based managerial compensation. As a result, the corporate world is constantly searching for the best financial performance measure to use for managerial compensation; the better a measure explains the changes in a corporation's value, the more beneficial it is in assessing managerial performance. Some typical methods to used to compensate and evaluate management include plans based on accounting performance or stock options / ownership. Recently, a new method has become a popular method to better align these interests - Economic Value Added (EVA).

This paper focuses on the improvements in firms that adopt EVA for managerial evaluation and compensation. It compares the performance changes in firms that adopt EVA and matching firms (based on industry, asset size, and profitability) that do not adopt EVA. The time period of this study spans from 1985-1997.

The results of this study show what types of companies would likely improve corporate performance through the adoption of EVA, and in addition, firms that could benefit from adopting EVA will choose to do so.

After the adoption of EVA, numerous studies claim the adopting firms experience significant improvement in operating performance and stock performance. Accordingly, I observed the changes in both the operating performance (measured by

returns on assets) and the stock performance (measured by abnormal stock returns, based on a portfolio of similar firms) of adopting and non-adopting firms.

The results of this study provide strong evidence that firms which adopt Economic Value Added tend to experience significant improvement in important performance metrics, specifically changes in returns on assets and abnormal stock returns. Adopting firms increased (from one year prior to adoption to three years after adoption) their annual return on assets by 2.68%, while non-adopters' annual return on assets declined by 0.58%. Even more convincingly, a large disparity exists in the stock performance of the adopting firms and non-adopting firms. Contrary to the results of certain previous studies, I found in the three years following EVA adoption, adopting firms outperformed the rest of the market by 25.66%, while the non-adopting firms under-performed the rest of the market by -21.10%. All of the results listed in this paragraph are significant at the 5% level.

These findings are consistent with prior research arguing that firms which adopt Economic Value Added tend to experience significant improvement in important performance metrics, specifically changes in returns on assets and abnormal stock returns. In summary, EVA can be a great way to create value for shareholders.

1. Introduction:

One of the most important problems of contemporary corporate finance is how to properly measure corporate performance. Without a sound mechanism to evaluate managerial performance, a corporation's management has no adequate standard to be judged by. This can destroy the firm's value very quickly through poor managerial decisions. For this reason, managers need to be evaluated and compensated based on a performance measure that truly demonstrates the changes in a company's value.

In order to maintain a successful business, it is vital for a company to compensate its executives based on the company's performance. These incentives give management the prerogative

to do their best to improve the company's performance; otherwise executives might not put a faithful effort into their jobs. What is in the best interest of a company's shareholders and what is in the best interest of the company's managers may be entirely different things. This conflict of interest is commonly referred to as the "agency problem." Due to this problem, it is critical to give management the incentive to improve a company's performance. According to Garvey and Milbourn (2001), "There is near unanimity in the belief that performance-based compensation is a critically important corporate governance mechanism." Hence, management compensation plans are in place to help coalesce shareholders' and manager's interests.

While the top executives of a large corporation typically receive actual salaries in upper six-to seven-figure range, a significant portion of their overall compensation comes in the form of bonuses. Traditional management compensation plans most frequently occur in two ways, providing bonuses based on accounting figures and/or issuing stock options. Accounting-based compensation will commonly reward management for increasing figures like the firm's earnings or sales. Stock options can give the holder the right to buy stock at a certain price within a certain timeframe. Thus, logic behind this sort of plan dictates that executives will want to do as much as possible to improve the company's stock price, in order to maximize their salaries (the more they raise the stock price, the more money they make).

However, as Jensen and Murphy (1990) argue, the overall compensation for a firm's executives does not adequately reflect the performance of the firm. Their study claims that a corporate leader has little incentive to improve the corporation's performance. According to their research, there is a very minimal, if any, correlation between executive compensation and corporate performance'.

If this is truly the case, then why are the performance measures used to compensate corporate managers so crucial? Jensen and Murphy (1990) claim the most important aspect of executive compensation is not how much you pay them, but how. According to the findings of Wallace (1997), firms that adopted a residual income measure for managerial compensation improved their residual income, essentially supporting the adage 'you get what you measure and reward.' Thus, if a corporation utilizes the best (i.e. most valued by investors) performance measure to evaluate and compensate its management, it will likely improve its performance in that metric. But does the maximization of certain accounting or stock variables actually lead to value creation and if so, which ones? This is the ultimate question in assessing methods of measuring corporate performance.

Biddle, Bowen, and Wallace (1997) argue that firms with managerial compensation plans based on earnings outperform other types of plans. Others, such as Jensen and Murphy (1990) claim compensation plans that utilize stock options or ownership are the most effective method. Yet another group of individuals

feel Economic Value Added (EVA) is the best way to solve this problem.

This paper focuses on the performance changes in firms that adopt a new performance measure (for managerial evaluation and compensation) that has recently become quite popular, EVA. It compares the performance changes in firms that adopt EVA and matching firms (based on industry, asset size, and profitability) that do not adopt EVA. The time period of this study spans from 1985-1997.

This research shows what types of companies would likely improve corporate performance through the adoption of EVA, and in addition, firms that could benefit from adopting EVA will likely choose to do so.

Most importantly, this paper also provides evidence that firms which adopt Economic Value Added tend to experience significant improvement in important performance metrics, specifically changes in returns on assets and abnormal stock returns. Adopting firms increased (from one year prior to adoption to three years after adoption) their annual return on assets by 2.68%, while non-adopters' annual return on assets declined by 0.58%. Even more convincingly, a large disparity exists in the stock performance of the adopting firms and non-adopting firms. Contrary to the results of certain previous studies, I found in the three years following EVA adoption, adopting firms outperformed the rest of the market by 25.66%, while the non-adopting firms underperformed the rest of the market by -21.10%.

Section 2 explains the concept of EVA, along with its alleged benefits and drawbacks. The hypotheses are listed in Section 3. The description of the sample and summary statistics of the sample are displayed in Section 4. Section 5 discusses the empirical results. The summary is located in Section 6.

2. What is EVA?

2.1 Concept of EVA:

Economic Value Added is a form of residual income; that is, it is the residue left over after all costs have been covered, according to Ehrbar and Stewart (1999). As such, it is a measure of how much value a company has created. What EVA does is require management to provide a return above what investors expect to receive. EVA and economic profit are relatively synonymous. Stern & Stewart trademark EVA, while economic profit is essentially the same thing, only it is used by Stern & Stewart's competitors like Boston Consulting Group or KPMG.

EVA takes into account the return stakeholders in a company expect. This is accounted for in a company's weighted average cost of capital (WACC).

$$WACC = R_E * (E / V) + R_D * (D / V) * (1 - T_c)$$

Where: R_E = cost of equity

R_D = cost of debt (%)

E = market value of equity

D = market value of debt

$V = D + E$

T_C = corporate tax rate

What WACC essentially does is it takes into consideration what every dollar of capital invested in the company is expected to return. After a company's WACC has been calculated, then EVA can be calculated using the following formula:

$$EVA = NOPLAT - (WACC * TC)$$

Where: NOPLAT = net operating profit less adjusted taxes

TC = total capital²

Through this computation, EVA is able to determine whether or not a company produced a return equal to, less than, or above the return its stakeholders expected. According to Ehrbar and Stewart (1999), the foundation of EVA's capital charge (TC) dates all the way back to Adam Smith, in that a business has to produce a minimum, competitive return on all of the capital invested in it. The most unique aspect of EVA is in its accounting for the required return of both debt and stockholders. This is unquestionably one of its most valuable traits.

2.2 Benefits of EVA:

One of the more compelling arguments for EVA is in its effects on all levels of employees. When firms implement EVA, Stern & Stewart sends some of its professionals out to orchestrate the process. They have a procedure that allows them to slowly integrate EVA into the firm. As employees are taught the specifics about value creation, they become much more aware about the effects their decisions have on the company's value.

For managers in a firm that gives bonuses based on EVA results, there is no limit to how much they can earn. Proponents of EVA claim this encourages managers to increase their company's performance as much as possible. Additionally, managers are encouraged to set more ambitious goals for the company, since managers are compensated on EVA instead of meeting the goals they set for the company (which would likely be set too low by management, in order to ensure they get their bonuses).

Various studies have found EVA adopting companies outperform non-adopters in certain areas. One of the most often quoted is in the improvements to adopters' stock performances. For instance, Wallace (1997) states, "Finally, weak evidence suggests that market participants respond favorably to adoption of residual income-based compensation plans, as evidenced by increased stock returns." Many articles written by the developers

of EVA, Joel Stern and G. Bennett Stewart, argue that EVA is highly correlated to market value added (MVA)³. Basically, they argue that MVA is (and should be) the overall goal a successful company achieves when it produces positive EVA.

Perhaps the most beneficial aspect of EVA is its ability to judge performance at the divisional level. For multi-divisional companies, the inability to judge and reward divisional performance apart from company performance is one of the most prevailing criticisms of bonuses through stock options. Using stock options can cause one or more divisional managers to take credit for the other divisional managers' efforts. If a company's stock price goes up, but one division performs poorly, that divisional manager will still reap the rewards of the other divisions' performance.

EVA can prevent this from occurring. Each division has its own "hurdle" to clear. For instance, a firm could have two divisions, A (WACC=10%) and B (WACC=20%). If A had a 13% return (3% above required return) and B had a 16% return (4% below required return), then the managers of division A would receive bonuses, and division B's managers would not take credit for division A's efforts, even though B's return was higher than A's.

EVA has exacting demands for what type of return a company is providing for its shareholders. Its supporters feel EVA does a better job of incorporating the overall impact a company's projects make on its invested capital. In their opinions, management is encouraged to follow shareholders' interests more closely with EVA-based plans than in traditional forms of managerial evaluation and compensation.

2.3 Criticisms of EVA:

As stated earlier, not all companies use the same adjustments to EVA. In fact, the number and type of adjustments that are used can vary widely. In his survey, Weaver (2001) found that of the 36 potential adjustments observed, the average company uses roughly nineteen (with a minimum of seven and maximum of 34). This variability in the determinants of EVA fuels a lot of criticism from its opponents, in addition to an adverse reaction from people unfamiliar with the metric. AT&T adopted EVA, only to abandon it later for several reasons, one being the complexity of the metric, according to Ittner and Larcker (1998).

Some research has found that EVA has a lower correlation to stock performance than other performance metrics. In their paper (frequently cited and/or attacked), Biddle, Bowen, and Wallace (1997) compare operating cash flows (CFO), earnings before extraordinary items (EBEI), residual income (RI), and Economic Value Added (EVA). Their empirical "... results suggest that, in terms of relative information content, earnings significantly outperforms RI, RI significantly outperforms EVA (although the gap here is smaller), and all three outperform

CFO." As they point out in the paper, these results almost mirror the results of Vuong (1989).

Other critics of EVA are quick to site that EVA is too present-minded. They feel it can encourage managers to liquidate their assets prematurely, in order for management to receive large benefits from selling parts of the company that may or may not be beneficial to liquidate⁴.

As stated earlier, EVA is one method in place to align managerial decisions with shareholders' interests. In a 1994 roundtable discussion, Professor Jerold Zimmerman argues EVA has solved part of this problem. He contends that the creators of EVA have succeeded in putting the net present value (NPV) / discounted cash flow (DCF) method into a form which can be used by some corporations for performance measurement. However, he feels EVA does not work well in firms that are unwilling to decentralize. In other words, for EVA to be effective firms must be willing to "empower" operating managers; they must be comfortable with less of a "top-down" corporate structure.

Some argue that EVA isn't the factor behind improved company performance. Rather, as Wallace (1997) notes, "Firms that adopt new performance measures in their compensation plans may be changing other aspects of their environment. This is alleged to be the case with firms adopting EVA. In particular, firms that use the consulting firm Stem Stewart and Co. to help them implement an "EVA financial management system" often increase the intensity of their incentives along with increased education leading to employees having a greater awareness of the opportunity cost of capital and value creation. It is therefore possible that the observed effects attributed to the residual income measure are at least partially the result of environmental changes."

Another criticism of EVA stems from the fact that a lot of EVA adopters were performing poorly at the time of adoption. As a consequence, critics claim the change to EVA isn't the primary factor in improved performance as much as the fact that something, rather, anything needed to be done in order to change the company's performance. For instance, Hogan and Lewis (2001) feel "closer examination of the adopting firms indicates that they are relatively poor performers prior to adoption of these plans, however, and that the improved stock return and operating performance may not be unique to [EVA] adopters.⁵" They maintain adopters of EVA improve their operations and stock performance, but the improvements are roughly the same as comparable firms that do not adopt EVA.

More specifically, Hogan and Lewis (2001) found that adopters significantly improved their long-term operating performance, as measured by numerous accounting measures such as returns on assets from the year prior to adoption to four years after adoption. Although they found improvement in operating measures such as ROA, they did not find the improved

performance to be significantly different from non-adopters. In addition, Hogan and Lewis find no significant difference in the stock performance of adopters (18.6%, on an annualized basis) and non-adopters (23.4%) in the four years following adoption.

3. Hypotheses:

Clearly, a lot of studies have been conducted in determining the best method to alleviate the "agency problem" in corporate management. More specifically, researchers have been trying to solve what form of managerial compensation produces superior results in companies' financial performances.

The purpose of this paper is to determine whether or not EVA adoption improves companies' financial performances. As Wallace (1997) found, the performance measures managers are compensated on will improve. As a result, the more important a performance measure is to an investor, the more beneficial it will be in judging managerial performance.

As many papers such as Hogan and Lewis (2001) suggest, the performance measures investors arguably care the most about - returns on assets and stock returns - should be the most relevant measures on which to base corporate performance. In the end it comes down to whether or not an investor makes adequate money on his or her investment.

This paper extends the work of Hogan and Lewis (2001), although it approaches the data in a slightly different manner. While their results suggest no significant improvement due to EVA adoption, their performance metrics may not reflect the true value creation of adopters.

The results of this study differ from Hogan and Lewis (2001) primarily due to the method of determining stock performance. This paper uses a more recent method of determining stock performance, designed by Lyon, Barber, and Tsai (1999). Rather than measuring stock performance based solely on a portfolio using the daily CRSP value-weighted NYSE-AMEXNASDAQ index, this paper uses a method which compares firms based on a portfolio that accounts for market value, book-to-market of equity, and prior-performance. Appendix C provides a description of the methodology behind this portfolio derivation.

A corporation will do what it feels is necessary in order to facilitate its primary function: to make money. As Wallace (1997) found, the performance measures managers are compensated on will improve. Thus, if a corporation can compensate managers on a performance measure that more closely approximates what shareholders deem to be important, it will likely do so, as one would expect these performance measures to then improve. Therefore, I argue:

H1: The companies that are expected to benefit the most from the adoption of EVA win, in fact, adopt EVA. In other words, companies are rational; they will attempt to operate in whatever manner proves to be the most profitable.

H2: Firms that adopt EVA should experience substantial improvements in accounting performance as measured by return on assets in addition to significant gains in their stock returns.

4. Description of Sample:

Appendix A contains the sample used in the following analysis. It is a combination of the samples from two papers: "Adopting residual income-based compensation plans: Do you get what you pay for?" by James Wallace (1997), and "The Long-Run Performance of Firms Adopting Compensation Plans Based on Economic Profits" by Chris Hogan and Craig Lewis (2001).

The sample includes fifty-seven firms that adopted compensation plans that use a residual income performance measure. The disclosure in each firms' proxy statements confirmed the adoption of an EPP as well as the specific year of adoption, which ranges from 1986 to 1994. After establishing a sample of adopters, matching firms are then included based on several factors. In Wallace's sample, firms that adopt EVA are matched with firms that utilize earnings-based compensation plans. Except for a handful of firms, matching firms have the same* four-digit SIC and comparable total asset size in the year before adoption. In the sample for Hogan and Lewis, a pool of matching firms in the same two-digit industry is made based on total asset size (between 25% and 200% of the corresponding adopters). Then, all of the non-adopters meeting this criterion are sorted based on which firm has the closest OIBD / Assets ratio, with the closest non-adopter selected as the matching company. If no firm meets this condition, then all of the non-adopters with assets of 90% to 110% of the adopter's total assets are ranked, and the firm with the closest OIBD/Assets is selected as the matching firm.

Many of the adopting firms (such as American Freightways Corporation and Quaker Oats Company) are included in both papers. If an adopting firm was included in both papers (albeit with a different matching firm), then the matching firm listed in Hogan and Lewis's paper is used, since it is a more current paper than Wallace's paper.

Summary statistics for the sample are displayed in Table 1. The sample period consists of data ranging from 1985 to 1997. Through the examination of the appropriate proxy statements, adopters are defined as firms that adopted EVA for managerial compensation. Non-adopters are the firms which have been paired up with the adopting firms, matched up based on the adopters' industry, total asset size, and profitability, as stated in the previous section.

All data was acquired through Compustat. It was collected for each firm in the sample from the year prior to adoption (year -1) to three years after adoption (year 3). The top and bottom outliers for both adopters and non-adopters in each category

were removed. ROA is defined as earnings before interest and taxes (EBIT) divided by total assets. Leverage is defined as total debt to total assets.⁶

5. Discussion of Empirical Data

5.1 Analysis for Probability of EVA Adoption:

Table 2 provides the probit analysis for the probability of EVA adoption. The dependent variable is a (0, 1) dummy variable for adopting EVA, where 1 denotes an adopting firm and 0 is a non-adopting firm. Appendix B explains the control variables' possible relationship with the probability of EVA adoption, as well as the predicted relationship to long-term performance. All of the accounting control variables are from the Compustat database.

Sales are found to be positively correlated to EVA adoption in all three models, two of which are statistically significant at the 10% level. This is consistent with claims that EVA is more beneficial for larger corporations, because they are subject to larger agency costs. Cash to Total Assets is very negatively correlated in all three models with the adoption of EVA, all at the 5% significance level. This is to be expected, as more established firms' managers are less likely to be pressured to change their operations. Dividend payout is also negatively correlated with EVA adoption in all three models (two at the 10% significance level); which is understandable, since less risky firms are argued to receive fewer benefits from adopting EVA.

More importantly, the two performance measures added in models 2 and 3 are positively correlated with EVA adoption. In model 2, the change in return on assets from year -1 to year 3 is very influential to the probability of adopting EVA, significant at the 10% level. Model 3 includes three-year abnormal stock returns (defined in Appendix C) which is positively correlated with the probability of EVA adoption at the 1% level. These two results support hypothesis H I, that firms which are expected to benefit the most from EVA will adopt EVA.

5.2 Changes in Returns on Assets:

Table 3 lists the performance changes of adopters and non-adopters. Δ ROA (Absolute) is the difference between ROA in year 1 (or 3) and year -1. Δ ROA (Relative) is the relative change in ROA from year 1 (or 3) and year -1. Its formula is⁷ :

$$\Delta \text{ROA (Absolute)} = \text{ROA}_{\text{YR 1 (OR 3)}} - \text{ROA}_{\text{YR -1}}$$

$$\Delta \text{ROA (Relative)} = (\text{ROA}_{\text{YR 1 (OR 3)}} - \text{ROA}_{\text{YR -1}}) / \text{ROA}_{\text{YR -1}}$$

The abnormal stock returns for one (and three) years are the abnormal returns from year 0 to year 1 (or 3).

Adopting firms dramatically improved their performance in all six categories. The medians for A ROA (Absolute) from year -1 to year 3 and A ROA (Relative) from year -1 to year 1 are significant from zero at the 5% level. The medians for the other

two ROA changes are significant from zero at the 10% level. This evidence is consistent with Wallace (1997) in claiming the adoption of EVA improves firms' return on assets. This partially supports the research of Hogan and Lewis, as they found that adopters significantly improved their long-term operating performance, measured by numerous accounting measures such as returns on assets from the year prior to adoption to four years after adoption. Although they found improvement in operating measures such as returns on assets, they did not find the improved performance to be significantly different from non-adopters.

Contrary to the results of Hogan and Lewis (2001), the changes in ROA for the firms that adopted EVA significantly outperformed the changes in ROA for the firms that did not adopt EVA in every single category. Half of the medians for non-adopting firms are significant from the difference in the two samples at the 5% significance level. Of particular note, the absolute change in the return on assets of adopters (year - 1, year 3) is 2.68%, while the absolute change in non-adopters' ROA is -0.58%. These medians are significant from each other at the 5% level. This analysis supports hypothesis H2, as it provides pretty conclusive evidence that the adoption of EVA can dramatically improve a company's return on its assets.

5.3 Changes in Abnormal Stock Returns:

The last two columns of Table 3 report the abnormal stock returns (defined in Appendix Q. Both the mean and median improvements over one and three years of EVA adopters considerably outperformed the market over both the one and three year time periods following adoption. Both the medians and even the means are significant from zero at the 5% level. This evidence supports Stem & Stewart's claims that adopting Economic Value Added can significantly increase a firms' MVA.

The differences in abnormal stock returns for adopters and non-adopters are also very significant. The median one-year and three-year abnormal stock returns for adopters (both significant at 5% level) are 8.62% and 25.66%, respectively. On the other hand, the non-adopters' abnormal stock returns (0.28% and -21.10%) were not as enviable. The three-year non-adopter abnormal return of -21.10% is statistically significant from the difference in the medians of the two sub-samples (adopters and non-adopters) at the 5% level. This provides strong evidence in support of H2, that the adoption of EVA can improve firms' stock performance.

5.4 Regression Analysis of Performance Changes in Samples:

Regression analysis of the performance changes in EVA adopters and non-adopters is provided in Table 4. The dependent variables in the four models are different performance measures: the absolute changes in return on assets from year -1 to year 1, relative changes in ROA from year -1 to year 3, abnormal stock

returns over a one year period (year 0 to 1), and abnormal stock returns over a three-year period (year 0 to 3). Five independent variables are regressed against these dependent variables, which are explained in further detail in Appendix B.

Of all the results from the analysis, the most important is the strong correlation found between the adoption of EVA and three of the four different performance measures. EVA adoption is determined using a "dummy" variable, i.e. a (0,1) statistic, where 1 denotes the adoption of EVA in year zero and 0 implies a firm did not adopt EVA in year zero. EVA adoption is positively correlated with the absolute change in return on assets (year -1, year 3), significant at the 5% level. One year abnormal returns are also positively correlated with adoption (at the 10% level). Most noticeably, the coefficient for three year abnormal returns (0.4976) is significant at the 5% level. This result provides a very strong confirmation of hypotheses H1 and H2.

These results are in stark contrast to those presented by Hogan and Lewis (2001), who find no significant difference in the annual stock performance of adopters (18.6%, on an annualized basis) and non-adopters (23.4%) in the four years following adoption. However, these differences are not that unexpected, as it should be mentioned that the results in this study utilize more recent methods for determining stock performance, designed by Lyon, Barber, and Tsai (1999).⁸

Again, both of the three year performance measures show EVA adoption to be positively correlated, significant at the 5% level, while adoption is positively correlated to the one year abnormal returns at the 10% level. The stronger correlation between adoption and three-year performance measures can be explained fairly simply. It takes time to implement EVA. The effects of adoption should be more pronounced at a three-year interval, as a longer time is provided for the adopting firm to adjust to its new financial management system.

6. Conclusion:

Determining the best way to measure corporate executive performance is a crucial problem for any firm. If managers can be properly evaluated, their compensation can be used to align managerial and shareholder interests, combating agency costs and helping maximize shareholder wealth.

This paper provides analysis as to why EVA is a proficient way to accomplish this. It contradicts the findings of Hogan and Lewis (2001), which establishes that even though adopters significantly improved their long-term operating performance (according to numerous accounting measures such as ROA and OIBD/Assets), their improved performance was not significantly different from non-adopters. In addition, Hogan and Lewis argue adopters' stock performances were not significantly different from non-adopters.

Meanwhile, this paper finds EVA adopters significantly outperform non-adopters in improvements to their operational

performance (as measured by returns on assets) and abnormal stock returns. For instance, adopters' median improvement in returns on assets from year -1 to year 3 is 2.68% (significant at the 5% level), whereas non-adopters' median change in returns on assets for the same period is -0.58% (also significant at the 5% level). Furthermore, adopters outperform the stock market (from year 0 to year 3) by a median of 25.66%, while non-adopters experience median abnormal returns of -21.10%. Both values are significant at the 5% level.

These results are consistent with prior research (O'Byrne, 1999, Stewart, 1994, Stem et al, 1995) arguing that firms which adopt Economic Value Added tend to experience significant improvement in important performance metrics, specifically changes in returns on assets and abnormal stock returns. In summary, EVA can be a great way to create value for shareholders.

Endnotes:

¹ Jensen and Murphy (1990) determine a wise decision from a CEO which increases a company's market value by \$100 million will result in a two-year increase in a CEO's compensation of \$6,700, while a decision (that is beneficial for executives, but not shareholders, such as the purchase of a new aircraft for the corporate fleet) which destroys \$10 million in shareholder value will result in lowering a CEO's compensation by \$25,900. Frankly, neither of these scenarios should matter much to someone who is likely making more than \$20,000 per week. In their opinion, a large part of this problem is due to the intense public criticism of the seemingly excessive compensation of corporate managers. In order to appease public opinion, corporate boards are less apt to truly pay managers based on the firm's performance, which, by essentially compensating executives at a relatively stagnant amount, executives are given little incentive to improve the performance of the firm.

² TC is roughly the value of all of a company's assets. However, before EVA can be calculated, adjustments are usually made to both NOPLAT and TC. Examples of this include adding research and development expenditures to NOPLAT or adding back accumulated goodwill and operating leases to TC. Over one hundred adjustments to these figures can be used in calculating EVA. Interestingly enough, not all companies use the same adjustments, and most companies tend to use only up to 5-6 adjustments consistently (Garvey and Milbourn, 2001).

³ MVA is defined as the difference between a company's current market capitalization and the economic book value of the capital it employs.

⁴ While this is a valid criticism, this argument can be applicable to virtually any executive compensation scheme. Typically, different compensation plans have measures that attempt to account for this "time-horizon" agency problem. According to Stem et al (1995), EVA combats this through the use of its "bonus bank," which partially delays (and possibly negates) the payment of EVA-based bonuses, dependant on the company's future health.

⁵ In their paper, Hogan and Lewis set out to determine the long-term effects of EVA adoption, particularly its effects on accounting operating performance (returns on assets (ROA), operating income before depreciation to total assets (OIBD/Assets), etc.) and stock returns.

⁶ Definition for leverage in terms of Compustat variables is: $\text{Leverage} = \frac{[(\text{data9} + \text{data34}) / \text{data6}]$

⁷ ROA definition is $\text{EBIT} / \text{Total Assets}$. ROA definition in terms of Compustat variables is: $\text{ROA} = \frac{[(\text{data13} - \text{data14}) / \text{data6}]$

⁸ Hogan and Lewis measure stock performance (for the four years after adoption) based on a portfolio using which uses the daily CRSP value-weighted NYSE-AMEX-NASDAQ index. This paper uses a method which measures stock performance (for the three years after adoption) based on a portfolio that accounts for the market value, book-to-market of equity, and prior-performance of firms.

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Faculty Comment:

Mr. Bell's mentor, Tomas Jandik, made the following comments about his student's work:

Matt's research topic was exceptionally relevant - both because of its importance for contemporary financial research and because it allowed Matt to acquire analytical skills and financial intuition very beneficial for his future business career. The project execution on Matt's part was flawless. Not only he was able to theoretically familiarize himself with the problem of optimal measurement of corporate performance, but he also undertook empirical data analysis of the long-term performance of firms adopting so called "performance compensation plans." He extended the work of several influential finance studies on this topic and, notably, found very contrasting results leading to different conclusions from previously published financial studies. As a result, Matt Bell's thesis is not just a simple literature review study. It is a quality empirical financial analytical project. In contrast to some previous financial studies, the results of Matt Bell's honors thesis suggest that companies adopting "Economic Value Added" methodology to compensate managers outperform their non-adopting peers in the long run.

The problem that Matt studied is far from clear cut. In fact, the ability of Economic Value Added methodology to motivate managers to create value has been quite a controversial topic in contemporary corporate finance. Whereas many people agree that managers who are paid based on their firm's performance make better corporate decisions and create more wealth for their investors, experts differ in their opinions on how to properly measure the "true" corporate performance.

Recently, an increasing number of finance practitioners has been claiming that a newly developed method for measuring corporate performance called "Economic Value Added" (EVA) can do the best job at measuring true corporate performance. EVA uses sophisticated financial techniques to create unique

profit targets—based on the nature of business and the amount of currently invested capital—for each of company's divisions. As a result, each divisional manager can be properly motivated to create value and thus, the proponents claim, EVA generates a superior performance-monitoring scheme compared to traditional stock and accounting profits based methods.

Matt Bell's research (based on sound financial methodologies) did uncover very interesting results that suggest Economic Value Added is indeed a superior method for motivating managers to create wealth. One can say that thanks to how controversial and unresolved EVA topics are, Matt Bell's honors thesis provides a true contribution to the contemporary finance research.

Appendix A. Sample

Adopters			Non-Adopters	
Name	CUSIP	Year of Adoption	Name	CUSIP
Georgia-Pacific Group	37329810	1986	Fort Howard Paper Company	34746110
Donaldson Co Inc	25765110	1987	AST Research Inc	00190710
CSX Corp.	12640810	1988	Santa Fe Pacific	80218310
Orange Co	68417710	1990	Riverbend International Corp	76857510
Briggs & Stratton	10904310	1991	Data General Corp	23768810
Crane Co.	22439910	1991	Capital Associates, Inc	13973020
Quaker Oats Co	74740210	1991	Deans Foods Co.	24236110
Brandon Systems Corp	10530310	1992	Rational Software Corp	75409P20
Cincinnati Milacron Inc	17217210	1992	Network Systems Corporation	64121710
Ball Corp	05849810	1992	Trimas Corporation	89621510
Cabot Oil & Gas Corp	12709710	1992	Unit Corporation	90921810
Vigoro Corp	92675410	1992	Mylan Laboratories	62853010
Applied Power	03822510	1993	BancTec Inc	05978410
Applied Bioscience Intl Inc	03791710	1993	Enron Corp	29356110
Wellman Inc	94970210	1993	Minerals Technologies Inc.	60315810
Scott Paper Co.	80987710	1993	Union Camp Corp	90553010
Harnischbeger Industries Inc	41334510	1993	Tandem Computers Inc.	87537010
Allegheny Teledyne Inc / Teledyne	01741510	1993	Carpenter Technology Corp	14428510
W.W. Grainger, Inc.	38480210	1993	Waxman Ind	94412410
National Data Corp	63562110	1993	Olsten Corp	68138510
Primark Corp	74190310	1993	Ceridian Corp	15677T10
American Freightways Corp	02629V10	1993	Intrenet, Inc.	46119010
Comptronix Corporation	20476C10	1993	Supertex Inc	86853210
Duracell International, Inc.	26633010	1993	Sunbeam Oster Co Inc	86707110
R P Scherer Corp	80652810	1993	Calgon Carbon Corp	12960310
L.A. Gear Inc	50170810	1994	Vans, Inc.	92193010
Coca-Cola Co	19121610	1994	Kellogg Co.	48783610
Eastman Kodak Co	27746110	1994	Loral Corp	54385910
Johnson Worldwide Associates	47925410	1994	Oneida Ltd	68250510
Kinetic Concepts Inc	49460W10	1994	Chromcraft Revington, Inc.	17111710
Pepsico Inc	71344810	1994	Anheuser Busch Cos. Inc.	03522910
Autoclave Engineers, Inc.	90921C10	1994	Gelman Sciences	36851410
TransAmerica Corp.	89348510	1994	Loews Corp	54042410
Deere & Co	24419910	1994	Apple Computer Inc.	03783310
HJ Heinz Co	42307410	1994	Whitman Corp.	96647K10
Ashland Inc.	04420410	1994	Petro-Canada Inc.	71644E10
Varity Corporation	92224R60	1994	Goodrich B F	38238810
Furon Co	36110610	1994	Carlisle Plastics Inc	14252210
Tektronix Inc	87913110	1994	United States Surgical Corp	91270710
Incstar Corp	45337010	1994	Gamma Biologicals Inc	36465710
Jefferies Group, Inc.	46145F10	1994	Legg Mason Inc	52490110
American Precision Inds	02906910	1994	Howell Industries, Inc.	44307310
Manitowoc Co	56357110	1994	Tebxon Crop	87970010

Appendix A. Sample (continued)

Adopters			Non-Adopters	
Name	CUSIP	Year of Adoption	Name	CUSIP
Equifax Inc	29442910	1994	Novell Inc	67000610
Merrill Lynch and Co., Inc.	59018810	1994	Salomon Inc	79549B10
Medtronic Inc	58505510	1994	Stryker Corp	86366710
Premark International Inc	74045910	1994	Pall Corp	69642930
Maritrans Inc	57036310	1994	Seacor Holdings (Seacor Smit)	81190410
Beckman Instruments, Inc.	07581110	1994	Perkin-Elmer	71404610
Tennant Co	88034510	1994	Kronos Inc	50105210
Intl Murex Tech Corp	46005H10	1994	Watson Pharmaceuticals, Inc.	94268310
Kaiser Aluminum Corp	48300710	1994	Maxxam Inc.	57791310
Revco D.S. Inc	76133910	1994	Longs Drug Store Corp	54316210
Eastman Chemical Company	27743210	1994	PPG Industries Inc	69350610
Merix Corp	59004910	1994	Koss Corp.	50069210
Matthews International Corp	57712810	1994	Synalloy Corp	87156510
Grancare Inc	38518910	1994	Humana Inc (Extendicare Inc)	30224T87

Appendix B. Control Variables Influencing the Probability of EVA Adoption and Long-Term Firm Performance

Size (Sales and Total Assets)	Positive: Larger firms are subject to higher agency costs, so they may benefit more from adopting EVA.	Larger firms are less likely to go bankrupt, they are more successful.
Free Cash Flows Total Assets	Negative: More successful firms are less prone to change their operations.	Positive: Market has already taken prior performance into account. Negative: If ex-post accounting performance is poor, then performance can likely go nowhere but up.
Market / Book (Assets)	Positive: Riskier companies are frequently considered to benefit more from EVA adoption.	Riskier companies are typically expected to have more growth opportunities, in addition to being more profitable.
Leverage	Negative: Firms with more debt are monitored more closely than firms with less debt, due to banks' monitoring of their investments.	Indeterminate: Highly levered firms are usually less risky and more profitable, but are also subject to a higher probability of bankruptcy due to the large amounts of debt.
Cash / Total Assets	Negative: More established firms are less likely to be pressured to change.	-
Interest Coverage	Negative: Same reasoning as Leverage.	-
Price / Earnings	Positive: Same reasoning as Market to Book (Assets).	-

Appendix B, Continued.

Dividend Payout	Negative: More mature firms that have less risk and fewer growth opportunities are more likely to pay dividends.	-
A ROA (Year -1, 3)	Positive: According to Wallace (1997), firms that adopt EVA are likely to improve ROA	-
3 Year Abnormal Stock Returns	Positive: EVA adopters have been argued to experience increased stock performance following adoption.	-

Appendix C. Abnormal Returns

Abnormal stock returns for each firm are calculated in the following manner, first utilized by Lyon, Barber, and Tsai (1999):

1) Fourteen size reference portfolios are generated by separating all firms listed on the New York Stock Exchange into deciles by market value at the time of adoption. The smallest size decile was then separated into quintiles (to account for the fact that Amex and NASDAQ firm are typically much smaller, overpopulating the lowest decile). Amex and NASDAQ stocks are then added into portfolios based on NYSE sizes.

2) Five book-to-market equity portfolios are also constructed. They are established by separating all firms into quintiles based on book-to-market in the year of adoption.

3) Three prior-performance reference portfolios are established by separating all firms into prior-performance terciles. Prior performance is measured as a twelve month buy-and hold strategy.

4) Each target firm is then matched to all firms that belong in the same size, book-to-market, and prior-performance portfolios. The abnormal return for each target firm is then calculated as the difference between the buy-and-hold return of the company and the buy and-hold return of the portfolio. If either the target firm or any other firm in the portfolio delists, then proceeds from the investment are re-invested into an equally-weighted market CRSP return until the maturity of the investment.

5) Finally, the abnormal sample firm portfolio return is then computed as the difference between average sample firm returns and average returns on matched portfolios.

Table 1: Sample Summary Statistics

The sample period consists of data ranging from 1985 to 1997. Adopters are defined as firms that adopted EVA, which was determined through the examination of appropriate proxy statements. Non-adopters are the firms which have been matched up to adopting firms, as stated previously in the paper. The following data was acquired through Compustat for the years prior to adoption (Year -1) to three years after adoption (Year 3) for both adopters and non-adopters. ROA is defined as EBIT divided by total assets. Leverage is defined as total debt to total assets.

Compustat Formulas for Variables: Total Assets = [data6] ROA = [(data13 - data14) / data6] Leverage [(data9 + data34) / data6] Market to Book (Assets) = [(data25 * data199 + (data6 - data60)) / data6] Price to Earnings = [data199 / data58] Capital Expenditures (CAPEX) to Assets = [data30 / data6]

	Adopters			Non-Adopters		
	Mean	Median	STD	Mean	Median	STD
Total Assets	3357.6	630.2	6968.5	4847.9	652.9	23416.9
ROA (Year -1)	10.08%	9.73%	5.48%	10.62%	8.67%	6.72%
ROA (Year 0)	10.45%	10.59%	6.04%	10.73%	9.76%	6.19%
Leverage	693.2	117.3	1623.8	403.5	75.2	786.0
Market / Book (Assets)	1.601	1.536	0.601	1.657	1.420	0.655
Price / Earnings	14.379	15.450	14.858	14.783	17.250	15.156
CAPEX / Assets	0.060	0.063	0.028	0.056	0.047	0.033

Table 2: Analysis of EVA Adoption Probability

Table 2 examines factors that may influence a firm's decision to adopt EVA. The dependent variable is a (0, 1) statistic, where the variable is equal to 1 if a firm adopted an EVA metric, and the variable is equal to 0 if a firm did not adopt EVA. Free Cash Flows to Total Assets is defined as (Operating Income Before Depreciation - Interest Expense - Income Taxes - Preferred Dividends - Common Dividends)/Total Assets. A ROA (Year -1, 3) is the absolute difference between a firm's ROA in year 3 and year -1. Interest Coverage is (Interest Expense + Pretax Income)/Interest Expense. 3 Year Abnormal Stock Returns (as defined previously) is a measure of the firms' abnormal stock performance from year 1 to year 3. T-statistics are in parentheses, and * demonstrate variables' significance at 1%, 5%, and 10%, respectively.

Compustat Formulas for Variables: Free Cash Flows/Total Assets = [(data 3 - data 5 - data 6 - data 9 - data 21)/data 6] Interest Coverage = [(data 5 - data 70)/data 51]

	Model 1	Model 2	Model 3
Intercept	0.6499 (1.28)	0.6849 (1.18)	0.7051 (1.22)
Sales	0.0618* (1.72)	0.0430 (1.07)	0.0720* (1.84)
Free Cash Flows / Total Assets	-2.4030 (-0.73)	-5.3751 (-1.38)	-3.9909 (-1.16)
Market / Book (Assets)	0.1142 (0.50)	0.2305 (0.97)	0.2316 (0.91)
Leverage	-1.3563 (-1.49)	-1.1031 (-0.97)	-1.7794 (-1.55)
Cash / Total Assets	-3.4533** (-2.01)	-5.3102** (-2.49)	-5.3742** (-2.47)
Interest Coverage	-0.0223 (-1.60)	-0.0189 (-1.24)	-0.0181 (-1.11)
Price / Earnings	0.0120 (1.40)	0.0192 (1.58)	0.0087 (1.19)
Dividend Payout	-0.4897* (-1.65)	-0.8424* (-1.81)	-0.5412 (-1.20)
Δ ROA (Year -1, 3)	-	5.6379* (1.85)	-
3 Year Abnormal Stock Returns	-	-	0.5888*** (2.63)

Table 3: Performance Changes of Adopting and Non-Adopting Firms

A ROA (Absolute) is the difference in firms' ROA in year 1 (or 3) and year -1. A ROA (Relative) is the relative difference in firms' ROA in year 1 (or 3). Its formula is $A\ ROA\ (Relative) = (ROA_{yR\ 1}\ (OR\ 3) - ROA_{yR\ -1}) / ROA_{yR\ -1}$. ***, **, and * denotes significance from zero at 1%, 5%, and 10%, respectively. ###, ##, and # denotes the statistical significance of the difference between subsamples of adopting and non-adopting firms on 1%, 5%, and 10%, respectively.

		Δ ROA (Absolute)		Δ ROA (Relative)		Abnormal Stock Returns	
		(-1,1)	(-1,3)	(-1,1)	(-1,3)	1 year	3 year
Adopters	Mean	0.84	1.71**	12.04	14.22	8.88**	30.51**
	Median	1.56*	2.68**	12.47**	19.50*	8.62**	25.66**
Non-Adopters	Mean	0.48	-1.35**	0.80	-16.30#	-2.66	-13.69**
	Median	0.99	-0.58**	3.66	-7.74**	0.28	-21.10**

Table 4 Regression Analysis of Performance Changes in Adopting and Non-Adopting Firms

T-statistics are in parentheses. ***, **, and * denotes significance from zero at 1%, 5%, and 10%, respectively.

Dependent Variables	ROA - Absolute (-1,1)	ROA - Absolute (-1,3)	1 Year Abnormal Returns	3 Year Abnormal Returns
Intercept	0.0155 (0.84)	-0.0045 (-0.23)	-0.1446 (-1.39)	-0.2354 (-0.78)
Adoption (0,1)	-0.0008 (-0.07)	0.0286** (2.41)	0.1275* (1.94)	0.4976** (2.60)
Free Cash Flows / Total Assets (Year -1)	-0.2421* (-1.75)	-0.8177*** (-5.69)	0.1288 (0.20)	0.2669 (0.13)
Assets (in \$thousands) (Year 0)	0.0012 (0.40)	-0.0026 (-0.89)	0.0099 (0.62)	-0.0110 (-0.24)
Leverage (in \$thousands) (Year 0)	-0.0024 (-0.17)	0.0087 (0.60)	-0.0308 (-0.40)	0.0835 (0.37)
Market / Book (Assets) (Year 0)	0.0045 (0.41)	0.0377*** (3.44)	0.0628 (1.01)	-0.0022 (-0.01)
N	93	82	81	82
Adjusted R-Square	-0.0045	0.3479	0.01949	0.02619
F-Stat	0.9167	8.1095***	1.3181	1.4358

SECTION III: SCIENCE AND ENGINEERING

**ANIMAL SCIENCE, BIOLOGY, CHEMISTRY, COMPUTER
SCIENCE AND COMPUTER ENGINEERING, ELECTRICAL
ENGINEERING, AND HORTICULTURE**

A SURVEY INTO THE PREVALENCE OF PARASITIC HELMINTHS IN BROILER BREEDERS

By Anita Sarathi
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Faculty Mentor: Professor Tom Yazwinski
Department of Animal Science

Abstract:

A survey was conducted to determine the prevalence of helminth infections in spent broiler breeders. Intestinal tracts from 10 birds from each of five farms were obtained and examined for parasite identification and quantification. *Heterakis gallinarum* infections were the most common, followed in order of decreasing incidence by *Capillaria obsignata*, *Ascaridia galli*, and *Raillietina cesticillus*. Peak worm burdens for individual birds were 121 (*A. galli*), 535 (*H. gallinarum*), 215 (*C. obsignata*) and 125 (*R. cesticillus*). Significant farm-to-farm variation in worm burdens was observed.

Introduction:

The nematodes *Ascaridia galli*, *Heterakis gallinarum*, *Capillaria obsignata*, and the cestode *Raillietina cesticillus* are four of the most common helminths found to infect chickens (Whiteman and Bickford, 1979). The roundworm *A. galli* is the largest nematode in chickens. Ascarids can cause economic losses due to lost feed efficiency and lowered egg production (Ikeme, 1971). The cecal worm, *H. gallinarum*, is thought to be relatively harmless in the chicken. However, studies have shown that *Heterakis* does cause both cecal and hepatic lesions in the chicken (Riddell and Gajadhar, 1988) as well as aids in the onset of "blackhead" disease in turkeys (Madsen, 1962). *Capillaria obsignata* may cause the most damage to the chicken's performance of all the nematodes (Taylor et al., 1993). Chickens infected with *C. obsignata* become depressed, emaciated, develop diarrhea, and in the case of breeder hens, may develop a secondary Vitamin A deficiency which results in lowered hatchability of eggs. The tapeworm, *R. cesticillus*, competes with the chicken for nutrients from ingested feed, and therefore can cause lowered feed efficiency and weight loss (Reid et al., 1964). Very little is currently known regarding the incidence and magnitudes of infections caused by the above helminths, especially in broiler breeders, and hence this current project was undertaken.

Materials and Methods:

Sample Collection. Ten intestinal tracts from birds originating from each of five broiler breeder farms were obtained

from a local processing plant. All tracts were obtained during the months of April and May 2003.

Parasite Isolation and Quantification. Procedures followed for parasite isolation, identification, and quantification are those that are currently recommended by the World Association for the Advancement of Veterinary Parasitology (Yazwinski et al., 2003). Briefly, each tract was incised lengthwise (from gizzard to cloaca, including the ceca) and all contents collected. Each tract was then soaked overnight in water under refrigeration, and the resultant soak fluid likewise collected. All collected materials were sieved appropriately, and the residues stereo-microscopically viewed for the parasite counts.

Statistical Analysis. All data (helminth counts) were analyzed by analysis of variance procedures using SAS (SAS Inst, Inc. Cary, NC) after transformation to the log (X+1) to reduce variance. Means were separated by the t-test ($P < 0.05$).

In determining significance of variation in parasite incidences between farms, positive or negative infection status of the intestinal tracts by each helminth was analyzed (compared) using the Fisher's Exact Test from PROC FREQ of SAS.

Results and Discussion:

Photographs of specimens of the four helminth species found in this study are provided in (Fig. 1). The incidences of the four parasite species, on a per farm basis, are given in Fig. 2. Incidences of infection among farms, varied significantly for

C. obsignata ($P < 0.03$), *A. galli* ($P < 0.03$), and *R. cesticillus* ($P < 0.02$). Incidences of *H. gallinarum* infection were not different among farms, with a high incidence (80 – 100%) on each of the surveyed farms.

Geometric means (by farm) for the helminths are given in Table 1. Infection magnitudes were consistent with incidences. *H. gallinarum* was found to be the most abundant helminth followed in magnitude by *C. obsignata*, *A. galli*, and lastly, *R. cesticillus*. The three nematode parasites appeared to develop similar patterns of incidence and magnitude whereas *R. cesticillus*, the only cestode parasite found, had the greatest infection levels

on a farm which ranked fourth out of the five farms for nematode presence.

From the survey results, it is apparent that parasitic helminth infections are common and of considerable magnitude in commercial broiler breeders at the end of their production period.

Given these findings, additional studies are currently being formulated with the Arkansas poultry industry so that several key questions might be answered:

- 1) At what point in the life of a broiler breeder are helminth infections acquired?
- 2) What infection levels (magnitude and incidence) are developed in the life of the broiler breeder?
- 3) Are the infection rates and magnitudes as seen in this survey similar to those that the birds have maintained during their yearlong life span?
- 4) What is the economic/productivity significance of commonly occurring helminthiasis in broiler breeders (feed efficiency, reproduction, secondary health considerations, etc.)?
- 5) What can be done to curb the levels of helminthiasis (husbandry, treatments, etc.)?

The helminths found in the current study have been shown to be true pathogens yet very little is known concerning their epidemiology and consequence (AAVP, 1986). Therefore, continued research in this area is indicated.

Acknowledgments:

The authors wish to thank Tyson Foods and Simmons Poultry for their time, material, and assistance in this research. In particular, thanks are extended to Judy Clark and Mark Henson (Simmons) and Bret Rings, DVM (Tyson) for their cooperation, time, and assistance. A special note of appreciation is extended to Dr. Albert Ahn and Allan Bates of the Hartz Mountain Corporation for the Hartz Mountain financing of the Class-to-Clinic initiative, which provided the funding for this undergraduate research project, and others, at the University of Arkansas.

Helminth	Farm				
	1	2	3	4	5
<i>A. galli</i>					
2 nd larval	0.4 ^c	4.1 ^a	1.2 ^{abc}	3.7 ^{ab}	0.7 ^{bc}
3 rd larval	0.2 ^b	8.8 ^a	3.8 ^a	3.7 ^a	0.2 ^b
4 th larval	0.0	1.2	0.5	1.3	0.6
Adult	0.4	0.2	0.3	0.3	0.2
TOTAL	1.2 ^b	16.1 ^a	7.4 ^a	9.1 ^a	1.5 ^b
<i>H. gallinarum</i>					
larval	6.7 ^b	41.2 ^a	6.2 ^b	21.3 ^{ab}	5.0 ^b
Adult	37.8 ^{ab}	77.1 ^a	38.1 ^{ab}	80.3 ^a	12.7 ^b
TOTAL	55.6 ^{ab}	125.3 ^a	51.9 ^{ab}	105.9 ^a	16.9 ^b
<i>C. obsignata</i>	1.2 ^c	40.5 ^a	8.5 ^b	16.6 ^{ab}	8.4 ^b
<i>R. cesticillus</i>	4.5 ^a	0.3 ^b	0.0 ^b	0.0 ^b	0.0 ^b

a,b,c Means on the same line with different superscripts are different ($P < 0.05$).

Table 1. Geometric means by farm for the helminths (and stages thereof if appropriate) in processed birds.

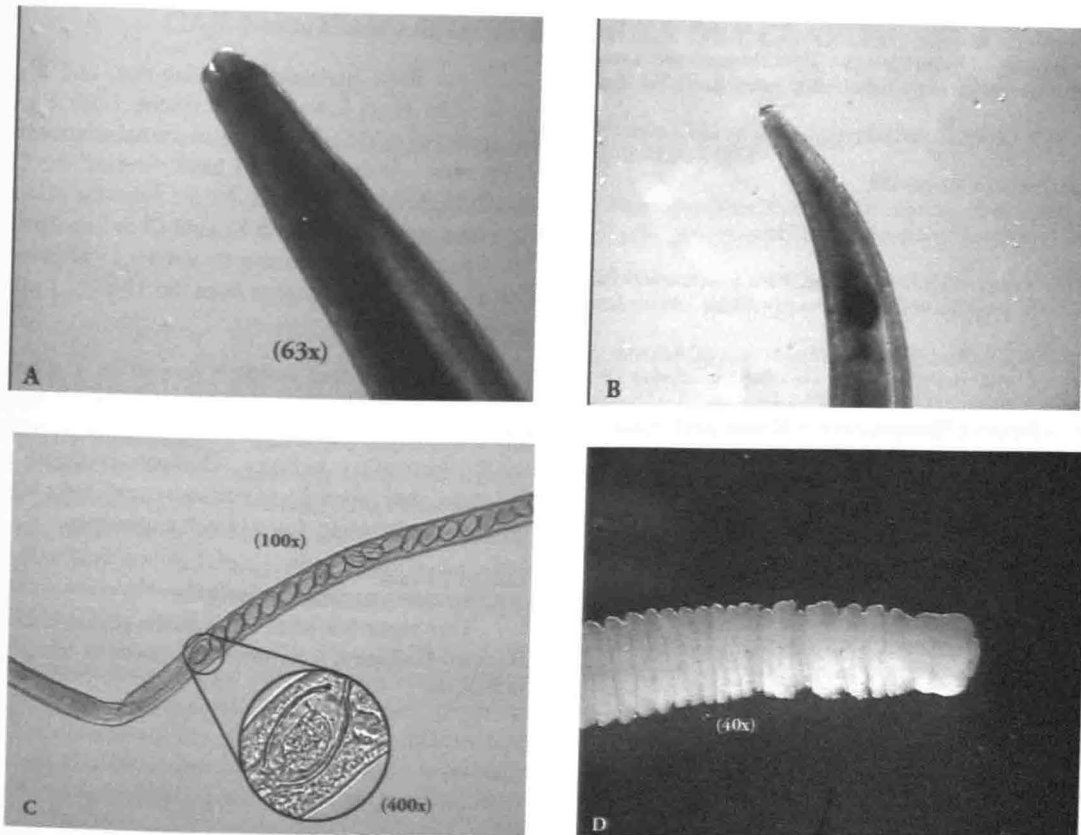


Fig. 1. Specimens of the poultry helminths found in this study; A. *Ascaridia galli*, B. *Heterakis gallinarum*, C. *Capillaria obsignata*, and D. *Raillietina cesticillus*.

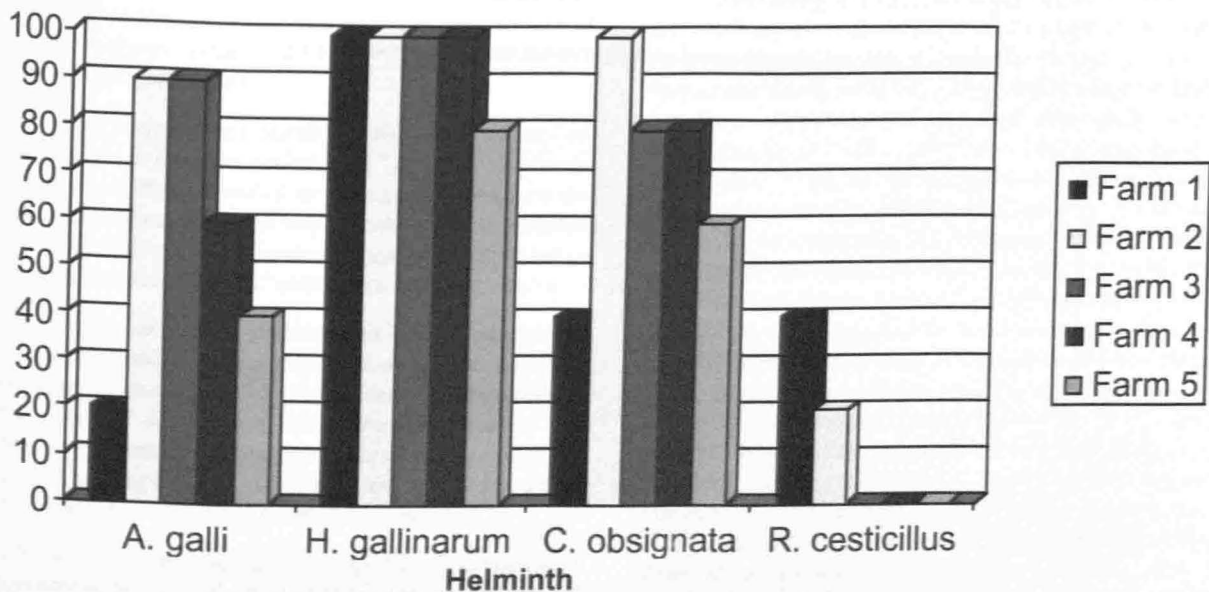


Figure 2. Incidences of helminth infections by farm, May and June 2003.

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Meet the Student-Author:

I am from Bartlesville, Oklahoma, and a graduate of Bartlesville High School. At present, I am a junior at the University of Arkansas majoring in animal science and minoring in Spanish. At the U of A, I have received the Chancellor's Scholarship, the Arena Seat Award from the Animal Science Department, the Fort Smith Kennel Club Scholarship, and the Wind Symphony Scholarship (trombone). After obtaining my Bachelor of Science degree from the U of A, I plan to attend medical school.

I undertook this research project as a special problem funded by the Hartz Mountain Corporation. It was extremely interesting and I learned a great deal about the "world of worms" within the poultry industry. I thank everyone at Tyson's, Simmons, the University of Arkansas, and Hartz Mountain who aided me in attaining this research experience.

Editor's Note:

This paper was selected from the papers published by the Bumpers College of Agriculture journal by its editor for inclusion in *Inquiry*.

CAN MARTIAN LIFE EXIST UNDER DRY CONDITIONS?

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Abstract:

Recently, we have begun to hear more and more about news coming from Mars. With the recent confirmation of evidence of liquid water in Mars' past, evidence indicating liquid water in Mars' present, and as many missions planned for this decade and the next than have successfully reached the planet in the last 40 years, life on Mars is beginning to become a more relevant issue in our study of the planet.

Although there have been no indications of multicellular life on Mars, there may be a possibility of microbial life in the subsurface. Since it appears that all of the necessary elements for life on Mars exist, it is instrumental for scientists to analyze terrestrial ecosystems that might be analogous to those on Mars.

Life on Earth has shown a great amount of diversity in ability to survive extreme environments utilizing a stunning array of energy sources, electron donors, electron acceptors, salinity, pressures, and temperature ranges. From the study of Mars-like terrestrial ecosystems, some scientists have suggested that the methanogens would be a possible candidate to survive Mars' subsurface conditions.

There are various Mars' conditions that could be tested on Earth to confirm or deny the methanogens' ability to survive on the planet. Since the survival of methanogens depends on the presence of liquid water, which would probably be seasonal at best on Mars, their ability to survive desiccation will be key in their potential to inhabit Mars' subsurface.

In this research, the methanogens *Methanobacterium formicicum*, *Methanothermobacter wolfeii*, and *Methanosarcina barkeri* were grown on JSC Mars-1 soil simulant and exposed to varying times of desiccation. Since the byproduct of the methanogens' growth is methane, methane was measured in the head gas of the samples upon rehydration and incubation. These measurements were used to determine survival.

The methanogens studied were capable of survival and subsequently methane production upon rehydration after all of the periods of desiccation tested. *M. formicicum* was tested over periods of 10 and 27 days, while *M. wolfeii* and *M. barkeri* were tested over periods of 10 days.

These results support the hypothesis that methanogens could survive in Mars' subsurface if liquid water were present. The methanogens could be a key ingredient in the terraforming of Mars, and at this point remain an increasingly possible candidate for past, present, or future Martian life.

Introduction:

Mars:

For decades man has looked to the stars and wondered if we are alone. While we have not received any indication of "intelligent life" beyond the Earth, much research is being put into the possibility of past or present life on other planets. In particular, Mars has been the subject of considerable research for extraterrestrial life as we strive to uncover the mysteries of the red planet and its potential to house life.

Even though Mars is considerably different than the planet that we live on, it still seems similar enough to be a potential reservoir for past, present, or future life. In Appendix A, you can find a chart listing some interesting characteristics of Mars and how they compare to Earth (17). Mars' atmosphere is made up of 95.32% CO₂, 2.7% N₂, 1.6% ⁴⁰Ar, 0.13% O₂, and less than 1% of CO, H₂O, ³⁶⁺³⁸Ar, Ne, Kr, Xe, and O₃ (38). Its surface has been theorized to consist mainly of basalt, hematite, crystalline iron oxides, 21 clay materials, Fe²⁺, carbonate, sulfate or bisulfate, and scapolite through spectroscopic data (44). It has been theorized that Mars soil houses a potent oxidant that rapidly converts Martian organic molecules into carbon dioxide (1), thus making organic nutrients scarce if not completely absent in Martian soil. Using electron paramagnetic resonance spectroscopy, it has been shown that superoxide radical ions form directly on Mars analog mineral surfaces exposed to ultraviolet radiation under a simulated Martian atmosphere that could accomplish this oxidation (50). It also appears that all of the water that we know of on the surface is frozen into two pronounced polar ice caps and sheets of ice distributed on the planets subsurface (45). This belief is the subject of much controversy and will be discussed later. These ice caps cycle continuously between their solid form with sublimation directly to gaseous water and carbon dioxide (8).

Because of the harsh conditions on Mars' surface and failed attempts to visualize any extraterrestrial life, it is believed that the most likely location for Martian organisms is beneath the surface. While we have found no indication of any life forms on Mars to this point, there has been considerable research regarding Mars evolutionary past and potential present subsurface microorganisms. This search for extraterrestrial life may be facilitated if ecosystems can be found on Earth that exist under conditions analogous to those present on other planets or moons. It has been proposed, on the basis of geochemical and thermodynamic considerations, that geologically derived hydrogen might support subsurface microbial communities on Mars in which methanogens form the base of the ecosystem (6). These organisms are the focus of this research.

If the methanogens, or any known Earth organisms, are able to grow on Mars, they will have to come into contact with liquid water. The existence of liquid water on Mars remains a critical issue to past or present life on Mars.

Up to this point, scientists have studied fluvial features on the surface of Mars from Surveyor images to theorize about the presence of surface liquid water in its past (33), but confirmation of evidence of past surface liquid water detected by the Opportunity Rover was released by NASA on March 2, 2004 (19). The history and size of the water reservoirs on early Mars can be constrained using isotopic ratios of deuterium to hydrogen. With laboratory measurements of the ultraviolet cross-sections of water and its isotopomers, and modeling calculations in support of a photo-induced fractionation effect, it has been theorized that Mars had an early warm atmosphere and has lost at least a 50m global layer of water (7).

Although the presence of liquid water in the past has seemingly been confirmed, the presence of liquid water on Mars continues to be important to the existence of life on Mars today. A variety of experiments and calculations have been done that theorize the possibility of the presence of liquid water on and beneath Mars' surface. Information released on June 22, 2000 confirmed gullies visualized by Mars Global Surveyor that could've been caused by present day running water (20). Experiments done in Mars-like conditions demonstrated that transient melting of ice on Mars' surface may occur in depressions and gullies nearly anywhere on the planet where thin ice is illuminated by normal-incidence insolation. This suggests that cold trapping of winter condensation could concentrate a sufficient amount of ice to allow seasonal melting in gullies (16). Another experiment done exploring the constraints of the abundance of atmospheric water vapor, escape fluxes of hydrogen and deuterium, D/H ratios in the atmosphere and in hydrous minerals found in one Martian meteorite, alteration of minerals in other meteorites, and fluvial features on the Martian surface were consonant with the visual evidence obtained by the Mars Global Surveyor satellite (11). Other experiments, done after the discovery of hydrogen below the surface of Mars' polar regions

by Mars Odyssey, used Mars like conditions to confirm that liquid water could be stable for extended periods of time on the Martian surface under present-day conditions (26). Another experiment combining Viking pressure and temperature data with Mars Orbital Laser Altimeter topography data has computed the fraction of the Martian year during which pressure and temperature allow for liquid water to be stable on the Martian surface. The experiment found that in certain geographical regions correlating to the distribution of valley networks, water could be stable in liquid form during up to 34% of the year (28).

Another important aspect of the search for life on Mars is the religious one. When we look at history, there have been a variety of scientific topics that have challenged the constraints of religion. The discovery that the Earth was not in fact the center of the universe, the discovery of scientific laws that seem to imply that the existence of a creator God would be unnecessary, cloning, and evolution are all examples of historically controversial scientific topics. The search for life on other planets is of course no different.

What would it mean if we found that we are not alone in this universe? For Christianity, the Bible does not mention the creation of life on other planets, and if there were life on other planets, would it be necessary for a Jesus Christ to be martyred on every inhabitable planet? If not, why was he sent to this planet, and how should we consider the religious rights of other intelligent life forms (23)?

In an essay regarding science and religion, Pope John Paul II said, "truth cannot contradict truth". If science or religion propose theories that are mutually exclusive, it must be apparent that one or both could be wrong, and ultimately truth will prevail. Since the search for life on Mars (and incidentally the study of methanogens) poses some questions that could potentially challenge ones beliefs, this search could become important in the never-ending quest for truth.

Mars Missions and Technology:

Even though there has been much research on Mars' potential, there still lie questions that could only be answered by traveling to the planet itself.

With five missions still exploring Mars (two of which arrived in 2004), seven previous successful missions to Mars in the past forty years, and as many as four planned missions to take off for the red planet in the next ten to twelve years, there are almost more missions occurring in this decade and the next than have been successfully conducted in the past forty years! The new missions boast a stunning array of scientific technology that will revolutionize Mars exploration consisting of various instruments for detecting subsurface water, a rock abrasion tool that is used to study the surface composition and texture, a camera more powerful than any other camera used on a space exploration mission used to identify surface obstacles that might hinder future missions, an interplanetary Internet that will be the

first link in a communications bridge back to Earth, an experimental optical navigation camera that will serve as a high-precision interplanetary lighthouse to guide future incoming spacecraft as they near Mars, airplanes and balloons used to survey Mars from a different perspective, a robotic arm used to dig into arctic terrain to search for environments suitable for microbes, a probe that takes soil samples and mixes them with water to observe the possible behavior that would be displayed in wet Martian soil, a roving long-range/long-duration science laboratory for refined and extensive scientific testing, deep subsurface drills, and many other scientific instruments to observe surface, atmospheric, and ultraviolet conditions (18).

There are various arenas for researching the potential of life on Mars. Although this field is ever expanding, some promising areas of study will be discussed below.

Polar Exploration:

Polar exploration is an important field of research because it investigates an ecosystem on the Earth for life that could be analogous to a Mars ecosystem.

The debris-rich basal ice layers of a high Arctic glacier have been shown to contain metabolically diverse microbes that could be cultured oligotrophically at low temperatures (0.3 to 40C). These organisms included aerobic chemoheterotrophs and anaerobic nitrate reducers, sulfate reducers, and methanogens. When electron microscopy of thawed basal ice samples were studied, various cell morphologies, including dividing cells were revealed. These findings suggested that the subglacial environment beneath a polythermal glacier provides a viable habitat for life and that microbes may be widespread where the basal ice is temperate and water is present at the base of the glacier and where organic carbon from glacially overridden soils is present. This environment provides a model for viable habitats for life on Mars, since similar conditions may exist or may have existed in the basal sediments beneath the Martian north polar ice cap (43).

Other studies have confirmed that the permanent ice covers of Antarctic lakes in the McMurdo Dry Valleys develop liquid water inclusions in response to solar heating of internal aeolian-derived sediments which serve as nutrient (inorganic and organic) enriched microzones for the establishment of a physiologically and ecologically complex microbial consortium capable of contemporaneous photosynthesis, nitrogen fixation, and decomposition. This consortium could also provide a viable habitat for microbial pockets in Mars' ice caps (39).

Another application for polar exploration is to study polar regions on Mars to learn more about the history and possible previous existence of microbial life. The Martian polar regions have accumulated extensive mantles of ice and dust that cover individual areas of approximately 106 km² and total as much as three to four km thick, and are thought to be comparatively young from the scarcity of superposed craters on their surface. These

regions preserve a record of the seasonal and climatic cycling of atmospheric CO₂, H₂O, and dust over the past approximately 105_108 years. Because of this cycling, the regions could serve as a Rosetta stone for understanding the geologic and climatic history of the planet including variations in insolation (due to quasiperiodic oscillations in the planet's obliquity and orbital elements), volatile mass balance, atmospheric composition, dust storm activity, volcanic eruptions, large impacts, catastrophic floods, solar luminosity, supernovae, and perhaps a record of microbial life (8).

Impact Excavation:

Because of the ubiquity of subsurface microbial life on Earth, examination of the subsurface of Mars could provide an answer to the question of whether microorganisms exist or ever existed on that planet (9).

Impact craters provide a natural mechanism for accessing the deep substrate of Mars and exploring its exobiological potential. Based on equations that relate impact crater diameters to excavation depth, the observed crater diameters that are required to prospect to given depths in the Martian subsurface have been estimated and related to observed microbiological phenomena in the Earth's subsurface. Simple craters can be used to examine material to a depth of approximately 270 meters. Complex craters can be used to reach greater depths, with craters of diameters greater than or equal to 300 km required to reach depths of 6 km or greater, which represent the limit of the terrestrial deep subsurface biosphere (9).

Also, several lines of evidence strongly support the exploration of large impact craters to study deposits important for astrobiology. The great depth of impact craters, up to several kilometers relative to the surrounding terrain, can allow the breaching of local aquifers, providing a source of water for lakes and hydrothermal systems. Craters can also be filled with water from outflow channels and valley networks to form large lakes with accompanying sedimentation. Impact melt and uplifted basement heat sources in craters greater than 50 km in diameter should be sufficient to drive substantial hydrothermal activity and keep crater lakes from freezing for thousands of years, even under cold climatic conditions. Fluid flow in hydrothermal systems is focused at the edges of large planar impact melt sheets, suggesting that the edge of the melt sheets will have experienced substantial hydrothermal alteration and mineral deposition. Hydrothermal deposits, fine-grained lacustrine sediments, and playa evaporite deposits may preserve evidence for biogeochemical processes that occurred in the aquifers and craters. Therefore, large craters may represent "giant petri dishes for culturing preexisting life on Mars and promoting biogeochemical processes" (37).

Methanogens:

Methanogens are methane-producing organisms of the domain Archaea. The archaea were once grouped among the

Eubacteria until 1974 when Carl Woese used DNA sequences to sort out parts of the bacterial family tree, and found that archaea were able to comprise their own major branch of the tree of life. Archaea share some genes with bacteria and eukaryotes, but they also contain a variety of genes that are unique (14). They are distinguishable from true bacteria by the possession of membrane lipids composed of isoprenoids (ether-linked to glycerol or other carbohydrates), a lack of peptidoglycan containing muramic acid, and distinctive 16S ribosomal RNA sequences (5).

Most methanogens grow by using H_2 as an electron source, while some can grow using a CO_2 -reducing pathway using a series of four two-electron reductions to convert CO_2 or bicarbonate to methane (5). It has been reported that certain methanogens will consume H_2 down to partial pressure as low as 4 Pa (4×10^{-5} atm) with CO_2 as the sole carbon source at a rate of 0.7 ng H_2 per minute per microgram cell protein. This lower limit of pH_2 for growth of methanogens is based on the assumption that the pH_2 needs to be high enough for one ATP to be synthesized per CO_2 reduced (25). In addition to being able to survive on H_2 and CO_2 , some methanogens can grow either without or with sparse organic nutrients (5). K. H. Nealson (35) said, "The ability to grow at the expense of inorganic redox couples allows microbes to occupy niches not available to the more metabolically constrained eukaryotes." Following this principle, the properties described above are consistent with the known limits of Mars' atmospheric and surface components, thus making them potential Mars organisms (36).

Besides their metabolic characteristics that give them unique abilities to survive in the Mars's subsurface, methanogens appear to have fewer salt bridges, less packed hydrophobic cores, and a reduction of proline residues in loop structures that confer the organism low temperature activity and included greater structural flexibility than other organisms (46). Also in order to grow and reproduce in high-salt, low-water activity environments, the halophilic archaea have made basic biochemical adaptations in their proteins, osmoregulation mechanisms, nucleic acids, and lipids that could help them in surviving Mars' subsurface (27).

With these things in mind, some scientists have theorized about the plausibility of either the present or past existence of methanogens on Mars.

Using geochemical and thermodynamic considerations, it has been proposed that geologically derived hydrogen might support subsurface microbial communities on Mars in which methanogens form the base of the ecosystem. More than 90% of the 16S ribosomal DNA sequences recovered from hydrothermal waters circulating through deeply buried igneous rocks in Idaho are related to hydrogen-using methanogenic microorganisms. Geochemical characterization indicates that geothermal hydrogen, not organic carbon, is the primary energy source for this methanogen-dominated microbial community. This information demonstrates that hydrogen-based methanogenic

communities occur in Earth's subsurface, providing an analogue for possible subsurface microbial ecosystems on other planets (6).

Scientists studying the composition of the shergottite, nakhlite, and chassigny (SNC) meteorites' isotope composition for carbon and organic matter grew a pure *M. formicicum* culture in a mineral nutrient medium in an atmosphere of H_2 and CO_2 (4:1) and confirmed that the isotope composition could in fact have been explained by the action of the methanogens (21). These scientists then theorized that the delta ^{13}C value of calcite is accounted for by the microbial reaction $CO_2 + H_2 \rightarrow CH_4 + H_2O$, as well as ^{12}C fractionation potentially performed by methanogens. The formation of the calcite of "SNC" meteorites was accomplished in an environment favorable for the activity of methanogens, thus providing an even stronger argument for the existence of methanogens in the meteorites (22).

Following the logic that organisms possibly could exist on Mars in the subsurface, scientists have tried to determine whether abundant hydrothermal or atmospheric energy is present on Mars to supply a subsurface biological ecosystem. For hydrothermal energy models, host rock based upon the composition of Martian meteorites was reacted with one of three groundwater compositions at high temperatures and the Gibbs energy for reactions that are important for terrestrial chemosynthetic organisms and likely representatives for putative Martian microbes were calculated. The results indicated that substantial chemical energy could be present depending on host rock composition to support suitable environments for Martian life (47). It has been shown that Martian organisms could be supplied with a large energy flux from the oxidation of photochemically produced atmospheric H_2 and CO diffusing into the regolith, but surface abundance measurements of these gases demonstrate that no more than a few percent of this available flux is actually being consumed. This suggests that biological activity is limited in the top few hundred meters of the subsurface, and implies that the apparent scarcity of life on Mars is not attributable to lack of energy. Instead, the availability of liquid water may be a more important factor limiting biological activity because the photochemical energy flux can only penetrate to 100-1,000m depth, where most water is probably frozen (48).

Terraforming:

An interesting prospect for the use of methanogens is in the terraforming of Mars. While global warming, overpopulation, and pollution step more into the forefront of our daily lives, terraforming Mars has become an increasingly interesting topic of debate and research that is pertinent to the study of methanogens.

It has been suggested that with the use of supergreenhouse gases, Mars' surface could be heated to and maintained at Earth-like temperatures (15), and Mars' atmosphere could be thickened so that liquid water is stable on the surface. This process has been theorized to need approximately 100 years to occur. The thick

carbon dioxide atmosphere that would result could support many types of microorganisms, plants, and invertebrates. If these organisms converted CO₂ into O₂ with an average efficiency equal to that of Earth's, it would take more than 100,000 years to create Earth-like oxygen levels necessary to support human life (31). It has been proposed that organisms under study today could "provide the hardy stock of pioneering Martian organisms" that would be followed by other life forms such as plants to begin this process (32). Methanogens could be instrumental in this process because of their ability to produce methane (a greenhouse gas) and ability to survive extreme environments.

The ethics of this situation are of course important (especially if microbial life already exists there today) to the advancement of making Mars habitable, and should be considered in depth before any action is taken. Please refer to McKay et al. (31) for further discussion considering the ethics of terraforming and to Mancinelli (29) for ethical considerations for the search for life on Mars.

Desiccation:

As expressed above, the availability of liquid water may be an important factor limiting biological activity because the photochemical energy flux of atmosphere can only penetrate to 100-1,000m depth, where most water is probably frozen (48).

Since it appears at this point that there is no liquid water on the surface of Mars, we can only hypothesize that liquid water exists beneath the surface. Even though there has been much scientific evidence pointing to liquid waters' presence on Mars, we do not know its amount beneath the surface nor do we know the depths beneath the surface that it would exist. Warmth gained through geothermal heating could theoretically melt ice layers in the subsurface, but this liquid water could be seasonal (as stated above with liquid water only being available some places 34% of the year on the surface) or too far from the surface to have access to the necessary energy for microbial growth. As a result of depth constraints and water changes, it appears that any organism that needs water to grow (all known Earth organisms) would have to be able to adapt and respond to desiccation (drying).

Since there hasn't been much literature on the ability of methanogens to survive desiccation, information from other organisms that have undergone significant desiccation studies will be of use.

Desiccation leads to dramatic lipid phase changes whereas carbohydrates, proteins and nucleic acids initially suffer spontaneous, reversible low activation energy Maillard reactions thus forming products that more slowly re-arrange, cross-link, etc. to give nonnative states. While initial products spontaneously may reverse to native states by raising water activity, later products only do so through energy consumption and enzymatic activity. Yet, native states of lipid membranes and associated enzymes are required to generate energy. Consequently, good reserves of high-energy compounds like ATP and of membrane

stabilizers like trehalose may be expected to enhance survival following drying and rehydration (10). It has also been noted that the inactivation of the anhydrobiotic organisms *Bacillus subtilis* (spores) and *Deinococcus radiodurans* during long-term exposure of up to several weeks to extreme dryness (especially vacuum) is correlated with an increase in the number of DNA-strand breaks and other DNA lesions (12). These DNA lesions will continue to accumulate if an organism is not given intermittent periods of activity to repair them. Unfortunately, it appears that if brief rehydration does not occur to reactivate an organism during prolonged desiccation, survival might be reduced to only a couple of decades (13). The survival of *B. subtilis* and *D. radiodurans* appears to depend on their repair of DNA damage (12). The removal of water through air-drying is lethal to the majority of organisms, yet some vegetative cells of bacteria and Cyanobacteria survive extreme dryness (2).

The Cyanobacteria have undergone quite a bit of scientific research for their abilities to survive extreme dryness, and could be useful in discovering mechanisms that would help with adapting other organisms to survive prolonged desiccation. Desiccation studies have shown that DNA damages seem to be reduced by the presence of the trehalose disaccharide mentioned above (41), as well as novel water-stress proteins with a protective function on a structural level (40).

Methanogens have shown signs of surviving periods of prolonged desiccation. Studies on sediment samples in methanogenic reservoirs in Australia have shown that the methanogens consistently recovered upon rewetting of the sediments (34) as well as survival and rapid reactivation after prolonged drying (3). In another study conducted on methanogens, their survival and potential CH₄ production increased dramatically in presence of pyrite (FeS₂) grains, while as much as 10% of the initial methanogenic population survived oxic desiccation. This information is in relatively good agreement with observations that methanogens in rice fields survive the periods when the paddy soil is dry and oxic (42).

If methanogens are to be able to exist on Mars' surface or subsurface, the existence of liquid water is potentially the most important rate-limiting factor. Since the existence of liquid water hypothetically seems to be sporadic on the surface at best and seasonally present in the subsurface (at least at depths shallow enough to receive any atmospheric energy), it appears that the methanogens' ability to survive on Mars revolves around their ability to survive periods of desiccation. This research was designed to test the ability of methanogens to survive desiccation.

Materials and Methods:

Organisms and Media:

Stock cultures of three methanogens obtained from David Boone (Portland State University) were grown on 3 different types of media: standard medium (MS) for *Methanosarcina barkeri* (4), standard medium with sodium formate added (MSF)

for *M. formicicum* (4), and standard medium without the organic materials for *Methanothermobacterium woffeii* (MM; 49). The anaerobically prepared media were added to test tubes inside of a Coy anaerobic chamber. The tubes were then sealed with butyl rubber stoppers and crimped with aluminum caps. The tubes were then removed from the chamber and pressurized to 200kPa with pure H₂ gas using a gassing manifold. When necessary, tubes were repressurized to 200kPa with a 75% H₂/25% CO₂ mix. One hour before the media were inoculated, 0.15ml of sterile sodium sulfide solution (2.5%) was added using a sterile 3ml syringe to eliminate any residual oxygen (4).

Data Collection:

Since the by-product of the growth of methanogens is methane, their growth was monitored by testing for the presence and amount of methane in the head gas of the culture tube. Readings were taken by removing a 1 ml sample of the head gas of the tube of interest with a 3ml sterile syringe and injecting it into a Hewlett Packard 5890 Series 11 Gas Chromatograph. The GC had a thermoconductivity detector, oven set at 45°C, and argon used as the carrier gas. The GC was set to measure the percent of H₂, N₂, CH₄, and CO₂ in the sample.

Desiccation Experiment:

For the desiccation experiment, the organism to be tested was transferred into its respective medium and allowed to grow for one week in optimal growth conditions. After a week's worth of growth, 4ml of the media/organism were transferred via a 5ml sterile syringe to 5g of JSC Mars-1 soil simulant, pressurized to 200kPa with H₂ gas, and allowed to grow in optimal growth conditions for approximately one week. After the growth process, the tubes were numbered and initial methane readings were recorded for each tube. If no significant methane readings were present in the majority of the tubes, the organisms were allowed more time for growth in the soil simulant. Once the organism growth was significant, the tubes were transferred into a Coy anaerobic chamber where they were uncrimped and unstoppered. Their contents were scraped into individually numbered (corresponding to the number of the tube whose contents they held) 15ml plastic beakers. The beakers containing the "mud" mixture were left sitting out in the open in the anaerobic chamber until all of the samples appeared dry to the eye. Once all of the mud was dry, the beakers were set inside a Nalgene Desiccator with Drierite under the platform. From this point, the beakers would remain in the desiccator until a predetermined time interval for removal. Once removed, the contents of the beaker would be scraped into a correspondingly labeled test tube and hydrated with 4ml of carbonate buffer. The tube would then be stoppered, crimped, subjected to 0.15ml of sodium sulfide (2.5%), pressurized to 200kPa with the CO₂/H₂ mix, and placed in the appropriate incubator for the organism. Methane readings were taken on each tube 24 hours, 1 week, 2 weeks, 3 weeks, 1 month, and then monthly after rehydration to monitor the organisms' growth.

Preliminary Desiccation Procedure:

Two of the earlier experiments were performed without a desiccator. These experiments both used *M. formicicum*. The results for these experiments are shown in Figures 1 and 2. This procedure is virtually identical to the procedure discussed above except petri dishes were used in place of 15ml beakers. The mud in the petri dishes was set out in the anaerobic chamber until all of the petri dish's mud had been uniformly dried. The "dust" was then scraped back into tubes at predetermined intervals, hydrated, stoppered, etc.

Results:

The results from the experiment can be seen in Figures 1-11. Generally, methane was absent 24 hours after rehydration, and the amount of methane grew to greater than 1% in around 80% of all samples after a month of incubation following desiccation (except in experiments seen in Figures 1, 2, and 3). Methane increased to greater than 10% in 78% of all samples after two months of growth (except in the experiment seen in Figure 1), and was present in 80% of all samples desiccated at the completion of the project (except in the experiments seen in Figures 8 and 11 that have yet to be completed). Methane was present in 86% of all samples desiccated at the completion of the project excluding the experiment seen in Figure 1. No observable trends were apparent in samples with absence of measured methane increase. Higher methane was seen in Figures 6 and 7, which is consistent with other *M. woffeii* data regarding growth rates.

In Figure 1, methane occurrence was only observed in samples desiccated one and eight days.

The results for these experiments, as well as initial methane readings taken before desiccation, can be seen in chart form in Appendix B.

(Editor's note: Space precludes publication of figures 2-11 and the tables of Appendix B. (Contact the author or his mentor for this information.)

Discussion:

It appears that the methanogens studied are capable of surviving at least some periods of desiccation. Even though *M. woffeii* tended to produce methane earlier and faster than the other organisms, longer range studies would lead to the belief that all of the organisms will produce significant methane with time.

All of the organisms displayed an ability to survive all of the periods of desiccation tested. *M. formicicum* survived ten days of desiccation and had methane levels above 3.0% in a sample desiccated for over 26 days. *M. woffeii* and *M. barkeri* both were able to survive periods of desiccation spanning ten days.

There were no observable trends for the lack of methane production in some samples, except for an occurrence of methane absence in samples desiccated for seven to nine days (usually eight) in Figures 2, 3, 4, 5, 6, 7, 9, and 10. No explanation for this phenomenon has been proposed as growth has occurred on samples dried seven to nine days in some experiments, as well as unexplained variations for growth on samples desiccated for eight days in Figures 1 and 2. There also seems to be no correlation between post-desiccation methane production, and pre-desiccation methane measurements shown in Tables 2, 4, 5, 6, 7, 8, 9, 10, and 11 in Appendix B.

No proposed explanation has been formulated for the non-congruity of Figure 1 with the rest of the results. This was the first experiment conducted by the researcher, so experimental error seems likely.

Many of these experiments were conducted simultaneously, so cross-contamination is a possibility, even though the growth conditions and non-relatedness of the results of the experiments would hold this unlikely. Unfortunately, experimenter error is also always a possibility.

Discovering a time limit of desiccation upon which the organism would not survive upon rehydration would seem critical. Since the hypothesis of liquid water availability at this point indicates that dryness would be a norm, periods of desiccation longer than ten days to a month seem more than likely. And since it has been theorized that survival for longer than a couple decades without intermittent rehydration is not likely with known organisms, it would be interesting to know if this were true for methanogens. It is interesting to note that the viability and methane production of methanogens tend to do better with rapid desiccation (42), the recovery of dried bacteria after desiccation increases with slow rehydration (24), and that desiccation procedures conducted at sub-room-temperature conditions (like those on Mars) might help preserve the organism and accommodate desiccation tolerance. Research regarding desiccation and rehydration rates could also provide a better understanding of the ability of methanogens to survive on Mars.

There have been some studies that indicate that the mechanisms necessary to survive desiccation are also useful for surviving ionizing radiation (30). If it became apparent that the methanogens are fit to survive prolonged desiccation, implications for ionizing radiation survival seem important. Since Mars' ecosystems experience a greater flux of radiation from the sun than those of the Earth, radiation survival would also be important for potential Mars organisms.

There could be a possibility that the JSC Mars-I soil simulant might confer higher desiccation tolerance. Experiments using non-desiccation tolerant prokaryotes with the desiccation procedure used here could provide further insight into the implications of this research and the characteristics of the soil simulant.

Conclusions:

I. *Methanobacterium formicicum*, *Methanothermobacter wolfeii*, and *Methanosarcina barkeri*, under the conditions tested here, survived desiccation for a period of at least ten days.

II. *Methanobacterium formicicum* survived desiccation for at least one month.

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	Mars	Earth
Average Distance from Sun	142 million miles	93 million miles
Average Speed in Orbiting Sun	14.5 miles per second	18.5 miles per second
Diameter	4,220 miles	7,926 miles
Tilt of Axis	25 degrees	23.5 degrees
Length of Year	687 Earth Days	365.25 Days
Length of Day	24 hours 37 minutes	23 hours 56 minutes
Gravity	.375 that of Earth	2.66 times that of Mars
Temperature	Average -81 degrees F	Average 57 degrees F
Atmosphere	mostly carbon dioxide some water vapor	nitrogen, oxygen, argon, others
# of Moons	2	1

Appendix A

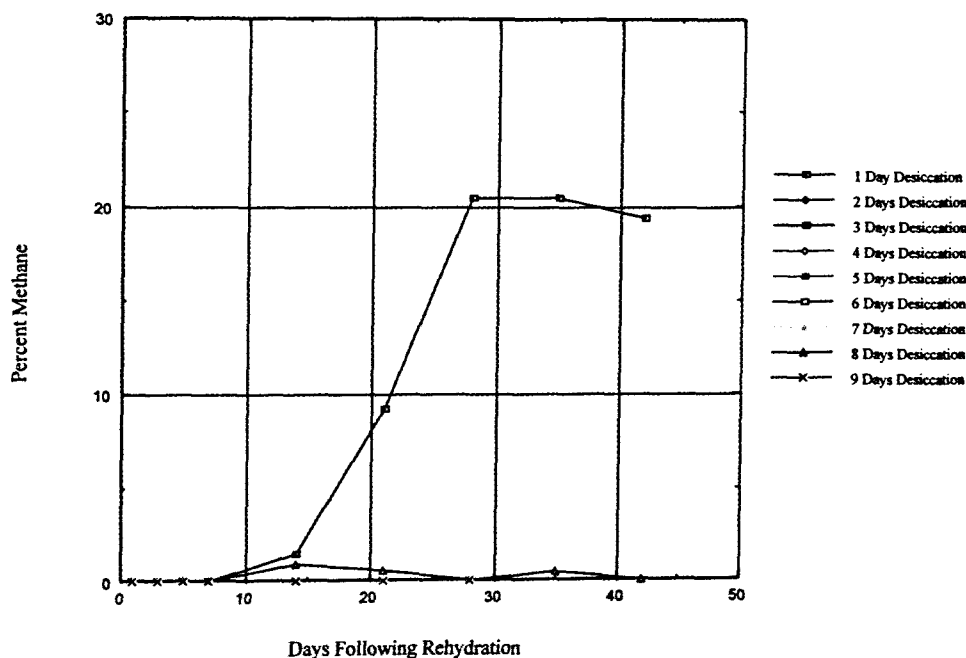


Figure 1: Methane production by *Methanobacterium formicum* following desiccation in petri dishes for the first experiment on *M. formicum*.

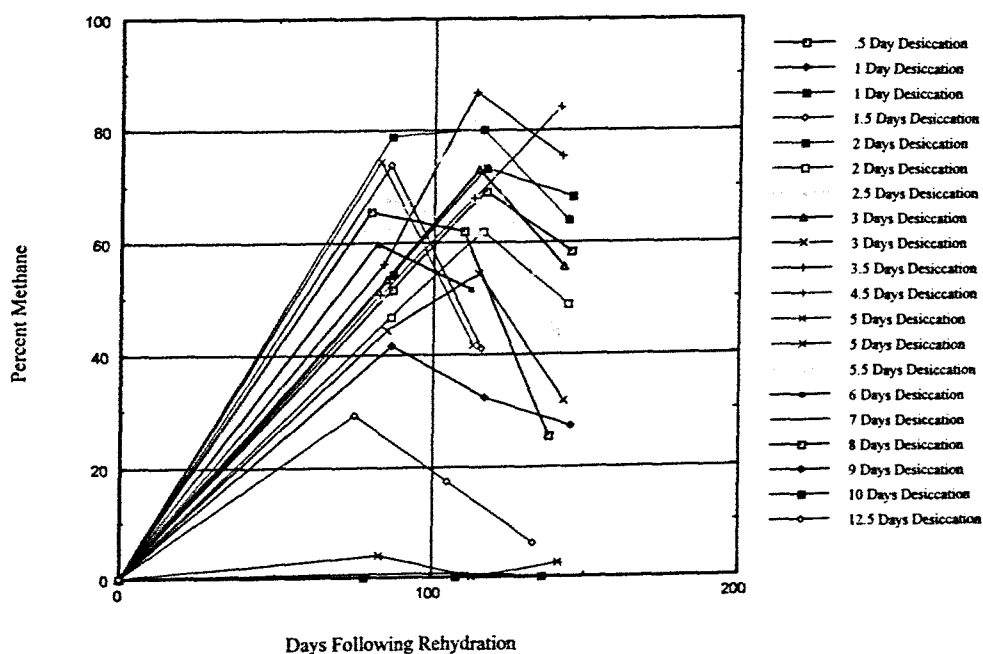


Figure 2: Methane production by *Methanobacterium formicum* following desiccation in petri dishes for the second experiment on *M. formicum*.

Faculty comment:

Mr. Kendrick's mentor, Dr. Timothy Kral, is very complimentary about his student's work. He said,

Throughout recorded history, humankind has been fascinated by the heavens above. I am not referring to a religious heaven, but rather to the star-filled universe. From the time that the lights in the sky were identified as stars and planets, humans have wondered about the possibility of life out there. Today there is great excitement in the air because we are closer than ever to discovering the answer to the question: Are we alone? Unfortunately, our exploration has been limited to the inner reaches of our solar system where we are fairly certain that other intelligent life does not exist. Nonetheless, discovery of the simplest microbe on another planetary body would have tremendous significance.

The target planet is Mars. Early in its history, Mars was an earthlike planet, with liquid water on its surface. It was warmer and had a thicker atmosphere than it does today. It would have been very conducive to life as we know it. Today, the surface is barren. Conditions would suggest that life as we know it could not exist. The surface is extremely cold (600° F average) and dry; the atmospheric pressure is less than one-hundredth that of Earth's; and it is constantly bombarded by lethal radiation.

Below the surface is another matter. Conditions are probably warmer with a higher pressure, and the rock above would protect from the radiation. If liquid water is present below the surface, and there is no reason to believe that it is not present, conditions would be conducive to an Earth organism known as a methanogen. Methanogens are microorganisms in the domain Archaea that live below the surface of the Earth and deep within our oceans. They may indeed be the predominate life form on planet Earth.

During the 12 years that I have been working in this area, we have been studying methanogens as life forms that potentially could survive and thrive below the surface of Mars. We have been exposing methanogens to conditions that approach those known to exist on Mars including lower pressure, lower temperature, dry conditions, radiation, and exposure to oxygen. (Methanogens are poisoned by molecular oxygen, as are most life forms on planet Earth.)

This year I am mentoring five honors students who are working on one of the conditions mentioned above. This letter is in support of Michael Kendrick who is competing for one of the undergraduate research awards. Michael approached me early last spring semester about doing research in my lab. He began his research last spring and has been heavily involved in it ever since. His project involves the effects of drying on methanogens. We know that methanogens would do well growing on a Mars soil simulant under reduced pressures until they dry out. Michael grew methanogens in a standard medium, added them to a Mars soil simulant, and then dried them for varying lengths of time. His initial experiments were performed in our anaerobic chamber in petri dishes. His later experiments utilized newly purchased desiccation jars. Michael discovered that the methanogens that we work with could survive drying for much longer periods of time than we imagined. *Why is this research critical?* As mentioned previously, for life to exist below the surface of Mars, liquid water would have to be present. Depending on the depth of that liquid water, seasonal surface changes (Mars has seasons just as Earth does) could result in water freezing or drying up for various periods of time. It is crucial to the knowing how long methanogens can survive under those potential dry periods. How long liquid water is present could be the limiting factor in determining whether life can exist below the surface of Mars. It is that important.

THE EFFECTS OF MULTIPLE MUTATIONS IN THE HYDROPHOBIC CORE UPON THE STABILITY OF STAPHYLOCOCCAL NUCLEASE

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Department of Chemistry/Biochemistry

Faculty Mentor: Dr. Wesley Stites
Department of Chemistry/Biochemistry

Abstract:

Previous work in the laboratory of my research advisor, Dr. Wesley Stites, has investigated the core packing of the protein staphylococcal nuclease. The core of a protein is critical in determining a protein's structure and stability. The hydrophobicity of the core has long been thought to be the principal driving force for folding, but recent work in the Stites lab has shown that optimization of van der Waals contacts and minimization of cavities, in our shorthand term, packing, is at least as energetically important. We are building upon this information in our attempt to better pack the protein core. If we can do this, we predict that the improvement in packing will make the protein more stable overall.

This project takes a closer look at the thermodynamically unfavorable left-handed alpha helix region in the core of staphylococcal nuclease. It has already been shown that there are angle strains on some of the residues that can be repaired by replacing the leucine at residue 38 with glycine. However, this created empty space within the core that greatly destabilized the protein. Our hypothesis was that by filling this space with larger amino acids at nearby locations, we would be able to correct this problem. Several mutations were made at residues 38, 39, and 125. The residues are all within close contact with each other and in the vicinity of the left-handed alpha helix. The following procedures were used: Kunkel DNA mutagenesis, transformation and preparation of M13 single stranded DNA, transfer of nuclease mutant gene from M13 to plasmid, Laemmli discontinuous protein SDS-Page gel, protein preparation and purification, and fluorometric titration.

The hypothesis that relieving angle strain near the left-handed alpha helix with a glycine, and then filling the space caused by that mutation with larger amino acids near it would increase the protein's stability was confirmed. However, new packing problems were generated so most mutations resulted in an overall decrease in stability.

Introduction:

Compared to many scientific disciplines, protein folding is a fairly new area of study (it has only been around for about 40 years) and is very highly researched. It is known that a protein's

function is dictated by its shape after folding—its natural or wild-type state. That folding is a natural process that is not yet understood. It has been shown that the information needed for a protein to spontaneously fold into its biologically active three-dimensional state can be found within the protein's amino acid sequence.¹ This would imply that scientists should be able to determine a protein's three-dimensional structure as well as its function by analyzing the protein's amino acid sequence. However, this is not yet possible and there are still many gaps in the known information that must be filled.

Useful techniques for the engineering of protein stability should make it possible to create a wide array of potential medical and medicinal improvements, as well as advancements in biochemical and industrial research.² Proteins are commonly used in pharmaceuticals, and increasing their stability would be a great advancement for that industry because it would allow these medicines to have longer shelf lives, and, potentially, to no longer require refrigeration.

The core of a protein is critical in determining a protein's structure and stability. The hydrophobicity of the core has long been thought to be the principle driving force for folding.² However, recent research by the Stites group has shown that optimization of van der Waals contacts and minimization of cavities, in a commonly used shorthand term, packing, is at least as energetically important. Van der Waals interactions occur when two dipoles interact with one another; the closer these two dipoles are to each other, the stronger the interaction will be.¹

Proteins are formed by chains of amino acids connected together in polypeptides, and then folded in various ways, forming multiple subunits that may also interact covalently.³ During folding, the non-polar residues almost always end up in the interior of the protein, and the polar ones on the exterior. This is what makes the core of the protein hydrophobic. Non-polar residues being buried happens as a result of the aqueous environments in which proteins often reside. In order for the protein to function properly, it must be able to do so within that water, instead of being forced away by its own non-polar residues. The clustering of non-polar residues into the interior of the protein, instead of out into the aqueous environment, also

makes the protein more thermodynamically stable.³ Other forces that contribute to protein stability are hydrogen bonding and electrostatic interactions between charged residues.⁴ If the amino acids are arranged neatly, and closely within the protein, then the van der Waals interactions will contribute to the overall stability.¹ Also, it has been shown that within the core of a protein the number of van der Waals interactions is much higher than the number of van der Waals interactions that occur between an unfolded protein and the solution. This indicates that the favorability of those interactions are much more important to the protein's overall stability.¹

Many studies have shown that in a well-packed protein core, mutations can make substantial changes.⁵ Proteins accommodate for these mutations by making small shifts in the backbone and to the side torsion angles.⁵ These shifts can cause the protein to become unfavorably packed and therefore more unstable. There have been attempts to correct for this computationally, but that usually requires repairing the backbone and/or correcting the torsion angles of core side chains.⁶ Since the strain on these angles seems to have such an affect on the way the protein behaves, we have begun to wonder if it would be possible, by eliminating some of the angle strain that is naturally in a protein, to increase the packing, and therefore the overall stability of the protein.

Inside the core of staphylococcal nuclease, there is a specific amino acid sequence that forms a left-handed alpha helix (see Figure 1). The left-handed helix is an unusual structure and is said to have an energetically unfavorable structure.¹⁴ This is shown in the protein's Ramachandran plot (Figure 2). The plot shows four residues in a left-handed alpha helix conformation within the core of the protein.¹⁴ It has been theorized that by packing this helix more tightly, it is possible to increase the van der Waals interactions, and therefore, the stability of the protein. Previously, Stites *et al.* published an article in the *Journal of Molecular Biology*² in which they attempted to decrease the number of unfavorable interactions by replacing strained residues with glycine. Glycine is a common mutation found at these sites. Glycine did relieve the angle strain in this area, however, this resulted in an overall decrease in stability due to the formation of empty space near the helix, specifically the space between residues 125 and 38 (both are leucine in the wild-type state). The hole that was created here disturbs packing. From this data it is now hypothesized that, in addition to the glycine mutation, if the surrounding residues are replaced with residues that will have better steric interactions, without leaving the space between these residues empty, then it will be possible to increase the protein's stability.¹⁴

Staphylococcal nuclease has 42 known homologues² that have variations in side chains of the hydrophobic core from the wild-type sequence. The most common variations involve isoleucine, leucine, and valine. Because these are the most frequently occurring residues, they define the consensus sequence

of nuclease.² This consensus is not in agreement with the wild-type nuclease sequence (see Table 1), showing that it is possible for more than one stable packing arrangement to exist.² The next thing to consider is how each of the residues affect each other. If one residue is a glycine, does that mean that another is always isoleucine? This is just one of many questions that our studies of nuclease seek to answer.

A series of papers published by Stites *et al.* in *Biochemistry*⁷⁻¹⁰ in 2001 established that packing is highly critical to protein stability. This paper will confirm the hypothesis that correcting the unfavorable interactions generated when replacing the leucines at residues 38 and 125 with glycines, as outlined in the previously discussed Stites paper¹⁴, will increase the protein's stability. Table 2 provides all of the mutations that are to be made at these two residues, as well as at residue 39, to correct for the empty space generated with the glycine mutations. By filling the space, but still finding a way to correct for the unfavorable van der Waals interaction that is caused by the left-handed alpha helix in this location, it is thought that the overall stability of the core will be improved. The mutation at residue 39 is used because there seems to be a relationship between residues 38 and 39. Also, by looking at the relationship between the most common amino acids at residues 38, 39, and 125, we will be able to have a better idea of how each of those residues affect each other.

Materials and Methods:

Mutagenesis, Protein Expression, and Purification. The method used to generate the specific mutations desired in the protein was Kunkel mutagenesis.¹⁵ Everything was done according to that previously published procedure.

Fluorometric Titration. In order to determine the free energy difference between the native and denatured states of the protein, fluorometric titration was used.¹ This free energy difference is commonly referred to as protein stability. It can be measured using an automated titrating fluorometer that was developed by the Stites lab and made by Aviv Associates.^{16, 17}

The computer software on the fluorometer generated a plot of fluorescence intensity versus guanidine hydrochloride concentration. From this plot it was possible to determine the stability of the protein. A good plot had many data points at the beginning and end of the curve (the flat portions). The curve should also have been smooth, indicating that the protein had been adequately equilibrated (see Figure 3).¹⁷ The data set and the titration curve were saved and taken to a computer that has Microsoft Excel. Once in this program, the data was put into a linear extrapolation plot of free energy versus GuHCl concentration (see Figure 4). The free energy was determined from the following equation:

$$\Delta G_{app} = -RT \ln K_{app}$$

$\hat{i}G$ is the apparent free energy when no denaturant is present¹⁷ and K_{app} is found by subtracting the fluorescence intensity measured at a specific denaturant concentration (I) from the fluorescence intensity of the native state (I_n) and divided that by the fluorescence intensity of the denatured state (I_d) subtracted from I :

$$K_{app} = (I_n - I) / (I - I_d).$$

The program also provides the values for the slope of the plot of the change in free energy with respect to the change in GuHCl concentration, and the midpoint concentration (the concentration of GuHCl at which half of the protein is denatured).

For each mutation, $\hat{i}G$ was then calculated by the subtraction of the free energy of wild-type nuclease (5.4 kcal/mol) from the apparent free energy of the mutant. For the double and triple mutants, $\hat{\epsilon}\hat{i}G_{single}$ was calculated by adding together the free energies of each of the single mutations that make up the double or triple mutant in question. Lastly, \hat{i}^2G_{int} was calculated for the double mutants, and \hat{i}^3G_{int} for the triple mutants. This was done by subtracting $\hat{\epsilon}\hat{i}G_{single}$ from $\hat{i}G_{double}$ (or $\hat{i}G_{triple}$ as the case may be).

Results and Discussion:

All of the guanidine hydrochloride denaturation data from the single mutants can be found in Table 3. Double mutant data is in Table 4 and triple mutant data is in Table 5. As predicted, none of the single mutations by themselves showed any improvement in the stability of the protein. Most had fairly small effects, but L125Y greatly destabilizes the protein.

$\hat{i}G$ is the change in free energy as the protein is denatured. The $\hat{i}G$ for wild-type nuclease is 5.4 kcal/mol; a $\hat{i}G$ value higher than this indicates that the protein has a higher stability than the wild-type, whereas a lower $\hat{i}G$ value indicates that the protein has been destabilized. $\hat{i}G$ is the value of the wild-type free-energy subtracted from the mutant free-energy. $\hat{\epsilon}\hat{i}G_{single}$ is the predicted $\hat{i}G$ of each mutation based on the sum of the free-energies of its single mutations. The energy of interaction (\hat{i}^2G_{int}) is the difference between the $\hat{i}G_{double}$ and the $\hat{\epsilon}\hat{i}G_{single}$. This is the primary calculation that is used to determine the effects of the double mutations on the protein. A positive value of \hat{i}^2G_{int} indicates that the combination of mutations is more favorable than expected. A negative value indicates that the mutations introduce more strain to the protein. The error for this calculation was estimated to be ± 0.2 kcal/mol. Within error, L38G/V39L showed no difference from the predicted value. All other double mutations showed an increase in stability. The most significant mutation is L38G/L125Y with a \hat{i}^2G_{int} of 1.2 kcal/mol. This is interesting because the single mutation of L125Y has a $\hat{i}G$ of -4.3 kcal/mol. This indicates that by combining 125Y with 38G, the interaction is favorable and both relieves angle strain and fills empty space. The 38G/39I mutation had a $\hat{i}G$ value of 5.5 kcal/mol, which is, within error, equivalent to wild-type; its \hat{i}^2G_{int} value was 0.5 kcal/

mol. This data indicates that the mutation is more favorable because it corrects for the angle strain in the area without affecting the overall stability of the protein.

The energy of interaction for the triple mutants (\hat{i}^3G_{int}) is the difference between the $\hat{i}G_{triple}$ and the $\hat{\epsilon}\hat{i}G_{single}$, just as it is for the double mutations. All of the triple mutants had positive values for the energy of interaction, showing that the strain has been reduced. The most striking of these is 38G/39I/125Y with a \hat{i}^3G_{int} of 1.8. This mutation is the most favorable of all of the mutations prepared in this study, further showing that the glycine-isoleucine combination is highly favorable, and even more so when the tyrosine is added to fill empty space, although the stability does decrease overall due to newly generated packing problems. The mutation at 38G/39L/125Y has a \hat{i}^3G_{int} of 1.2, which is the same value as the \hat{i}^2G_{int} for 38G/125Y. This once again shows that the leucine at residue 39 makes little difference when combined with a glycine at residue 38. Within error, the same thing is true for 38G/39L/125F and 38G/125F which have \hat{i}^3G_{int} values of 0.5 and 0.6, respectively.

None of the mutations increased the overall stability of the protein; this is a problem caused by the protein's packing, and will require more investigation. However, the method of combining single mutations to fill space, and correct for strained angles and unfavorable interactions has proven to be useful. The multiple mutations investigated here are much more stable than the effects of the single mutations at each position would lead one to predict.

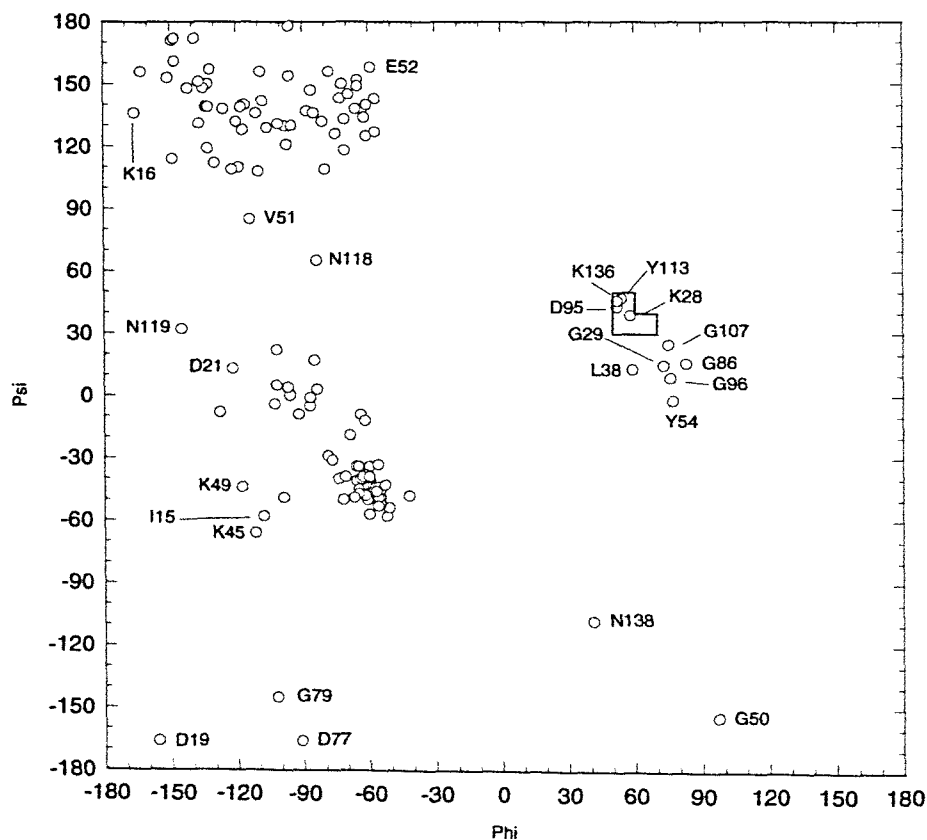
Conclusions:

Although none of the mutations resulted in an overall increase in stability, the energies of interaction were almost always positive. This confirms the hypothesis that correction of the angle-strain in the left-handed alpha helical region of the protein increases the stability in that region by relieving angle strain. However, the data also shows that the overall stability of the protein is decreased with almost all of the mutations. This is the result of further interactions that are generated in the original mutations. Further study would reveal what these interactions are. Correcting for these interactions would likely create more unfavorable interactions, starting a chain reaction that could quickly spread across the protein (although would probably only require correction at five or six more residues), but eventually lead to a more stable version of the entire protein. This is the packing problem. We have solved the issue of angle strain, and small unfavorable interactions. We can correct for these things, but they do not correct for the overall packing problem, and more research must be done to find a way to solve this bigger protein stability issue.

Appendix A (Figures):



Figure 1: A ribbon diagram of staphylococcal nuclease. The left-handed alpha helix is shown in red and is displayed on the left of the molecule.



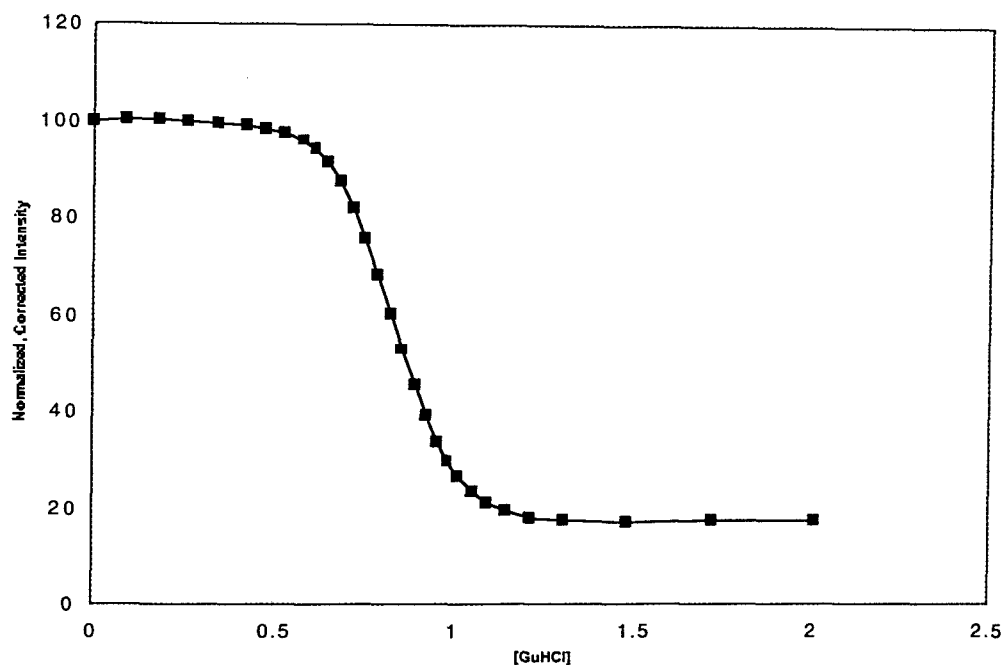


Figure 3: A fluorescence intensity plot of wild-type staph. nuclease..

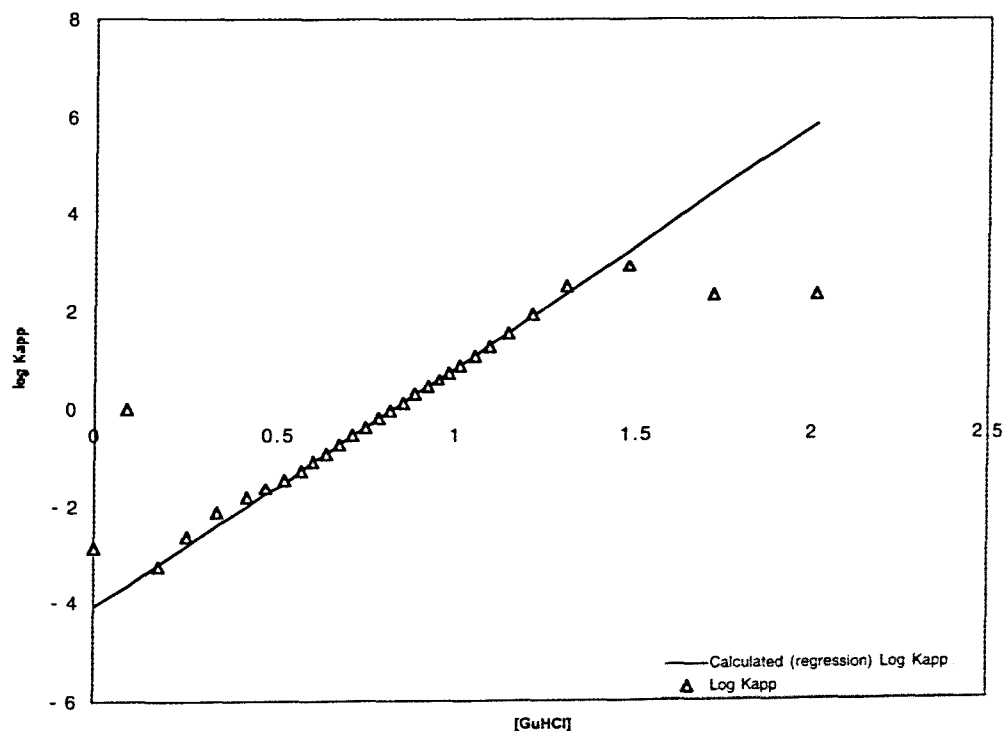


Figure 4: The log of the denatured intensities versus guanidine hydrochloride concentration plot with a linear extrapolation to zero guanidine hydrochloride.

Appendix B (Tables):

Table 1: The occurrence of each amino acid at each of the three residues analyzed in this study, with the consensus and nuclease sequences.

Residue Number	38	39	125
Amino Acid			
Isoleucine	0	42	2
Leucine	4	1	15
Valine	3	14	2
Phenylalanine	0	0	10
Tyrosine	1	0	16
Methionine	0	1	1
Cysteine	4	0	1
Alanine	3	0	1
Aspartate	3	5	0
Glutamate	2	0	1
Glycine	35	0	0
Histidine	0	0	1
Asparagine	4	1	0
Proline	0	0	1
Glutamine	1	0	2
Serine	1	0	1
Threonine	0	0	1
All others	0	0	0
Consensus	G	I	Y
Wild-type	L	V	L

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Table 2: A list of all of the mutations to be made and their shorthand codes, and mutation numbers.

Position(s)	Mutation	Code	Assigned Number
Leu38	Gly	L38G	32
Leu38, Val39	Gly, Ile	L38G/V39I	33
Leu38, Val39	Gly, Leu	L38G/V39L	34
Leu38, Val39, Leu125	Gly, Leu, Phe	L38G/V39L/L125F	141
Val39	Ile	V39I	23
Leu125	Phe	L125F	35
Leu125	Tyr	L125Y	36
Leu38, Leu125	Gly, Phe	L38G/L125F	83
Leu38, Leu125	Gly, Tyr	L38G/L125Y	84
Leu38, Val39, Leu125	Gly, Ile, Phe	L36G/V39I/L125F	139
Leu38, Val39, Leu125	Gly, Ile, Tyr	L38G/V39I/L125Y	140
Leu38, Val39, Leu125	Gly, Leu, Tyr	L38G/V39L/L125Y	142
Val39, Leu125	Ile, Phe	V39I/L125F	8
Val39, Leu125	Ile, Tyr	V39I/L125Y	
Val 39, Leu 125	Leu, Phe	V39L/L125F	
Val 39, Leu 125	Leu, Tyr	V39L/L125Y	

Table 3: Single Mutant Data

Mutant	m_{GuHCl}^a	C_m^b	$\Delta G_{\text{H}_2\text{O}}^c$	$\Delta G_{\text{single}}^d$
L38G	6.26	0.81	5.1	-0.3
V39I	5.3	0.83	5.3	-0.1
V39L*	6.68	0.68	4.5	-0.9
L125Y	5.85	0.20	1.1	-4.3
L125F	6.33	0.68	4.3	-1.1
WT	6.53	0.82	5.4	-

^a Slope value (change in free energy with respect to the change in GuHCl concentration), units of kcal mol⁻¹M⁻¹. Error estimated to be ± 0.09 .

^b Midpoint concentration (concentration of GuHCl at which half of the protein is denatured), units of mol/L. Error estimated to be ± 0.01 M.

^c Free energy difference between native and denatured states in the absence of denaturant, units of kcal/mol. Error estimated to be ± 0.1 kcal/mol.

^d Difference between the stability of wild-type protein, and the apparent stability of the mutant. Error estimated to be ± 0.17 kcal/mol.

* data previously published in

Biochemistry, 40, 46, 2001, 13999

Table 4: Solvent denaturation data for double packing mutants.

Table 5: Triple mutant data.

Mutant	$\Delta G_{\text{H}_2\text{O}}^a$	C_m^b	m_{GuHCl}^c	$\Delta \Delta G_{\text{triple}}^d$	$\Sigma \Delta \Delta G_{\text{single}}^e$	$\Delta^3 G_{\text{int}}^f$
L38G/V39L/L125Y	1.1	0.21	5.31	-4.3	-5.5	1.2
L38G/V39I/L125Y	2.5	0.41	6.07	-2.9	-4.7	1.8
L38G/V39L/L125F	3.6	0.65	5.55	-1.8	-2.3	0.5
WT	5.4	0.82	6.53	-	-	-

^a Free energy difference between native and denatured states in the absence of denaturant in units of kcal/mol. Error is estimated to be ± 0.1 kcal/mol.

^b Midpoint concentration (concentration of guanidine hydrochloride at which half of the protein is denatured) in units of M. Error is estimated to be ± 0.01 M.

^c Slope value (change in free energy with respect to change in guanidine hydrochloride concentration) expressed relative to wild-type value of 6.53 kcal/(mol Σ M). Error is estimated to be ± 0.02 .

^d Difference in free energy between the free energy of the protein with triple substitutions and the free energy of wild-type protein.

$\Delta \Delta G = \Delta G_{\text{H}_2\text{O}}$ (triple mutant) - 5.4 (WT). Error is estimated to be ± 0.2 kcal/mol.

^e The sum of the $\Delta \Delta G_{\text{single}}$ values of corresponding single substitutions.

$\Delta^3 G_{\text{int}} =$

$\Delta \Delta G_{\text{triple}} -$

$\Sigma \Delta \Delta G_{\text{single}}$

. Error is estimated to be ± 0.2 kcal/mol

*Data is original, table and footnotes are from reference 9.

A COMPARATIVE EVALUATION OF .NET REMOTING AND JAVA RMI

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Abstract:

Distributed application technologies such as Microsoft.NET Remoting, and Java Remote Method Invocation (RMI) have evolved over many years to keep up with the constantly increasing requirements of the enterprise. In the broadest sense, a distributed application is one in which the application processing is divided among two or more machines. Distributed middleware technologies have made significant progress over the last decade. Although Remoting and RMI are the two of most popular contemporary middleware technologies, little literature exists that compares them. In this paper, we study the issues involved in designing a distributed system using Java RMI and Microsoft.NET Remoting. In order to perform the comparisons, we designed a distributed distance learning application in both technologies. In this paper, we show both similarities and differences between these two competing technologies. Remoting and RMI both have similar serialization process and let objects serialization to be customized according to the needs. They both provide support to be able to connect to interface definition language such as Common Object Request Broker Architecture (CORBA). They both contain distributed garbage collection support. Our research shows that programs coded using Remoting execute faster than programs coded using RMI. They both have strong support for security although implemented in different ways. In addition, RMI also has additional security mechanisms provided via security policy files. RMI requires a naming service to be able to locate the server address and connection port. This is a big advantage since the clients do not need to know the server location or port number, RMI registry locates it automatically. On the other hand, Remoting does not require a naming service; it requires that the port to connect must be pre-specified and all services must be well-known. RMI applications can be run on any operating system whereas Remoting targets Windows as the primary platform. We found it was easier to design the distance learning application in Remoting than in RMI. Remoting also provides greater flexibility in regard to configuration by providing support for external configuration files. In conclusion, we recommend that before deciding which application to choose careful considerations should be given to the type of application, platform, and resources available to program the application.

Introduction:

A distributed system is a collection of loosely coupled processors interconnected by a communication network [8]. From the point view of a specific processor in a distributed system, the rest of the processors and their respective resources are remote, whereas its own resources are local. Generally, one host at one site or machine, the server, has a resource that another host at another site or machine, the client (or the user), would like to use [8]. The purpose of the distributed system is to provide an efficient and convenient environment for such sharing of resources.

A distributed application is one in which the application processing is divided among two or more machines [8]. This division of processing also implies that the data involved is also distributed. Distributed application technologies such as Microsoft.NET Remoting, Distributed Component Object Model (DCOM), Java Remote Method Invocation (RMI), and Common Object Request Broker Architecture (CORBA) have evolved over many years to keep up with the constantly increasing requirements of the enterprise. They all are based on objects that have identity and they either have or can have state [1]. Developers can use remote objects with virtually the same semantics as local objects. This simplifies distributed programming by providing a single, unified programming model. They are also associated with a component model. A *component* is a separate, binary-deployable unit of functionality [3]. Using components in a distributed application increases its deployment flexibility.

In this paper, we focus on Microsoft.NET Remoting and Java RMI. These two are by far the most popular distributed technology at present. Java RMI, acronym for Remote Method Invocation, is designed by Sun Microsystems which targets working on distributed objects on Java virtual machines [2]. RMI allows Java developers to make calls to objects in different Java Virtual Machines, whether they are in different processes or on different hosts. .NET Remoting is designed by Microsoft Corporation as a successor to DCOM. .NET Remoting is the manner in which .NET makes objects callable over a network. In contrast to RMI's emphasis on Java-only development, .NET Remoting supports multi-language interoperability. Both of these technologies share similarities and differences. For

developing distributed application, a lot of times developers are confronted with the question of which technology to choose. This is often a daunting task. This paper attempts to make a comparative evaluation between these two very popular distributed technologies in various aspects of designing a distributed application.

In order to perform these comparisons, we have designed a simple distance learning application in both technologies. In the rest of the paper, we give an architectural background of Remoting and RMI, describe the distributed distance learning application, and present the experimental results of the evaluation. In conclusion, we show our observations in regard to which application to choose, and recommend any future research work that can be done in this area.

Overview of Architectures:

Microsoft.NET Remoting Architecture

.NET Remoting enables client programs to call methods of remote objects. When the client creates a connection to the server object, the .NET Framework creates a proxy object on the client [3]. The proxy object provides the client with the same view of the server object that it would have if the server objects were in its application space. It can call the server object's methods through the proxy object. Figure 1 depicts this process. The figure shows a client method that calls a method on the remote object through the proxy object created at run time. Any data passed by the client method to the proxy is packaged by a formatter so that it can be sent across the network. The process of packaging the data for transaction is called *marshalling* [3].

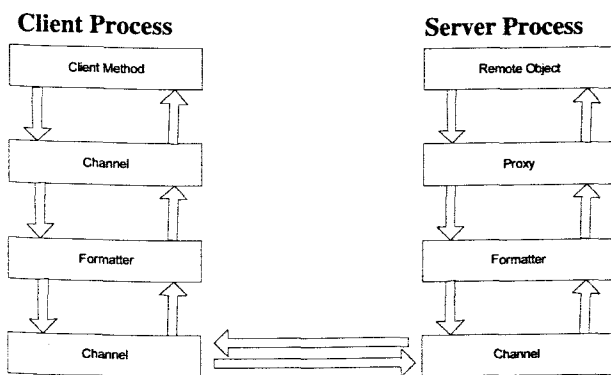


Figure 1: How Remoting Works

After the data is marshaled by the formatter, the data is sent through the channel, out across the network to the server. A formatter on the server unmarshals the data and calls the appropriate method on the server. It passes the data to the

method. When the server object's method finishes its processing, it send any data it might need to return back to the formatter, and the entire process is reversed.

Java RMI Architecture

The Java RMI architecture is based on the *broker* pattern [4]. The *broker* pattern is a broker with indirect communication between proxies. The Java RMI architecture consists of three layers: the *stub/skeleton* layer, the *remote reference* layer and the *transport* layer [4].

RMI is a layer on top of the Java Virtual Machine which leverages the Java system's built-in garbage collection, security and class-loading mechanisms [6]. The application layer sits on top of the RMI system. A Remote Method Invocation from a client to a remote server object travels down through the layers of the RMI system to the client-side transport [8]. Next, the invocation is sent - potentially via network communication - to the server-side transport, where it then travels up through the transport to the server.

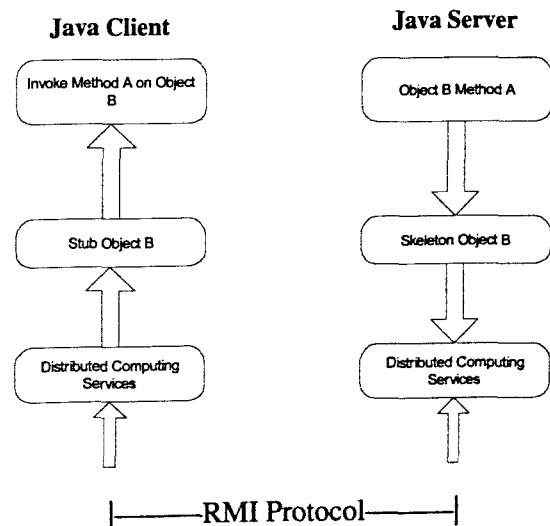


Figure 2: How Java RMI works

A client invoking a method on a remote server object actually uses a stub or proxy as a conduit to the remote object [6]. A client-held reference to a remote object is a reference to a local stub, which is an implementation of the remote interfaces of the object and which forwards invocation requests to it via the remote reference layer.

Distance Learning Application:

The distributed application we have designed is a simple distance learning application. The remote methods in the application includes:- adding a course, deleting a course, view schedule, view a class description, view and submit homework/

quizzes/handouts. These remote methods are defined in the remote server implementation class. The client makes a call to these remote methods with an object initiated during the connection to the server. We use TCP as the communication protocol. For storing information regarding courses, schedule, or course assignments we used simple text files. The reason for choosing text files as storage location is due to the fact if we use database such as Microsoft Access or MySQL and used Open Database Connectivity (ODBC) or Java Database Connectivity (JDBC) as the application programming interface, the comparison between RMI and Remoting will not be fair since database transactions will significantly affect the performance. We wanted to use the same storage facility for both applications and focused our measurements on the distributed programming aspects only. While designing the application we tried to keep very similar programming techniques and algorithms.

object in this case is the attempt the client makes to ask for a service from the server. A student can also submit his or her assignments, participate in quizzes, and view handouts for a particular class. The student also receives immediate feedback on his or her quiz grades online. We are currently adding support for instructors so that they can login as a course administrator and update homework, handouts, quizzes and lecture material online.

Comparative Evaluation:

In this section we list some of the similarities and differences between Java RMI and .NET Remoting. .NET Remoting and Java Remote Method (RMI) are functionally equivalent. Both systems allow applications to communicate between processes and machines, enabling objects in one application to manipulate objects in another. Some of the key similarities and differences are listed in the table below:-

	RMI	Remoting
Inheritance	Single Class, Multiple interface inheritance	Single Class, multiple interface inheritance
Communication	Socket	Channel
Naming Service	RMI Registry, mapping from named server object to URL	Hash table of object references
Configuration	System Property	XML file
Remotable	Remote interface	MarshallByRef
Protocol	JRMP, IIOP	HTTP, TCP, SOAP
Activation	Can be activated	Singlecall, Singleton, CAO
Format	Serialization	SOAP or Binary Formatter
Distributed Garbage Collector	Yes	Yes
Error	Remote Exception	Remote Exception
Skeletons	Integrated within the framework	Integrated within the framework

Figure 3: Key Differences between RMI and Remoting [2]

When a client (student) connects to the server (the host university/college), he or she has to verify his login name first. After that a menu prompts with options to add or delete classes, view the student's current schedule of classes, homework, quizzes or handouts. After a student selects an option a remote call to the method is made with appropriate parameters and after processing the request the result is printed back to the client. The remote

Similarities:

Although Microsoft.NET Remoting and Java Remote Method Invocation (RMI) are implemented quite differently and are based on different business philosophies, they are remarkably similar in many ways. These similarities include:

i) Copies and References:

In common with RMI, Remoting provides the distinction between classes that will be referenced remotely and class that will be copied across the network via serialization [5]. Serialization is the process of converting a set of object instances that contain references to each other into a linear stream of bytes, which can then be sent through a socket, stored to a file, or simply manipulated as a stream of data [3]. Serialization is the mechanism used by RMI to pass objects between Java Virtual Machines (JVMs), either as arguments in a method invocation from a client to a server or as return values from a method invocation. Similarly, all of the .NET primitive types are annotated with the *Serializable* attribute. Following is an example of how to make a class serializable in .NET Remoting:

```
Using System;

[Serializable]

public class View_Grades{

    //do something

}

In Java RMI:-

import java.io.*;

public class View_Grades extends AbstractList
implements List, Cloneable, java.io.Serializable {

    //do something

}
```

ii) Customizing Object Serialization:

The .NET framework allows a type attributed with the *SerializableAttribute* custom attribute to handle its own serialization by implementing the *ISerializable* interface [5]. This interface defines one method, *GetObjectData*:

```
void GetObjectData(Serialization info,
StreamingContext context);
```

The Java RMI provides a similar functionality *java.io.Externizable*, which allows programmer to take responsibility of the serialization process. Whereas in Remoting the *ISerializable* interface contains only one method *GetObjectData*, in RMI *Externizable* contains two methods [3]:

```
public void readExternal (ObjectInput
in);

public void writeExternal (ObjectOutput
out);
```

iii) Object-Oriented Remote Procedure Call (RPC):

Remote Procedure Calls (RPC) is a traditional mechanism that allows applications to call procedures that exist on other computers [2]. RPC makes use of proxy methods that have the same signature as the remote method but also has code Remote Procedure Calls (RPC) is a traditional mechanism that allows applications to call procedures that exist on other for transferring data between the client and the server [2]. Parameters are bundled and sent to the server where they are unbundled and passed into the requested method. The return values are treated in the same way.

Both Java RMI and .NET Remoting implement an object oriented approach in remote method calls built on top of existing RPC mechanism. While RPC allows the program to call procedures over the network, RMI and .Net Remoting permits to call an object's methods over the network [2]. In order to make a remote method call over the network, the program needs to call the method through the server object that was initiated during the connection.

The following code snippet shows how to make remote method calls in .NET Remoting:-

```
MySearchIntf      MyObject      =
MySearchIntf)Activator.GetObject

typeof(MySearchIntf) , "tcp://
localhost:8085/MySearch");

MyObject.Add_Course(course);
```

Here we have activated a server object called *MyObject* and invoked a remote method named *Add_Course* on that object.

The following code snippet shows how to make remote method calls in Java RMI:-

```
SimpleRMIInterface myServerObject =
(SimpleRMIInterface) Naming.lookup("//
" +
serverName + "/"
SimpleRMIImpl");

myServerObject.Add_Course(temp);
```

Here we bind the server object *myServerObject* to the object in the client and then invoke a remote method *Add_Course* on that object.

iv) Interface Definition Language (IDL):

CORBA, the acronym for Common Object Request Broker Architecture, is a widely used communications model for building distributed (multi-tier) applications that connect both cross-platform and cross-language clients to server-based services. Neither RMI nor .Net Remoting require a secondary language for defining the remote interfaces, such as CORBA IDL [2]. However both .NET Remoting and Java RMI provides support for building CORBA Server. Making that connection requires a way to describe .NET objects as CORBA objects so that J2EE

.NET objects, so that managed .NET code can interact with them [11]. In other words, you need some mediating code that can translate objects and method calls from CORBA's representation to the .NET framework's representation [10].

v) *Remote Object Lifetime:*

Java RMI provides support for Distributed Garbage Collection. Server tracks clients who have its stub and keeps a count of such clients [2]. Count is decremented when client explicitly relinquishes reference. If the reference count reaches zero, the object is garbage collected. An object's *lease* is essentially a counter that specifies its lifetime [3]. RMI also lets distributed references to be leased. Clients automatically try to renew leases as long as a stub has not been garbage collected [4]. .NET Remoting employs similar concept of object leasing. Leases are controlled by the server's lease manager object, which is created in the server's application domain. By default, .NET Remoting gives client activated and singleton objects a lease of five minutes [3]. It decrements the lease at certain intervals. Each time a client accesses the object, the lease manager increases the lease by two minutes [3].

Differences:

i) *Naming Service:*

In order to create a socket connection, it is necessary to have a machine address and a port. However, you also want to avoid hard coding the server locations into a client application. In order to solve this problem, RMI makes the client "ask" a dedicated server which machine and port they can use to communicate with a particular server [3]. This dedicated server is often known as a *naming service* [3]. In RMI, the default naming service that ships with Sun Microsystem's version of the JDK is called the *RMI registry*. Messages sent to the registry via static methods that are defined in the *java.rmi.Naming* class [3]. RMI registry is usually started as a standalone server. Unfortunately there is not a reliable way to be backwards-compatible with the RMI registry in terms of being backward-compatibles with already existing naming services and with future versions of the naming services. One advantage to having a naming server is that you do not need to know the server address or the port number.

.NET does not rely on a registry to locate instances of remote classes. Instead of using naming services, a client communicates with the server on a pre-specified port [2]. Services must be *well-known*, meaning that the client must know the location of the remote service at run time. In Remoting on the server side you create an instance of a *TCPChannel* or *HttpChannel* class, and pass its constructor a port number. Thus, the port number is the port on which the server listens for the client. Then the program needs to register the channel via the static method *RegisterChannel* [6]. In this way, .NET Remoting

eliminates any need for have a separate naming services in order to locate the remote services.

ii) *Language and Platform Interoperability:*

A significant difference between RMI and Remoting is that when you develop with Java, it provides a single language targeted at multiple operating systems, whereas, .NET provides multiple languages (C#.NET, Visual Basic.NET, and C++.NET) targeted primarily to a single operating system (Windows). RMI application can be run on any operating system that has Java Virtual Machine (JVM). Both Java RMI and Remoting are tightly coupled with their languages which indicate that these technologies do not interoperate with each other [2].

.NET Remoting meets the interoperability goal by supporting open standards such as HTTP, Simple Object Access Protocol (SOAP), Web Service Description Language (WSDL), and Extensible Markup Language (XML) [6]. To communicate with non .NET clients and servers, a developer can implement a SOAP formatter.

RMI Inter-ORB Protocol (RMI-IIOP) provides a convenient way for any language that "speaks CORBA" to talk to Java [2]. The CORBA IIOP protocol is part of the JDK 1.3 specification. One of the advantages of RMI-IIOP over CORBA is the developers do not need to learn the CORBA Interface Definition Language (IDL).

iii) *Performance Speed:*

In order to compare the speed of Remoting and RMI, we performed clock timing on remote method calls. We have instantiated a *date* object before the method call and instantiated another *date* object after the method call returned to the calling class. After that, we took the difference in time in the process in milliseconds. The performance depended on how fast the method was able to retrieve data from a text file and then write that data to another text file and add it to the student's record. We performed this benchmarking on two remote methods, namely, *Add_Course* and *Delete_Course*. For adding courses we counted from the time it took for adding up to ten courses and same for deleting courses as well. The following two graphs show the performance comparison of RMI and Remoting when called with *Add_Course* and *Del_Course* remote method:

In both of these graphs, .NET Remoting runs about twice as fast as RMI does and the differences are greater as the number of courses increases. We tried to perform this benchmarking as much fair as possible. Two important things to point out here that, we used Visual Studio.NET 2003 and Borland JBuilder 8.0 SE as editors and we ran these benchmarks on a Windows machine. Following are the code snippets for the test methods:

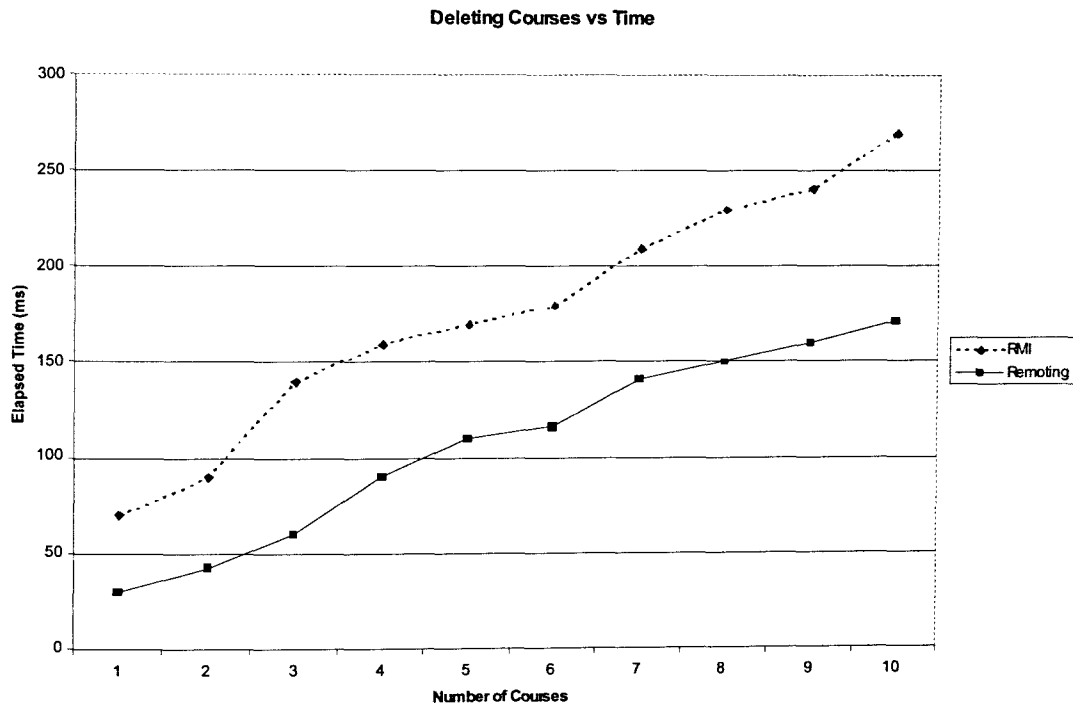


Figure 4: Performance Comparison of RMI and Remoting for adding courses

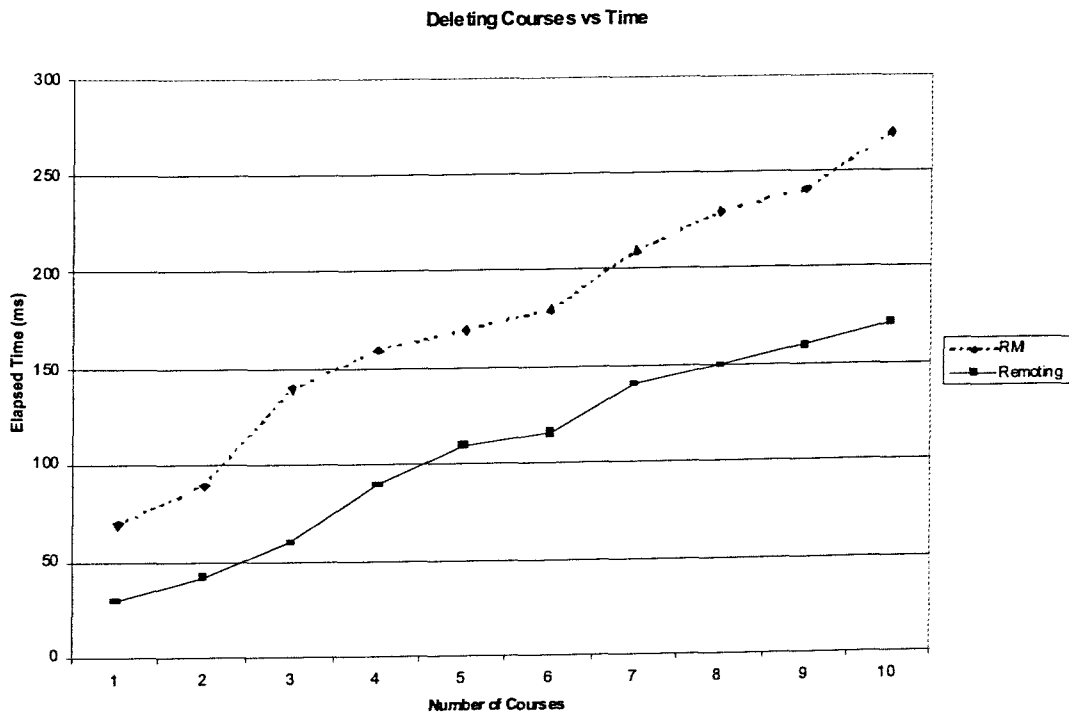


Figure 5: Performance Comparison of RMI and Remoting for deleting courses

In .NET Remoting:

```

DateTime s = DateTime.Now;
start = s.Millisecond;
MyObject.Add_Course(course);
DateTime f = DateTime.Now;
finish = f.Millisecond;
total = total+ (finish-start);

```

In Java RMI:

```

Date d = new Date();
sTime = d.getTime();
myServerObject.Add_Course(temp);
Date d2 = new Date();
fTime = d2.getTime();
dTime = dTime + (fTime-sTime);

```

iv) Security:

No aspect of distributed systems has gotten more attention lately than security. The .NET's Common Language Runtime (CLR) automatically provides a minimal form of checking to ensure that none of the program's assemblies have been altered or replaced [3]. It utilizes a technique called *hashing* to generate an identifier for each assembly based on assembly's contents. Every assembly generates a unique hash which is stored by Visual Studio in a hash file [3]. Besides this automatic checking, .NET also supports strong-named assemblies. This helps the .NET framework prevent *spoofing* on a network. .NET also provides a Signcode tool called *SIGNCODE.EXE* with Visual Studio so that developers can assign trust levels to the assemblies [3]. It also provides tools to authenticate signatures and validate custom certificates issued by entities such as VeriSign. However, the best way to implement a secure remoting system is to host the remote server inside Internet Information Service (IIS) [6]. The best part of hosting inside IIS is that you can use strong security features without changing client's code or the server's code.

Java RMI adopts a different approach. It provides security policy files that defines what kind of permission a program has. There are nine basic type of permissions:- AWT, File, Network, Socket, Property, Reflection, Runtime, Security, and Serializable [3]. Every RMI application needs to contain a *security.policy* file that will indicate the type of permissions available. Java2 also comes with a simple GUI application, called *policytool*, that helps you edit policy files. Within a running JVM, permissions are enforced by an instance of the *SecurityManager* class [3]. When a program attempts to do something that requires permission, the instance of *SecurityManager* is queried to see whether the operation succeeds.

v) Ease of Programming:

In developing this simple distance learning application, we found developing remote applications in .NET Remoting is easier than Java RMI and other texts [4] also concur with similar opinions. .NET has a rich debugging API. .NET Remoting is quite flexible in terms of building application. You can configure a Remoting application using a configuration file or programmatically. Both server and client can be configured in this way. Using configuration files allow the administrators to configure the application's Remoting behavior without recompiling the code [6]. Remoting also has more options in terms of publishing and activating remote objects. The framework can be configured depends on the application needs [2]. For example, an application can use either HTTP or TCP as the communication protocol, and either SOAP formatter or binary formatter as the object serialization. Following is an example of a *MyServer.config.exe* file configured using a configuration instead of programmatically:

```

<configuration>
  <system.runtime.remoting>
    <application name="MyServer">
      <service>
        <wellknown mode="Singleton"
          type="MyServerLib.MyServeImpl,
            MyServerLib" objectUri="JobURI" />
      </service>
      <channels>
        <channels ref="http" port ="8085" />
      </channels>
    </application>
  </system.runtime.remoting>
</configuration>

```

vi) Publishing and Activation Object Service:

Java RMI includes a generic and reusable factory implementation, called the *Activation Framework*, which handles the details of launching servers on remote machines easily and transparently [2]. Instead of using *UnicastRemoteObject*, the remote implementation extends the *Activation* class.

In Remoting there are two types of activations- *client activation* and *server activation* [4]. When a server publishes a service, the activation type defines how and when the object will be created, and how lifecycle of the object will be controlled. When a client registers for an activated service, the runtime is provided with information about how to create new proxies to represent the remote type. There are two variants in the server activation of objects- *Singleton* and *SingleCall* [4].

vii) Implementation of Remote Objects:

In Java RMI the developer has to create an Interface where the developer declares all the remote methods with appropriate remote exceptions. This Interface class is implemented by the server implementation class where these remote operations are defined. However, in Remoting you are not required use an

Interface class. However, a client must be able to obtain the metadata describing the remote type [6]. A solution to this problem is to have the client add a reference to the assembly containing remote objects implementation.

.Net remoting cannot run a non-default constructor when connecting to well-known objects [2]. Java RMI does not have this limitation.

Conclusion:

Although .NET Remoting and Java TMI share some common traits mostly due to the fact that they both are object-oriented distributed technology, the basis and structure of the .NET Remoting is different from Java RMI. .NET Remoting service is easier to program and provides greater flexibility features such as the configuration files. RMI was added to Java after the original release of the platform, while the Remoting system has always been a part of the .NET framework from the beginning. This provides .NET Remoting a deep integration with the underlying platform. Both Java RMI and .NET Remoting preserves the security features provided by their individual run time environment. In addition to that, Java RMI also provides support for security policy files for stronger security. Remoting is much faster and has excellent debugging support. .NET Remoting does not define a standard protocol; it only has a set of channels, formatter and message sinks, adding more flexibility to the developer. Java RMI on the other hand is free.

To conclude, both .NET Remoting and Java RMI are great solutions to develop distributed applications, which to choose depends on the type of application, platform, resources and tools available for designing the application.

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Faculty Comment:

Mr. Ibrahim's faculty mentor, Professor Amy Apon, made the following comments about her student's work:

The computer industry is a very rapidly changing field of study. New software tools and versions of tools from vendors such as Sun Microsystems, IBM, The Open Software Group, and Microsoft, become available on a regular basis. However, the personnel and training effort required by companies that want to use these new tools is enormous, so that very often old tools with less capability continue to be used even when newer, more capable tools are available. In addition, it is difficult for college students to learn new tools since professors also must learn how to use these tools in order to incorporate them into their classes. In general, there is a lack of understanding in the industry about what may be gained by using a new tool as compared to an existing tool or other newer tools.

For his research, Taneem has performed an unbiased study and comparison of two competing technologies, Microsoft .Net, and Java-based tools for distributed computing. The problem of comparing the entire programming capability of .Net and Java-based tools is too large for a single project, and Taneem has chosen to limit his comparison to the remoting capability of .Net and the Java RMI system. Some of the study is quantitative. As a part of his project, Taneem has learned each of these new tools and has implemented a substantial test software system using each tool. This example provided by this code in both systems is a very nice contribution alone. He has written benchmarking code that executes equivalently in both systems and has compared the relative speed of execution of the two tools. In addition to the quantitative study, a portion of Taneem's research is qualitative, and includes a literature search and comparative study along several specific criteria, including inheritance, communication, naming service, configuration, protocol, activation, format, distributed garbage collection, error handling, and skeletons, and perceived ease of use.

The results of Taneem's study show that it is possible to perform a good comparison of Microsoft .NET and Java RMI as an undergraduate research project. It also demonstrates that there is potential for companies and universities to move to new tools with a reasonable amount of effort. Taneem found significant differences in the speed of execution of the two tools, with .NET outperforming Java RMI by about a factor of two. Taneem found similarities and differences on several criteria. He found .NET to be an easier programming environment and describes in experiences in detail. The results of this research are particularly important because there are not many studies of this type, and a contribution is greatly needed in this area.

PARAMETER EXTRACTION SOFTWARE FOR SILICON CARBIDE SCHOTTKY, MERGED PIN SCHOTTKY AND PIN POWER DIODE MODELS

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Abstract:

A software program for on-state parameter extraction is presented for the realization of a high quality model for SiC Schottky, Merged PiN Schottky, and PiN Power diodes based on McNutt and Mantooth's Comprehensive SiC Diode model [1].

Introduction:

There has been an increasing interest in Silicon Carbide (SiC) for many applications in high power electronics. SiC offers high current carrying capabilities, high thermal conductivity, high temperature operation, and a high breakdown field, which makes it superior to silicon semiconductor technology. The advantages of Silicon Carbide (SiC) have been recognized for more than three decades. However, single crystal wafers of SiC have only been accessible since around 1990. Therefore, SiC devices are relatively new and slowly becoming commercially available.

In order to increase the acceptance of a SiC electronic device, providing design engineers with an accurate semiconductor device model is of crucial importance. Design engineers need a reliable representation of the electronic device they are going to utilize in order to simulate proposed designs and detect flaws before building a prototype. This results in the ability of the designer to vary parameters in the design with relative ease. Most importantly, in the case of a faulty design, an accurate device model predicts any undesired behavior of the system, which in turn prevents the waste of financial resources as well as any personal injuries to users of the design.

McNutt [1] has developed an accurate model and parameter extraction procedure for SiC Schottky, Merged PiN Schottky and PiN Power diodes. Nevertheless, the model parameter extraction is a cumbersome, time-consuming task. This is the reason for the efforts made in developing software to extract the parameters of the model. The software here presented enables

users to extract the on-state model parameters themselves and thus permits the simulation of new SiC diodes as soon as they are introduced.

Software Platform:

The software platform of choice for the development of the on-state model parameter extraction software is Labwindows/CVI[®]. Labwindows/CVI[®] is an integrated C programming environment designed for the development of data acquisition and data processing software. The C programming environment of Labwindows/CVI[®] allows for the easy implementation of model equations required to extract the model parameters. It also allows the generation of a graphic user interface (GUI) with its numerous controls such as knobs, buttons, menus, numerical displays and graphs. This facilitates the parameter extraction process making the operation of the program and feature selection visually intuitive.

Organization of Front Panel:

In this section, the organization and structure of the software is described. The software front panel is presented in figure 1. The software provides the user with file managing features on the *File* pull-down menu. The software opens and operates on the current-voltage data provided on a .txt file. The *Edit* pull-down menu allows the user to zoom in an area of interest in the curve as well as to reestablish the initial appearance. The front panel has two graph displays. The top graph display shows the currents through the diode versus voltage across the four ideal diodes that represent the SiC diode as it can be observed from figure 2. The bottom graph display presents the currents through the SiC diode versus voltage across the anode and cathode terminals of the SiC diode. The top right numerical displays X1, Y1, X2, Y2 give the coordinates of the blue and yellow cursors in the top graph display respectively. The temperature numerical display allows the user to extract the parameters at different temperatures. The function of the other buttons and numerical displays will be

explained during the Extraction Sequence section of this paper along with the step to which they are associated.

Topology and Parameters to be Extracted:

Figure 2 shows the topology for the on-state characteristics of the SiC diode. Four ideal diodes in parallel and a series-connected resistor model the SiC diode. As it can be observed from figure 1, the current I through the SiC diode is composed of four different currents namely Low-level depletion region combination (I_R), Low level injection (I_L), High level injection (I_H), and Emitter recombination (I_E). All these different currents are determined through the basic diode equation as shown in equation (1)

$$I_x = I_{sx} * (\exp(V' / (vt * n_x)) + 1) \quad (1)$$

where V' is the voltage across the diode, and I_{sx} and n_x are the model parameters and are unique for the four diodes illustrated in figure 1. The parameters are I_{SR} , I_{SL} , I_{SE} , I_{SH} , n_R , n_L , n_E , and n_H .

The resistor in series with the four diodes limits the exponential growth of the total current I to a more linear increment. The value of this on-state resistance rs is needed to determine the voltage V' across the diodes using equation 2.

$$V' = V - I * rs \quad (2)$$

Extraction Sequence:

The extraction process is divided into a sequence of steps where only a few parameters are obtained at each step. These steps are 1) Calculating rs , 2) Plotting I - V' logarithmically, 3) Calculating the I_{sx} and n_x parameters for the regions of low, medium, and high currents and associate them with I_R , I_L , I_E , or I_H . In addition to these steps, the user has the option of providing desired values of n_R , n_L , n_E , and n_H in order to obtain the corresponding I_{SR} , I_{SL} , I_{SE} , and I_{SH} .

1) Calculating rs

Figure 3 shows a typical I - V curve of a SiC diode. As can be seen from this figure, the curve is not purely exponential because of the linear component associated with rs . The effect of rs is more noticeable at higher voltages, and it is therefore the best region to extract this parameter. The software allows the user to set the limits of the region where the curve behaves linearly by placing the two cursors as shown in figure 3. Once the limits have been set the *Calculate Slope & Inverse Slope* button calculates the on-state resistance rs and the voltage V' using equation (2). The value of rs is displayed in the *Inverse slope (Rs)* numerical display.

2) Plotting I - V' logarithmically

The next step in the extraction sequence is plotting I - V' logarithmically. The plot

Current without rs effect button displays the I - V' curve linearly as in figure 4a. In the linear representation of the I - V' curve, the contributions of the I_R , I_L , I_E , and I_H currents are not visible because the curve looks purely exponential (that is just one exponential curve) rather than a combination of exponential currents (namely the contribution of I_{SR} , I_{SL} , I_{SE} , and I_{SH}). The *Plot Mode* switch on the front panel allows the user to plot the graphs linearly or logarithmically. When I - V' is plotted logarithmically, the contributions of I_{SR} , I_{SL} , I_{SE} , and I_{SH} are more obvious, and the user can distinguish the number and location of the regions that make up the I - V' curve as shown in figure 4b.

3) Calculating I_{sx} and n_x parameters for the regions of low, medium, and high currents

Figure 4b shows a typical I - V' plotted logarithmically. The curve exhibits changes in its concavity at different points as shown by the arrows. These different concavities determine the regions that make up the curve. Even though the software does not restrict the user from including all four currents I_R , I_L , I_E , and I_H to form I through the SiC diode, there are only a few combinations of these that have physical meaning. Additionally, the number of currents I_{sx} that compose I are typically two and in some cases three [1]. For the curve shown in figure 4b there are two I_{sx} currents contributing to the total current. The regions are selected by placing the cursors on the curve delimiting each region. Then each region's parameters are calculated by pressing the *Capture Low*, *Capture Medium*, and *Capture High* buttons depending on the region selected. The values for the saturation currents and their respective n components are displayed in the *Is Low*, *N Low*, *Is Medium*, *N Medium*, *Is High*, and *N High* numerical displays. The *Associate with* control display allows the user to transfer the values of the parameters extracted to the current component of his or her choice. Then, the numerical displays on the left side of the front panel I_R , n_R , I_L , n_L , I_E , n_E , I_H , and n_H will hold these values. The *Plot I diode* control button plots the total I current through the SiC diode including the effect of all the currents that have been check-selected. Figure 5 shows the data and

fitted curves for both cases where rs is present (a) and for the purely exponential curve (b), which are in excellent agreement with each other. If the user wishes to display the effect of only one current, he can do so by pressing any of the *Plot I_R* , *Plot I_L* , *Plot I_E* , or *Plot I_H* control buttons.

One important additional feature of the program is the ability to extract any I_{sx} value for any given n_x value. For example, after selecting a region of interest the user may enter any value for n_x and then press the *Recalculate Low*, *Recalculate Medium*, or *Recalculate High* buttons depending on the region chosen. This will return a value I_{sx} that will fit that part of the region for the given n_x .

Conclusion:

A parameter extraction software for Silicon Carbide Schottky, Merged PiN Schottky and PiN Power Diode Models is presented. The software here presented enables users to extract the on-state model parameters themselves and thus permits the simulation of new SiC diodes as soon as they are introduced. The graphic interface facilitates the process of the parameter extraction making it visually intuitive. The parameters obtained from this software generate a simulation that is in excellent agreement with the measured data.

Acknowledgements:

I would like to recognize Ty McNutt, Dr. A.B. Lostetter, and Maruf Hossain for their important contributions and suggestions to this work.

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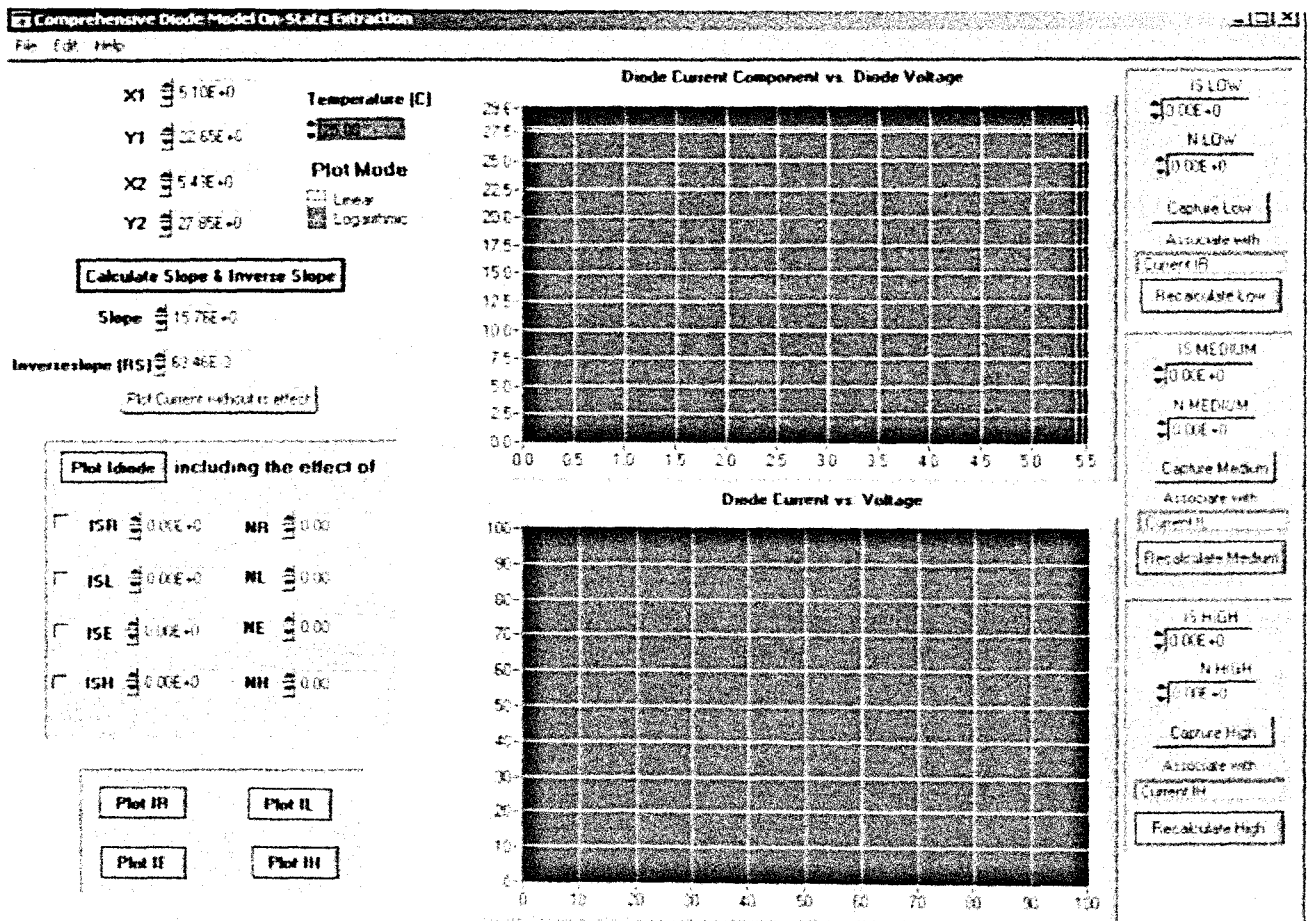


Figure 1- Front panel appearance.

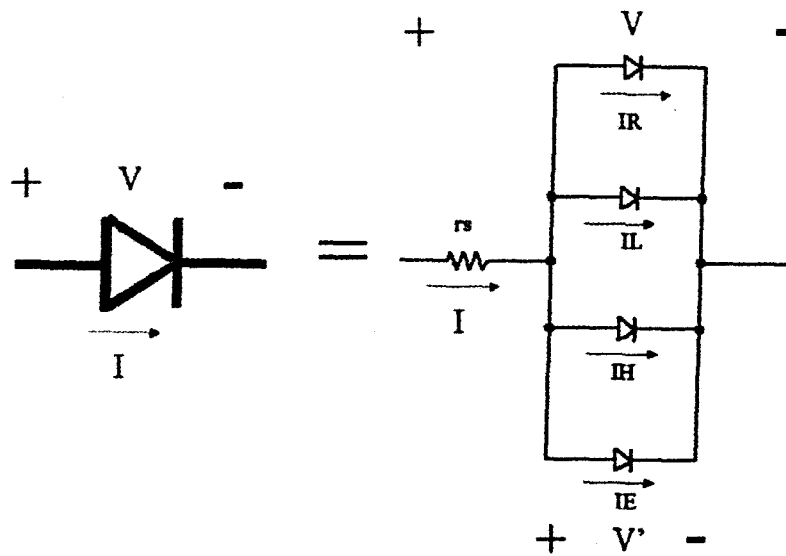


Figure 2- Topology for the on-state characteristics of the SiC diode.

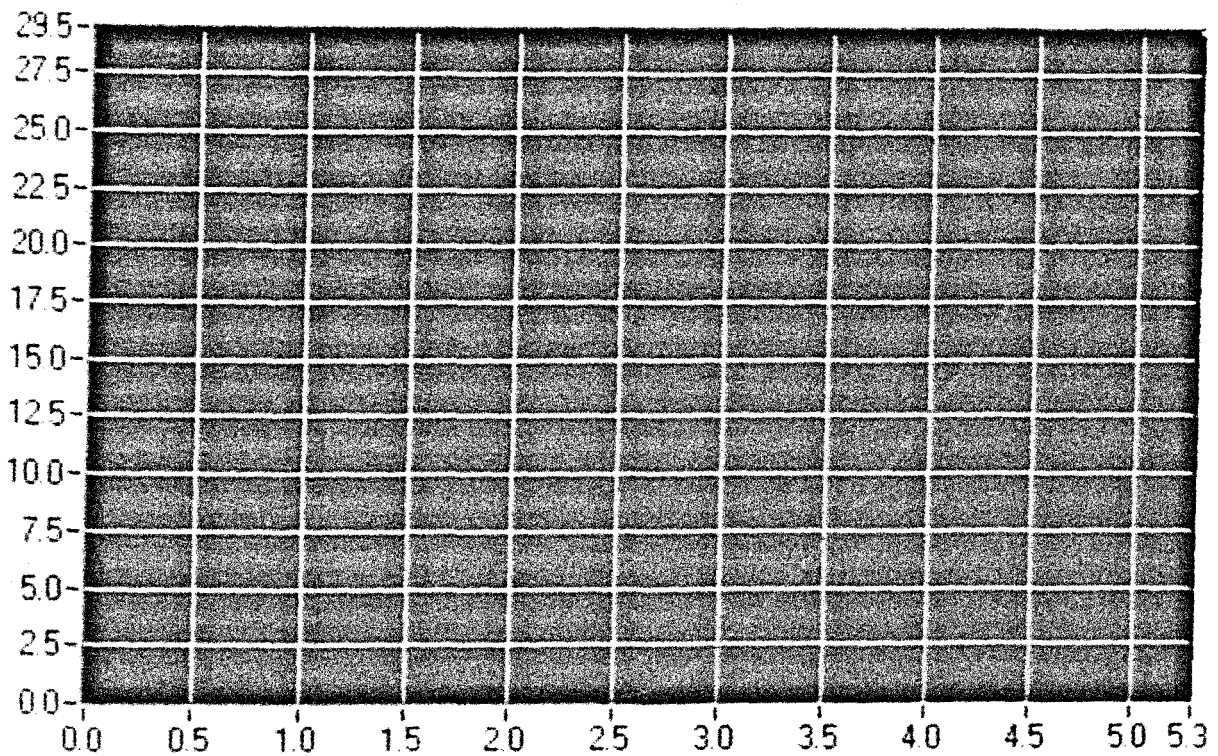


Figure 3- Characteristic I-V curve of SiC diode.

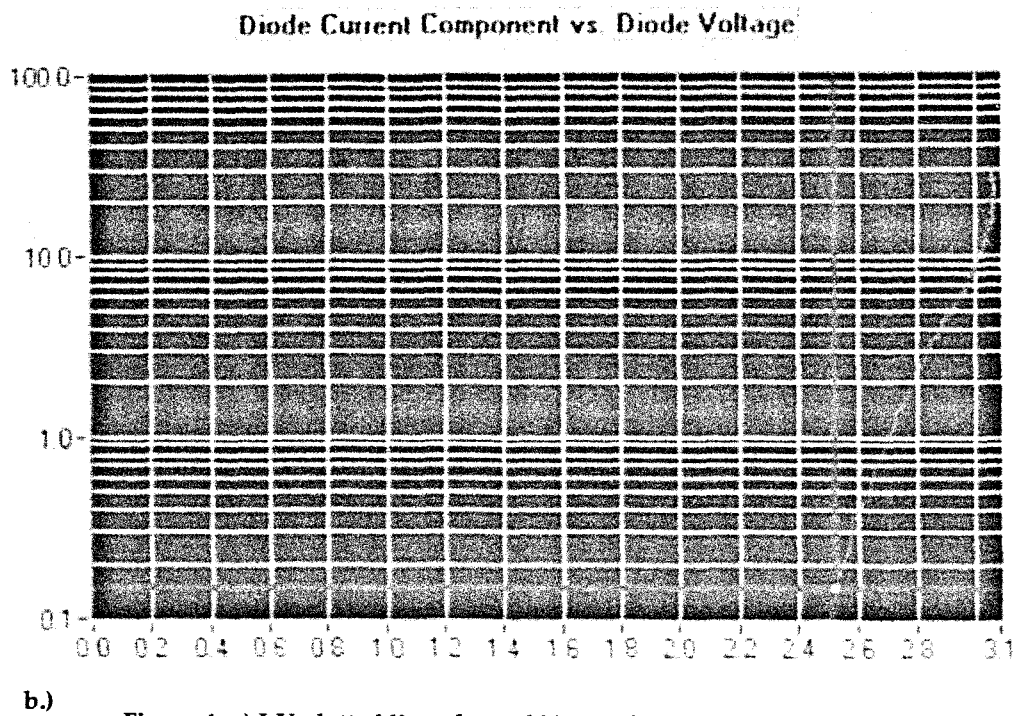
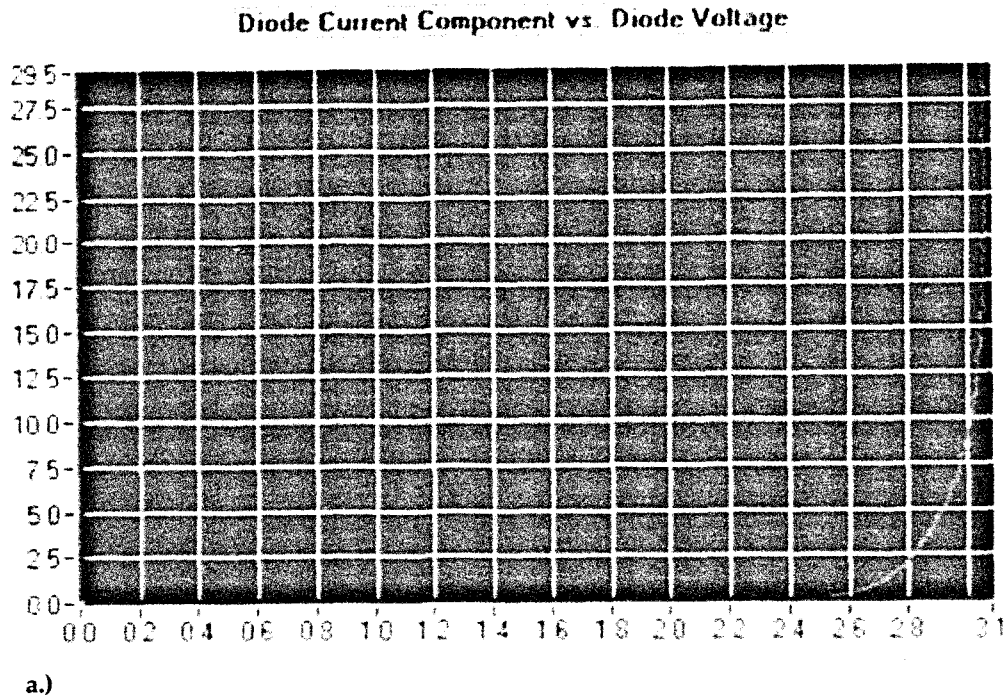


Figure 4- a) I-V plotted linearly, and b) I-V plotted logarithmically.

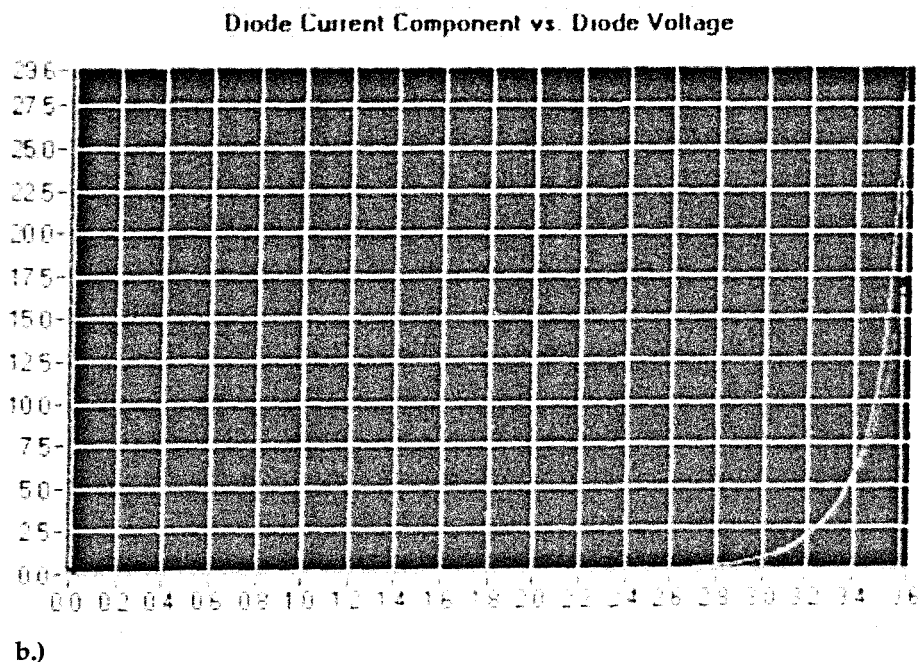
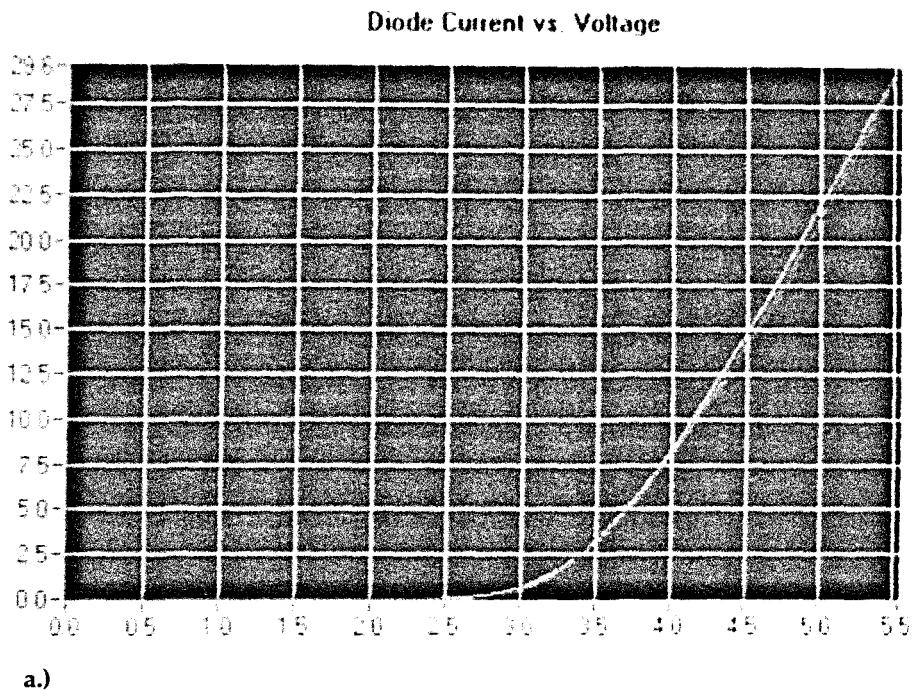


Figure 5- a) Data and fitted curves including r_s , and b) Data and fitted curves not including r_s .

Faculty Comments:

Alan Mantooth, Mr. Cilio's mentor, made the following comments about his student's work:

Edgar Cilio has worked in the Mixed Signal Computer Aided Design Laboratory for the past 2 years. He will complete his bachelor's degree in electrical engineering this fall. Edgar is a very bright, hard working young man that has done a great job in my lab working on projects relating to silicon carbide device technology. Edgar has a very high grade point average and combines this with the natural curiosity required of all good researchers. Edgar was also a member of the 2003 Solar Electric Boat Team for which I was faculty advisor. He had the responsibility of running the wireless telemetry project.

This project involves designing and building a wireless link from the on board meters and gauges to a laptop computer running special software to track the health of the boat's batteries, the speed of the boat, the efficiency of the solar panel array, and other important functions. This was a new challenge for Edgar, and he did a great job.

Edgar's research in my lab has involved writing software to drive instrumentation, developing custom

test circuitry for silicon carbide device characterization, and developing parameter extraction techniques for those device's compact models. His work will soon enable us to publicly release our device models along with a full complement of parameter extraction tools. This will be extremely well received by the power electronics community.

Another member of the electrical Engineering faculty who is familiar with Mr. Cilio's work, Department chair Aicha Elshabini, had the following to say:

Mr. Cilio's technical and research interests are in the areas of Circuit Design, Artificial Neural Networks, and Digital Signal Processing. His interesting and important undergraduate work in the SiC Power Device Modeling group consists of the automation of SiC electronic device parameter extraction sequences using LabVIEW and LabWindows/CVI. His research work consisted on developing a parameter extraction software for SiC Schottky, Merged PiN Schottky and PiN Power diodes since the parameter extraction procedure is a cumbersome, time consuming task. The software he has developed enables users to extract the on state model parameters themselves and thus permits the simulation of new SiC diodes as soon as they are introduced.

PROPAGATION OF THORNLESS BLACKBERRIES UTILIZING ADVENTITIOUS SHOOTS FROM ROOT CUTTINGS

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Faculty Mentors: Professor John Clark and Associate Professor Curt Rom
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Abstract:

Studies were conducted in early 2003 to determine the effect of root source and length on yield of adventitious shoots from root cuttings and on subsequent plant yield for University of Arkansas-developed thornless blackberries. In the first study, roots from 'Arapaho' and 'Apache' plants grown in an aboveground bed containing commercial potting soil were compared to field-grown roots. Bed-grown roots averaged 6.9 shoots per 15 cm root cutting while field grown roots averaged 3.4. 'Apache' produced more shoots/root cutting compared to Arapaho, (5.9 vs. 4.4 shoots/root cutting, respectively). In a comparison of 15- vs. 30-cm-long root cuttings of 'Apache', 'Arapaho', and 'Ouachita', shoot yield of 30-cm roots was higher than that of 15 cm roots, but total yield of shoots per root unit was not increased by the longer root cuttings. Rooting of adventitious shoots neared 100% in both studies, and resulting quality of plants from these shoots was very good. This minor modification to the traditional method of planting root pieces to yield individual plants could lead to a more efficient and productive yield of propagules. The use of adventitious shoots from root cuttings for blackberry plant propagation appears to be a viable method for nurserymen to consider.

Introduction:

Traditional methods of blackberry (*Rubus* subgenus *Rubus* Watson) propagation include tip layering, softwood cuttings, root cuttings, and tissue culture (Caldwell, 1984). While all successful, some methods often require lengthy establishment and growing periods and often do not meet virus-tested stock demands when virus-tested stock plant material is limited or when propagation must be conducted in enclosed structures with very limited space. These methods are commonly used due to familiarity and cost efficiency, and generally the use of root cuttings is the most widely practiced type of propagation for Arkansas-developed cultivars (John R. Clark, personal communication). In general, Arkansas-developed blackberries are very successful under this method. However, a simple modification in the use of root cuttings could lead to a more efficient yield of propagules. The forcing of multiple adventitious

shoots and subsequently rooting them to produce individual plants would allow propagators to yield more plants from a single root cutting. This method has been used in raspberry production as a successful means to increase propagule yield (Jennings, 1988). Also, a nursery in Switzerland that propagates and grows University of Arkansas-released cultivars has found this method to be efficient for both raspberries and blackberries (Markus Kobelt, Rhein-Baumschulen, Buchs, Switzerland, personal communication).

Cultivar and source of root cuttings have been regarded as possible reasons for variation in subsequent plant stand and quality. Observations involving bed-grown root cuttings indicated they varied in performance compared to field-grown root cuttings (Charles Boyd, Cedar Valley Nursery, Centralia, Wash.). Arkansas blackberry cultivars have been shown to vary in the percent sprouting of root cuttings (Clark and Moore, 1999), therefore, an evaluation of cultivar effects is needed in the evaluation of root cutting feasibility for plant production.

The objectives of our studies were to: 1) compare field-grown roots to soil-less, bed-grown roots in adventitious shoot production for two cultivars, and 2) determine if root cutting length affects resulting adventitious shoot number, plant size, and quality for three cultivars. Our intent is to provide this information to blackberry nurserymen as an alternative method to maximize propagation potential.

Materials and Method:

Experiment 1: Cultivar and Root Source Study

Thirty field-grown roots of the thornless blackberry cultivar Arapaho were collected from the University of Arkansas Agricultural Research and Extension Center, Fayetteville. The same number of 'Apache' roots was collected from the University of Arkansas Fruit Substation, Clarksville, all in December, 2002. The diameter of the roots was measured and root pieces were cut to 15 cm and placed in sealed, moist plastic bags in cold storage at approx. 3°C. The average diameter of the bed-grown roots was 2.4 mm while the field-grown roots averaged 4.7 mm. On 19 January 2003 (approximately one month of storage), the root cuttings were removed from storage and placed in drained,

plastic tubs containing PromixÆ soil-less potting mix (Sun-Gro Horticulture, Bellvue, Wash.) to a depth of 6 cm. The roots were maintained in the containers until mid-June. The containers were kept in a greenhouse with a daily minimum temperature of approx. 18°C and a daily maximum temperature of approx. 25°C. Roots were placed in the containers in a randomized complete block design of 10 replications, with three roots of each cultivar/root source per replication. Adventitious shoots were removed each 7-10 d as they emerged and length of shoots at removal was 3 to 5 cm. Harvested adventitious shoots were then stuck into JiffyÆ peat pellets (Jiffy Co., Batavia, Ill.) and placed under an intermittent mist system until rooted. Adventitious shoots generally rooted within 7 to 12 d. Up to 10 rooted shoots were then potted in 10 cm pots containing PromixÆ soil-less potting mix, maintained in the greenhouse, grown, and later evaluated for quality in May 2003. Each 0.8 cubic-meter bag of potting media received 50 mL of Osmocote 14-14-14 (The Scotts Co., Marysville, Ohio) per 0.03 cubic meter of soil for fertilization. Data collected included 1) date of adventitious shoot collection, 2) total number of adventitious shoots yielded, 3) plant establishment and survival percentage, and 4) overall resulting plant-quality rating from 1 to 5; 1 = excellent plant health and growth and 5 = poor plant health and growth.

Experiment II: Cultivar and Root Length Study

Field-grown roots of 'Arapaho' and 'Ouachita' were collected from the same Fayetteville location, and 'Apache' from Clarksville in December, 2002. Roots of each cultivar were cut into lengths of 15 and 30 cm and placed in plastic containers in soil-less medium as described in Study I. Roots were also evaluated for quality in May and all roots were maintained in the containers until mid-June. Roots and harvested adventitious shoots received the same greenhouse treatments as in Experiment I. The study was arranged as a randomized complete block design with four replications of each treatment combination, with three roots of each cultivar and length per replication. Data collected were the same as in Experiment I.

Data for both studies for shoot yield, plant survival, and plant quality were analyzed by analysis of variance using JMP (JMP, version 4, SAS Institute Inc. Cary, N.C.) and treatment means were compared using t-tests ($P < 0.05$).

Results:

Experiment I:

There were significant effects for root source and cultivar for adventitious shoot production per root cutting, but not for the interaction of root source and cultivar. 'Apache' averaged 5.9 adventitious shoots per root, compared to 'Arapaho' with 4.4 (Table 1). This observation agrees with a study by Clark and Moore (1999), in which adventitious shoot yield from 'Apache' root cuttings was higher than that of 'Arapaho.' Bed-grown roots produced on average 6.9 adventitious shoots per root, significantly greater than field-grown roots, which averaged

only 3.4 adventitious shoots per root (Table 1). Adventitious root collection began approximately 4 weeks after placement of the roots in the medium. Overall, adventitious shoot harvest was greatest in the first 7 weeks of study after first-shoot emergence, but was greatly reduced thereafter (Fig. 1). For bed-grown roots, there was a tendency for earlier shoot development and subsequent adventitious shoot harvest particularly in the first 2 weeks after first emergence. Eleven weeks after initial planting of roots, 75% of 'Apache' and 72% of 'Arapaho' bed-grown shoots had been harvested. Field-grown adventitious shoot yield was also greatest in the first 11 weeks of the study, however in comparison to bed-grown sources, shoot development in field-grown sources was somewhat delayed. Adventitious shoot yield fell off greatly after the first 11 weeks after initial root planting for both bed-grown and field-grown sources (Fig. 1).

The percent survival for the adventitious shoots upon removal from the root cuttings and placement under mist neared 100% (data not shown), indicating near complete success of rooting and subsequent plant survival using this method. Once potted, the plants grew vigorously and did not show any signs of nutrient deficiencies or further weaknesses. Quality ratings on resulting potted plants indicated excellent performance and there were no differences among cultivars or root sources (data not shown).

Experiment II:

There were significant effects for root length but not cultivar in this study and the interaction of root length and cultivar was not significant. Root length of 30 cm for all three cultivars yielded a mean of 6.1 adventitious shoots per root, while the average for 15-cm roots for the three cultivars was 3.4 adventitious shoots per root (Table 2). The overall plant yield, in a practical sense, was not different in that longer roots simply yielded about the same number of adventitious shoots as did two of the shorter roots. Similar to Experiment I, adventitious shoot harvest was greatest in the first 11 weeks of the study and did not appear to be affected by root length or cultivar (data not shown). Cultivars showed small numerical differences in shoot number, but none were significant. Plant quality ratings showed slight numerical differences for root length and cultivar, but none were significant (data not shown). Overall plant quality was very good for all cultivars and root lengths.

Discussion:

The major objective of our studies was to determine if propagation of thornless blackberries utilizing adventitious shoots from root cuttings proved to be a more efficient and higher yielding method than the traditional root-cutting propagation commonly used in the industry. We were equally interested in ensuring that plant quality, using this propagation method, is as good as that produced from other, more traditional methods. The survivability of plants using this method was excellent. Once the

adventitious shoots rooted and were potted, they grew vigorously and could quickly be grown into a marketable plant. This finding could be particularly valuable to a nurseryman.

Using this method, the amount of root material needed for an increased number of plants yielded per root would be much less than the more common yield of one plant per root cutting. This could be of particular value if, for instance, nurserymen grew plants for root cuttings in enclosed structures, such as beds in screenhouses that excluded virus vectors, and subsequently used the roots to force adventitious shoots. Growers using this method could expect significantly higher adventitious shoot production in the thornless cultivar 'Apache', although this method is also useful for the other cultivars. Growers could also expect to double adventitious shoot yields if bed-grown roots were used. It is possible that field-grown roots become more lignified, therefore yields are less due to lack of undifferentiated root cells.

Further studies on this topic might include the evaluation of rooting hormone on adventitious shoot production. Evaluating the use of shorter bed-grown roots in greater quantities and comparing the resulting number of adventitious shoots may result in an even greater yield of propagules.

The University of Arkansas released the first commercial primocane-fruiting blackberry cultivar in early 2004. These unique plants, which produce fruit on current-season canes (primocanes), rather than overwintered, 2-year-old canes (floricanes), will likely be limited to only tissue culture or root-cutting propagation. Softwood-cutting propagation will likely not be feasible due to primocane morphology being immediately in flowering mode rather than vegetative mode during the growing season. The use of adventitious shoots emerging from longer root cuttings could be a valuable method of propagating these new cultivars, in that these small shoots will be vegetative in growth and not in the flowering mode at this juvenile stage. Further evaluation of this technique will reveal the potential of this method with these unique plants.

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Clark, J. R. and Moore, J. N. 1999. 'Apache' thornless blackberry. *HortScience* 34:1291-1293.
Jennings, D.L. 1988. Raspberries and blackberries: Their breeding, diseases and growth. Academic Press, London. pp. 160.

Editor's Note:

This paper was selected from the papers published by the Bumpers College of Agriculture journal by its editor for inclusion in *Inquiry*.

Table 1. Number of adventitious shoots per root resulting from bed- and field-grown roots of 'Apache' and 'Arapaho' blackberries.

Cultivar	Bed-grown	Field-grown	Cultivar main effects
Apache	8.0	3.8	5.9a ^z
Arapaho	5.8	2.9	4.4b
Root source main effects	6.9 A ^z	3.4 B	

^z Upper case letters represent a significant main-effect difference for root source; lower case letters represent a significant difference for cultivar ($P < 0.05$). The interaction of cultivar by root source was not significant in the data analysis.

Table 2. Number of adventitious shoots per root at two root lengths among three cultivars.

Cultivar	Root length		Cultivar main effects
	15 cm	30 cm	
Apache	2.5	5.8	4.2
Arapaho	4.6	5.3	5.0
Ouachita	3.1	7.2	5.2
Root length main effects	3.4 A ^z	6.1 B	

^zUpper case letters represent a significant difference among root lengths, ($P < 0.05$).

Fig. 1. Dates of adventitious shoot collection from 'Arapaho' and 'Apache' blackberry roots from bed- (BG) or field-grown (FG) sources.

