

THE COLLEGE OF NEW JERSEY

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Preface

First, the student-authors: The high quality of their work is quite apparent. But they should also be commended for their courage. The ancient Greeks disdained especially the people who shut their doors and did not go into the marketplace. They knew that those who decline to share their ideas and discoveries yield the marketplace to the zealots, the bigots, and the hoodlums. These student-authors have taken the risk of stepping beyond their doors into the public place, and we owe them our attention and thanks.

Second, the sponsoring professors: In a famous 1981 interview, culture-critic George Steiner explained his idea of a first-rate university: “that the students should come within smelling distance of those cancerous, passionate, possessed beings who eat ideas, who live thought.” The authors represented here have met those beings in the teachers and mentors who have encouraged these essays. These professors deserve our appreciation and thanks.

Third, the larger importance: When former Polish president and Nobel laureate Lech Walesa spoke at The College of New Jersey in November, he told his audience that intolerance and violence and suffering could not be overcome by bombs and bullets; they could only be defeated by intelligence and reason. He went on to challenge the students: “If I had your opportunities,” he said only half in jest, “I would have five Nobel prizes by now.”

These authors have begun their journey. They deserve our applause.

Lee Harrod
Coordinator, Honors Program
Professor of English

A Message from the Editor

The essays in this volume, ranging in subject matter from the work of Antiguan-born writer Jamaica Kincaid to the RNA of zebrafish, epitomize the spirit of intellectual collaboration among students and professors that distinguishes the pursuit and creation of knowledge at The College of New Jersey. Moreover, the essays in this volume proudly embody the mission of The College to cultivate the potential of each individual member to produce work of extraordinary merit for the enrichment and benefit of the world in which we live.

I wish to thank the many people who have contributed to Volume IV of the *TCNJ Journal of Student Scholarship* beginning with the students (and the professors who encouraged them), whose overwhelming response to the call for papers made the editor's final selections for publication both a joy and a challenge. I would also like to extend my gratitude to those faculty members who generously served as advisers and sponsors for each paper submitted. The administration of President R. Barbara Gitenstein and Provost Stephen R. Briggs graciously provided moral and financial support and release time, without which this volume would not have been possible. The staff of the Office of Academic Affairs, including Robert Cobb, Monica Frascella, and Nancy Freudenthal, has been kind, patient, and helpful with a variety of concerns and inquiries. My dealings with Associate Vice President Jesse Rosenblum and Anthony Marchetti of the Office of College Relations have also been a pleasure. For consultation on production matters, I thank Lisa Angeloni, dean of admissions. I offer special thanks to the members of the editorial board of the *Journal* for lending their time and expertise to the reviewing of papers in the midst of many other responsibilities. Paulette LaBar of the Department of English kindly and expertly assisted in the editing of the essays printed in this volume and periodically updated the Web site of the *Journal*. To Professor Lee Harrod, director of the Honors Program at TCNJ, I owe thanks for his contributing the preface to Volume IV. Finally, I would like to thank Associate Editor Romulo Ochoa for his wise and generous advice and assistance throughout this enterprise. As these acknowledgements indicate, this volume has been the product of a community-wide effort.

For information about the *Journal*, including submission procedures, format requirements, and application forms, please telephone the editor at: 609/771-2155 or contact him by e-mail at: dventuro@tcnj.edu; or, visit the *Journal* Web site at: <http://sjournal.intrasun.tcnj.edu>.

Now, I invite you to turn to the essays published in this volume, and to read and enjoy them.

Professor David Venturo
Editor

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The Father, the Fury, the Sound, the Son: An Examination of Patrilineage in *The Sound and the Fury*

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ABSTRACT

“The Father, the Fury, the Sound, the Son” is concerned with the relationships between father, grandfather, and son in William Faulkner’s *The Sound and the Fury*. In particular, it envisions the suicide of Quentin Compson, narrator of the “June Second, 1910,” portion of the novel, as a product of cultural and familial decline. Using a variety of sources, including the text itself, the essay examines two generations of patriarchs in the fictional Compson family, and their influence on Quentin, their descendant and heir. Within this genealogy is intertwined an examination of the development of Southern cultural values from the Civil War to the modern era.

INTRODUCTION

Faulkner often told interviewers that the genesis of *The Sound and the Fury* was the image of a little girl with muddied drawers, climbing up a pear tree to get a peek through the window at her grandmother’s funeral. Faulkner was enamored of the image of the undoing of this little girl’s innocence. Yet as much as *The Sound and the Fury* concerns this symbol, it is equally affected by the character of her brother, first-year Harvard student Quentin Compson, whose decision to commit suicide, as sole male descendant of the Compson family, upsets more than just the course of his life. Like his sister, Quentin is caught at a crossroads between innocence and experience; unlike her, however, he is unwilling to let experience take its

natural and inevitable course. It takes a father intimate with the Compsons’ checked history to wrest Quentin from his youthful illusions, and send him on his tragic and inexorable path.

Through the “June Second, 1910,” portion of the novel, Quentin’s narrative, we get a vision of the Compsons, particularly of its patriarchs, wrought with more intimacy than in perhaps any other section of the book. First, there is the grandfather, the honored Civil War general, whose real-life achievements could never realistically live up to his legend. Next is his son, Quentin’s father, the bitter old ex-lawyer who, surrounded by the signs of his failures and of his family’s slow decline, has made a life out of dispelling the fragmented hopes and dreams of those around him. And then, there is Quentin, the “bitter prophet and inflexible corruptless judge” of the family¹—the sensitive, intelligent young man who forfeits his life in coming to terms with the manifold questions of time, honor, and purity which haunt him.

Central to Quentin’s psychological conflict in *The Sound and the Fury* is his obsession with the bygone glories of his once-illustrious surname. The first Compson left Scotland for Kentucky in 1779, along with a son and a grandson. This son, Charles Stuart, once a member of a British army regiment under General Tarleton, was later forced to flee Kentucky after being identified as one of the more boisterous members of a confederation whose aim was to cede the Mississippi Valley

to Spain.² His son, Jason Lycurgus, quickly worked his way up to the top ranks at a Chickasaw Agency in Okatoba, eventually acquiring a parcel of land the size of a park, replete with slave quarters, stables, and pavilions. On this land was bred a governor, Quentin MacLachlan, as well as a Civil War general, Jason Lycurgus II (AC 206).

Throughout his monologue, Quentin wrestles with a patriarchal tradition that is alternately prideful and pitiful—but consistently rendered in the bronze cast of nostalgia. For example, the Compson children are ordered “not to touch it not even to talk loud in the room” of their house where their grandfather’s desk sits gathering dust.³ In order to come to terms with himself, Quentin must come to terms with the men who came before him—the father and the Civil War general—and somehow contend for himself a place within this stormy lineage.

His task is confounded largely by the influence of his most immediate ascendant: his father, Jason Lycurgus III, a broken and cynical old man, more at home with the verse of Catullus than with his own family. His looming personality corners Quentin into a monstrous predicament of conscience, from which death proves to be the only escape. Pivotal in perpetuating Quentin’s struggle is his father’s belief in the imminent extinction of the Compsons. Jason III, unlike Quentin, knows intimately the details of his father’s failed military career and is therefore considerably less enamored of the general. He is well apprised of his own failure in life, as well: a miserable wife, one child who is retarded, and one a prematurely-doomed casualty of promiscuous sex. As befits one in possession of such knowledge, Jason III has little hope for the future and little belief in the widespread cultural myth of the gallant Southern family—rich in historical heroism, and destined to insulate itself from the horrors of the modern world through its practice of old-fashioned family values. In a deceptively hopeful move, Jason Lycurgus III sells off the last of his family’s property so that

Quentin can move north to attend Harvard for a year—“your mother’s dream,” he tells his son, warmly (SF 65). To Quentin, however, Harvard reveals itself as little more than a place “where the best of thought... clings like dead ivy vines upon old dead brick” (SF 61).

Accordingly, Jason III constantly fails to establish any meaningful relationship with his son. Bereft of any sense of the honor of his family, he instead implores Quentin to adopt a masculine ideal as Compson protector and ruffian, in order to make up for what he cannot give him in pride. But this serves only to compound the feelings of failure in the mind of his passive, sensitive son. Although Mr. Compson may express some hope for Quentin’s future by sending him to Harvard, he is utterly inept in his attempts to communicate this hope to him. Jason III is no doubt a learned man, a lover of Greek, yet he has none of the aptitude or self-restraint requisite for the parent of a teenage son. His cynical, world-weary dictums—such as, “man is the sum of his misfortunes... One day you’d think misfortune would get tired, but then time is your misfortune” (SF 66)—always verbalized in a uniformly glum and defeated tone, help only further to burden his son with the hopelessness of his own point of view—and all this at a difficult age at which Quentin needs all the positive reinforcement he can get.

This is, in essence, what drives Quentin’s conflict and leads inevitably to his suicide: the discrepancy between the young man’s naturally romanticized view of the world and his father’s determination to rid him of his illusions before they can be naturally debunked. This confluence of the world-weary and the naïve brings Quentin to an emotional crossroads before he has reached the level of maturity needed to deal successfully with such a problem. In the end, the question remains whether he has died from his illusions, or from the pain of forsaking them.

Grandfather

The Sound and the Fury was published in 1929, a year which the critic C. Vann Woodward regards as the beginning of the

Southern Renaissance: an acme of the “literary arts—poetry, fiction and drama,”⁴ which included such luminaries as Faulkner, Lillian Smith, and Allen Tate. Although critics disagree over the reasons such a renaissance came into being—industrial prosperity, the reinvigorating effects of an influx of outsiders⁵—most point to a creative boom resulting from the delicate friction of the Southern past with the decidedly antagonistic pressures of the modern world: the alienation of the individual versus the alliance of the family, abstract thinking versus the concrete world. It was upon this ground that the mystic, tragic character of the South assumed the form of a prolonged holler against the threat of its own obliteration.

Central to this crisis of identity, from which a literary renaissance gained its impetus, and, indeed, central to all cultural transformations, is the existence of cultural myth: what Lewis Mumford has called the dream in which each culture lives.⁶ It is the idealized pillow on which a culture rests its head—to escape an impending change or doom, and to summon an image, invariably of the past, which is the embodiment of everything that is longed for and good about a culture. For Faulkner’s South, this was what Richard H. King termed “the Southern family romance.”⁷ King finds the Southern family romance “between the lines... of Southern literature and life.”⁸ He conceives of it as the collective fantasy of the South, an idealized conception of the honorable and generous Southern family. It was constituted, he says, of “the values, attitudes, and beliefs” that white Southerners held about their history, their people, and their way of life.⁹

The notion of the family unit arose from a uniquely Southern phenomenon in which several large and powerful families would come to dominate rural counties. Indeed, the inhabitants of such counties, both white and black, would often bear conspicuous physical resemblances to one another, while sharing a relatively small divergence of surnames. Southern society, King writes, was seen “as the family writ large.”¹⁰

Every member of the family held symbolic significance, from the eldest child to the mother to the slaves. But first and foremost in the family romance was the patriarch. He was the powerful and heroic presence in the family whose prestige was increased by his life before, and involvement in, the Civil War. He belonged to the age of generals and heroes. In the early decades of the 20th century, an interesting trend surfaced in the South’s adherence to this romantic legend. As the heroes of the war grew more removed in time, their myths grew grander by leaps and bounds. Grandsons began to revere their grandfathers even more than their fathers had. These grandsons became the men of Quentin Compson’s generation. Accordingly, compared to the gallantry of their grandfathers, their fathers seemed “rather unheroic and prosaic to their sons.”¹¹ King explains that the family romance thus allied grandson and grandfather in a relationship of awe and reverence, while pitting “son against father” in a rather more perfunctory way.¹²

Numerous episodes in Quentin’s monologue provide us with evidence of this particular phenomenon. Besides the episode recounting the symbolic passing down of his wristwatch, Jason Lycurgus II is first mentioned in the novel by Shreve, Quentin’s roommate at Harvard, which suggests that Quentin has already made him well aware of his grandfather’s legend (he does so extensively in *Absalom, Absalom!*). Discussing the Deacon’s frequent presence in military parades of every sort, Shreve comments, “Just look at what your grandpa did to that poor old nigger” (*SF* 52), an allusion to his participation in the Civil War.

Eric Sundquist has written of the division of present from past in the Southern experience as creating a “pressured situation in which the past becomes an ever more ghostly and gloriously imposing model to the... extent that... it cannot be recaptured, relived, or even clearly remembered.”¹³ In the final delirium before taking his life, Quentin identifies death with his grandfather, as the

“private and particular friend” (*SF* 111). In a hallucination, Quentin sees his grandfather in uniform, waiting on a hill for Colonel Sartoris to arrive, and “they were always talking and Grandfather was always right” (*SF* 111). Quentin’s conception of his grandfather attributes to him the same characteristics of mythic authority and awe traditionally associated with the figure of death.

Yet, it is illuminating to temper Quentin’s feelings toward his grandfather with actual evidence of his life as provided in Faulkner’s addendum to *The Sound and the Fury*, the “Appendix Compson 1699–1945.” There we learn that when Jason II was made a general in 1861, it was not for his heroism, nor apparently even by military order, but “by predetermined accord and agreement by the whole town and county” (AC 206), as befitting the son of a governor. With callous matter-of-factness, Faulkner writes of the prophetic powers of the townspeople in guessing that “the old governor was the last Compson who would not fail at everything he touched save longevity or suicide” (AC 206). Callousness aside, however, Faulkner is right. The Brigadier Jason Lycurgus II failed at Shiloh in 1862, and again at Reseca in 1864. In 1866, he mortgaged the first piece of the Compson Domain to a New England businessman, and for the next forty years he slowly mortgaged the remainder of the estate, until all that was left was the old Compson place itself. Jason II died in an army cot in the hunting and fishing camp where he spent most of his last days (AC 206).

What, then, are we to make of the illustrious Compson scion but a terrific failure? For Southerners attempting to carve out a niche for themselves in the increasingly modernized world, the failure even to evidence a heroic past must have seemed a damning example of their increasing irrelevance. King writes of the Southern family romance, to which Quentin so desperately clings, “Decline was an integral part.”¹⁴ Whether or not Quentin, in his obsessive search for the lost honor of the Compson family, is aware of his grandfather’s fallibility is unknown.

What is clear, however, is the cynical education Quentin receives from his father, Jason III, characterized by the latter man’s lazy resignation toward “what should have been a princely line,” that instead became a “princely line decayed.”¹⁵ The relationship between father and son ultimately leaves Quentin wrestling with pervasive feelings of inadequacy, failure, and guilt—as brother to Caddy, and as family heir and son.

Father

More than any other, Jason III’s voice appears throughout Quentin’s long monologue of “June Second, 1910,” usually prefaced with the words, “Father said.” When Quentin muses on the ideas that have dominated his imagination—in particular, the inflexibility of time and the notion of the Compsons’ honor “supported by the minute fragile membrane of [Caddy’s] maidenhead” (AC 207)—his father’s manifold comments and maxims spring readily into his mind.

Quentin engages in an extended dialogue with his father throughout his section which brings to light, among other things, the cynical words Jason III imparted to his son on his high school graduation and his world-weary attitude toward Caddy’s virginity.

Most pronounced, however, are Quentin’s impulsive masculine reactions to perceived threats, reactions that often stand in contrast to his sensitive temperament—and which no doubt have been ingrained in him by his father. In his confrontation with Herbert Head before the family mantel (the very heart of the Compson family), Quentin dares Head to see how long he’d last in a fight against him. He is quick to decry Head for his alleged participation in a cheating scandal at Harvard and fires invectives at him as caustic as “To hell with your money” (*SF* 70). It may surprise the reader to find out that Head is at least ten years Quentin’s senior. Similarly, in a meeting with another of his sister’s lovers, Quentin seems to be driven by a preordained sequence of actions: “he ought to drive Caddy’s seducer out of town, and if the seducer refuses to go, he ought to shoot him.”¹⁶

But whatever masculine attributes Quentin fancies himself in possession of, his actions fail to demonstrate them. In his encounter with Dalton Ames on the bridge near his home, Quentin is absurdly incapable of being intimidating. When he arrives, Ames is breaking bark into pieces, throwing them over the edge and floating them down the river. "I came to tell you to leave town" (*SF* 101) he announces, while Ames remains focused on the bark, and inquires about Caddy. Quentin threatens to kill him if he stays past sundown. But as soon as Ames asks him his age, Quentin's hands begin to shake. He strikes at him, but before he can connect, Ames has got both of his arms by the wrists. Ames goes so far as to offer Quentin his gun, but Quentin refuses and again tries to hit him to no avail. "Do you feel alright?" (*SF* 102) Ames asks him. Fine, Quentin answers and leans against the railing of the bridge until he leaves. "I had just passed out like a girl," he laments later, "but even that didn't matter anymore" (*SF* 103). Quentin possesses neither the ability nor the temperament to live up to his masculine fantasies—a condition which is not confined to his encounter with Ames. He fails in his confrontation with Gerald Bland, in preventing Caddy from marrying Herbert Head, and even in making the slightest headway toward influencing his sister.

Doreen Fowler has made an important association between Quentin's feelings of masculine inadequacy and Freud's idea of castration anxiety.¹⁷ When Quentin first approaches the three boys fishing off a bridge near Cambridge, he is struck by the memory of a conversation he had back home with one of the Compsons' Negro slaves: "Versh told me about a man who mutilated himself. He went into the woods and did it with a razor, sitting in a ditch" (*SF* 73). The act described by Versh is clearly auto-castration, but Quentin sees no solace in ridding himself of the organ burdening him with the expectations of his sex. "It's not not having them," he says, "It's never to have had them then I could say O That That's

Chinese I don't know Chinese" (*SF* 73). Such an act, for Quentin, would not "obliterate the memory of having had a sex," or turn "sex [into] an alien language," as Andre Bleikasten suggests.¹⁸ Quentin wants never to have had a sex, to be able to approach it as if it were a foreign tongue. The impossibility of such a transformation leaves him saddled with the longing to be as "manly" as Head or Bland. Fowler cites Quentin's preoccupation with phallic symbols—the clock tower, the smokestacks, Ames's gun—during his walk through Boston as conclusive evidence of this.¹⁹

Yet despite Quentin's illusions of his father as a man whose sense of conduct and honor are worth emulating, Jason III appears in his reminiscences "not as father or friend but as a voice which can juggle words and ideas while insisting on their emptiness,"²⁰ Olga W. Vickery has observed. Quentin recalls him at his high school graduation, presenting Quentin with the watch his grandfather once wore, the definitive heirloom of ancestral pride: "no battle is ever won he said. They are not even fought... victory is an illusion of philosophers and fools" (*SF* 48). Coming from the heir of a Civil War general, on the occasion of his son's graduation, this is a dubious statement, indeed. Mr. Compson seems to have given up caring long ago. Bred to become a lawyer, Jason III kept an office upstairs in the Compson mansion, where the only activity seems to have been the fading away of the old, gallant surnames emblazoned on the documents that filled the filing cabinets. He spends his days now complaining of his wife's brother, Uncle Maury, and "with a decanter of whiskey and a litter of dogeared Horaces and Livys and Catulluses, composing caustic and satiric eulogies on both his dead and his living fellowtownsmen" (*AC* 207). Quentin recalls his sister saying that their father will be dead in a year if he does not stop drinking.

Certain episodes recounted in "June Second, 1910," are of particular import in illustrating the friction between Quentin's innate romanticism and his father's unyielding penchant for

putting these ideas to rest. First, there is the concept of virginity as a symbol of purity and honor, with which Quentin is obsessed. He believes that in order to be considered a man, he must do away with his virginity, whereas Caddy must retain hers if she is to be considered a respectable woman (*SF* 93). Throughout his monologue, Quentin has considerable difficulty coming to terms with Caddy's having given up her virginity voluntarily. He repeatedly wonders out loud to her if it was not because the man proved to be stronger than she was, imagining her in a situation that could explain away her actions (*SF* 95). He enters into hostile, yet abortive, relationships with all of her lovers, trying in vain to hurt them or drive them away, according to his sense of their jeopardizing the family honor. Quentin wrestles with his own virginity, as well. While in the Blands' car, he wonders, "if it was that simple to do it wouldn't be anything and if it wasn't anything, what was I" (*SF* 93).

Quentin's father, however, is chillingly unsympathetic toward the romantic notions harbored by his teenaged son. Jason III has long ago given up on preserving his daughter's virginity, resigning himself to the idea that virginity is a singularly male invention: "Because it means less to women, Father said" (*SF* 50). When Quentin asks movingly, "Why couldn't it have been me and not her who is unvirgin," his father says flatly that "nothing is even worth the changing of it" (*SF* 50). As Quentin confesses himself further to his father, Mr. Compson tells him that virginity is unnatural, a relatively clear-headed statement which turns dismissive when he compounds it with the observation that "all tragedy is second-hand" (*SF* 74).

The distorted relationship between father and son becomes more evident with Quentin's desire to have an incestuous relationship with Caddy. His fantasy is for them to become isolated from the rest of the world, then "merge like a flame swirling up for an instant then blown cleanly out along the cool eternal dark" (*SF* 111). He wants brother and sister to have

never existed, to remain in a hell together, eternally protected from suitors and sex by a purifying wall of flame. Quentin's desire is not sexual, but emotional and metaphysical, the very apotheosis of his reverence for Southern history and the family name. Faced with the corruptive influences of modernity, wantonness, and extinction, Quentin seeks to shelter his romanticized conception of Caddy, the Compsons, and the South through the abstract notion of incest. Yet when pressed, he does not commit the act, and his father immediately sees through to this: "I think you are too serious to give me any cause for alarm," he says (*SF* 112). It seems that Mr. Compson knows what Quentin has invested on the shoulders of Caddy—the very preservation of the Compson name and of the Southern historical myth, coupled with a natural brotherly sense of overprotection—yet, he can say nothing more comforting than that. Instead, he recommends that Quentin save up to go to Maine for a month, cynically adding that "watching pennies has healed more scars than Jesus" (*SF* 113).

Coupled with his desire to isolate his sister from the "loud world" (*SF* 112), Quentin is deeply pensive about the concept of time, as befits a young man living in an age which he believes to be nothing more than a poor copy of the past. In particular, Quentin wants his life, in the face of what he perceives as his family's glorious past and his failure to live up to it, somehow to slide beneath the radar, to make it seem as if he had never existed. He is soothed by the Latin, "*Non fui. Sum. Fui. Non sum*" (I was not. I am. I was. I am not.), words that describe states of being, but that cancel each other out when phrased in this way (*SF* 110).

Quentin seeks earnestly to escape his father's conception of time, as made manifest in an imaginary conversation between father and son that Quentin concocts in his head: "was the saddest word of all there is nothing else in the world its not despair until time its not even time until it was" (*SF* 113). Mr. Compson believes that all present and future time serves the past; that it's not time unless "it was."²¹ The

past qualifies the present, the future, all life, and all emotions (“despair”). Faced with the recognition of his inadequacy as the male heir, and of his inability to restore honor to the Compsons, Quentin seeks refuge in “temporary,” a word that is littered throughout the closing pages of his monologue: “and I temporary it will be better for me for all of us,” he says (*SF* 113). “Temporary” is a word that insists on revision. Quentin ultimately seeks the revision of his role as scion in the tragic family drama played out in his father’s defeatist words. Under the weight of so many grand abstractions and illusions, it is only as a shadow, a fleeting ghost, that Quentin can suffer to exist.

Son

Andre Bleikasten has said that Quentin’s crisis in *The Sound and the Fury* is not simply that of a “neurotic young man,” but of a “tragedy of inheritance.”²² In addition to the pressures of dealing with his own teenage problems, Quentin is doomed to contend with the tragedies inherent in the waning of two generations of Compson patriarchs. To support his assertion, Bleikasten cites remarks Faulkner made at the University of Virginia:

*The action as portrayed by Quentin was transmitted to him through his father. There was a basic failure before that. The grandfather had been a failed brigadier twice in the Civil War. It was the—the basic failure inherited through his father, or beyond his father.*²³

As a young man burdened with the desire to find in this tradition an ennobling and glorious past, Quentin can be readily seen as a “poor player,” trying on different historical roles as they suit his conception of Southern nobility and redemption.²⁴ At one point, Quentin innocently patronizes a black man on the street from the window of his train cabin en route to Harvard; at another, he tries violently to drive Caddy’s fiancé away. In the words of Bleikasten, one moment, he is the “romantic hero,” the next, a “southern gentlemen.”²⁵

However, as is inevitable after listening to his father’s sundry stories of the Compsons’

decline, Quentin ultimately can find no suitable male model to imitate. His greatest desire—to place himself in a role commensurate with his mythical conception of the Compsons and the great Southern tradition—ultimately leaves him “gliding from substitute to substitute down to the very last—death.”²⁶ Yet, for a fleeting moment toward the end of his discourse, Quentin seems finally to have found a fitting part to play within this miserable decline.

In a letter dedicated to clearing up his publisher’s confusion over the printing of the Appendix in a new edition of *The Sound and the Fury*, Faulkner indicated that the title should not read “The Compsons,” but simply:

COMPSON

1699-1945

“because it’s really an obituary, not a segregation” (AC 203).

It is tempting to think of how Quentin would have reacted to the news. With horror, or with relief? Or with acquiescence? Could he have come to embrace, along with his father and grandfather, the idea that the Compsons were finished? One of his memories, near the very end of his life, may give us a clue. Quentin recalls how Uncle Maury was considering getting a job one day when his father interjected and said, “if he Father could support five or six niggers that did nothing at all... he certainly could board and lodge Uncle Maury now and then” (*SF* 111). He would even lend him money, he joked, because Uncle Maury was constantly reminding him of the superiority of his own lineage. In her feeble fury, Mrs. Compson “would cry and say that Father believed his people were better than hers” (*SF* 111), and that he was ridiculing Uncle Maury to teach the children the same thing.

However, Quentin sees something different. He sees his father teaching them that “all men are just accumulations dolls stuffed with sawdust swept up from the trash heaps where all previous dolls had been thrown away” (*SF* 111). What is striking is that his father doesn’t say this; Quentin does. In his

own quiet, melancholy way, Quentin has found himself—his final model—among the stuffed sawdust dolls waiting to be swept away. A few moments later, packing up his things, Quentin seems not to be in the throes of a violent conflict, but—like his father and his grandfather before him—in the arms of a resigned peace.

NOTES

- ¹Olga W. Vickery, "The Sound and the Fury: A Study in Perspective," *The Sound and the Fury* (1959; New York: W. W. Norton, 1994) 284.
- ²William Faulkner, "Appendix Compson 1699–1945," *The Sound and the Fury* (1946; New York: W. W. Norton, 1994) 205. (Hereafter cited as AC).
- ³William Faulkner, *The Sound and the Fury* (1929; New York: W. W. Norton, 1994) 111. (Hereafter cited as SF).
- ⁴Richard H. King, "A Southern Renaissance," *The Sound and the Fury* (1980; New York: W. W. Norton, 1994) 246.
- ⁵King 247.
- ⁶King 249.
- ⁷King 249.
- ⁸King 249.
- ⁹King 249.
- ¹⁰King 250.
- ¹¹King 252.
- ¹²King 252.
- ¹³Eric J. Sundquist, *Faulkner: The House Divided* (Baltimore: The Johns Hopkins U. P., 1983) 7.
- ¹⁴King 252.
- ¹⁵J. Blotner and F. L. Gwynn, eds., *Faulkner in the University: Class Conferences at the University of Virginia, 1957–1958* (New York: Random House, 1965) 235.
- ¹⁶Cleanth Brooks, "Man, Time, and Eternity," *The Sound and the Fury* (1963; New York: W. W. Norton, 1994) 293.
- ¹⁷Doreen Fowler, "'Little Sister Death': *The Sound and the Fury* and the Denied Unconscious," *Faulkner and Psychology* (Jackson: U. P. of Mississippi, 1994) 8.
- ¹⁸Andre Bleikasten, *The Ink of Melancholy* (Bloomington: Indiana U. P., 1990) 76–77.
- ¹⁹Fowler 8.
- ²⁰Vickery 284.
- ²¹Richard Godden, "Quentin Compson: Tyrrhenian Vase or Crucible of Race?" *New Essays on The Sound and the Fury* (Cambridge: Cambridge U. P., 1993) 112.
- ²²Bleikasten 84.
- ²³Bleikasten 84.
- ²⁴Bleikasten 74.
- ²⁵Bleikasten 74.
- ²⁶Bleikasten 71.

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The Impact of Colonialism in Jamaica Kincaid's *At the Bottom of the River*, *Annie John*, *Lucy*, *A Small Place*, *The Autobiography of My Mother*, and *My Brother*

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ABSTRACT

Jamaica Kincaid, an Antiguan writer, explores the past of her colonized country in each of her works. It is in these books that she maps the struggle for political power between the English colonizers and the colonized onto familial interactions, particularly the mother-daughter relationship. Inevitably, love and hate become intertwined in both political and personal interactions. In these works, Kincaid creates fictional characters who, like herself, fight for personal autonomy and an understanding of humanity. These characters serve a dual purpose. Not only do they draw the foreigner into the everyday struggles of the Antiguan, but they also enable Kincaid to explore her own feelings of anger and hatred toward the English and for her mother whose dominant personality, she claims, has controlled her life. She shows us how colonizers are responsible for her society's questionable values, derision of the weak, and marginalization of females, as well as her own mother's coldness. It is only once Kincaid gives voice to the darker societal truths and her own personal emotions that she can begin to move on and accept love into her life.

INTRODUCTION

In *At the Bottom of the River*, *Annie John*, *Lucy*, *A Small Place*, *The Autobiography of My Mother*, and *My Brother*, Kincaid's reaction to the colonial situation in Antigua, her homeland, is addressed. In Kincaid's own mind, the tyranny of her mother often symbolizes the domination of the English, Antigua's colonizers.

Consequently, in each of Kincaid's books, the domination that characterizes the association between colonizer and colonized is portrayed through various interpersonal relationships, particularly the mother-daughter relationship. Through the voice of her protagonists, Kincaid explains that love and admiration of the English have caused many Antiguans either to accept their role in the colonial situation or imitate the behavior of their conquerors. In each of her works, Kincaid gives this explanation with anger—anger that holds her apart not only from oppression, but also from love. Each of her works chronicles Kincaid's internal journey from rebellion and hatred to acceptance and love.

Kincaid begins chronicling her reaction to colonial and maternal subjugation in *At the Bottom of the River*, a grouping of lyrical pieces stemming from the subconscious, and *Annie John*, a bildungsroman. Both works focus on growing older and the mother-daughter relationship. The two books are so similar that critic Wendy Dutton has described *Annie John* as the “decoder” for *At the Bottom of the River* (406). Of *Annie John*, and consequently most likely *At the Bottom of the River*, Kincaid unwillingly admits, “The feelings in it are autobiographical. I didn't want to say it was autobiographical because I felt that that would be admitting something about myself, but it is” (Cudjoe 1167). The influence of England on its colony Antigua, as well as the autobiographical nature of the story, is evident throughout both works.

Unsurprisingly, the British education of Annie John and the girl in *At the Bottom of the River* is very similar to the author's. Kincaid notes that she herself had, "sort of a middle-class English upbringing... the best table manners you ever saw" (interview 1166). Both protagonists have British educations both inside and outside school. Annie attends a school where she is taught the British version of Antiguan history, complete with the story of how Europeans "discovered" Antigua, while the narrator in *At the Bottom of the River* attends church and reads a poem in school about chimney sweeps. Proper behavior, particularly proper sexual behavior, was an important part of English society as well. As James Walvin depicts Victorian society, "The concept of the 'fallen woman' was... a fate imposed upon thousands of women by a society unwilling to tolerate... free or 'errant' sexual ways among women" (125-6). Walvin also explains the ostracism and lack of medical care such women could expect. Annie's mother, as well as the mother in "Girl" from *At the Bottom of the River*, is particularly concerned about her daughter becoming "a slut." She calls Annie this cruel name after seeing her speak with a few boys in the street, and completes Annie's education on Victorian values by having her take lessons from a woman who teaches European manners. Similarly, "Girl," the stream-of-consciousness piece that begins *At the Bottom of the River*, is composed of directions issued by an unnamed mother. Amidst explicit descriptions of how to perform various domestic tasks is the statement, repeated in a variety of ways, warning the girl against becoming promiscuous. In one instance, the mother tells her, "try to walk like a lady and not like the slut you are so bent on becoming" (3).

In each novel, the relationship between mother and daughter serves as a symbol of colonialism, a situation that constantly frames everyday experience, and often encourages the colonized to adopt the characteristics of the colonizers. In *Annie John*, Annie's mother is a powerful force in her life. Annie realizes that

her mother will always affect her life, whether or not she is actually in her mother's presence. As she notes, "I could not be sure whether for the rest of my life I would be able to tell when it was really my mother and when it was really her shadow standing between me and the rest of the world" (*Annie John* 107).

Annie's insight parallels the colonial situation. Just as the shadow of Annie's mother affects Annie's perceptions and behavior, so England affects the actions and beliefs of Antiguan people. Shadows of England are present in the language, religion, and values of the Antiguan people. As Annie sets out to leave Antigua, her mother tells her, "It doesn't matter what you do or where you go, I'll always be your mother and this will always be your home" (147). More than anything else, this sentence signals that Annie, as well as Kincaid herself, cannot avoid dealing with a past influenced by colonialism. This message foreshadows the inability of characters in subsequent books to escape it as well. Similarly, the narrator of "My Mother" from *At the Bottom of the River* symbolically notes the pervasive power of the colonizer, "I had grown big, but my mother was bigger and that would always be so" (56), while later, in "Wingless," the narrator acknowledges her future as a woman raised in a colony when she observes, "I shall grow up to... impose on large numbers of people my will, and also, for my own amusement, great pain" (22).

It is Annie's desire to break away from her mother and her mother's values that underscores her friendships. Throughout *Annie John*, Kincaid chronicles Annie's childhood through friendships—first with Gwen and her classmates, and then with The Red Girl. She hopes to keep Gwen a secret from her mother, but her mother approves of the friendship, which prompts Annie to move on. She later befriends her neighbor The Red Girl, but that friendship ends after her mother becomes suspicious about her whereabouts. As the novel closes with Annie's departure from the island, it becomes apparent how much her anger at her mother and her strictness has damaged her

friendships. Of her old friends, Annie says, "I could have left without saying any good-byes to them and I wouldn't have missed it" (137). She is angry not just with the people who inhabit her world, but also Antigua itself. Looking around her island home for the last time, Annie observes, "my heart swelled with a great gladness as the words 'I shall never see this again' spilled out inside me" (145). The characteristic anger that marks Annie's inability to connect with others or come to terms with her homeland is a theme that emerges in many of Kincaid's works.

While Kincaid's *Lucy* is not a sequel to *Annie John*, it is about a girl who has left Antigua and it does reflect the same themes as *Annie John*. *Lucy* is the story of the title character, a girl who, like Kincaid herself, is an Antiguan who travels to the United States to care for other people's children while studying nursing (Cudjoe 1164). Although Lucy enjoys spending time with the children, she is filled with anger toward the English, and, as the United States is a country colonized by the English and their descendants, her anger extends to all North Americans. Throughout the novel, Lucy strives to reconcile her negative, preconceived notions of colonists with the individuals she finds before her—Mariah and Lewis, her rich, kind employers.

In *Lucy*, the protagonist is far from the physical presence of her mother, and from the place of her colonial upbringing. However, like Annie, she cannot escape her childhood or her roots. Lucy's mother casts a long, powerful shadow. Her difficulty connecting with others is partly attributed to her relationship with her mother. Lucy's mother, a metaphor for Great Britain, is intent on giving Lucy a proper English upbringing. Lucy notes, "my whole upbringing had been devoted to preventing me from becoming a slut" (127). While this aspect of her upbringing was a bone of contention, the central reason that Lucy has come to despise her mother is that her mother proudly planned the higher education of her sons while completely ignoring

Lucy's. The value her mother places on the education of her sons is indicative of the patriarchal society of the colonizers. Just as Kincaid's mother embraces the patriarchal religion and government of the British and rejects the matriarchal society of her African roots, so she accepts the importance placed on the education of boys as future heads of a patriarchal society.

Lucy is intent on remaining her own person and avoiding the influence of the conquerors of her island that she so hates. She does not want to become like her employer or her mother, or to adopt the English ways of which her mother is so fond. Lucy explains, "I felt that I would rather be dead than become just an echo of someone" (36). However, her insistence on standing apart from anyone related in any way to the colonizers (and those Antiguan who insist on following their ways) comes at the expense of having personal connections and love in her life. Critic Thulani Davis concurs: "It is as if in choosing to leave home to loosen her connection to people, the young woman finds she can no longer make any connections at all" (11).

Lucy's distance from others appears deliberate at first. Toward the beginning of the novel she explains, "I didn't want to love one more thing in my life, didn't want one more thing that could make my heart break into a million pieces at my feet" (23). She does not feel love for her boyfriends or her friends. Of Hugh, her first boyfriend in America, she observes, "To latch onto this boy... was... certainly not for me" (71). Later in the novel, Lucy uncaringly observes that her new boyfriend and roommate are getting together and notes, "I only hoped they would not get angry and disrupt my life when they realized I did not care" (163).

The one relationship in Lucy's life that forces her to change is her association with her employer, Mariah. Her involvement with Mariah and her family in the beginning of the novel is, for her, typically distant. Shortly after arriving, the family she is living with notices

her aloofness. Lucy explains, "They said I seemed not to be a part of things... as if they weren't like family to me... as if I were just passing through" (13). Not understanding why their friendliness is being rebuffed, they begin to refer to Lucy as "the Visitor" (13). Lucy's attitude results from her equating Americans with the English. After all, Americans conquered the native peoples of the land they now occupy and imported slaves to do their work, just as the English did in Antigua. In fact, historically, many Americans were English. Lucy is unable to focus on anything but her anger and the past, and she wants her employers to know that she is not like them. When Mariah eagerly shows her a daffodil for the first time, Lucy angrily relays the story of how she was forced, at the age of ten, to memorize a poem about the daffodil, a flower known only to her conquerors. She gives this as an example of her people's fixation on all things English, and the desire of the English to make Antiguans think and act like them. She feels that Mariah is trying to do the same, and she tells the story to show Mariah how different they truly are. After a few moments, she realizes the difference between her depiction of the conquerors and Mariah. She notes, "It wasn't her fault. It wasn't my fault. But nothing could change the fact that where she saw beautiful flowers I saw sorrow and bitterness" (30).

While Lucy can recognize that anger toward Mariah as an individual is misplaced, she is unable to let go of her harsh perspective and unyielding anger. She cannot understand why Mariah does not act according to her preconceived depiction of a heartless conqueror. When Mariah proudly tells Lucy that she is part Indian, Lucy can only wonder, "How do you get to be the sort of victor who can claim to be the vanquished also?" (41).

It is only once Mariah's life is no longer perceived to be perfect that Lucy can view her as a woman rather than a symbol and enjoy a relationship with Mariah that is not impeded by the roles of conqueror and conquered. As a happy woman whose every wish has been fulfilled, Mariah's is the life of the conqueror. As

a woman whose husband has cheated on her and led her to divorce him, Mariah has no place in Lucy's black and white understanding of the world—a world in which the conquered are the only ones who feel pain.

Ironically, Lucy comes to accept and care for Mariah by thinking of Mariah in the context of other women back home whose husbands cheated on them. However, while she can understand the personal connections between others, she insists on seeing herself as different and alone. When Lucy tells Mariah that she will never forgive her mother for valuing her brother's education over her own, Mariah gives her a book on women's liberation. When Lucy admits that she never thought her parents would ever die, Mariah says most people feel this way. In response, Lucy notes, "I had to suppress the annoyance I felt at her for once again telling me about everybody when I told her something about myself" (139). Even at the end of the novel, Lucy has difficulty connecting with others, let alone loving them. The novel closes with a poignant and painful entry that Lucy has scrawled in her journal. She writes, "I wish I could love someone so much I could die from it" (164). As tears of shame roll down her face, Lucy begins to recognize herself for whom she has become, and the reader is left hoping that love might eventually take the place of her anger and hate.

The Autobiography of My Mother addresses colonialism through both an extended metaphor and concrete images. Written from the point of view of the protagonist Xuela, the book opens with the metaphor that permeates the book from beginning to end. Xuela notes, "My mother died at the moment I was born, and so for my whole life there was nothing between myself and eternity" (*Auto.* 3). At first, this novel seems distinctly different from Kincaid's other novels that focus in varying degrees on the character of the mother. However, each of Kincaid's previous novels followed the progression of her own life. Her childhood took place under the rule of England and her mother (as in *River* and

Annie), while her young adulthood took place in the United States (as in *Lucy*). By the time Kincaid wrote *The Autobiography of My Mother* in 1996, Antigua had been autonomous for 15 years. Just as Antiguan no longer had another country as an intermediary between themselves and the rest of the world (and many young Antiguan of today were born never having experienced the rule of England), so Xuela is born without anyone to protect or control her. Initially, she believes that she is free to observe her homeland without love or hatred.

Although the physical presence of her mother and England is absent, they both still wield power over Xuela's life. Throughout the novel, the image of Xuela's mother hovers on the edge of her subconscious, while the more concrete evidence of the island's past appears again and again in the form of language, religion, and behavior. Xuela's first words are in English (*Auto.* 7), her most memorable punishment is for breaking a plate with the word *heaven* on it (a symbol of the importance of Christianity, the conqueror's religion) (9), and the school she attends mandates the wearing of English school uniforms (11), and the study of the history of the British Empire (14). Heartbroken and angry at the extent to which colonialism has influenced her life, Xuela notes, "everything in my life, good or bad, to which I am inextricably bound is a source of pain" (*Auto.* 7). Clearly, Kincaid realizes that the physical absence of the domination of colonizers or a mother would not alter Xuela's circumstances or emotions.

The behavior of Antiguan reveals the most insidious effects of colonialism. Xuela's teacher, a woman of African descent, was trained by Methodist missionaries and learned to hate herself. As Xuela describes the classroom climate: "She did not love us; we did not love her; we did not love one another, not then, not ever" (*Auto.* 15). Describing a fellow classmate, Xuela notes, "any instinct to protect the weak had been destroyed in him" (*Auto.* 20). She describes her society as one in which the winners are

esteemed, and the losers are reviled, even among themselves. Xuela, like Kincaid herself, had a grandmother who was a Carib Indian. Since the Caribs fared worse than the Africans (the Caribs became extinct), Xuela is looked down upon as weak by her classmates (16).

The depiction of Xuela's school explains how Antiguan children begin to assume the characteristics of their conquerors, while Xuela's description of her father reveals the end product of the Antiguan educational system. Her father held a high political office in Antigua, one in which he was given the responsibility of helping his people. However, as Xuela notes, "My father was a thief, he was a jailer, he spoke falsehoods, he took advantage of the weak" (*Auto.* 54). By means of such descriptions, Xuela notes that her father had become "an incredible mimic" (*Auto.* 139) of the English. She observes that, like the conquerors of his own country, her father cared only to acquire more material objects (107), and had "treacherously" joined the island's church (139). Her father is not alone in his desire to be like the English. Those men who were not in a position to conquer through the wielding of government power and material acquisition, like Xuela's father, adopt the characteristics of the English in another way. As Xuela notes, their lives are "reduced to a list of names that are not countries, and the number of times [they] brought the monthly flow of blood to a halt" (175-6). Their accomplishments are measured by the number of women they have seduced, and their successes are proven by the number of illegitimate children they have sired.

Xuela holds herself apart from the obsession her countrymen have for conquering. She is unwilling to be conquered either by admiration of the English and their ways, or by love from them. She, like her father, is partially shaped by hatred. However, her hatred is for the English. Both she and her father have had their emotions twisted and turned off by colonialism, forced into a loneliness in

which they cannot love the people to whom they are inextricably bound. Xuela marries Philip, an Englishman whose love she refuses to return. She notes, "I was capable of... making his suffering real to myself, but I would not allow myself to do it" (219). Although Philip bears no relation to the conquerors except through blood, Xuela cannot forgive him. Instead, she clutches onto the one form of power she has—the power over her husband's emotions. Love, she believes, would be a weakness. As Xuela maintains, "Love would have defeated me. Love would always defeat me" (29). Xuela, like the character Lucy, subverts the power of her nation's conquerors by conquering any inclination she may have to love.

In *A Small Place*, Jamaica Kincaid takes a break from fiction to detail in an extended essay the state of her island following its independence. She describes her people's feelings toward England, the government's corruption, and the low status of Antigua in the world community. Mainly, she expresses her anger at the transformation of her home into a spot for tourists, and casts about, looking for someone on whom to focus that anger.

Kincaid's essay is written to the nameless tourist who, however innocently, is unwittingly caught between the colonizer and the colonized. She contrasts the idyllic place they want to see with the reality: a place full of people still strongly affected by its colonial past. Kincaid notes that just as during her youth, English traditions still prevail. Antiguans speak English, and, paradoxically enough, thank a British God for their independence from Great Britain (9). She describes the education received by many Antiguan young adults at the Hotel Training School, a respected institution, as an education "that teaches Antiguans how to be good servants, how to be a good nobody, which is what a servant is" (55). Inadvertently, Antiguans embrace the life of servitude familiar to their ancestors, and, like those slaves, the Antiguans of today will serve rich people of primarily European descent.

Kincaid writes of a shared guilt over the deteriorated state of her island. She lingers over descriptions of the corruption in her island's government, but notes that the English have brought Antigua to where it is today. Kincaid details corruption within the current government, citing excessive government car loans for government-owned dealerships (7), prostitution houses run by government officials (59), and the indulgence of a known drug smuggler (11). However, she addresses the English tourist with the question, "Have you ever wondered why it is that all we seem to have learned from you is how to corrupt our societies and how to be tyrants? You have to accept that this is mostly your fault" (35). While it is true that the Antiguan people would not be where they are or who they are today if the English had not engaged in the horrible trade of human beings, the culpability of the descendants of the slave traders remains for Kincaid an unsettled question. It is this ambiguity that is at the crux of both Kincaid's essay and *Lucy*. In *Lucy*, the title character has difficulty thinking of her employers as anything other than conquerors. In this piece, Kincaid's anger is directed at the bewildered, ignorant tourist. However, at the end of this essay and throughout *My Brother*, a later novel, Kincaid begins to move past her anger. On her final page, Kincaid explains, directly and eloquently, the state of the colonized and the colonizer today. These are the roles with which Annie John, Lucy, Xuela, and particularly Kincaid herself have wrestled. She notes what all her guilt and anger add up to:

once you cease to be a master, once you throw off your master's yoke, you are no longer human rubbish, you are just a human being, and all the things that adds up to. So, too, with the slaves. Once they are no longer slaves, once they are free, they are no longer noble and exalted; they are just human beings (81).

Kincaid maintains that while forgiveness is not in order, a focus on the present and future is necessary in order to move forward.

In *My Brother*, an autobiographical novel focusing on Kincaid's brother's slow death

from AIDS, Kincaid is finally able to move forward. While this introspective book relies on the metaphor of Kincaid's previous novels that portrays the mother as a symbol of colonialism, she finally manages to move beyond her hatred for her mother and anyone remotely connected with colonialism, focus on the present, and establish loving relationships in her life.

The root of Kincaid's change of heart is her own altered circumstances. She is no longer a little girl trapped in her island home, or a young adult unsure of what her future will hold. She is a firmly established writer with a home and family in Vermont. Kincaid is able to note the ways in which she is similar to the conquerors of her island now that she is American and well-off, but she does not feel self-hatred or despair. Indeed, she notes them only with equanimity, revealing the positive and negative results of her altered station in life. She sadly asks her mother about the destruction of a tree, "In my now privileged American way (my voice full of pity at the thought of any kind of destruction, as long as my great desires do not go unmet in any way)" (*Brother* 125). However, her privileged life also has enabled her to afford AZT to prolong her brother's life.

Kincaid has realized the wish of Lucy—she truly has come to love someone—someone whom she may have once associated with the conquering class: her husband. She describes her love for her husband as, "a love I had not expected or ever really knew existed; I would rather bad things or unpleasant things happen to me. I can't bear to see him suffer" (*Brother* 100). In this book, she completes the circle of love and acceptance through her feelings toward her brother. She begins the memoir by remarking, "I was—absorbed with the well-being of my children, absorbed with the well-being of my husband, absorbed with the well-being of myself" (*Brother* 7). The news of her brother's illness shakes her out of her everyday routine, forcing her to consider her feelings for her brother and her island home. She is

so overwhelmed that she decides to visit the brother she has not seen since early childhood. She comes to recognize her feelings for him, saying, "I wanted to thank him for making me realize I loved him" (21).

Kincaid also explores and analyzes her relationship with her mother, a kinship she has portrayed with anger and dislike through characters such as Annie and Lucy. As an adult, she is capable of distinguishing her powerful mother from the oppressive colonizers. In an interview, she notes, "My mother used to be an anglophile, but I realize now that it was just a phase of my mother's life" (Cudjoe 1165). In *My Brother*, Kincaid addresses her ambivalent feelings toward the people of her homeland. She explains, "I love the people I am from and I do not love the people I am from" (149). After making this appraisal of the feelings that led her to write the previous five emotionally-charged books, she expresses a contentment with her future: "One day something may happen and I will understand that all the things I now feel ... are in fact love; that I loved my brother ... my mother, my other brothers, and Mr. Drew (the father of my brothers)" (*Brother* 149).

Jamaica Kincaid's books detail the effects of colonialism on Antigua, Antiguan, and, more specifically, herself. Colonialism turned her family and friends into people who mimicked English behavior and beliefs, and, in her mind, her mother into a symbol of European domination. Kincaid depicts the pervasive power of the English and her mother during her childhood in *At the Bottom of the River* and *Annie John*, and in *Lucy*, she details her feelings of anger during her first year in the United States. In the latter two books, she reveals how her anger at the conquerors has prevented her from forming loving relationships in her life. In *My Mother*, Kincaid writes of a character who has never experienced the physical presence of her mother or the English, but fights the same emotional demons as the protagonists in previous books. The author's extended essay, *A Small Place*, helps the reader see Kincaid's

accusations of the colonizer on a larger scale while simultaneously enabling Kincaid to recognize the uselessness of her anger. In this work, she concludes that descendants of slaves and descendants of masters must stand on their own two feet instead of remaining fixated on the plights and actions of their ancestors. In *A Small Place*, Kincaid lets go of her anger intellectually, and in *My Brother*, she finally learns to love. She has found love in a nation she once associated with conquerors, and, with more difficulty, love among her own people. While she is no longer "noble and exalted," as she once described slaves in *A Small Place*, Kincaid has become a human being.

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Nationwide Newspaper Coverage of the Supreme Court's Decision to Halt the Counting in *Bush vs. Gore*: A Community Structure Approach

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ABSTRACT

On December 9, 2000, the United States Supreme Court ruled to halt the counting of Florida ballots in the 2000 presidential election, creating heated controversy when the presidency was awarded to the Republican candidate. Using a community structure approach elaborated in national studies by Pollock and colleagues (1977-78, 1994-2002), this study examines the relationship between specific city demographics and content analysis of nationwide newspaper coverage of the Supreme Court decision to halt the counting in *Bush vs. Gore*.

Using the DIALOG Classroom Information Program newspaper database, all articles 100 words or longer on the topic were drawn from a national cross-section sample of 21 newspapers from December 9, 2000, to March 31, 2000, yielding 492 articles. Content analysis combining the attention score each article received (placement, headline size, story length, and presence of photos/graphs) and overall article direction (favorable, unfavorable, neutral) resulted in individual newspaper "Media Vector" scores—a measure of media "thrust."

Pearson correlations confirmed three major hypotheses: "violated buffer," "media access," and "stakeholder." Violated buffer hypotheses expect the higher the percentage of privileged groups in a city, the less favorable the reporting on either biological threats or threats to an established way of life. High percentages of the following city characteristics are all strongly linked with unfavorable reporting on the Supreme Court decision to stop the ballot

count: measures of privilege—annual household incomes over \$100,000 ($r = -.563$, $p = .004$), college graduates ($r = -.547$, $p = .005$), attendance at cultural events ($r = -.401$, $p = .040$), and a measure of "media access"—newspaper circulation in a city ($r = -.478$, $p = .014$). "Stakeholder" factors varied—voting Democratic in the 1996 presidential election ($r = -.481$, $p = .014$) is linked to negative coverage. Voting Republican, by contrast, is linked to positive coverage ($r = .414$, $p = .031$). Stepwise multiple regression analysis revealed that the combination of college graduates and newspaper circulation accounted for 32% of the variance in newspaper coverage. Factor analysis and regression of the factors yielded similar results. The major surprise: The very privileged groups that voted disproportionately for Bush are linked to relatively unfavorable newspaper coverage of the Supreme Court decision that propelled him into office.

INTRODUCTION

The United States Supreme Court made history in December 2000 by awarding George W. Bush the presidency without acknowledging every citizen's vote. It is difficult to say whether or not the decision was a breach of justice. Gore supporters would say that the United States Supreme Court's partisan decision denied thousands of Florida citizens the right to exercise their vote. On the other hand, supporters of Bush would argue that it was time for America to make a decision.

The 2000 presidential election between Al Gore and George W. Bush resulted in the

selection of a president who wasn't elected by the popular vote. The United States Supreme Court made a ruling the effects of which will last for at least four years. Court decisions such as *Roe vs. Wade* could be overturned with the aid of the newly elected conservative president. Major economic and foreign policy decisions are affected. Our everyday lives have been irrevocably changed because of this controversial outcome.

When an event creates so much controversy, it is interesting to explore the role of media in the controversy. The major media play a significant role in educating people about political parties, candidates, and their plans for the country, and are among our key players in "framing" issues for public discussion and opinion formulation. Newspapers serve as a major information resource for leaders and decision-makers as well as the average citizen. Newspapers are also the main agenda setters for other media. For all of these reasons, newspaper coverage of the United States Supreme Court's decision in *Bush vs. Gore* is a vital topic for communication research.

It is expected that cities with higher percentages of Republican voters would treat the ruling in *Bush vs. Gore* more favorably than cities with a majority of Democratic voters. It can also be predicted that cities with higher minority populations would offer more negative coverage of *Bush vs. Gore*. Therefore, it is useful to study how demographics are related to media coverage. This study evaluates the coverage of the United States Supreme Court's final decision in *Bush vs. Gore* to stop the counting of ballots in Florida. It will compare newspaper coverage from different cities to measure how the same decision was reported in cities throughout the nation. This analysis will provide different insights into the "Supreme Court's conservative majority, who were supposedly acting as referee in a race, stuck out a foot, tripped one of the contestants and then said, 'Too bad. You didn't cross the finish line in time'" (Levine, 2000, p. H5).

Scholarly Articles and Communication Literature: Results of *Bush vs. Gore* Search Research was conducted in communication journals and online databases for articles dealing with the Supreme Court's decision in the case of the 2000 presidential election. However, little significant information concerning *Bush vs. Gore* and the media's coverage of the Supreme Court's final decision is documented in communication literature. The most pertinent information regarding the topic was found in sources indexed in political, economic, and business literature.

A search via the Communication Institute for Online Scholarship (CIOS) used key terms such as "politics and election" and "media and politics." The search resulted in 47 matches that provided little relevant information regarding *Bush vs. Gore*. Journals pertaining to communication research, such as *Journalism Quarterly*, *Political Communication*, and *Southern Communication Journal* were also searched. Terms such as "media and Supreme Court," "media and politics," "politics and election," and "press and politics" provided little data.

A search was conducted on ComAbstracts, an online database, using key phrases such as "media coverage and president." This yielded a substantial number of articles on the role of media in framing issues on presidential elections, but the Supreme Court and media were not discussed. ComIndex, another online database that provides complete bibliographic information on approximately 31,500 articles from 70 key international journals and annuals, was also used during the research process (Pollock, Castillo, Solomon, & Griffiths, 2000, p. 5). Key headings such as "media and politics," "media and court decision," and "media and election" revealed little relevant information. A search through CommSearch, another online database, using similar terms showed similarly slender results on the Supreme Court and media. Obviously, because of its recent occurrence, little information is currently available on *Bush vs. Gore* in communication journals.

These results, nevertheless, are unsettling considering the importance of *Bush vs. Gore* to communication studies.

Although information on *Bush vs. Gore* was scarce in communication journals, articles were readily available in electronic periodicals and political journals. EBSCOhost is an online database that provides access to more than 308,000 articles in more than 27,500 individual issues of approximately 2,100 electronic journals published in the past four years (Pollock, Castillo, Solomon, & Griffiths, 2000, p. 5). A broad search using the key terms "press and politics," "media and politics," "judges and media," and "Supreme Court and count" revealed thousands of matches. One such article was found in *Humanist* and titled "Media Myopia and the Future of Democratic Politics" which, like most of the articles accessed, faulted the media for the confusion that surrounded *Bush vs. Gore* (Buell, 2001, p. 35). The article suggests, "Florida became almost as much of a badge of shame to the media mavens as it was a legal crisis for the Bush and Gore camps" (Buell, 2001, p. 35).

Many articles were found by conducting a search of online political science databases and journals. Key terms such as "press and politics" resulted in listings of 26 articles, "media and politics" showed 978 articles and "Supreme Court and media coverage" found seven matches. Although most of the articles were irrelevant to media coverage of *Bush vs. Gore*, several showed some significance. An article in *American-Spectator* suggested that the media display a biased view when it comes to covering political topics (Eastland, 1991, p. 27). The May 1998 issue of another political journal, *Current*, provided an article titled "Cast a Cautious Eye on the Supreme Court" suggesting that a journalist's duty is to emphasize the "wide separation of 'politics' and 'law'"; media should not act as the Supreme Court's publicist but rather as a mode of education for the public (Kennedy, 1998, p. 39).

Expansive research on the media's role in the Supreme Court's final decision in *Bush*

vs. Gore yielded little information in communication journals, but relevant articles were found in political, economic, and business resources. The present study is an effort to redress the imbalance by investigating the relationship between city demographics and newspaper coverage of the Supreme Court's decision in *Bush vs. Gore*.

A Community Structure Approach

The community structure approach is a useful vehicle for explaining variations in newspaper coverage of emotionally and politically charged issues such as the decision to stop the counting in *Bush vs. Gore*. The community structure approach also reaches beyond traditional media content analysis in order to connect theory with data, an activity that has been too infrequently practiced among scholars using content analysis methodologies (see Shoemaker, 1987; Shoemaker & Reese, 1990, 1996; Riffe & Freitag, 1996).

The community structure approach is defined as "a form of quantitative content analysis that focuses on the ways in which key characteristics of communities (such as cities) are related to the content coverage of newspapers in those communities" (Frey, Botan, & Kreps, 2000, p. 238). This approach builds on the work of researchers Tichenor, Donohue, and Olien (1973, 1980) in Minnesota; Demers (1996a, 1996b) in Minnesota; and elaborated by Pollock and others nationwide (1977, 1978, 1995-2000), and suggests that community or city characteristics are systematically linked to newspaper reporting on critical public events that reflect political and social change. (For a definition of the community structure approach and a description of its uses, see Frey, Botan, & Kreps, 2000, pp. 238-239.)

Today, the community structure approach integrates many findings that have emerged from previous studies concerning local or community structure and newspaper coverage of political and social change (Pollock and Yulis, 1999). According to K. A. Smith (1984), "the media may be viewed as prominent subsystems within the larger social systems of the community; thus, they tend to

reflect the values and concerns of dominant groups in the community they serve" (p. 260).

Political and social interest groups have exercised substantial power through their public involvement and have been important factors in shaping the outcomes of highly controversial public debates in this country. These influential "stakeholders" include such groups as Republicans and Democrats, women, minorities, and homosexuals (Demers and Viswanath, 1999, p. 419). By recognizing some of the significant factors that influence change on critical issues and by incorporating the community structure approach, this study maps the relation between local city characteristics and media coverage of the Supreme Court ruling to stop counting votes in the 2000 presidential election.

HYPOTHESES

Hypotheses were constructed using the community structure approach as refined by previous researchers. Seventeen individual hypotheses fell into four cluster groups: stakeholders, violated buffer, vulnerability, and access.

Stakeholders

"Stakeholders" are people who have a high interest in, or level of concern with, an issue. A proposition advanced by McLeod and Hertog suggests that the greater the size of a protest group, the more attention and favorable coverage that group will receive in mass media (McLeod & Hertog, 1992, 1999). For the purposes of this study, it can be assumed that the greater the number of recognized "stakeholders" in a city, the more newspaper coverage is likely to reflect their concerns. The "stakeholder" categories of partisanship, age, gender, ethnicity, and sexual orientation are relevant in examining the newspaper coverage of *Bush vs. Gore*.

For example, in previous research it has been shown that the larger the number of organizations or businesses marketing their products or services to the gay community in a city, the more favorable the newspaper

coverage of the efforts to legalize same-sex marriage (Pollock & Dantas, 1998). In addition, stakeholders such as senior citizens, or women in the workforce, have been linked respectively to relatively positive coverage of Dr. Kevorkian and negative coverage of legalization of physician-assisted euthanasia (Pollock, et al., 1995; Pollock & Yulis, 1999).

Partisanship

It is obvious that *Bush vs. Gore* is a partisan issue. Florida's predominately Democratic Supreme Court declared that all the votes should be counted, a ruling that favored the Democratic candidate, Al Gore. The case was brought before the Republican-dominated U. S. Supreme Court, which ruled that time was up for the recounting of ballots because the United States needed a president. This decision handed the presidency to the Republican candidate, George W. Bush.

The key division of opinion on the Supreme Court decision is between Bush supporters and Gore supporters (Moore, 2000). Ninety-three percent of Bush supporters agreed with the Supreme Court ruling while 81 percent of Gore supporters disagreed (Moore, 2000). Partisanship was found to be an important factor in the community structure studies of the Anita Hill and Clarence Thomas hearings and in Social Security reform (Pollock & Killeen, 1995; Pollock, Tanner, & Delbane, 2000). Consequently, it is reasonable to expect that there may be a correlation between the proportion of those citizens in a city who voted Republican in the 1996 presidential election and favorable newspaper coverage of the decision. Thus:

H¹: The higher the percentage of those in a city who voted Republican in the 1996 presidential election, the more favorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(County and City Extra, 2000)

H²: The higher the percentage of those in a city who voted Democratic in the 1996 presidential election, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(County and City Extra, 2000)

Age

Other differences in reaction to the Supreme Court decision are found in divisions of age, gender, and ethnicity. According to a Gallup poll released December 14, 2000, Americans under 50 disagreed with the Court's decision, while older Americans took the opposite point of view (Moore, 2000). Similarly, researchers using a community structure approach have determined that the youth or age of stakeholders is a significant factor in determining newspaper bias in covering the trying of juveniles as adults (Pollock, Auletta, et al., 2000). Therefore:

H³: The higher the percentage of citizens over 75 in a city, the more favorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Lifestyle Market Analyst, 2000)

Gender

Gender is another category which reveals different views of *Bush vs. Gore*. Men favor the ruling and women are split evenly (Moore, 2000). It is likely that the working woman of 2000 might be threatened by the GOP's conservative opposition to legalizing the RU-486 abortion pill. Consistent with gender concerns, the community structure approach confirmed a link between the percent of women in the work force and relatively favorable newspaper coverage of human cloning (Pollock, Dudzak, et al., 2000).

Independent, working females tend to favor the more liberal presidential candidate to help insure their rights as women. This has been true in every presidential election since 1980. The gender gap is a permanent feature of contemporary politics (Bowman, 2000). It is a fact that women, as a whole, tend more often to vote Democratic whereas men are generally more likely to vote Republican (Bowman, 2000). Accordingly:

H⁴: The greater the percentage of working women in a city, the less favorable the newspaper coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (U. S. Census Bureau, Census 2000)

Ethnicity

For many of the same reasons that women are more likely to vote Democratic, minority races tend to choose this same political affiliation. The liberal views of the Democratic Party correspond with the concerns of many minority groups. For example, Pollock, Robinson, and Murray found a positive correlation between a high percentage of black residents in a city and pro-choice abortion coverage (1978). Thus:

H⁵: The greater the percentage of African Americans in a city, the more unfavorable the newspaper coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (U. S. Census Bureau, Census 2000)

H⁶: The greater the percentage of Hispanics in a city, the more unfavorable the newspaper coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (U. S. Census Bureau, Census 2000)

Sexual Orientation

Past research has shown that the larger the number of businesses and organizations owned by gays and/or lesbians, or catering to a primarily gay and lesbian clientele in a city, the more favorable the coverage of same-sex adoption (Pollock & Tobin, 2000). Moreover, other research has found that the greater the number of businesses or organizations marketing to the gay community in a city, the more likely city newspapers are to report favorably on efforts to legalize same-sex marriage or to pass hate crime legislation (Pollock & Dantas, 1998; Pollock, Moran, et al., 2001). It is known that the Democratic Party has relatively liberal opinions regarding the rights of homosexuals. Gore offered a clear stance on legalizing protection for "domestic partnership." Bush, conversely, opposes adoption by homosexuals and the extension of hate crime laws to protect gays. It is reasonable to assume that a majority of the homosexual population favored a Democratic president. Therefore:

H⁷: The greater the number of businesses owned wholly or partly by gays and/or lesbians, or welcoming a primarily gay and lesbian clientele in a city, the more unfavorable the expected coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Gay Yellow Pages, 2001)

Privilege: Violated Buffer

The "violated buffer hypothesis," developed by Pollock and colleagues, predicts that the higher the percentage of privileged groups in a city, the less favorable the reporting on either biological threats or threats to an established way of life (Frey, Botan, & Kreps, 2000, p. 239). Past research conducted on media coverage of Magic Johnson's HIV announcement, tobacco advertising aimed at children, the Internet, and Dr. Kevorkian's activities have all supported the violated buffer hypothesis (Pollock, Awarchow, & Kuntz, 1994; Pollock, Niski, et al., 1999; Pollock & Montero, 1998; Pollock, Coughlin, Thomas, & Connaughton, 1996). Examining indicators of privilege, such as the percentage of the population with professional/technical occupational status and the percentage of households with annual income over \$100,000, suggests a relationship between these city characteristics and newspaper coverage of *Bush vs. Gore*.

Since the U. S. Supreme Court ruled to stop the counting of ballots in Florida, one can argue that the civil rights of voters throughout the U. S. were violated because all of the votes in Florida were not acknowledged. According to a Gallup poll released January 16, 2001, only 42% of Democrats approve of the job the Supreme Court is doing, in comparison to an August 2000 poll, in which 70% of Democrats approved. These results suggest that Democrats think differently about the U. S. Supreme Court in the aftermath of its controversial role in the 2000 presidential election and believe that the decision was based not on sound legal reasoning, but on partisanship. This is particularly evident when one considers that lower-income areas, which tend to vote Democratic, relied more heavily on punch-card ballots than on the machine-read ballots available in higher-income areas, which tend to vote Republican. Since the U. S. Supreme Court suspended the counting before it made a final decision, it prevented a significant number of punch-card ballots from being tallied.

The decision made by the U. S. Supreme Court led many to question the integrity of the institution. Many reporters and attorneys throughout the nation were shocked by the U. S. Supreme Court's intervention. Many citizens concluded that the U. S. Supreme Court, an institution expected to uphold justice, had manipulated the political system. If the U. S. Supreme Court itself can be so unabashedly partisan, then there is little hope for fairness elsewhere. Although the economically and educationally privileged may have voted for Bush, their faith in the system may have been shaken by the U. S. Supreme Court decision, leaving feelings of vulnerability and concern that the ruling poses a threat to a cherished way of life. Therefore:

H⁸: The higher the percentage of college graduates living within a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Lifestyle Market Analyst, 2000)

H⁹: The higher the percentage of those employed in professional/technical operations within a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Lifestyle Market Analyst, 2000)

H¹⁰: The higher the percentage of households attending cultural, fine, and performing arts events, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Lifestyle Market Analyst, 2000)

H¹¹: The higher the percentage of those with annual incomes over \$100,000 in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (Lifestyle Market Analyst, 2000)

Vulnerability

Issues that exemplify the vulnerability hypothesis include the coverage of *Roe vs. Wade*, the Patients' Bill of Rights, and ethnic disputes in Crown Heights, New York. A national community structure approach study revealed that the higher the percentage of residents living below the poverty line in a city, the more favorable the coverage of *Roe vs. Wade*, the Patients' Bill of Rights, and the

more non-partisan the reporting in the Crown Heights conflict (Pollock, Robinson, & Murray, 1998; Pollock & Castillo, 2000; Pollock & Robinson, 1977; Pollock & Whitney, 1997). It is reasonable to expect that those in a city who are living below the poverty line and the unemployed will generally oppose the U. S. Supreme Court's decision to stop the counting. Gore's liberal platform, which supports welfare and tax cuts for the middle to lower classes, would directly benefit those living below the poverty line and the unemployed. Bush's platform was conservative and favored tax cuts for the upper-middle to upper classes. The partisanship of the U. S. Supreme Court decision threatened the prospects of households that fall below the poverty line and of the unemployed in American cities. Accordingly:

H¹²: The higher the percentage of households that fall below the poverty line in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (City and County Extra, 2000)

H¹³: The higher the percentage of unemployed citizens in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore. (City and County Extra, 2000)

Media Access

When examining media access, previous studies provide guidance. Some studies have shown that there is an association between access to many different media outlets and openness to new ideas. A series of studies in Minnesota by Tichenor, Donohue, and Olien has shown that a city with many media outlets can be expected to accept and advance myriad positions, attitudes, and ideas regarding important events (1973, 1980).

Other studies, moreover, link the number of media outlets not simply with a plurality of viewpoints, but more explicitly with media viewpoints generally accommodating political or social change. Concurring with these observations, Hindman claims that the more society has access to information, the greater the ability of social actors to initiate projects that

promote social change or challenge those in power (Hindman, 1999, pp. 99–116). It seems as though the greater the number of media outlets or media “reach,” the more effectively media shape public opinion or even threaten the interests of powerful groups. A proposition articulated by Emanuel and Cecilie Gaziano asserts that collectivities acquiring relatively more knowledge through the media can be expected to be more effective in challenging elite groups and in using power to effect change that benefits them (Gaziano & Gaziano, 1999, pp. 117–136). In addition, Dunwoody and Griffin, in their studies of community structure, suggest that the more pluralistic the community, the greater the potential for the media to challenge the prevailing power structure (Dunwoody & Griffin, 1999, pp. 197–226).

Newspapers

Newspaper circulation can test the relationship between media access and reporting of social change. It is reasonable to assume that the greater the newspaper circulation in a city, the more open to new ideas the coverage in those papers will be. If the circulation size of a newspaper is large, then people from varied cultural, social, economic, and political groups are more likely to read the newspaper, and the coverage will more likely encompass a variety of perspectives in order to attract as many readers as possible. A previous study using the community structure approach found that high newspaper circulation correlated positively with reporting that accommodates social change, in this case favorable reporting on Ryan White, the hemophiliac boy with HIV/AIDS (Pollock, McNeill, et al., 1995). Nationwide studies of news coverage of legalization of same-sex marriage and of human cloning support the projections of Tichenor, Donohue, and Olien associating larger newspaper circulation with a plurality of reporting perspectives and relative openness to political and social change. (See, respectively, Pollock, McNeil, Pizzatello, & Hall, 1996; Pollock & Dantas, 1998; Pollock, Dudzak, et al., 2000). As a result:

H¹⁴: The higher the newspaper circulation in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(Lifestyle Market Analyst, 2000)

Radio

Radio is also a significant media outlet. It provides the public with a powerful forum through which ideas and viewpoints can be argued and discussed. For instance, Pfau and colleagues have found that radio exposure is the primary source of information on unfamiliar and newly emerging political candidates, more important than interpersonal experiences (Pfau, et al., 1997, pp. 6–26). In particular, studies on newspaper coverage of Ryan White as well as legalization of same-sex marriage have revealed that the more FM radio stations operating in a city, the more accommodating the reporting on social change, specifically the more favorable or sympathetic the coverage of someone with HIV/AIDS or to the legalization of same-sex marriage (Pollock, McNeill, et al., 1995; Pollock & Dantas, 1998). FM and AM radio can be linked to different perspectives on social change.

AM Stations

AM radio is associated with negative coverage of the issue of the Patients' Bill of Rights, while Democratic Party affiliation, physician density, and poverty are associated with positive coverage (Pollock & Castillo 2000). Regarding *Bush vs. Gore*, it is reasonable to expect similar radio-linked results.

Therefore:

H¹⁵: The larger the number of AM radio stations in a city, the more favorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(Gale Directory, 2000).

FM Stations

According to Pollock and Dantas, "Nationwide Newspaper Coverage of Same-Sex Marriages," there is a strong, positive association between a larger number of FM radio stations and relatively favorable coverage of legalization of same-sex marriage (Pollock & Dantas, 1998). Similarly, the

larger the number of FM stations, the more favorable the coverage of physician-assisted suicide (Pollock & Yulis, 1999). It is reasonable to conclude from these findings:

H¹⁶: The larger the number of FM radio stations in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(Gale Directory, 2000)

Cable

Community-access channels and the wide range of viewpoints available on the medium give special importance to cable networks. Atkin and LaRose (1991) noted that over 60 percent of cable networks have at least one community-access channel. In addition, they assert that such community-access channels attract one in six regular cable subscribers (Atkin & LaRose, 1991). Additionally, Baldwin, Barrett, and Bates (1992) reported that cable subscribers are more likely to depend on cable news broadcasts rather than local television stations. Subscription to cable stations exposes individuals to a plurality of viewpoints, specifically access to global television news stations such as CNN. Thus's (2000) examination of CNN's framing of the Kosovo conflict revealed that television news pictures supported the agenda promoted by the U. S. military, an agenda that called for a policy change favoring intervention for humanitarian purposes. Thus, access to cable stations can reinforce values within a community and also expose viewers to a wide range of viewpoints. In previous nationwide studies using the community structure approach, access to larger numbers of cable stations was found to be linked to newspaper perspectives accommodating social change, such as relatively positive coverage of Ryan White and legalization of physician-assisted suicide (Pollock, McNeill, Pizzatello, & Hall, 1996; Pollock and Yulis, 1999). With regard to *Bush vs. Gore*:

H¹⁷: The greater the number of cable stations in a city, the more unfavorable the coverage of the Supreme Court's decision to halt the counting in Bush vs. Gore.
(Gale Directory, 2000)

METHODOLOGY

Sample Selection

Using the community structure approach, this study explores coverage of the Supreme Court ruling in *Bush vs. Gore* in 21 major newspapers nationwide. The time period sampled for these articles was December 9, 2000, to March 31, 2001. This range encompasses a period of time when the subject of *Bush vs. Gore* assumed major importance. The articles represent all relevant articles of 100 words or more in length within the sampled time frame, and are based upon geographic dispersion, representing a national cross section of the United States. The resulting 494 newspaper articles were collected from the DIALOG Classroom Information Program newspaper database available to college libraries.

The set of newspapers includes *The Albany Times-Union*, *Arizona Republic*, *Augusta Chronicle*, *Baton Rouge Advocate*, *Boston Globe*, *Buffalo News*, *Charleston Gazette*, *Memphis Commercial Appeal*, *Dayton Daily News*, *Denver Post*, *Detroit Free Press*, *Grand Forks Herald*, *Lexington Herald-Leader*, *Milwaukee Journal*, *Philadelphia Inquirer*, *Pittsburgh Post*, *St. Louis Post-Dispatch*, *San Diego Union-Tribune*, *San Francisco Chronicle* and *The Seattle Times*. Neither *The New York Times* nor *The Washington Post* was selected for analysis because both papers are considered to be, in many ways, "national" newspapers reflecting the views of national decision-makers as well as local concerns. In addition, any newspapers in Florida or Texas were omitted because of the pro-Bush biases associated with those states. Even though Tennessee is the home state of Al Gore, it was included in the sample because the vice president failed to win it.

Measures of Attention, Direction, and Coefficients of Imbalance

After each of the articles was read, it was assigned two scores. The first was an attention or display score. This numerical rating, ranging from three to 16 points, is based on the following criteria: placement (front page

of first section, front page of inside section, inside prominent [A3 or A7], or other), headline word count, length-of-article word count, and presence or absence of photograph (with/without caption). Articles that receive a higher number of points are considered to have received more attention.

TABLE 1: Attention Score* (for coding databases)

DIMENSION	4	3	2	1
Prominence	Front page of first section	Front page of inside section	Inside first section	Other
Headline Size (in number of words)	10+	8-9	6-7	5 or fewer
Length (in number of words)	1000+	750-999	500-749	150-499
Photos/Graphics	Two photos or graphics	One photo or graphic		

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The second score assigned to each article was a directional score, derived from an evaluation of the content, using the entire article as a sampling unit. The designations of favorable, unfavorable, or neutral/balanced toward *Bush vs. Gore* were assigned to each article by three different coders, using the following criteria: Coverage considered *favorable* to *Bush vs. Gore* included those articles viewing this decision positively. Articles were also deemed favorable when a majority of the text contained positive sentiments about *Bush vs. Gore*. Coverage *unfavorable* to *Bush vs. Gore* included articles that focused on negative coverage of the Supreme Court's decision. Articles were also deemed unfavorable to *Bush vs. Gore* when most of the text focused on negative features of the decision. *Balanced/neutral* coverage included articles that treated both sides of the debate about equally, or strove to maintain a disinterested, unbiased perspective, raising questions about *Bush vs. Gore* without making an obvious judgment. After the collected articles were assigned their directional scores, three researchers coded a systematic sub-sample of one-half of the articles to yield a Holsti's Coefficient of Intercoder Reliability of .92.

Media Vector Calculated

Using a Coefficient of Imbalance

A more complex statistic was calculated that combines measures of the likelihood that

readers will be exposed to the material (the attention score) and the evaluation of the article content (directional score) to yield a sophisticated, sensitive single score for each newspaper's overall coverage of *Bush vs. Gore* for the entire sampling period. After each article was assigned an attention and a directional score, these were combined using the Janis-Fadner Coefficient of Imbalance for each newspaper to calculate a "Media Vector." The resulting coefficient is called a "Media Vector" because it resembles a vector in physics, a concept that combines both magnitude (in this case, "attention") and direction to arrive at a measure of "impact" or "thrust." The "Media Vector" concept therefore measures media "thrust."

The attention and direction scores can be combined to calculate the Media Vector for each newspaper, as follows:

TABLE 2: Single-Score Content Analysis: Calculating the Media Vector

u = sum of the attention scores coded "unfavorable"
 f = sum of the attention scores coded "favorable"
 n = sum of attention scores coded "neutral/balanced"
 $r = f + u + n$

If $f > u$ (or sum of the "favorable" attention scores is greater than the sum of the "unfavorable" attention scores), then use the following formula:

Coefficient of Favorable Imbalance: (answers lie between 0 and +1)
 $C(f) = (f2 - fu) / r2$

If $f < u$ (or the sum of the "unfavorable" attention scores is greater than the sum of the "favorable" attention scores), then use the following formula:

Coefficient of Unfavorable Imbalance: (answers lie between 0 and -1)
 $C(u) = (fu - u2) / r2$

The resulting statistic, which can vary from +1.00 to -1.00, permits quantitative comparisons of each newspaper's coverage of *Bush vs. Gore*. Scores between zero and +1 indicate favorability and scores between zero and -1 indicate unfavorability toward *Bush vs. Gore*. Articles using the Media Vector in communication research have been published in such journals as *Comparative Politics, Society, Journalism Quarterly, Mass Communication Review, Journal of International Communication, Newspaper Research Journal (2), The New Jersey Journal of Communication*, and the edited, refereed collection *Communication Yearbook*. (See respectively Hurwitz, Green, & Segal, 1976;

Pollock & Robinson, 1977; Pollock, Murray, & Robinson, 1978; Pollock, 1995; Pollock, Shier, & Slattery, 1995; Pollock, Coughlin, Thomas, & Connaughton, 1996; Pollock, Kreuer, & Ouano, 1997; Pollock & Whitney, 1997; Pollock & Guidette, 1980).

PROCEDURES

The exploration of the relationship between city characteristics described in the hypothesis and the Media Vector was carried out using four statistical procedures. First, Pearson correlations were conducted to measure which city characteristics were most strongly associated with the coefficients of imbalance. Second, regression analysis was used to determine the relative strength and importance of each independent variable. Third, factor analysis clustered city characteristics into distinct, key city dimensions to improve the explanatory power of the independent variables linked to coverage of the Supreme Court's decision. Fourth, the regression of factors correlated the significant dimensions of the factor analysis with the coefficients of imbalance. All four procedures demonstrate clearly the strong association between specific city characteristics and coverage of the issue.

RESULTS

TABLE 3: Media Vector

City	Newspaper	Media Vector
Grand Forks	<i>Grand Forks Herald</i>	.192
Baton Rouge	<i>Baton Rouge Advocate</i>	.082
Memphis	<i>Commercial Appeal</i>	.036
Buffalo	<i>Buffalo News</i>	.011
Milwaukee	<i>Milwaukee Journal</i>	-.011
Phoenix	<i>Arizona Republic</i>	-.013
Dayton	<i>Dayton Daily News</i>	-.028
San Diego	<i>San Diego Union-Tribune</i>	-.080
Seattle	<i>Seattle Times</i>	-.100
Lexington	<i>Lexington Herald-Leader</i>	-.101
Pittsburgh	<i>Pittsburgh Post</i>	-.101
Albany	<i>Albany Times Union</i>	-.112
Denver	<i>Denver Post</i>	-.114
Detroit	<i>Detroit Free Press</i>	-.116
Boston	<i>Boston Globe</i>	-.122
St. Louis	<i>St. Louis Post-Dispatch</i>	-.133
Hackensack	<i>Record</i>	-.160
Charleston	<i>Charleston Gazette</i>	-.168
Augusta	<i>Augusta Chronicle</i>	-.174
San Francisco	<i>San Francisco Chronicle</i>	-.186
Philadelphia	<i>Philadelphia Inquirer</i>	-.206

Varied Coverage, Mostly Negative

The coefficients of imbalance of individual newspapers were ranked by their Media Vector from most to least favorable in their coverage of the U. S. Supreme Court's decision. Pearson correlation and significance tests were calculated to test the relationship between distinct city characteristics and variations in reporting. The Media Vectors ranged from +.192 to -.206, demonstrating that newspaper coverage of this issue varied significantly across the nation. Of the 21 studied, four papers exhibited favorable coverage, while 17 papers scored negatively.

TABLE 4: Pearson Correlations and Significance Levels

Variable	Pearson Correlation	Significance (1 tailed)
College Graduates	-.596	.002
Newspaper Circulation	-.534	.006
Income of \$100,000+	-.508	.009
Gay Market Index	-.485	.013
Democrats	-.474	.015
Republicans	.414	.031
Cultural Events	-.384	.047
FM Stations	-.350	.060
Working Women	-.304	.090
Professional/Technical	-.272	.116
Over 75 Years Old	-.206	.185
AM Stations	-.196	.197
Cable Stations	-.214	.232
Poverty Line	.166	.236
Hispanic	-.159	.246
Unemployed	-.138	.275
African American	-.045	.423

A Pearson correlation analysis (shown in Table 4) was used to determine whether city characteristics could be linked to differences in reporting. The results yield a strong correlation linking negative newspaper coverage of the Supreme Court ruling in *Bush vs. Gore* to several specific demographic variables: the percentage of college graduates in a city ($r = -.596, p = .002$), newspaper circulation in a city ($r = -.534, p = .006$), people with annual incomes of over \$100,000 ($r = -.508, p = .009$); additionally, the percentage of people who voted Democratic in the 1996 election ($r = -.474, p = .015$), the percentage of people who voted Republican in the 1996 election ($r = .414, p = .031$), the percentage of people attending cultural events ($r = -.384, p = .047$). No other significant correlations were found using Pearson correlations.

Regression Further Substantiates Pearson Correlations

In analyzing coverage of the decision of the Supreme Court to halt the counting in *Bush vs. Gore*, two variables correlated highly with the Media Vector in a step-wise multiple regression analysis: college graduates and newspaper circulation. The regression analysis reveals that the percentage of college graduates has the most influence over newspaper coverage of the Supreme Court's decision, accounting for 25% of the variance. Combined with college graduates, newspaper circulation within a city provided 32% of the variance of newspaper coverage.

TABLE 5: Regression Analysis

Model	R	R Squared	R Squared Change	F Change	Sig. F Change
COLLGRAD	.499	.249	.249	5.975	.025
COLLGRAD, NEWSCIRC	.567	.321	.072	1.802	.197

Factor Analysis and Regression of Factors

To refine the results further, a factor analysis of city characteristics was run to isolate city characteristics that cluster frequently. Factor analysis of city characteristics for the 21 cities sampled yields six factors, all with component Eigen values of 1.00 or greater. The six factors are as follows: College Graduates/Partisanship, Ethnicity/Vulnerability, Generation, Privilege/Access, Women/Access, and Professional. Beneath each factor heading in the following table is its specific variable components:

TABLE 6: Factor Analysis

Component	Factor Loading
Factor 1: Partisanship and College Graduates	
% College Graduate	.723
Republican	-.952
Democratic	.958
Factor 2: Ethnicity and Vulnerability	
Hispanics	.880
% Below Poverty Line	-.813
Unemployed	.822
Factor 3: Generation	
FM Radio	.887
Over 75 Years Old	-.919
Factor 4: Privilege/ Access	
% Over \$100,000	.816
Newspaper Circulation	.886
Factor 5: Working Women/Access	
Working Women	.766
Cable	.935
Factor 6: Professional	
Professional/Technical	.867

The six factors were themselves subjected to further step-wise multiple regression against the Media Vector, with the results shown in Table 7. That analysis yielded two significant factors collectively accounting for 30 percent of the variance: "Privilege/Access" (composed of income over \$100,000 and newspaper circulation), with 17 percent of the variance; "Partisanship/College Graduates" (Democratic, Republican and percent college graduates), with an additional 12 percent of the variance as seen in the chart below:

TABLE 7: Regression of Factors—Model Summary

Model	R	R Squared	Change Statistics		
			R Squared Change	F Change	Sig. F Change
Privilege/ Access	.416	.173	.173	2.514	.139
Partisanship/ College Grads	.549	.301	.128	2.017	.183

Regional Newspaper Coverage of the Supreme Court Decision Is Consistent with Public Opinion

The following chart, Table 8, compares average Media Vectors for each of four regions—reflecting levels of favorable or unfavorable newspaper coverage of the Supreme Court decision to stop the counting in *Bush vs. Gore*—and regional comparisons of public opinion on who voters regarded as the rightful winner of the presidency. The following question was used to survey public opinion in December 2000: *If everyone who tried to vote in Florida had their votes counted for the candidate who they thought they were voting for with no misleading ballots and infallible voting machines—who do you think would have won the election, George W. Bush or Al Gore?*

TABLE 8: Regional Comparison between Media Vectors and Public Opinion

REGION	Average Media Vector for Region	% think Bush would have won
Northeast	-0.106	16
Midwest	-0.019	26
South	-0.065	36
West	-0.099	21

This public opinion survey was conducted by the Harris Poll in December 2000 and the data is held at the Howard W. Odum Institute for Research in Social Sciences at the University of North Carolina at Chapel

Hill. The question was asked to a national sample of people 18 or older.

Two patterns are clear. First, the regional newspaper coverage least favorable to the Supreme Court's decision (an average Media Vector of $-.106$) is in the Northeast and the West (an average Media Vector of $-.099$). Consistently, the lowest levels of public opinion favorable to Bush's effective selection by the Court are also in the Northeast and West. Second, the regional newspaper coverage most favorable to the Supreme Court's decision to stop the counting (an average Media Vector of $-.019$) is in the Midwest and the South (an average Media Vector of $-.065$). Not surprisingly, the highest levels of public opinion favorable to Bush becoming president are also found in the Midwest and South.

These findings reflect the evidence that most of Bush's support comes from the Midwest and the South. Conversely, Gore's supporters are predominately located in the Northeast and Western regions. Therefore, regional comparisons suggest a strong correspondence between regional newspaper reporting on the Supreme Court's decision and public opinion regarding the rightful winner of the presidency.

Analysis and Discussion: Privilege More Important than Partisanship

Overall, the pattern in newspaper coverage was unfavorable to the Supreme Court's decision. Our analyses uncovered seven significant results, supporting the violated buffer, media access, and stakeholder hypotheses. The percentage of college graduates, percentage of households with annual incomes over \$100,000, and percentage of households attending cultural events are linked to unfavorable coverage of the Supreme Court's decision to halt the counting, thus supporting the violated buffer hypothesis. Pearson correlation analysis confirmed the hypothesis. Although the Supreme Court decision to halt the vote-counting was widely regarded as a "partisan" event, reported as dividing Republicans and Democrats nationwide in public opinion polls, newspaper coverage

tended to reflect more precisely the concerns of the relatively privileged groups. The result is a curious paradox. Although privileged groups are widely regarded as favoring Bush and the Republican Party generally, the very same groups are linked to relatively negative coverage of the Supreme Court decision that made Bush's ascension to office possible. Perhaps newspapers in this instance reflected less the obvious immediacies of political partisanship than long-term concerns with the perceived legitimacy of both presidential elections and Supreme Court proceedings generally. As a result, the community structure approach has illuminated a link between privilege and media reporting previously unexplored or paid little attention in other analyses of media coverage of the Supreme Court decision to halt the counting.

In addition, it was found that the greater the newspaper circulation in a city the more unfavorable the coverage of *Bush vs. Gore*, supporting the access hypothesis. The stakeholder hypothesis also showed significance in regard to the percentage of people who voted Democratic or Republican in the 1996 presidential election with newspaper coverage essentially narrowing voting discretions.

CONCLUSION

A study of 17 hypotheses regarding newspaper coverage of the Supreme Court's decision to stop the counting in *Bush vs. Gore* revealed six significant correlations. The media provided a variety of perspectives on the Supreme Court's decision, but unfavorable perspectives prevailed. Since this issue divided the country along political, economic, and social lines it is important to remember that the repercussions of the decision will continue to affect the population. Specifically, the Supreme Court's image of nonpartisanship has been damaged.

The community structure approach is worthy of attention in exploring controversial events. This approach has proven useful in investigating differences in newspaper reporting in the United States. The community structure approach is a research perspective

that can be easily employed and is readily available. Easy accessibility to newspaper databases, such as Lexis/Nexis and DIALOG, combined with informational directories on census data makes this strategy an efficient research strategy. Further, the accessibility of this method is useful to those who lack the resources to invest in more expensive forms of research, such as surveys, and has the potential to yield far-reaching results.

New perspectives

Although many communications scholars study the media's influence on individual behaviors, the community structure approach permits an investigation of an audience's potential influence on media coverage. The findings of this study amplify the importance of the community structure approach as providing a potentially fresh perspective in communication research (Pollock, Mink, & Puma, 2000). The study primarily found a significant relationship between city characteristics and unfavorable coverage of the Supreme Court's decision to halt the counting in *Bush vs. Gore*. Sampling could be expanded to include a wider representation of cities and periods. In particular, the capacity of the community structure approach yielded results suggesting that privilege can be more important than partisanship. This finding reveals both community and media concern with the long-standing legitimacy of national institutions such as the presidency and the Supreme Court, and suggests that community structure studies can be useful in uncovering a wide range of less obvious links between city demographics and reporting on political and social change.

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Alternatives to Incarceration: A Solution to Skyrocketing Correctional Costs

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ABSTRACT

Tens of billions of dollars are spent annually in the United States to pay for rapidly growing incarceration rates, yet we have not considered less expensive, and more effective, alternatives. "Alternatives to Incarceration: A Solution to Skyrocketing Correctional Costs," explains why incarceration as a primary crime-control strategy is not logical; what citizens look for in offender punishment; and how alternatives to incarceration will save money, while appeasing the public, if they are used instead of incarceration as a means of controlling crime and punishing offenders.

INTRODUCTION

With nearly two million people in American prisons, the incarceration rate in the United States has reached a record high. Directly related to America's spiraling incarceration rate, correctional spending is over \$40 billion a year nationally, and rising.¹ Two explanations for today's growing incarceration rate are 1) police are arresting a larger number of criminals than ever before and 2) felony arrests are more likely to lead to incarceration.² As Joseph Califano explains: "It is not surprising that the expense of building and operating prisons is the 800-pound gorilla in most state budgets. With [correctional] spending rising at a breakneck pace—increasing 28% from 1995 to 1996—incarcerating prisoners is the most rapidly growing expense faced by governors and state legislatures."³ Skyrocketing correctional costs are primarily caused by increasing

incarceration rates. One way to mitigate the rising costs of incarceration is to use alternatives to incarceration.

The crime problem is real, but while prison is one way to punish criminals, it may not always be the best solution.⁴ Before the 1970s, many offenders were placed on probation, in the belief that offenders could be rehabilitated and held accountable for their misdeeds in the community. However, when rehabilitation came under sustained attack in the 1980s, offender treatment was replaced by a strict law-and-order ideology and a widespread belief that offenders should be severely punished.⁵ "No matter what the question has been in American criminal justice over the last generation," observes Franklin E. Zimring, director of the Earl Warren Legal Institute, "prison has been the answer."⁶

As incarceration rates increase, additional prison space is needed and more prisons are built. According to Harry Allen and Clifford Simonsen:

If current punishment trends continue, the nation will need to open a new 1,600-bed prison every week for the next five years and will need to hire 16,000 new correctional officers each year for the next five years.⁷ The \$3 billion required to build just six prisons would be enough resources to hire an additional 53,000 new teachers for California classrooms, send 579,000 young persons to college, or enroll 538,000 children in Headstart programs.⁸

The true cost of incarceration is much greater than actual spending by correctional agencies. Economists estimate that .5% to .7% of gross domestic product is lost by incarcerating

felons who could otherwise be released into the community through alternative sentencing.⁹ However, before proposing a solution to skyrocketing correctional costs, one must understand why additional prisons are being built. The United States now imprisons more people than any other country in the world and incapacitating offenders has become the nation's primary crime-control strategy.¹⁰ Incapacitation, in criminal-justice parlance, means to make offenders incapable of committing a crime. Since some criminals commit multiple offenses, the incapacitation theory assumes that incapacitating offenders will directly lower crime rates.¹¹

Theodore Caplow and Jonathan Simon note that "American incarceration numbers increased fivefold between 1973 and 1997... Changes in penal policies and practices, not changes in crime rates is the primary explanation."¹² Politicians seeking reelection on the "get tough" bandwagon have spearheaded the enactment of a series of acrimonious policies including determinate sentencing, mandatory minimum sentences, and "three-strikes" laws. These policies annually cost \$5.7 billion and add 276,000 new prisoners to our state prisons.^{13,14} Furthermore, the adoption of "get tough" correctional policies coincided with the 1945 to 1976 baby boom, which increased the number of people likely to commit crime and be incarcerated. Allen and Simonsen suggest, "These three forces (a large number of persons at risk to commit crime, the shift to conservative beliefs about how to deal with offenders and crime, and enactment of more stringent punishments) contributed to an ever-increasing stream of offenders being committed to prison."¹⁵ In addition, the expansion of constitutional rights to inmates, ordered by the U. S. Supreme Court in the 1960s and 1970s, requires the building of additional prison space to house an increasing number of inmates. These overcrowded prisons, coupled with the constitutional requirement not to subject inmates to "cruel and unusual punishment," have further increased correctional spending.^{16,17}

If "get tough" correctional policies have seriously exacerbated the prison problem, why then, have politicians chosen to use incarceration as a primary crime-control strategy? The most likely answer is that lawmakers and the public have a false belief that incarcerating offenders deters crime—specifically, to the individual being incarcerated, and generally, to those who might consider a similar act.¹⁸ Deterrence theory may sound logical in an increasingly conservative era, but research does not support a cause-and-effect relationship between incarceration and reductions in crime. According to Allen and Simonsen, as well as many other criminal justice professionals, for punishment to serve as a deterrent it "must be swift, visible to others, closely linked to the forbidden action so that it discourages future recurrences of that crime, certain, and categorical."¹⁹ The current system of criminal justice in the United States is anything but swift, certain, and categorical, and as a result, deterrence-based crime-control strategies do not work. Allen and Simonsen observe that many factors contribute to make punishment the least effective means of reducing crime:

1. The use of punishment for deterrence must avoid the overseverity of application that arouses public sympathy for the offender.
2. Those persons most likely to be imprisoned are already accustomed to experiencing deprivations and frustration of personal goals routinely in daily life.
3. It is impossible to fashion a practical legal "slide rule" that will determine exact degrees of retribution appropriate for a list of crimes ranging from handkerchief theft to murder.
4. The simple application of naked coercion does not guarantee the subjects of its force will alter their behavior to conform to new legal norms or to improve their conformity with norms previously violated.
5. The possibility of deterrence varies with the chances of keeping the particular type of crime secret and consequently of avoiding social reprobation.²⁰

Only 36% of all crimes are reported and far fewer result in arrests and convictions.²¹ Therefore, in addition to Allen's and Simonsen's reasons for prison's inability to deter crime, it is preposterous to assume that the relatively low number of criminals actually incarcerated could deter a much larger number of criminals, or would-be criminals, who have not been caught.

Since deterrence theory has been discredited by both history and reason, social revenge is the only justification for punishing criminals in this fashion.²² The use of incarceration satisfies the collective rage of society, especially crime victims and their families.²³ The rage citizens feel toward criminals is understandable, but should it be the primary basis for public policy? Should Americans "get their pound of flesh" through anti-crime measures that are not justified as effective through scientific evidence? I think not.²⁴

"While there seems to be a great deal of information available on the prevalence of crime in America," writes Katarina Ivanko, "there is very little in the way of understanding, and even less in the way of solutions."²⁵ To prevent the need for prison construction, thus neutralizing correctional spending, crime must be treated as a social problem, similar to drugs, teen pregnancy, dropping out of high school, divorce, unemployment, and AIDS.

The overall incarceration rate in the United States has been increasing since 1967, while the overall crime rate for the United States, between 1967 and 1998, has fluctuated.²⁶ Research data clearly show no correlation between the incarceration rates and the crime rate. Other social problems in the United States, such as unemployment; divorce; teen pregnancy; marijuana, cocaine, and heroin use; and high school dropout rates have been steadily declining since 1967.²⁷ Not only has the U. S. crime rate remained high despite these declines, but one could argue that crime reductions are more closely associated with the larger social factors mentioned above rather than narrow correctional factors.²⁸

Based on a Gallup survey in the United States, the importance of religion in the eyes of Americans has increased since 1987, possibly reinforcing informal controls, such as moral norms or the fear of committing a sin, which deter people from committing crimes.²⁹ In addition, increased high-school graduation rates, community policing, and the rise in minimum wages may have been factors in decreasing crime rates.³⁰ As Katarina Ivanko emphasizes: "Crime is not something that can be eliminated by creating a criminal underclass that is incarcerated and forgotten."³¹

Most citizens want public safety, crime prevention, punishment, and restitution as outcomes of criminal sentences. The best way to achieve the first two of these objectives is to prevent crime. The latter two are reactions by the criminal justice system. If we, as a society, come to view crime as a public-health concern, a public-health model—based on primary, secondary, and tertiary treatments—can be applied to criminal justice. In other words, society could apply cost-effective and efficient crime-control strategies that emphasize primary and secondary crime-prevention policies and practices. For example, a primary strategy for combating lung cancer is to prevent the disease by discouraging people from beginning to smoke. A secondary strategy is to help people stop smoking. Finally, a tertiary treatment for lung cancer involves surgery to remove the infected lung. The same model can be applied to crime. Crime can be prevented through informal controls, such as families, church groups, schools, and peers. Once the disease of criminal behavior infects a criminal, the criminal must be rehabilitated. The last resort to control crime should be incarceration. Tertiary strategies (prison) incur the greatest costs and produce the worst results. As Marc Mauer remarks:

Low-income people with drug problems often have trouble finding suitable drug treatment facilities. Many times, they can't get help before their drug problem turns into a crime problem. If one of my kids had a drug problem, I wouldn't call the police or a prison warden to help him. I would find the best treatment possible, and if it didn't work, I'd find another one.³²

American prisons now hold over 150,000 armed robbers, 125,000 murderers, and 100,000 sex offenders.³³ I do not dispute the need to remove these people from society. However, more than half of all state and federal prison inmates are serving time for non-violent drug or property offenses.³⁴ It is just as much in the interest of public safety to rehabilitate those who can be treated, as it is to keep incorrigibles behind bars. Most convicts will one day be released from prison and return to society. Ignoring these men and women will only ensure recidivism. American prison systems must rehabilitate as many offenders as possible, or society will pay a heavy price.

If the public can live with effective and less costly community-based sanctions such as probation, intensified supervision programs (ISP), house arrest, electric monitoring (EM), drug counseling, and offender rehabilitation, while still punishing the criminal, then America could reduce the need to incarcerate large numbers of offenders and thus the need to build new prisons. According to a public opinion survey conducted by Doble Research Associates, many Americans would actually prefer community-based alternatives to incarceration:

Alabama respondents were frightened by what they saw as an increase in crime. As a result, many were willing to consider sweeping changes in the criminal justice system.³⁵ [However,] Alabamians [did] not want to build more prisons by raising taxes or cutting state spending; these were not seen as solutions to the problem of prison overcrowding.³⁶

It is unlikely that citizens of other states would be less willing than Alabamians to consider alternatives to imprisonment; therefore, the sentiments of Alabamians, in regard to prison alternatives, represent the views of many other citizens in the United States. According to Doble:

When respondents were presented with sentencing options beyond prison and probation, when they were educated about the relative costs of various punishments, they moved away from imprisonment as the preferred punishment for certain classes of offenders. Respondents often felt frustrated when asked to sentence 23 hypothetical offenders with only two

sentencing options, prison and probation. In the pretest, Alabamians said that in 18 of the 23 cases, the offender should be incarcerated. In five of the 23 cases, offenders were judged as deserving probation. In these cases, fewer than one respondent in three favored incarceration. After learning about alternative sentences, most respondents favored incarceration in only four of the original 23 cases. Three of these cases involved violence, and the fourth was a man convicted of selling drugs for the fifth time.³⁷

Alternatives to incarceration are beneficial for several reasons: first, they help judges make the punishment fit the crime; second, alternatives have greater potential to rehabilitate an offender; third, they are less expensive than incarceration; fourth, they are cost-effective; and finally, alternatives appease the victim's desire for punishment.³⁸

The money America pays to incarcerate offenders pays for a cell and punishment. Since alternatives are less expensive, reduce recidivism, punish the criminal, and are gaining public acceptance, America should adopt sentencing alternatives as its primary crime-control strategy. If a new drug reduced death rates by five percent, it would be heralded as a medical breakthrough. However, even though offender rehabilitation can reduce recidivism by 10% to 50%, the public knows little about it.³⁹ Recent public opinion polls reveal broad public support for credible alternatives to incarceration. Why, then, does America keep following present practices? Politicians have to stop using tough but unrealistic rhetoric that has led many Americans to believe incarceration is the only way to prevent crime and reduce recidivism. Alternative sanctions are less expensive than incarceration; more cost-effective; ensure public safety; prevent recidivism; *punish* convicted offenders; and most importantly, will reduce currently skyrocketing correctional spending. Proven alternatives to incarceration are a "miracle drug" to help cure the social disease called crime in America.

NOTES

- ¹Marc Mauer, *Race to Incarcerate* 81 (The New Press 1999).
- ²Harvard Law Review Association, *Development in Law: Alternatives to Incarceration*, 111 Harv. L. Rev. 1875 (1998).
- ³Joseph A. Califano Jr., *A Punishment-Only Prison Policy, America*, Feb. 21, 1998, at 3-5.
- ⁴Harvard, *supra* note 2 at 1875.
- ⁵Harry E. Allen & Clifford E. Simonsen, *Corrections in America* 200 (8th ed., Prentice-Hall 1998).
- ⁶Eric Schlosser, *The Prison-Industrial Complex, The Atlantic Monthly*, Dec. 1998, at 52.
- ⁷Allen & Simonsen, *supra* note 5 at 61.
- ⁸*Id.* at 53.
- ⁹Harvard, *supra* note 2 at 1875.
- ¹⁰*Id.*
- ¹¹Allen & Simonsen, *supra* note 5 at 58.
- ¹²Theodore Caplow & Jonathan Simon, *Understanding Prison Policy and Population Trends in 26 Prisons* 63 (Michael Tonry & Joan Petersilia eds., University of Chicago Press 1999).
- ¹³Allen & Simonsen, *supra* note 5 at 200-201.
- ¹⁴Vincent Schiraldi, *The Undue Influence of California's Prison Guards' Union: California's Correctional-Industrial Complex*, *Center for Juvenile and Criminal Justice: In Brief*, Oct. 1994, at 1.
- ¹⁵Allen & Simonsen, *supra* note 5 at 201.
- ¹⁶*Id.* at 60.
- ¹⁷*Id.* at 144.
- ¹⁸*Id.* at 56.
- ¹⁹*Id.*
- ²⁰*Id.* at 59.
- ²¹Samuel Walker, *The Police in America* 135 (3rd ed., McGraw-Hill 1999).
- ²²Allen & Simonsen, *supra* note 5 at 11.
- ²³*Id.* at 55.
- ²⁴Jody L. Sundt, et al., *The Tenacity of the Rehabilitative Ideal Revisited, Criminal Justice & Behavior*, Dec. 1998, at 426-442.
- ²⁵Katarina Ivanko, *Shifting Gears to Rehabilitation, Corrections Today*, Apr. 1997, at 20-21.
- ²⁶United States Department of Justice, Bureau of Justice Statistics, *Sourcebook of Criminal Justice Statistics* 1998 (GPO: 1999).
- ²⁷*Id.*
- ²⁸See the United States Department of Justice, Bureau of Justice Statistics, *Sourcebook of Criminal Justice Statistics* 1998 for referenced trendlines.
- ²⁹*Id.*
- ³⁰Mauer, *supra* note 1 at 82.
- ³¹Ivanko, *supra* note 26 at 20.
- ³²Eugene Kane, "Opening a New Prison Is Cause for Tears, Not Cheers," *Milwaukee Journal Sentinel*, Oct. 10, 1999, at 3.
- ³³Schlosser, *supra* note 6 at 52, Oct. 10, 1999, at 3.
- ³⁴Mauer, *supra* note 1 at 81.
- ³⁵John Doble & Josh Klein, *Punishing Criminals: The Public's View, An Alabama Survey* 12 (1989).
- ³⁶*Id.* at 23.
- ³⁷*Id.* at 4, 26-32.
- ³⁸*Id.* at 41.
- ³⁹Dr. Mario Pappozzi, personal communication, February (2000).

Effects of Prematurity and Low Birthweight on Speech and Language Development

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ABSTRACT

This investigation explored the effects of prematurity and low birthweight on speech and language development. Two infants born prematurely and with low birthweight were observed at play and while interacting with their primary caregivers and the researchers in their home. The primary caregivers also completed a parent questionnaire and the MacArthur Communicative Development Inventory: Infants. Although the analyses of the inventory and observations revealed two different linguistic profiles, no significant deficits were noted. Clinical implications are presented and suggestions for future research are provided.

INTRODUCTION

The effects of prematurity and birthweight on the development of speech and language skills have been the focus of much research within the past decade and remain a controversial issue. According to the current literature, low birthweight infants, as a group, have more health and developmental problems than normal birthweight infants do, and as the birthweight decreases, the number and severity of the problems increase (Brown, Bendersky, & Chapman, 1986; Santrock, 1997). Yet, Robison & Gonzales (1999) report that results of research demonstrate that developmental outcomes of prematurity may not be observed until the school-age years.

A review of the literature pertaining to the effects of prematurity and birthweight on

speech and language development reveals contradictory results. Some research suggests that delays in language development should be expected, whereas other researchers report that language delays are not any more frequent for premature than for full-term infants (Gallagher & Watkin, 1998). Briscoe, Gathercole, & Marlow (1998) assessed receptive and expressive vocabulary and expressive language ability of pre-term and full-term children between the ages of 3 and 4 years and found that the pre-term children scored lower than the full-term children on all measures. In a study conducted by Luoma, Herrgard, Martikainen, & Ahonen (1998), speech and language comprehension and production were assessed at the age of 5 years in a cohort of children born premature at less than 32 weeks' gestational age in comparison to full-term children with similar age, sex, and social background. Findings indicated that these pre-term children without major neurological disability were slower than full-term children on rapid word retrieval, displayed difficulties in comprehending relative concepts, and also showed subtle signs of dysnomia (difficulty recalling and recognizing names of persons, places, or things).

In contrast, a longitudinal study of 28 premature and 28 full-term children conducted by Menyuk, Liebergott, & Schultz (1995) indicated outcome measures of no significant difference between the two groups in either language comprehension or production. Yet, the premature children were on the whole less than half the average weight at birth of

the full-term children, and had significantly poorer Apgar scores (see Appendix A for a copy of the Apgar scoring chart). Menyuk et al. comment that their study was conducted with relatively healthy premature infants with no accompanying birth defects. They suggest that as long as there are no long-lasting health problems associated with the premature birth, prematurity alone as a biological risk does not negatively affect language development. Furthermore, Stevenson, Roach, Leavitt, Miller, & Chapman (1988) found that pre-term children actually performed better than full-term children on receptive language measures. This could be attributed to Stevenson and colleagues' use of gestationally corrected age instead of chronological age for pre-term children during scoring of assessment measures. Using the gestationally corrected age could result in assessment scores demonstrating an advantage for the pre-term children, since they are being compared to other infants with less extrauterine experience.

An in-depth look at the research revealed the following tendencies. The previously cited researchers who found speech and language delays evident in pre-term and low birth-weight children were those who studied children of preschool age or older, while the researchers who found no significant language delays were those who studied pre-term children at the younger infant and toddler stages. It is possible that older children showed language delays because preschool and school-age children require more advanced and complex language skills to be considered competent speakers. The language assessments for older children appear more comprehensive, allowing for more opportunity to compare the assessment results to a normative population. The assessment measures for infants and toddlers tend to be more subjective in that they rely on parental observation and reporting. Language milestones for infants and toddlers are guidelines rather than definitive boundaries because development, especially during this period, is more of a continuum.

The purpose of this study was to determine if the biological risks associated with pre-term birth and environmental factors contribute to a delay in the language and speech development of premature infants as compared to full-term infants. To ascertain the infants' acquisition of developmental language milestones as compared with normative data, two separate case studies of pre-term infants and personal interviews with their primary caregivers were performed. Evidence drawn from case studies is likely to be more subjective than results from empirical research; therefore, the intent of the study was to make a case for further, more extensive research in this area rather than to focus on generalization of the findings. Furthermore, the study was designed to heighten awareness of the potential language difficulties that could exist in children born prematurely.

For the purpose of this study, several definitions of key terms are provided. The March of Dimes Birth Defects Foundation (1999) defines a pre-term birth as any birth occurring prior to 37 weeks' gestation. Santrock (1997) states that pre-term births occur before 38 weeks' gestation. Robison & Gonzalez (1999) concur that births prior to 38 weeks' gestation are to be classified as pre-term births. Although there are slight discrepancies in the definition for pre-term birth, it is clear that births occurring prior to 37 or 38 weeks' gestation are considered pre-term births. Many infants born pre-term also have low birthweight. According to many sources (Gallagher & Watkin, 1998; March of Dimes Birth Defects Foundation, 1999; Robison & Gonzalez, 1999; Santrock, 1997), a low-birthweight infant is defined as an infant born with a weight of less than 2500 grams (5 lbs. 8 oz.). The definition for very low birthweight varies from less than 1500 grams (3 lbs. 4 oz.) to less than 1800 grams (4 lbs.) (Barrera, Kitching, Cunningham, Doucet, & Rosenbaum, 1991; March of Dimes Birth Defects Foundation, 1999; Menyuk, Libergott, Schultz, Chesnick, & Ferrier, 1991; Robison & Gonzalez, 1999). According to Robison & Gonzalez, extremely

low birthweight refers to a weight of less than 750 grams (1 lb. 10 oz.).

Another key term frequently used in current research is gestationally corrected age. This refers to adjustments that are made to the chronological age to account for the period of time that would normally be considered prenatal development. Therefore, to arrive at the child's gestationally corrected age, the number of weeks premature is subtracted from the child's chronological age (Costarides, Shulman, Trimm, & Brady, 1998).

METHOD

Participants

Two premature, low-birthweight infants, 11 months and 16 months of age, participated in the study. Neither child attended daycare. A more detailed description of the participants follows.

Procedure

Three masters-level graduate students in speech-language pathology observed and videotaped the children individually in their homes for approximately 90 minutes each during three separate observations. Each child was observed separately, then the children were observed together for the third and final observation session to investigate components of peer-peer interaction. During all observations, the participants played with familiar toys in a familiar environment. The observations included interactions with the infants' primary caregiver(s) and with two unfamiliar adults.

The primary caregivers completed a parent questionnaire, which the students developed to document infant speech-language developmental milestones (see Appendix B). The MacArthur Communicative Development Inventory: Infants (CDI) (Fenson et al., 1993), a standardized, norm-referenced assessment, was given to each parent for completion prior to the observation sessions. The parent questionnaire and CDI results, based on the infant observations, were used to assess the children's skills, in comparison to well-established speech and language guidelines for full-term

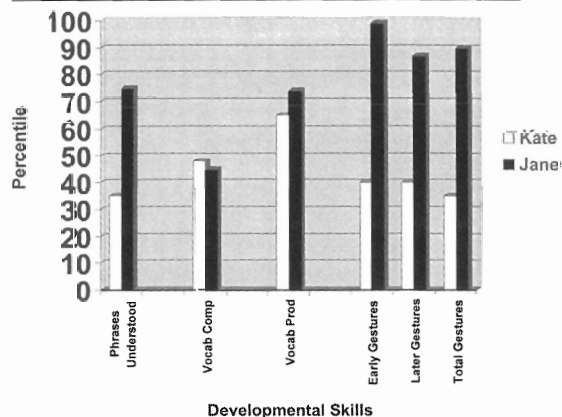
children at the corresponding ages (Shipley & McAfee, 1998, pp. 32-34).

Child #1 with History of Prematurity and Low Birthweight

Kate (a pseudonym) was 11-months old when her mother completed the case history questionnaire. Her mother reported that Kate was born at 34-1/2 weeks' gestation (pre-term), with a birthweight of 5 lbs. 3 oz., or 2353 grams (low birthweight). Her mother also reported that Kate's Apgar score was less than 7. Kate's mother stated that Kate's condition post-birth was "generally very healthy," however she was jaundiced for two days. Her general health to date is considered good. Her mother reported that Kate had a cold at 11 months. Despite adequate prenatal care, maternal anorexia prior to the pregnancy and during the first trimester as well as maternal smoking during the first trimester was reported. Family members in the household include Kate's mother and father, maternal grandmother, grandfather, aunt, uncle, and uncle's girlfriend. Kate spends most of her time with her grandmother. Kate does not have any siblings.

Developmentally, Kate's mother reported that she was able to sit without support at 4 1/2 months, crawl at 8 1/2 months, and stand at 10 months old. Kate first smiled when spoken to at 2 months, first responded to her name at 8 months and first responded to "no" at 8 months old. She began babbling using consonant-vowel syllables at 9 months old. Her first word, as reported by her mother, was "doggie," produced at 10 months of age.

Table 1: Summary of MacArthur Communicative Development Inventory: Infants



Child #2 with History of Prematurity and Low Birthweight

Jane (a pseudonym) was 16 months old when her adoptive mother completed the case history questionnaire. Per the parent questionnaire, Jane was adopted at birth and born at 7 months' gestation (approximately 29 weeks' gestation), which, according to the literature, classifies her birth as pre-term. She was born with a weight of 3 pounds (1275 grams), which is very low birthweight according to the previously stated definitions. Jane's scores for the one-minute and five-minute Apgar tests were 3 and 7, respectively. According to Jane's mother, Jane's general condition post-birth was "pretty good considering the situation; low birthweight [was the] only concern before [being] discharged from [the] hospital." Remarkable conditions that may have affected the pregnancy include drug use by her birth mother and no prenatal care. Jane's mother revealed that Jane had two colds, one at 4 months and one at 16 months. She also had an ear infection at 13 months.

Jane lives with her mother, father, and 2-1/2-year-old sister and spends the majority of her time with her mother, who is a full-time homemaker. Developmentally, Jane's mother reported that she learned to sit without support by 10 months, crawl at 10 months, stand at 12 months, and walk at 12-1/2 months. Jane first smiled when spoken to at 5 to 6 months, first responded to her name at 7 to 8 months and first responded to "no" at 10 to 12 months old. She began babbling using consonant-vowel syllables at 8 to 9 months old. Her mother reported that her first word, "daddy," was produced at 11 to 12 months old. According to her mother, at the time of the observation, Jane was naming simple objects, for example, shoe, dog, and apple, and combining words.

RESULTS

On the MacArthur CDI, Kate scored at the 35th percentile in the Understanding Phrases (e.g., "Do you want more?") subsection, a measure of receptive language ability. In the

Vocabulary Checklist subsection, receptive language was measured at the word level, with Kate scoring at the 48th percentile. Expressive language at the word level was measured as well, and Kate scored at the 65th percentile for her age group. She scored at the 35th percentile in the Actions and Gestures subsection, which assesses early communicative gestures, such as games and routines, actions with objects, and imitating other adult actions (see Table 1 for Kate's MacArthur Communicative Development Inventory results).

During the observations of Kate, attempts were made to determine whether she had reached the major developmental milestones of speech and language commensurate with the chronological age expectations of her full-term infant peers. Although variability in individual development is to be expected, observations of Kate revealed that she used very few vocalizations. Instead, she relied heavily on crying to express wants and needs, as opposed to using more sounds and gestures to indicate those wants or to get attention. This observation correlated well with Kate's 35th percentile ranking in the CDI's Total Gestures subsection. Moreover, babbling was not evidenced during the two observation sessions; however, this could be attributable to many factors, such as fatigue or wariness of strangers. Kate was very comfortable with gesturing "bye-bye," however, and did participate actively with the caregiver during this shared social routine. Kate was observed to look at a familiar person upon command. Yet, she did not point, volitionally or upon command, to familiar people or objects, such as her aunt, father, or the family dog, nor was she responsive to simple requests, such as "Clap your hands" or "Do you want to get down?" These are some expected milestones for her age as reported by Shipley and McAfee (1998). Moreover, Kate did not respond with any vocalizations to questions, such as "Do you want this cracker?" Instead, she simply reached for the cracker and/or cried. Kate demonstrated communicative

intent by repeatedly reaching for and manipulating objects to get what she wanted.

Jane displayed a different profile on the MacArthur CDI. Jane scored at the 75th percentile and 45th percentile for phrases understood and words understood, respectively (the receptive language measures). The expressive language measure, which involved production of words, placed Jane at the 74th percentile. In the Actions and Gestures subsection, she scored at the 90th percentile. The observation of Jane indicated that she had reached most, if not all, of the developmental speech and language milestones expected for full-term infants of the same chronological age. Although her repertoire still included earlier developing skills, such as vocal play and some babble, her speech generally reflected adult-like patterns of intonation. She predominantly used a combination of speech sounds, words, and gestures to communicate her intentions, wants, and needs. Jane responded to and followed simple commands from her mother (e.g., "Go get your sister."). She was able to imitate adult behavior (e.g., telling her father "No, no, no."). Jane was also able to respond to simple questions (e.g., "What does the snake say?") The expected response is "sssss.") (See Table 1 for Jane's MacArthur Communicative Development Inventory results.)

Because of the preponderance of egocentric play and limited interaction between the infants, there was insufficient data for analyzing peer-peer interaction during the final observation session.

DISCUSSION

The literature review, data gathering, and analysis phases of the current study revealed a high degree of variability and inconsistency in the terminology used for the classification of low-birthweight status and prematurity, use or non-use of gestationally corrected age, and outcomes of previous research. These differences created a unique challenge in comparing the findings of this study to the documented research.

Results of the current study reflect two different linguistic profiles for the two participants. Kate demonstrated a possible delay in language acquisition. On the other hand, Jane appeared to demonstrate age-appropriate language skills. These results should be interpreted with caution because research to date has shown that assessment measures such as the CDI, observations, and parent questionnaires are limited in predictive ability. These measures are usually criterion-referenced with a broad range of acceptable performance (Robison & Gonzales, 1999). Furthermore, according to Bloom (as cited in Brown, Bendersky, & Chapman, 1986), "the areas of content, form, and use of language cannot be predicted from antecedents found in the vocal behaviors of the first year of life; but these behaviors do reveal the integrity within the cognitive, motor, and auditory systems which are themselves predictors of potential for future skills" (p. 317).

The authors expected to see salient delays in Jane's language skills as a result of her preterm and very low-birthweight status, poor maternal prenatal care, and maternal drug use. However, these delays were not evidenced. These observers note that this may be a result of Jane's adoptive family providing her with much support for language acquisition despite the severity of biological risks. This is consistent with current research indicating that the sensitivity of premature, low-birthweight infants to the effects of enriched environment and responsive parenting can compensate for initial biological risks (Censullo, 1994; Stevenson et al., 1988). In Kate's situation, the home environment interactions were both adult-centered and child-centered, at times more enriching than at others, depending on which family member was watching her. This inconsistency in communicative interactions may possibly be a contributing factor in Kate's delayed achievement of expected language milestones, as reported by these observers.

It is reasonable to conclude that, given the contradictory research findings in the literature and previously discussed infant

observations, there is not enough consistent evidence that prematurity or birthweight alone negatively influences speech and language development. As stated above, some studies found that children born pre-term with low birthweight did show language delay, whereas other studies found no significant delay. The discrepancies in these findings could possibly be explained by different methodologies used by the different researchers; studies differ in the composition of comparison groups, the criteria used for selecting subjects, the different assessment instruments used, and the criteria employed for defining low birthweight. Future research should be more consistent with regard to the aforementioned factors.

CLINICAL IMPLICATIONS

The research on pre-term and low-birthweight children has concentrated on the preschool ages and older children; there is a dearth of information on communication development in infants with prematurity and low birthweight. At the present time, it is "premature" to assume that children born prematurely with low birthweight will eventually exhibit speech and language delays.

The clinical implications are that pre-term and low-birthweight infants should be monitored closely for their development of communicative intent and speech and language during their scheduled well-baby checkups for possible speech and language delays. However, it should be noted that if there are delays, they might not surface until the school-age years, concomitantly with the increased language demands of the curriculum.

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APPENDIX A. Apgar Scoring

The Apgar Scoring Chart			
Sign	Score 0	Score 1	Score 2
1. Heart Rate	Absent	Below 100 beats/minute	Over 100 beats/minute
2. Breathing Effort	Absent	Slow, irregular	Good, crying lustily
3. Muscle Tone	Limp	Some bending of arms, legs	Active motion
4. Reflex irritability	No response	Cries, some motion	Vigorous cry
5. Color	Blue, pale	Pink body; blue hands	Completely pink

APPENDIX B: Infant Case History Questionnaire

Infant's Name: _____ Date of Birth: _____
 Address: _____ Phone: _____
 City, State, Zip: _____
 Mother's Name & Age: _____ Father's Name & Age: _____
 Mother's Occupation: _____ Father's Occupation: _____
 List infant's brothers/sisters: _____ With whom does infant live?
 (include names and ages) _____

With whom does infant spend most of his/her time? _____
 What is infant's primary language? _____
 How does infant usually communicate (gestures, words, etc.)? _____
 How does infant interact with others? _____

Prenatal and Birth History

Describe mother's general health during pregnancy (illnesses, accidents, medications, etc.): _____
 Length of pregnancy: _____ Type of Delivery (circle one):
 Length of labor: _____ head first feet first breech Caesarian
 Birthweight: _____
 APGAR score: _____
 Describe general condition of infant post-birth: _____

Describe any unusual conditions that may have affected the pregnancy or birth: _____

Medical History

Provide the approximate ages at which infant suffered the following illnesses and conditions:

Allergies _____ Asthma _____ Chicken Pox _____
 Colds _____ Convulsions _____ Croup _____
 Dizziness _____ Draining Ear _____ Ear Infections _____
 Encephalitis _____ German Measles _____ Headaches _____
 High Fever _____ Influenza _____ Mastoiditis _____
 Measles _____ Meningitis _____ Mumps _____
 Pneumonia _____ Seizures _____ Sinusitis _____
 Tinnitus _____ Tonsillitis _____ Other _____

Has infant had any surgeries? If yes, what type and when? _____

Describe any major accidents or hospitalizations: _____

Is infant taking any medications? If yes, identify: _____

Developmental History

Please provide the approximate age at which infant began to do the following:

Crawl: _____ Sit without support: _____ Stand: _____ Walk: _____

Please provide the approximate age at which infant began to do the following:

Turn head to look in direction of sound: _____
 Smile when spoken to: _____
 Respond to name: _____
 Respond to "No": _____
 Babble using consonant-vowel syllables (ba, da, ga): _____
 Use single words (e.g., no, mom, doggie, etc.): _____
 Combine words (e.g., me go, daddy shoe, etc.): _____
 Name simple objects (e.g., dog, car, tree, etc.): _____

Are there or have there ever been any feeding problems (e.g., problems with sucking, swallowing, drooling, chewing, etc.)? If yes, describe: _____

Describe infant's response to sound (e.g., responds to all sounds, responds to loud sounds only, inconsistently responds to sounds, etc.): _____

Person completing form: _____
 Relationship to infant: _____
 Signed: _____ Date: _____

Adapted from Shipley, K. G. & McAfee, J. G. (1998). Assessment in Speech-Language Pathology: A Resource Manual. San Diego: Singular.

The Relationship between Toy-Playing Skill and Spatial Ability

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ABSTRACT

This study examines the relationship between toy-playing skill (using Legos™) and spatial ability. It also investigates the relationship between children's reported levels of liking and time spent playing with toys and related activities and their spatial ability. This study expands upon an earlier study done by Brosnan (1998) in which a verbal game was added to serve as a control task to rule out the possibility that children with high general intelligence simply perform well on all tasks including spatial-ability measures and in Lego™ play. No significant sex differences were found for the scores on the spatial measures for this sample. Males' Lego™ performance was found to be predictive of their performance on spatial measures; however, this was not found for females. Lastly, correlations were found between reported toy-playing frequency and liking and spatial ability within sex, but not for the sample as a whole.

INTRODUCTION

Spatial ability has been studied by psychologists for decades (e.g., Sherman, 1967; Maccoby & Jacklin, 1974; Linn & Petersen, 1985; Baenninger & Newcombe, 1989; Levine et al., 1999). Linn and Petersen define spatial ability as the "skill in representing, transforming, generating, and recalling symbolic, non-linguistic information" (p.1482). It is composed of many processes and can be studied through a variety of tasks and measures (Linn & Petersen, 1985). Since spatial

ability is a broad topic of study, researchers tend to focus on one or two processes. Linn and Petersen (1985) divided spatial ability into three areas of focus: mental rotation, spatial perception, and spatial visualization.

Mental rotation is defined as the "ability to rotate a two- or three-dimensional figure rapidly and accurately" (Linn & Petersen, 1985, p. 1483). Shephard and Cooper (1982) explain mental rotation as a Gestalt-like, analogue process and that a subject's reaction time for a mental-rotation problem will be related to the amount of time the item must be rotated in order to complete the problem (Shephard & Cooper, 1982). According to Cooper (1983), individuals must rely on strategies when completing mental-rotation tasks. These strategies vary between individuals and may include visually rotating the object in their minds or rotating parts of the object. Individuals may need to adjust their strategy choices depending on the specific problem because the strategies, which solve simple problems, may not work as well for complex problems (Linn & Petersen, 1985).

Spatial visualization is the second category of spatial ability defined by Linn and Petersen (1985). These tasks are typically complex and involve multi-step manipulations of spatial information. Examples of spatial-visualization tasks are the problems found in the Differential Aptitude Test (spatial relations subtest). Subjects are shown patterns and asked to choose the one figure from among five figures that can be created by folding the pattern. Some spatial-visualization tasks overlap with

spatial-perception and mental-rotation tasks but they are placed in a separate category because of their complexity. The last category of spatial ability is spatial perception, which is commonly measured with tests such as the Rod and Frame Test. These tasks require subjects to "determine spatial relationships with respect to the orientation of their own bodies, in spite of distracting information" (Linn & Petersen, 1985, p.1482).

The existence of sex differences in spatial ability has been a heavily researched area (Maccoby & Jacklin, 1974; Baenninger & Newcombe, 1989; Caplan, MacPherson, & Tobin, 1985) for which ample support has been found (Linn & Petersen, 1985; Baenninger & Newcombe, 1989; Voyer et al., 1995; cf. Caplan et al., 1985). Through their meta-analysis, Linn and Petersen (1985) reported significant sex differences in mental-rotation and spatial-perception tasks, both favoring males.

McGuinness & Morley (1991) had children complete a two-dimensional puzzle as well as a three-dimensional model using Lego™ blocks. No sex differences emerged with the two-dimensional task; however, a main effect for sex was found in the speed of completion of the three-dimensional task. Boys were significantly faster at building the Lego™ model, a task that requires visuo-spatial ability (McGuinness & Morley, 1991). Kerns and Berenbaum (1991) found similar results with children aged 9 through 12. In their study, boys performed at higher levels than girls on all of the spatial tasks, with significant sex differences found with the three-dimensional mental-rotations task.

For the many researchers who support the existence of sex differences in spatial ability, there are conflicting ideas about the age at which these differences become apparent as well as questions about the nature and magnitude of the differences (Linn & Petersen, 1985). Some researchers have demonstrated the existence of sex differences in spatial ability in children as young as four- and five-years old (e.g., Levine et al., 1999;

McGuinness & Morley, 1991). Others have found support for a male advantage in spatial ability beginning between the ages of 8 and 12 and continuing through middle adulthood (Kraft & Nickel, 1995). Various theories have been proposed to explain the presence of sex differences at differing ages (Linn & Petersen, 1985). One theory is that spatial ability is genetically determined and therefore is present at birth. The theory is referred to as the X-linked recessive gene hypothesis (Gitler & Vitouch, 1994). This theory may help to explain the presence of sex differences emerging at very young ages. Another theory is that puberty plays a role in the emergence of sex differences in spatial ability. In 1978, Harris proposed that hormonal changes occurring in puberty affect the spatial ability in males and females resulting in sex differences (Caplan et al., 1985).

While some theorists rely on biological and genetic explanations (Harris, 1978; Gittler & Vitouch, 1994), others believe that experience and environment play an important role in sex differences in spatial ability (Baenninger & Newcombe, 1989; 1995). Evidence has been found illustrating that boys are encouraged from a young age to play with toys that require spatial manipulation and creativity such as Legos™, Erector™ sets, and blocks. It has also been found that boys tend to play more frequently with toys that are mathematical in nature (Baenninger & Newcombe, 1989). These toys "provide users with concrete experiences in the manipulation of objects and patterns, construction, and movement through space" (Tracy, 1987, 127). As a result, children's toy choices and play experiences may help explain the sex differences found in spatial ability. As Sherman (1974) hypothesized, frequent exposure to activities such as these should result in better spatial ability for both sexes. Consequently, both boys and girls should be encouraged to play with all types of toys including those that are spatial in nature.

Researchers have focused in various studies on this proposed relationship between

toys and activities that enhance spatial ability and the sex of the individuals engaging in these activities (Serbin, 1979; Tracy, 1987, 1990). However, it may not be just the spatial quality of the activity or toy, but the intersection of sex-typing with spatial quality that fosters sex differences in spatial ability (Baenninger & Newcombe, 1989). Serbin and Connor (1979) found evidence that when children of both sexes play with toys labeled "boy's toys," there is a relationship between their play and the development of spatial, not verbal, skills. They found the opposite to be true for children playing with "girl's toys." Some theorists believe that females may develop a practice deficit in spatial skills because of less frequent exposure to and experience with "boy's toys" (Serbin & Connor, 1979). This deficit may manifest itself in more pronounced sex differences in spatial abilities.

Over the past years, sex differences in spatial ability have been found to be decreasing in magnitude (Feingold, 1988). One explanation may be the change in children's activities that has occurred over time and/or the decrease in the importance of choosing sex-typed activities (Baenninger & Newcombe, 1989). Although a decrease in the magnitude of sex differences has been found, it is important to continue this area of study because "clarification of sex differences in spatial ability has implications for areas such as science and mathematics education" (Baenninger & Newcombe, 1989, 1480). For example, Tracy (1990) found significant differences in the science achievement of students depending on their level of spatial ability. Higher spatial ability was correlated with higher science achievement.

This study will examine the relationship between toy-playing skill and spatial ability using Lego™ blocks, in which spatial ability is measured using a mental-rotation task and an embedded-figures task. Most previous studies regarding this relationship involve measurement of the amount of time spent and the number of activities engaged in (or

toys played with), and correlated these data with spatial-ability scores. This does not allow the researcher to determine whether or not a subject's spatial ability improves because of toy play, or whether those with high levels of skill simply choose spatial activities more often than those individuals with low levels of skill. The frequency of play with certain toys may not be the best indicator of spatial ability; rather, it may be the skill with which the children play that actually affects their spatial-ability scores. Thus, the present study, while still correlational in nature, will extend previous research by correlating a subject's toy-playing skill with his/her spatial-ability score as well as correlate a subject's toy-playing frequency and his/her spatial-ability score.

Only one previous study could be found which actually examined the relationship between toy-playing skill and spatial ability (Brosnan, 1998). The author showed that children of both sexes who showed high levels of skill in Lego™ building also performed very well on a test of spatial ability. Brosnan (1998) found that female subjects reported playing with Legos™ more often than male subjects; however, this conflicts with information Brosnan (1998) had gathered from the Lego™ company which stated that "in 1996 Lego™ UK reported that 88% of their Lego™ blocks were sold for use by boys" (20).

There were two problems with Brosnan's study. First, there was no control task. It may simply be that children with high general intelligence do well on all tasks, two of which happen to be Lego™ building and spatial tests. A control task, such as a verbal game, needs to be added to the protocol to rule out this possibility. Thus, if the correlation is a result of specific skills in spatial ability, and not general intelligence, scores on the verbal game should not be correlated with scores on a spatial measure (or with scores on Lego™ building, for that matter). The second problem with Brosnan's 1998 study was that there was no measure of spatial activity preference or degree of time spent in spatial play. In this

way, the study suffered from the opposite problem of earlier studies; it measured play skill without accounting for frequency of spatial activity. The present study is designed to correct these problems.

Specifically, it is hypothesized in the present study that the children who report higher levels of spatial toy-playing frequency and liking (e.g., building and construction, models, puzzles) will score higher on spatial-ability measures. It is also expected that boys will report playing with Legos™ and other related spatial toys more often than girls and as a result will score higher on the spatial-ability measures. However, sex differences should be mediated by the amount of spatial play in which the children engage. Lastly, it is hypothesized that Lego™ skill will be positively correlated with spatial performance.

METHODS

Participants

Eighty-four children, 46 males and 38 females, were recruited from two parochial schools in northern New Jersey. Forty-eight children were in third grade, 14 in fourth grade, and 22 in fifth grade. They ranged in age from 8 to 11, with a mean age of 9.2. Students' teachers agreed to participate. Consent forms for the students were sent home to the children's guardians and returned with a signature before the study began.

MATERIALS

Group Embedded Figures Test: The test contains a total of 25 problems divided into three sections. The subjects are given two minutes to complete the seven problems in the first section, five minutes to complete the nine problems in the second section, and five minutes to complete the nine problems in the third section. The subjects are instructed to stop at the end of each section and not to return to any previous sections if they have any extra time. This test has been found to be reliable, showing sex differences in which males perform slightly but significantly better than females.

Each problem involves an illustration of a complex figure within which the subject is required to find a simple figure. A group of simple figures are found on the last page of the booklet and alphabetically labeled. Each complex figure has a letter underneath, which represents the simple figure, which can be found within the complex figure.

The subject was given one point for every problem that he/she answered correctly in the second and third sections. The questions in the first section were not counted in the final score. Two final scores were given for each subject, a true score and a liberal score. True scores were based on the answer key provided with the test. The liberal score was based on the author's judgment and answers were marked correct if the subject seemed to have found the object but made a mistake tracing correctly.

Mental-Rotations Test: This test consists of 42 problems, each of which shows pictures of two objects. The subject has to decide whether or not the objects are the same objects viewed from different angles or different objects. If the objects are different, no matter how they are rotated, the objects will never match. Before completing the test, the subjects are asked to complete ten practice problems, which the researcher explains in order to enhance the subjects' understanding of the task.

The subjects are given four minutes to complete as many problems as possible. At the end of two minutes, they are asked to make a mark under the problem they are working on and then to continue for another four minutes. At the end of the eight minutes, the subjects who are not finished are asked to make a mark under the problem on which they are working. If necessary, the subjects are allowed to work for an additional four minutes.

A subject's score was calculated by subtracting the number of problems he/she answered incorrectly from the total number of problems the subject completed within the allotted time. A score was calculated for a subject's performance within the first period of four minutes and the second period of four minutes.

Modified Tracy Toy and Play Inventory: This measure consists of 69 toys and activities. For each toy or activity, the subject is asked to rate how frequently he/she plays with it and how much he/she likes the toy or activity. In order to rate the frequency of play, the subjects mark their answers on a rating scale of three different-sized clocks—small, medium, and large. In order to rate the subjects' liking of a toy or activity, they are asked to use a rating scale of faces, ranging from a happy face to a sad face.

Word Game: The verbal task is a modified version of a word game found in a children's game book (Maleska, 1992). In order to complete the task, the children have to answer 15 clues by using words found in the provided word bank. Each clue is numbered and has a corresponding spot in a puzzle that is found next to the clues. The participant has to determine the correct answer for each clue and then write the answer on the appropriate line in the puzzle. After completion, the participant has to determine which words rhyme with the word *dark*. All of the puzzle pieces that contain words that rhyme with *dark* are colored in and together they create an image of a shark. To score the verbal game, each participant was given a point for each correct answer placed on the appropriate line in the puzzle (a maximum of 15 points). Then the participant was awarded a point for each of the puzzle pieces he/she correctly colored (maximum of 5 points). The two scores were added together for a final score (a maximum of 20 points).

Lego™ Task: This task was taken from a commercial Lego™ book, *Lego™ Modelers: Animals* (1999). The giraffe was chosen because of the spatial abilities required to build the animal and the skill required properly to align the giraffe's head and feet on its body. Also, the authors felt that the giraffe looked the most realistic and would reduce the amount of confusion for the children. The Lego™ company was contacted for the necessary elements for construction of the giraffe and they graciously assisted the research effort.

To score the participants' performance on the Lego™ task, the author first determined whether or not the giraffe's head was positioned in the proper direction. Next, the number of piece errors was calculated. A piece error was defined as any time the participant used an incorrect piece, incorrectly colored a piece, placed the piece in the wrong direction or simply placed it incorrectly, or if the piece was missing entirely from the giraffe. Lastly, the number of level errors was calculated. A level error was defined as any time the participant added or did not include a level of pieces, added extra pieces on a particular level, or used the correct pieces for the level but reversed the order in which they belonged.

PROCEDURE

Children were tested in mixed sex groups in a classroom during school hours. The author, who was trained in the procedure, administered the tests to the children. First, the children were given an informed consent form, which was read to them. They were told that their guardians had already signed a form, but that we wanted them to agree to participate as well. Each group of children was then given either the Embedded Figures Test or the Mental-Rotations Test. The author read and explained the directions for each test and answered any questions. The author then explained sample problems to the children to make sure that they all understood the directions.

The children then completed the task within the appropriate times allotted for each section of the measures. After completion, the children filled out the Modified Tracy Toy and Play Inventory. The author explained the directions and helped the children read the list of toys and activities. Following the completion of the Toy and Play Inventory, the children were given either the Embedded Figures Test or the Mental-Rotations Test depending on which they had taken earlier. At the end of the administration of the tests, the children were given a small school supply to thank them for participating in the study.

On a separate day, children were asked to complete the Lego™ task and the word game. Half of the children completed the Lego™ task first and half of the children completed the word game first. For the Lego™ task, the children were given step-by-step directions and more pieces than are necessary to build the giraffe. They were instructed to use the exact pieces specified in the directions, without making any substitutions or changes. The children were timed and stopped after 20 minutes if they had not already completed the giraffe. For the word game, the children were each given a crayon and the author explained the directions. The children were timed and stopped after 20 minutes if they had not already completed the game. At the end of the two tasks, the children received another school supply to thank them for their participation in the study.

RESULTS

Item six (Tinker Toys™) on the *Modified Toy and Play Inventory* was dropped from the analysis because of the high number of subjects who did not provide a response. Higher means were found for female subjects on 40 of the 68 toys or activities, when scored for how much they liked the toy or activity, and on 37 of the 68 toys or activities, when scored for the amount of time which they played with the toys or activities. Higher means were found for male subjects on 28 of the 68 toys or activities, when scored for how much they liked the toy or activity, and on 31 of the 68 toys or activities, when scored for the amount of time they played with the toys or activities.

The 68 items on the *Modified Toy and Play Inventory* were divided into 10 categories (see Table 1). An inter-rater reliability score of 96% was achieved for the categorization of the activities.

Table 1. Aggregated Categories of Toys/Activities from the Modified Tracy Toy and Play Inventory.

Group Sports	Individual Sports	Make-Believe	Arts and Crafts	Science
Ping Pong	Yard Darts	Toy Tea Sets	Stickers	Electric Race Cars
Soccer	Boomerang	Toy Kitchen Sets	Magnetic Boards	Electric Train Sets
Basketball	Marbles	Toy Cars	Chalkboard	Telescopes
Tetherball	Golf	Dress Up	Spirograph™	Chemistry Sets
Tennis	Bowling	Toy Farm Sets	Playdoh™	Rocket Sets
Kickball	Baton Twirling	Toy City Sets		Electrical Sets
Pool/Billiards	Ice Skating	Toy Zoo Sets		Science Sets
Croquet	Skateboarding	Toy Cash Registers		
Horseshoes	Jump Rope	Playing Store		
Volleyball	Pogo Stick	Toy Picnic Sets		
Frisbee	Swinging	Toy Gas Stations		
Badminton	Skiing	Housecleaning Sets		
Baseball	Canoeing	Dollhouses		
Football	Stiltwalking	Doctor/Nurse Kits		
Row Boats				
Building Erector™	Models Airplane Models	Puzzles Jigsaw Puzzles	Ride-On/Wheeled Big Wheels™	Video Games
K'NEX™	Model Cars	Rubick's Cube™	Bicycle	Video Games
Blocks	Ship/Boat Models		Wagon	
Legos™				

Levine's test for equality of variance demonstrated the existence of great variability in the distribution of spatial scores. Male scores were bimodally distributed, whereas female scores were normally distributed (see Figure 1 and Figure 2).

Figure 1. Distribution of Male Scores on the Mental-Rotations Test

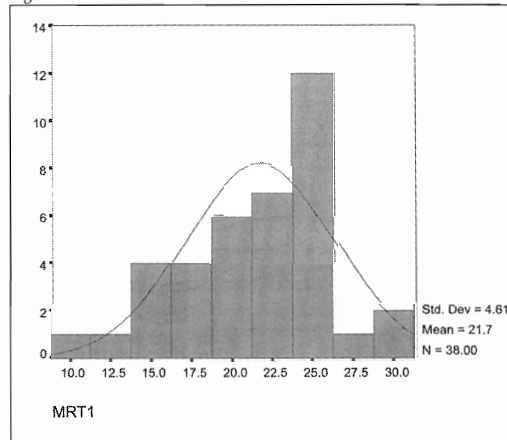
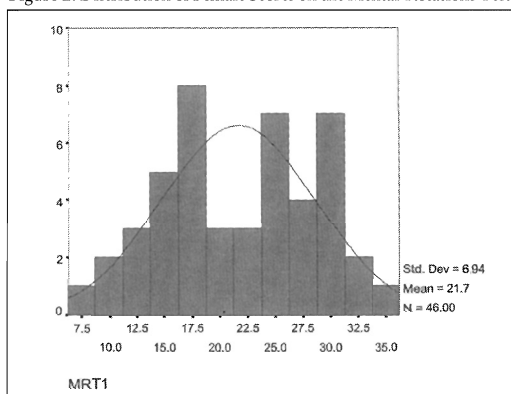


Figure 2. Distribution of Female Scores on the Mental-Rotations Test



T-tests were performed for both sexes' reported frequency and liking of the aggregated toys or activities resulting in significant differences (see Table 2). In a replication of Brosnan's 1999 findings, no differences were found between the amount of time and liking boys and girls reported for Legos™.

Table 2. Significant Sex Differences Found in the Frequency of Time Spent Playing with Toys/Activities within Categories and the Amount of Liking Reported for the Toys/Activities within Categories

Category	Sex	Mean	t	df	Sig.
Time spent with Arts and Crafts	male	8.63	-2.207	82	.030*
	female	9.87			
Time spent in Individual Sports	male	25.34	-2.043	82	.044*
	female	28.24			
Time spent in Make-Believe	male	18.35	-3.741	60.82	.000**
	female	24.05			
Liking of Arts and Crafts	male	9.78	-3.161	82	.002*
	female	11.45			
Liking of Models	male	6.87	2.988	82	.004*
	female	5.45			
Liking of Individual Sports	male	29.1	-2.103	82	.039*
	female	31.89			
Liking of Make-Believe	male	19.39	-3.549	81	.001**
	female	28.30			

* $p < .05$, ** $p < .001$

T-tests were performed for both sexes' scores on the spatial measures and for Lego™ task performance (error scores). No significant sex differences were found on the spatial measures. Significant sex differences were found for Lego™ piece errors ($t = -2.383$, $p < .05$), such that boys (mean = 4.59, $s.d. = 5.35$) made fewer piece errors than girls (mean = 8.42, $s.d. = 6.27$).

Correlations between the samples' scores on the spatial measures (MRT, Embedded Figures Test) and the responses on the Modified Toy and Play Inventory yielded three significant

findings. Significant correlations were found between true scores on the Embedded Figures Test and the amount of liking subjects reported for individual sports ($r = .271$, $p < .05$), and between the liberal scores on the Embedded Figures Test and the amount of liking subjects reported for individual sports ($r = .262$, $p < .05$). A significant negative correlation was found between scores on the MRT and the amount of liking subjects reported for group sports ($r = -.361$, $p < .001$).

Significant correlations were found between the true scores of males on the Embedded Figures Test and the amount of time they spent playing with building/construction toys ($r = .381$, $p < .05$). Significant correlations were also found between the liberal scores of males on the Embedded Figures Test and the amount of time spent playing with models ($r = .336$, $p < .05$) and building/construction toys ($r = .377$, $p < .05$). Significant correlations for females were found between the scores on the Mental-Rotations Test and the time they spent playing with science/electrical toys ($r = .347$, $p < .05$) and the time they spent playing individual sports ($r = .322$, $p < .05$).

Correlations between Lego™ task scores (specifically the Lego™ error scores) and spatial-abilities scores were performed. Significant correlations were found between males' Lego™ piece-error scores and their liberal and true scores on the Embedded Figures Test ($r = -.356$, $p < .05$; $r = -.368$, $p < .05$). Correlations were performed between Lego™ piece errors and the time spent performing the aggregated Toy and Play Inventory activities. No significant results were found.

A 2 x 2 factorial Analysis of Variance was conducted with Embedded Figures Test scores as the dependent variable, and sex and correct positioning of the giraffe head on the Lego™ task as the independent variables. A statistically significant main effect for head positioning was found ($F = 6.351$, $p = .015$). Both females and males who correctly positioned the head of the giraffe scored higher on the Embedded Figures Test.

There was very little variability within the scores from the word game with most participants scoring the maximum number of points. As a result, the game did not serve as the control task as the author had intended.

DISCUSSION

It was hypothesized that Lego™ skill would be positively correlated with spatial performance. Some support was found for this hypothesis. Both males and females who correctly positioned the giraffe's head on its body were found to have higher scores on the Embedded Figures Test. This task was considered to be a good measure of Lego™ skill because when correctly positioned, the head of the giraffe was oriented in a different direction from the legs and feet. It was also found that males' Lego™ performance was predictive of their performance on spatial measures. This may support the idea that males can like and/or frequently engage in or play with spatial activities or toys and not show improvement in their spatial ability, unless they are playing with skill. However, the males in this sample might also be very intelligent and as a result scored highly on the spatial measures and exhibited a high level of Lego™ skill. Since the verbal task used in this study did not act as a control task, this finding cannot be definitively explained. Moreover, this finding cannot be applied to females since the results were not significant for this study's sample.

This study also hypothesized that the children who reported higher levels of toy-playing frequency and liking would score higher on the spatial-ability measures. It was expected that boys would report playing with Legos™ and other related spatial toys more often than girls and, as a result, would score higher on the spatial-ability measures. However, boys and girls exhibited no differences in reported Lego™-play frequency or liking, or in spatial abilities. This may be explained by the fact that the distributions of Mental-Rotations scores for the males and females were dramatically different. As a

result, it can be assumed that they are not from the same population. Also, these findings may simply support Feingold's (1988) conclusion that cognitive gender differences are disappearing. Various social and academic influences may be serving to even out the playing field in the area of spatial ability. For example, some schools now have math curricula which involve some spatial training. As evidenced by many studies, there is a positive relationship between training and spatial-ability scores (Baenninger & Newcombe, 1995). If both male and female children are receiving the same spatial training, it is possible that sex differences are disappearing.

Interestingly, significant sex differences were found between toy-playing frequency and liking and spatial ability, which may mean that different toys and activities foster spatial ability in girls and boys. It may not be important to have all children engage in the same type of toy playing in order to increase their spatial performance. Rather, children may need to be encouraged to play with the toys and activities with which the high-scoring members of their own sex are frequently engaged. Toys, other than ones that have historically been labeled as spatial toys, may also encourage spatial ability in children. For example, the reported liking of individual sports was positively correlated with male and female spatial scores. A significant correlation was also found between the females' reported frequency of time engaged in individual sports and their scores on the Mental-Rotations Test. This may mean that some aspect of individual sports helps to improve and/or foster spatial ability.

Overall, girls reported playing with toys at much higher rates than boys. This may be explained by the influence of sex-typed toys and activities. Many of the male subjects did not provide answers for some of the toys such as tea sets and kitchen sets, which have historically been deemed "girl's toys." Girls, however, were much more flexible with their reports. Research has consistently found that children prefer to play with toys which are

sex-typed for their particular sex (Martin, Eisenbud, & Rose, 1995). This preference begins at a very young age and has a strong influence on children's experiences.

A major limitation of this present study was the use of the Group Embedded Figures Test. This test did not produce the scores expected by the authors. It is believed that using the Individual Embedded Figures Test would have been a better choice because many of the participants seemed to struggle with the task and become very frustrated. Another concern is that a large number of the children who were administered the test were only 8-years old, which may have been slightly too young for this test. Using the Individual Embedded Figures Test would allow the administrator better to explain the directions and help to alleviate some of the frustration experienced by the participants.

Another limitation of the present study was the narrow age range of the participants (mean of 9.2 years). A wider age range extending to older children would have been better, since the spatial-abilities measures were better suited to older children. Lastly, the verbal task in this study did not serve its intended function because it proved to be too easy. A more challenging verbal task must be chosen in future research in order to control for general intelligence.

Future research should continue to focus on this relationship between toy-playing skill and spatial ability, especially in females. In this study, Lego™ skill was not related to spatial performance in females, which may mean that a completely different task needs to be used with females. As mentioned earlier, there may be some toys which have never been considered spatial in nature but in fact serve to foster spatial ability. Finally, in future studies, researchers need to be aware of the tremendous influence of sex-typing when asking children about their toy preferences because, as demonstrated in this study, boys are more reluctant to report liking or spending time with toys not commonly associated with their sex.

The relationship between spatial ability and daily life is complex and it affects the lives of individuals from childhood through adulthood. Understanding the implications and influences spatial ability has on the lives of individuals is very important, especially from a developmental perspective. If spatial ability can be fostered in children of both sexes from a young age, school performance, especially in math and science, may be dramatically increased. Fostering equal performances in the area of spatial ability by males and females can serve as yet another step toward gender equality within the academic and professional arenas.

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TCNJ 2000 Lunar Rover (Moon Buggy): The Road to a National Championship

ABSTRACT

Four engineering students at TCNJ were recruited by the primary adviser of TCNJ Lunar Rover Project to form the 2000 team. They were charged with the task of designing and manufacturing a human-powered vehicle to enter in the NASA-sponsored "Great Moon Buggy Race." The national competition is held annually at Marshall Space Flight Center in Huntsville, Alabama. Specifications of the human-powered vehicle must conform to all the rules and regulations set by NASA. The 2000 challenge began in the summer of 1999 and reached its conclusion 11-1/2 months later. A Gantt Chart outlining major deadlines was generated early in the process in order to help the team keep to schedule. Each of the four students concentrated on the design and fabrication of the necessary components and sub-systems of his/her designated area of the project. Design of each system required concerted performance with all other systems. Consequently, each team member had to understand the other members' designs and recognize that a change made in one area could drastically affect the other areas. Mathematical models were meticulously incorporated for the design of every component and system. This process also relied on educational versions of commercially available and commonly used engineering software. The management aspects of the project were challenging for all team members. A high level of enthusiasm and a willingness to work long hours were crucial to completing

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the project in time for the critical testing period. Design of the vehicle was completed by mid-December 1999. Fabrication began in early January 2000 and was completed by early March. The vehicle was ready for testing and calibration a full four weeks prior to the competition date. This enabled the team members to road-test the vehicle in excess of fifty miles and get to know the performance characteristics of the vehicle inside out. The individual and collaborative efforts of the team members resulted in an outstanding vehicle. In April 2000, the prototype vehicle was entered in the NASA-sponsored "Great Moon Buggy Race," and captured the national championship. The College of New Jersey team set a new performance record at the 2000 event, thanks largely to its skill at integrating the individual parts of the project into a smoothly functioning whole.

INTRODUCTION

The human-powered lunar rover vehicle design competition is a NASA-sponsored event held annually at The Marshall Space Flight Center in Huntsville, Alabama. The sponsor's objective is to put "*undergraduate talent, ingenuity, resourcefulness and endurance to the test in an event whose heritage lies in the greatest adventure undertaken by humankind.*" The project entails the design and fabrication of a two-person, human-powered vehicle modeled after the "Lunar Rover" used in the Apollo 15 mission of 1971. The vehicle must theoretically be used for transport on the surface of the moon. At the competition,

one female and one male driver must ride the vehicle as quickly as possible through the extremely demanding half-mile course that simulates conditions on the moon.

The weight of the vehicle plays an important role in terms of its mobility, power consumption, and ease of transport. The two drivers must lift and carry the vehicle for 20 feet just before they start the race. The vehicle must fit into a 4- x 4- x 4-foot volume area. This constraint has encouraged the student engineers to create designs that enable the vehicle to fold into the required volume and then unfold. The unfolding and assembly times are then added to the run time of the vehicle. The vehicle must be safe and stable, with room for devices such as a two-foot diameter disk antenna, and a one-cubic-foot space for radio, camera, two batteries, and a display console. Each team must complete the course twice and the better of the two run times is used for the competition results.

There were four design-team members assigned to the TCNJ Lunar Rover 2000 project. Each member was responsible for integrating his or her part of the design into the overall plans for the vehicle. Volunteers (potential team members of the following year's team) participated in the design and manufacturing process to enhance their knowledge and experience. The four parts of the TCNJ 2000 Lunar Rover Design Project and the associated designers were:

- Frame and Folding Mechanisms: Maxwell Demcsak
- Drive Train and Braking Systems: Jeffery Monahan
- Steering and Seating Design: Lisa Keat
- Suspension and Folding Design: Eric Jankowski

In April 2000, the prototype vehicle was entered in the NASA-sponsored "Great Moon Buggy Race," and earned first place over more than thirty different college and university entries. This short report summarizes the individual and collaborative design efforts of the team members. It also outlines the basis for the team's design decisions.

Design Standards and Constraints

NASA provides the following list of design rules for each "Great Moon Buggy Race" competition. The team also set its own goals and expectations, which are listed here along with NASA's rules.

Method of Propulsion

The vehicle must be human-powered. No energy-storage devices, such as flywheels, are allowed. The vehicle is not required to have a reverse gear, although it may be necessary if the steering system is not sufficient. The team agreed to the necessity of an all-wheel-drive system because of the severity of the course terrain encountered at the 1999 competition.

Size and Assembly

The entire vehicle, including components and accessories, must be collapsible to fit inside a 4- x 4- x 4-foot volume area. The team decided that the vehicle would fold somewhere near the middle to fit inside the box. A team-designed, self-locking mechanism at this connection would insure the shortest possible assembly time.

Passenger Capacity

The vehicle must accommodate two persons: one male, one female. There is no specific requirement that the riders be in the seated position, but the team decided that two seats, positioned front-back, would be best for the layout of the vehicle.

Weight

At the competition, the two drivers must carry the unassembled vehicle a distance of 20 feet before the assembly process can begin. There is no weight constraint set forth by NASA, but keeping the vehicle weight as low as possible was one of the team's top priorities. The team set a maximum weight of 110 pounds early in the design stage.

Clearance

No passenger body part may be closer than 15 inches from the surface of the ground. The team established a ground clearance of 10+ inches for the loaded vehicle, providing a minimum driver clearance of over 20 inches.

Passenger Safety

All sharp edges and protrusions found on the vehicle must be eliminated or padded. Passengers must wear helmets, eye protection, and appropriate long clothing.

Aesthetics

Attractiveness of design is not a NASA requirement, but it does reflect highly on the team and the institution it represents. Consequently, the design team resolved that the completed vehicle must be of professional appearance.

Performance

The vehicle must complete in the shortest possible time a rigorous half-mile course that simulates lunar terrain. A course time of five minutes is considered highly competitive. This was an important team goal. However, since course conditions become more severe virtually every year, the achievement of this goal is always problematic.

Equipment/Accessories

The vehicle must carry the following items during the competition:

- United States flag
- Simulated TV camera (2" x 3" x 6")
- Simulated high-gain antenna (2 feet in diameter)
- Two simulated batteries (4" x 6" x 8" each)
- Simulated electronic controls (one cubic foot minimum)

The following sections describe the individual contributions of each team member to the project.

Frame and Folding Mechanisms:

Maxwell Demcsak

The frame of the Lunar Rover is the main supporting component of the vehicle. All other vehicular components, including the suspension, drive train, and steering system, must be attached to the frame in some way. The frame of the vehicle must be strong enough to withstand the dynamic forces it will experience during the competition, but at the same time be lightweight enough to maximize the performance of the vehicle. The vehicle also has design constraints imposed

by NASA, including the requirement that it must fit inside a 4- x 4- x 4-foot cube.

In order to satisfy these constraints, the team designed mechanisms to allow the frame to fold. It was crucial to analyze the final designs of critical components of the frame in order to maximize the strength-to-weight ratio, optimize the design, and thus increase the overall performance of the vehicle. The selection of materials and section sizes was key to optimizing the design. The overall configuration and design of the frame had to accommodate the housing and support all other components of the vehicle.

The folding mechanism of the Lunar Rover was a crucial component of the vehicle. To allow the vehicle to fit when folded within the spatial constraints imposed by NASA, the frame was divided into two sections. The front and rear sections of the vehicle consisted of pieces of 3" x 5" rectangular aluminum tubing with a thickness of 1/8". The two sections were held together by a folding mechanism, which consisted of a hinge, a C-channel, and a pin.

The two sections of the frame were held together by a hinge, which was mounted on the bottom face of the vehicle, and allowed the frame to fold. The C-channel was welded to the front section of the vehicle. When unfolded, the channel came into contact with the rear section of the vehicle, upon which it was designed to fit perfectly. A hole was bored into the two sides of the channel, in a position that would line up with the hole bored into the frame. When these holes were aligned, a pin, which was designed to lock the front and rear portions of the frame into the planned unfolded orientations, could be slid through them.

In order to optimize the design of the folding mechanism, the team ran *ANSYS* simulations. *ANSYS* revealed the stresses that would occur within the folding mechanism. By knowing these stresses, it was possible to discover critical points of the components, the size, material, and design of which could then be determined and optimized.

The weight of the vehicle and the two drivers applied stress to the frame and folding mechanism of the vehicle, as it traveled through the rough terrain of the course. These dynamic loads put particular stress on the locking mechanism, which was near the center of the vehicle. The portion of the C-channel surrounding the pin experienced especially high-stress concentrations. In order to be certain that the locking mechanism would withstand the stresses imposed on it, this section of the vehicle was analyzed thoroughly. Firsthand calculations were used to determine a preliminary design and dimensions for the locking mechanism. Since firsthand calculations were limited in determining the stresses within the components, ANSYS was then used to finalize the design.

The locking mechanism was drafted on ANSYS using exact dimensions. The load enforced by the pin as it held the two sections of the frame together while the vehicle was traveling was applied to the locking mechanism in the ANSYS simulation. A simulation was then run, and the normal and shear stresses along the hole were displayed. Once the results of the simulations were known, it was possible exactly to determine the points of greatest stress. The final design of the locking mechanism displayed areas of stress concentration, which were reinforced to stay within allowable ranges of the material.

Drive Train and Braking Systems:

Jeffery Monahan

As a member of the 2000 TCNJ Lunar Rover team, I was primarily responsible for the drive-train design of the vehicle. The function of the drive train is to transmit power from the riders' legs to the vehicle's wheels in a smooth and efficient manner. The drive train had to have a sufficient range of gear ratios so that the vehicle could "crawl" over large obstacles at slow speeds but also have a top speed of approximately 20 miles per hour on paved flats. Since the overall weight of the vehicle was very important to its performance, every effort was made to keep the weight of the drive train to a minimum.

The final design of the drive train utilized a combination of bicycle components, driveshafts, and universal joints. After careful analysis of gear ratios and torque transmission, the team selected components that would provide an adequate range of speeds and withstand the forces placed upon them. The drive train began with a standard mountain bike three-speed crankset that was linked to a seven-speed transmission. From there, power was relayed to a series of driveshafts and then to the wheels. One of the most interesting and challenging aspects of the drive train involved the use of telescopic driveshafts. Because of the design of the steering and suspension systems, the driveshafts had to change length when the wheels were steered and the suspension was flexed. The team considered many designs, including one that relied on an interlocking hexagonal/square shaft and sleeve to provide the telescopic action. Weight considerations and manufacturing constraints dictated the choice of a simpler design requiring a lengthened universal. The keyway was left unlocked so that the driveshaft could slide in and out of the universal joints when necessary. Because the vehicle was human powered and its horsepower was variable, this simple design performed to expectations.

In addition, the student engineers decided to employ a fully differentiated, four-wheel-drive drive train. This means that each wheel is positively powered, but when a sharp corner is turned, the outside wheel rotates faster than the inside wheel. This allows for a smoother, faster turn and eliminates any "scrubbing" effects by the tires. This goal was achieved by using the ingenious hub designs of the 1999 Lunar Rover team and optimizing the dimensions for the force spectrum of this year's vehicle. The team generated a detailed drawing of the modified hub with *Pro-Engineer* software. This file was then transported into the CPU of a CNC machine so the units could be fabricated. Interestingly, the power-train design was able to accommodate two sets of different-sized

tires: in dry conditions, 26"-diameter x 2.1"-wide wheels would be used; in wet/muddy conditions, the robust design called for 28"-diameter x 2.8"-wide wheels.

Steering and Seating Design: Lisa Keat

The steering design is a sensitive matter because of space and geometry constraints at the front end of the vehicle. Steering components must be compatible with the frame, suspension, and drive train, and be optimized to ensure lightest possible weight, maximum mechanical advantage, minimal bump-steer, and desired turning radius. Since optimizing the steering system is a three-dimensional problem, several geometric factors had to be simultaneously incorporated to ensure maximum maneuverability of the vehicle on the rigorous track. The team generated *Working Model* simulations better to understand the spatial availability and mechanical advantages of alternate designs. Moreover, the strength-to-weight ratio had to be considered in selecting materials for the steering components. In the end, the design selected for the steering achieved a remarkable 6-foot turning radius and zero bump-steer.

The team considered several designs before assembling the vehicle, including a rack-and-pinion system that would provide a tight turning radius for the sharp corners of the course; however, space constraints made a steering wheel/rod an unacceptable option. Another option included a series of links that would permit a push/pull motion of the handlebars instead of a rotating configuration, but both space constraints and manufacturing complexity made this choice unfeasible. The final design, however, was based on a simplified version of this concept. A third option relied on a four-wheel-steering design in which the drivers were positioned back-to-back, with one driver steering the vehicle in one direction, and the other, in the opposite, but space constraints at both ends of the vehicle were too severe. The team also concluded that such an arrangement would add unnecessary complexity to the system.

The seating arrangement was crucial to the overall design of the vehicle because it determined the vehicular dimensions necessary for each driver. In particular, the significant difference in height between the male and female drivers posed a serious engineering challenge. Placing the taller of the two in the rear would have so increased the overall length of the vehicle that it would have violated the 4- x 4- x 4-foot requirement. Moreover, the seats themselves were carefully selected so as to achieve minimum weight and maximum ergonomic comfort of the drivers.

The team encountered several difficulties while designing and manufacturing the steering and seating components. It was, for example, initially very difficult to determine what steering configuration would produce the best results. *Working Model* software was used to compare different arrangements of links and plates to determine which would provide the most suitable balance between space and turning radius. In the initial stages of the project, *Working Model* was very useful for evaluating competing alternatives, and for predicting the performance of the chosen design. Another complication arose during assembly, when steering components were being attached to the frame. Fortunately, the team redesigned these components, and the next attempt was successful. In the course of its work, the team recognized that relying on *Working Model* software alone would not produce an accurate model. It was necessary to use *Pro-Engineer* models as well in order to save time and increase modeling accuracy.

Suspension and Folding Design:

Eric Jankowski

The spatial constraints imposed by the rules of the competition necessitated a full-dimensional analysis of the vehicle, which had to be completed before design of the suspension and folding system began. The 2000 Lunar Rover used a suspension system with parallel four-bar linkages and coil-spring, air-damped shock absorbers. Because of the rigorous terrain of the competition, the team extensively modeled and analyzed impact

loads. First-order calculations were performed based on the weight distribution of the vehicle, with the rough dimensions being determined on paper. The team generated *AutoCAD* models of the entire suspension system, then constructed a full-scale prototype to determine proper fit for all components of the vehicle. Before production, a final review included impact-load analysis and *ANSYS* simulation of stresses in critical members.

The competition requirements mandated that the vehicle fit inside a 4- x 4- x 4-foot box for transport. The team recognized the necessity of producing a folding vehicle in order to reduce assembly and running time during the competition. Using the point-to-point dimensions already established, a side-view of the frame and wheels was constructed manually in 1/4 scale. This paper model was used to examine potential folding scenarios. After several iterations, the team generated a final design in *AutoCAD*. A two-dimensional, computer-aided drawing of the folding scenario allowed for more precise iterations that ultimately led to exact placement in the box. This folding design allowed the team to assemble the vehicle in less than four seconds.

As the design process evolved, a team leader emerged as well. As team captain, I handled the purchasing of materials, the scheduling of the fabrication timetable, and the supervision and coordination of the various design projects. The vehicle was completed by the end of February 2000, which gave the team over four weeks to test it. These testing sessions, during which the vehicle was driven more than 50 miles, were crucial to TCNJ's success during the competition.

Application of Engineering Software

The following sections provide a summary of the application of different types of engineering software that enabled the team members to accelerate and better execute the individual and collaborative design decisions.

- Frame and Folding Mechanisms

1. *AutoCAD* was employed to conduct dimensional analysis for folding the vehicle into a 4-foot cube.
2. *ANSYS* was used for situations in which mathematical modeling was neither feasible nor reliable. It revealed the proper signatures of stress, thus enabling the designer to make the appropriate changes/reinforcements.
3. *AutoCAD* was also used to present the finalized dimensions of the components for fabrication, welding, and assembly.

- Drive Train and Braking Systems

1. A detailed drawing of the hub was generated using *Pro-Engineer*, and then this file was transported into the CPU of a CNC machine to fabricate the units.
2. *AutoCAD* was utilized to present the final dimensions of the components for fabrication, welding, and assembly.

- Steering and Seating Design

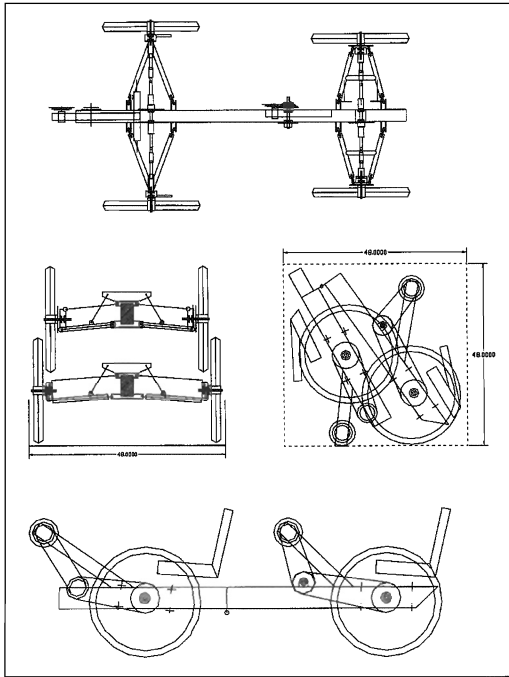
1. *Working Model* made possible the optimizing of the kinematic chain for achieving a demanding 6-foot turning radius for the vehicle.
2. *ANSYS* was utilized for selecting the smallest-sized, power-distribution plate that met the stress criteria. A stainless-steel, rather than an aluminum plate, was chosen.
3. *AutoCAD* was utilized to present the final dimensions of the components for fabrication, welding, and assembly.

- Suspension and Folding Design

1. *Working Model* was employed for assessing the kinematic and kinetic behavior of the suspension system and associated force signatures.
2. *ANSYS* was used for situations in which mathematical modeling was neither feasible nor reliable. It revealed the proper signatures of stress, thus enabling the designer to make appropriate changes/reinforcements.

3. *AutoCAD* was utilized to present the final dimensions of the components for fabrication, welding, and assembly.

Figure 1. Top, Front, Folded, and Side Views of TCNJ 2000 Lunar Rover (Moon Buggy)



Two Principal Engineering Challenges

One of the most challenging features of the project was designing each system so that it would perform optimally in concert with all the others. This required each team member to familiarize him- or herself with other members' designs and to recognize that a change to one area could drastically affect another. Indeed, the success of the vehicle was chiefly indebted to the remarkable coordination of the team members' design projects.

In addition, the management aspects of the project were quite a challenge for all team members. Bringing the whole project together, from the early design stage to the final product, required highly organized management skills. Without a full month for testing the performance characteristics of the vehicle, it is safe to say that success at the Huntsville competition would have been much more difficult.

The Finished Product

The finished product was a human-powered vehicle with the following outstanding features:

Design and Performance Characteristics of TCNJ 2000 Lunar Rover (Moon Buggy)

1. Fully differentiated all-time, four-wheel drive
2. Independent suspension with adjustable dampening
3. Two independent high-performance power trains
4. Revolutionary frame with high strength-to-weight ratio
5. Collapsible chassis to fit into a 4- x 4- x 4-foot transportation box
6. Easy-to-assemble in less than five seconds
7. Steering with zero bump-steer and a 6-foot turning radius
8. Ergonomic seating and handling with adjustable positions
9. Quick-response hydraulic disk brakes
10. 26-inch-diameter x 2.1-inch-wide all-terrain wheels, with custom hubs, interchangeable with 28-inch-diameter x 2.8-inch-wide wheels

Figure 2. TCNJ 2000 Lunar Rover (Moon Buggy) with over fifty miles of testing before the competition.

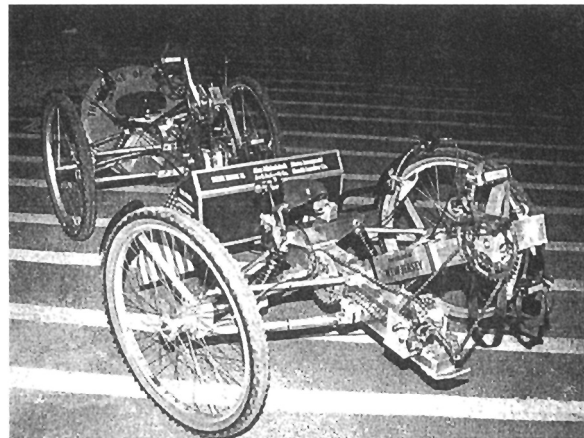
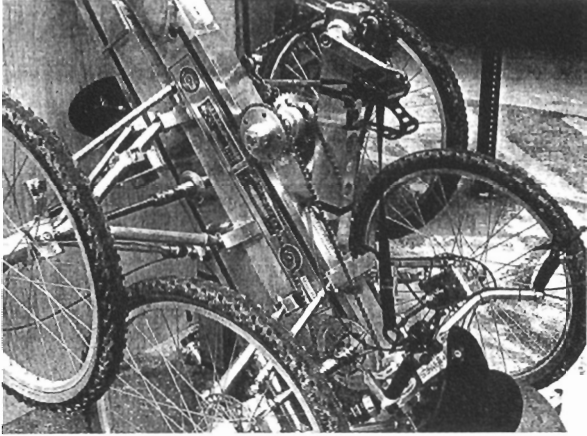


Figure 3. TCNJ 2000 Lunar Rover (Moon Buggy) in folded position for fitting in a 4-foot cube.



ACKNOWLEDGEMENTS

The team members and advisers would like to thank the following individuals for the special contributions they made in paving the road to a national championship:

- Mr. Alexander Michalchuk—without whom many of the team's fantastic designs could not have materialized into reality.
- Mr. Richard Jadcak—for his professional advice and the use of his CNC facilities for fabrication of the custom-designed hubs, and machining the high-strength axles.
- Mr. Steve Jurczynski—for his professional advice and assistance in the welding of critical components of the vehicle.
- Department of Engineering and the administration of TCNJ for their steady support of the project.

Taphonomy of Fossil Turtles from the Lowermost Navesink Formation in Monmouth County, New Jersey

ABSTRACT

Rare occurrences of fossil turtle carapace and plastron fragments are preserved within the lowermost Navesink Formation in Monmouth County, New Jersey. Several of these turtle remains contain diagnostic characteristics that can be attributed to members of the *Trionychidae* and *Toxochelyidae* families. Other specimens are highly fragmentary and permit only generic anatomical identification. Abundant teeth from chondrichthians co-occur with these turtle remains as a macrofossil residuum in the same stratigraphic horizon, as do fossils from mollusks, decapods, osteichthians, and other reptiles. Stratigraphically, the carapace and plastron fragments occur directly above a type-two disconformity reflecting third-order, regressive-transgressive sea-level cyclicity between the Marshalltown and Navesink Depositional Sequences and Global Sea Level Cycles UZA 4.3-4.4 of Haq et al. (1988). The rarity and fragmentary nature of these turtle fossils represents a complex taphonomic history that is the result of extensive reworking of the upper Wenonah-Mt. Laurel Formation and the subsequent re-deposition along the base of the lowermost Navesink Formation. Turtles and other macrofossils that occur directly above the contact between these formations are thought to represent upper Campanian to lower Maastrichtian ages.

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INTRODUCTION

Evidence of upper Cretaceous turtles along the inner coastal plain of New Jersey has been well documented for over 150 years. As early as 1851, Leidy identified the occurrence of *Trionyx priscus* and *Chelonia grandeva* through costal and vertebral plates from the glauconitic sands of New Jersey. Regional literature contains numerous references to fossil turtles of both historical and recent significance (e.g., Leidy, 1856; Cope, 1868; Wieland, 1904; Hay, 1908; Zangerl, 1953; Miller, 1955; Baird, 1964; Fastovsky, 1985; Baird, 1984, 1986a; and Parris et al., 1986). A current compilation by Gallagher (1993) identified 14 different New Jersey Cretaceous genera belonging to six different turtle families including: *Pelomedusidae*, *Dematemydidae*, *Trionychidae*, *Protostegidae*, *Toxochelyidae*, and *Chelonidae*. Of these families, Ernst and Barbour (1989) indicate that *Protostegidae* and *Toxochelyidae* are extinct taxa. Gallagher (1993) noted that New Jersey's marine cheloniids suffered heavy losses at the Cretaceous-Tertiary boundary. *Pelomedusids* disappear above the basal Hornerstown Formation and *Osteopygis* sp. is the only species of 13 Cretaceous marine cheloniids to be found in the Paleocene (Gallagher 1993).

Identification of fossil turtle species in New Jersey has been complicated by name assignment based on fragmentary specimens, and there appear to be far fewer species than those named. For example, in a survey of New Jersey *Osteopygis* sp. from all major collections, Zangerl (1953) indicated that there are only a few more specimens than described

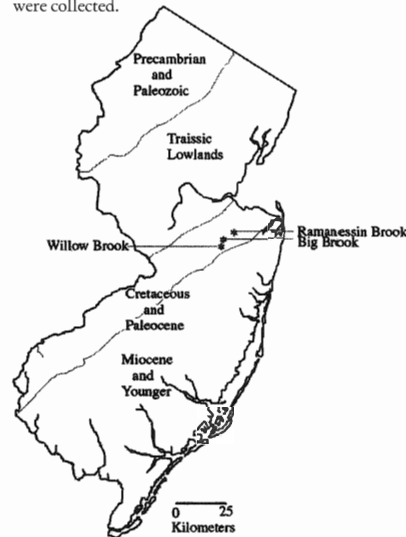
species. This study attributed differences in individual specimens to variations related to marine adaptations and age, concluding these materials represent only a single species of *Osteopygis*. This interpretation is further supported by Gallagher (1993) who identified 61 invalid reptilian taxa from a total population of 105 reptilian taxa which included turtles in the Northern Atlantic Coastal Plain.

The majority of fossil turtle discoveries in New Jersey have occurred in the late Maastrichtian, Hornerstown Formation of Burlington and Gloucester Counties with some of the more noteworthy specimens being limited to a single, but exceptional greensand locality, the Inversand Quarry located in Sewell, Gloucester County. Extremely well-preserved specimens of *Peretresius ornatus* (Baird, 1964); *Taphrosphys sulcatus* (Gaffney, 1975); *Adocus beatus* (White, 1972); and *Dollochelys atlantica* (Parris et al., 1986) have been collected from this locality.

Other upper Cretaceous formations such as the Wenonah-Mt. Laurel and Navesink formations are known to yield much more limited and fragmentary turtle assemblage (e.g., Baird, 1986a; Lauginiger, 1986; and Gallagher, 1993). Species identified from the Wenonah-Mt. Laurel Formation include: *Trionyx* sp. and cf. *Protostega*, while the Navesink Formation includes: *Pneumatoarthrus peloreus*, *Atlantochelys mortoni*, *Neptunochelys turberosa*, *Osteopygis emarginatus*, *Peretresius ornatus*, and *Corsochelys* sp. (Baird, 1986a; Baird, 1986b; Lauginiger, 1986; and Gallagher, 1993).

This report describes and identifies the taphonomic history of a small assemblage of carapace and plastron bones recovered from Big, Hop, and Ramanessin brooks in Monmouth County, New Jersey (see Figure 1). The turtle assemblage was collected with abundant chondrichthian teeth as well as fossils from mollusks, decapods, osteichthians, and other reptiles that accumulated as a lag deposit directly above a disconformity separating the uppermost Wenonah-Mt. Laurel Formation from the lowermost Navesink Formation in Monmouth County, New Jersey.

Figure 1. Location map for Big, Hop, and Ramanessin brooks in the Northern Coastal Plain of New Jersey where turtle fossils were collected.



The seven fragmentary turtle specimens described in this study were collected over a 15-year period and are included in the geologic collections at The College of New Jersey.

FIELD METHODS

Water erosion along Big, Hop, and Ramanessin brooks in Monmouth County has exposed accessible cross sections of the upper Cretaceous Wenonah-Mt. Laurel and Navesink formations. Unconsolidated outcrop sediments were sieved with 0.5-centimeter screens. Turtle specimens discussed in this paper were collected along with other fossils from screen-washed sediment. Only *in situ* material was collected and identified. All turtle specimens were fragmentary and where possible, all pieces were collected and articulated to their original anatomical configuration. Turtle fossils were identified and described by anatomical comparison with repositied museum collections from the Yale Peabody Museum (YPM), American Museum of Natural History (AMNH), and New Jersey State Museum (NJSM), and upper Cretaceous turtle literature from: Leidy, 1856; Cope, 1868; Wieland, 1904; Hay, 1908; Zangerl, 1953; Miller, 1955; Baird, 1964; Fastovsky, 1985; Baird, 1984, 1986a, 1986b; and Parris et al., 1986.

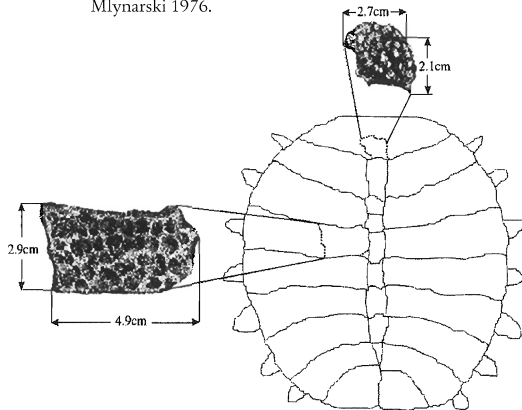
Description and Identifications of Recovered Specimens Family Trionychidae

Trionyx sp. Leidy, 1851

Materials: costal, nuchal

The costal and nuchal exhibit concentric dorsal pitted surface sculpturing and lack inter-scutule sulci marks. The lateral portion and rib projection of the costal are missing, while the ventral side preserves the neurapophysis for vertebral attachment. The costal preserves nearly parallel, sutural facets for articulation to adjacent costals and neurals and represents a medial location along the carapace (see Figure 2). The nuchal preserves some of the original sutures for articulation to the first neural and the ventral side preserves a neurapophysis for articulation to the dorsal portion of thoracic vertebra.

Figure 2. Costal and nuchal from this study relative to carapace elements seen in *Trionyx* sp. Carapace sketch redrawn from Mlynarski 1976.



Baird (1986b) noted that dorsal surface sculpturing does not permit precise identification below the family level. However, he further stated all trionyhid remains from the Cretaceous of the Atlantic Coastal Plain are, by convention, assigned to either *Trionyx priscus* or *Trionyx halophilus*. Examination of type specimen *Trionyx halophilus* AMNH 1476 that was later figured in Hay (1908), p. 513, bears a striking resemblance to both the costal and nuchal collected during this study. AMNH 1476 represents approximately 35 fragments from New Castle County, Delaware, that are probably attributable to the Mt. Laurel Formation.

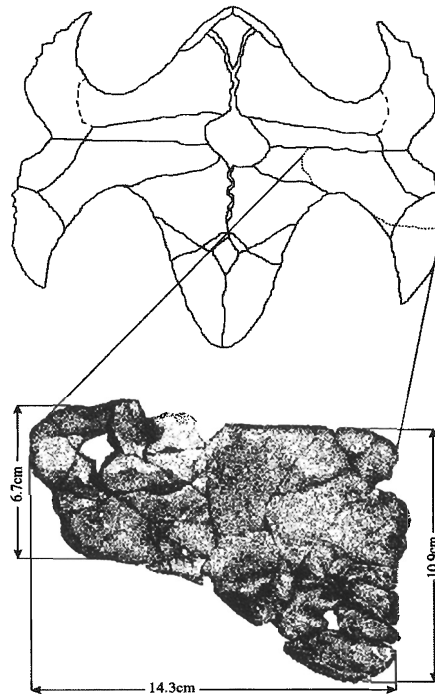
Family Toxochelyidae

cf. Osteopygis emarginatus Cope, 1869

Material: left hypoplastron

The hypoplastron exhibits a relatively smooth surface ornamentation, faintly marked with irregular, linear grooving. Although the outermost edge of the lateral prong has been lost, a small "Y"-shaped sulcus impression is preserved along the outermost edge of the bone. The nearly straight, interior edge of the hypoplastron thins and preserves some original suture marks for articulation to the adjacent left hypoplastron (see Figure 3).

Figure 3. Hypoplastron from this study relative to plastron elements seen in *Osteopygis emarginatus* YPM 783. Plastron sketch from Zangerl 1953.



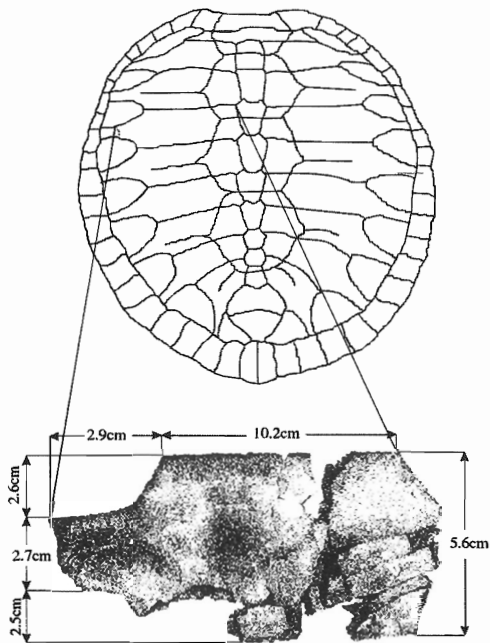
The type specimen of *Osteopygis emarginatus* AMNH 1485 from Barnsboro, New Jersey, preserves many plastron elements including a hypoplastron that is similar in size and surface ornamentation to the specimen collected during this study. The right hypoplastron from *Osteopygis emarginatus* AMNH 1334 collected in Birmingham, Burlington County, New Jersey, is almost a perfect match for the adjacent hypoplastron.

cf. Family Toxochelyidae

Material: costal

Although the majority of the rib projection is missing, the large lateral fontanelles that occur on each side of the rib projection are consistent with representatives of the Family *Toxochelyidae*. Much of the outermost edge preserves the suture facets for articulation with adjacent costals and the neurals. The rib projection is offset at a slight angle relative to the roughly parallel anterior and posterior edges of the costal. This configuration is consistent with that of the second or third costal along the left anterior portion of the carapace in *Toxochelyid* turtles (see Figure 4).

Figure 4. Costal from this study relative to carapace elements seen in Family *Toxochelyidae*: *Dollochelys atlantica*. Carapace sketch redrawn from Parris et al., 1986.



Toxochelyid genera identified from New Jersey include *Dollochelys*, *Osteogygis*, *Peretresius* and *Prionchelys*. The costal is much more robust than that of carapace elements seen in *Dollochelys* sp. and specimens such as NJSM 12295 which is thought to be ancestrally related to the geologically older *Toxochelys* sp. (Zangerl, 1971 and Parris et al., 1986). Deep vermiculate sculpturing with a sunburst of papillae characteristic of *Pertresius* sp. and

other specimens such as NJSM 11051 are absent from this costal. This suggests that the costal belongs to *Osteogygis*, *Prionchelys*, or another as yet unidentified *Toxochelyid* genera. *Indeterminate Specimens:* peripheral, hyo/hyoplastron, costal

The peripheral bone contains a shallow, centrally located pit for rib insertion and fine, linear-grooved surface ornamentation. The thick and obtuse morphology lacks a well-developed flange and the specimen compares favorably to peripherals from a medial location in the marginal series. The hyo/hyoplastron is missing the outermost portion of the lateral prong. The interior edge along the lateral prong is thick and rounded and the bone tapers along its exterior edge facilitating articulation to the overlying carapace. The costal represents a reduced-shell turtle and preserves some sutural facets for articulation to adjacent costals and neurals. A nearly straight sulcus mark, offset to the middle of the costal and roughly parallel to the anterior and posterior edges, occurs along the length of the bone. Additionally, the smooth-surfaced costal contains a centrally located pit that is circular in outline and does not perforate the bone. This pit is consistent with parasitic lesions described by Zangerl (1953) (p. 264).

DISCUSSION

Age and Taphonomic Interpretations of Monmouth County Turtles

The ages of the Wenonah-Mt. Laurel and Navesink formations have been well-established from multiple biostratigraphic indicators, in particular ammonites, mollusks, chondrichthians, and foraminifera (Fowler, 1911; Stephenson et al., 1942; Richards et al., 1958; Olsson, 1963, 1987, 1988; Cappetta and Case, 1975; Olsson and Nyong, 1984; Cobban, 1974; Petters, 1976, 1977; Sohl and Smith, 1980; Case, 1982; Kennedy and Cobban, 1994; Case, 1995; Kennedy et al., 1995; Sugarman et al., 1995; and Becker et al., 1996). Current microfossil interpretations place the boundary between the Campanian and Maastrichtian stages within

the upper Wenonah-Mt. Laurel Formation. Microfossil evidence was derived from seaward subsurface well data collected predominately along dip of the Wenonah-Mt. Laurel and Navesink formations (Olsson, 1963, 1987; Olsson and Nyong, 1984; and Petters, 1976, 1977). Macrofossil evidence supports a boundary placement roughly equivalent with the contact between the Wenonah-Mt. Laurel and Navesink formations. Macrofossil evidence was derived from landward outcrops collected predominately along strike of the Wenonah-Mt. Laurel and Navesink formations (e.g., Stephenson et al., 1942; Kennedy and Cobban, 1994; Kennedy et al., 1995; Sugarman et al., 1995; and Becker et al., 1996).

The disparity in Campanian-Maastrichtian boundary placement in the New Jersey Coastal Plain has been discussed by various researchers, with a consensus yet to be achieved (see Olsson, 1963; Petters, 1976; Kennedy and Cobban, 1995; Sugarman et al., 1995; and Becker et al., 1996). We interpret differences in placement of the Campanian-Maastrichtian Boundary, lower in the section from microfossil well data and higher in the section from macrofossil outcrop data, to reflect the expression of a sequence boundary along southeastward dip from the seaward correlative conformity to landward disconformity. As a result, biostratigraphically significant fossils occurring along or near this sequence boundary in dip section would be time-transgressive and result in differing relative age interpretations. This interpretation is supported by Gallagher (1993) who provided a detailed discussion of facies changes associated with the Wenonah-Mt. Laurel and Navesink formations in both strike and dip sections across the South Jersey High and Raritan Embayment.

The lowermost Navesink Formation occurs directly above a disconformity that contains the primary macrofossil-bearing lag in the Monmouth County area (Becker et al., 1996). This lag has been noted to occur at the boundary between the Marshalltown and

Navesink Depositional Sequences and Global Sea Level Cycles UZA 4.3-4.4 of Haq et al., 1988 (Sugarman et al., 1995; and Becker et al., 1996). In all likelihood, the concentration of turtles and other macrofossils in the lag deposit separating the Wenonah-Mt. Laurel and Navesink formations in Monmouth County outcrops along strike, must reflect eroded Campanian fossils, which have been subsequently mixed and re-deposited with Maastrichtian representatives.

It is interesting to point out that similar lag deposits containing an abundance of macrofossils including turtles, along the Atlantic and Eastern Gulf Coastal Plains outcrops, also occur along upper Cretaceous stage or substage boundaries. These lags represent contacts between formations or formations and members (see Table 1). Contact placement, the abundance of macrofossils, and the first and last appearance of biostratigraphically important macrofossils in these stratigraphic sections are apparently also the product of sea-level cyclicity.

Table 1

State	Formation and/or Member	Age	Example Reference(s)
North Carolina	Black Creek and Pee Dee	Campanian-Maastrichtian	Sohl and Christopher, 1983, and Robb, 1989
Georgia	Blufftown Formation and Cusseta Sand Member	approximately the lower-upper Campanian	Schwimmer, 1986, and Becker et al., 1996
Alabama	Eutaw Formation and Tombigbee Sand Member	Santonian-Campanian	King and Skotnicki, 1994, and Becker et al., 1998
Northeastern Mississippi	Bluffport Marl Member of the Demopolis Formation and underlying unnamed member	Campanian-Maastrichtian	Derstler, 1988

Paleohabitat Interpretations

All turtle specimens described in this study were collected from the same stratigraphic horizon within the lowermost Navesink Formation. Members of the Toxochelyidae family were thought to represent fully marine, open-water omnivores by analogy to modern cheloniids and leatherbacks (Gallagher, 1993). *Trionyx* sp., a semi-aquatic soft-shelled turtle, was thought to be an ambush, pursuit predator

of freshwater and estuary habitats (Gallagher, 1993, and Ernst and Barbour, 1989).

The side-by-side association of turtles from differing paleohabitats supports the association of the primary macrofossil-bearing lag in Monmouth County with a type-two discontinuity in outcrop sections separating the Wenonah-Mt. Laurel and Navesink formations. We interpret the regressive-transgressive event separating the Marshalltown and Navesink Depositional Sequences and third-order eustatic cycles of 3 and 4 of UZA 4.4 of Haq et al., (1988) as the taphonomic agent responsible for the accumulation of turtle bones. The rarity and fragmentary nature of carapace and plastron remains further support reworking and admixing of different paleohabitats and their association with sea-level cyclicity.

Additionally, associated macrofossils and sedimentary components that co-occur with the turtle remains also support this viewpoint. The lowermost Navesink Formation contains organics, fossil wood, and well-rounded quartz pebbles to approximately two centimeters, suggesting a close affiliation of this shallow marine deposit to an estuary-deltaic complex (Owens and Sohl, 1969; Martino and Curran, 1990; and Becker et al., 1996). Marine components also found in the lowermost Navesink Formation include macrofossils such as ammonite and mollusk steinkerns preserved in siderite, abundant chondrichthian and osteichthian teeth, in addition to bones and teeth from other reptiles such as mosasaurs and crocodiles.

CONCLUSIONS

Fossil turtles from the lowermost Navesink Formation of Monmouth County provide important clues to the complex taphonomic history of macrofossil deposits in the Northern Coastal Plain of New Jersey. Our research indicates that third-order, sea-level cyclicity plays an important role in: 1) the rarity and fragmentary nature of fossil turtles in the Monmouth County area, 2) the association of different turtles characteristically representing different paleohabitats,

3) outcrop age interpretation containing fossil turtles, and 4) formation of lag deposits in the Atlantic and Eastern Gulf Coastal Plains where fossil turtle remains are found.

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A Spectrophotometric Analysis of Stellar Winds in Hot Binary Star Systems

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ABSTRACT

One of the discovered properties of hot, massive binary star systems is the presence of a stellar wind. The stellar wind can be studied by spectrophotometric means. Certain ions, C IV, Si IV, and N V, have absorption doublets in the ultraviolet range of the IUE satellite telescope, and these ions are used as tracers and indicators of the stellar winds.

From the images provided by IUE, the integrated flux within the line profiles of the tracer ions has been calculated using IDL software routines. These fluxes are plotted versus phase in order to generate light curves. Light curves for different parts of the line profile—the absorption, core, emission, and entire profile—are compared with those for a bandpass in the continuum part of the spectrum. By analyzing the light curves, a great deal of information about the star and its wind envelope can be determined, such as the relative sizes of the wind envelopes around each star in a binary system. From the line profiles, the terminal velocities of the tracer ions can be calculated using the Doppler equation.

INTRODUCTION

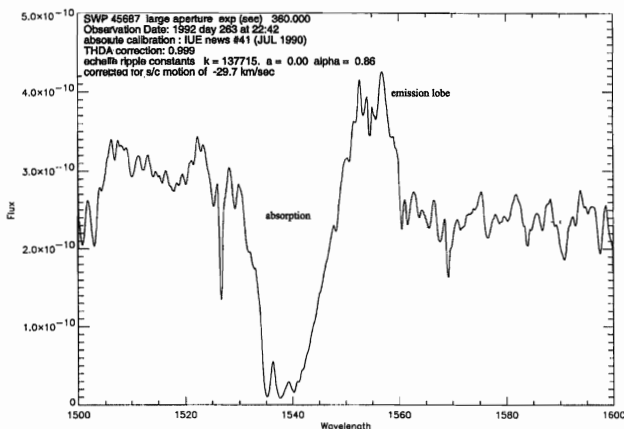
With the advent of orbiting astronomical observatories, it has become possible to observe stellar ultraviolet radiation, which is not accessible to ground-based installations. One such satellite telescope is the “International Ultraviolet Explorer” (IUE), launched in 1978. Spectrophotometric data gleaned by IUE and other space telescopes have provided a body of data indicating

highly ionized gasses streaming away from hot, luminous stars. These stars are early main sequence stars of spectral type O or B, or giant and supergiant stars. Such stars are much more massive and luminous than the sun. It is the high radiation pressure from stars that causes ions to be accelerated away from their surface at very high speeds. The actual mechanism is an exchange of momentum between the outward flowing photons and the ions in the stellar atmosphere. The result is an evaporation of atmosphere from the star, and this outward flow is called a stellar wind. In some cases, the radiation pressure of these very hot stars is so great as to drive the winds to speeds of thousands of kilometers per second.

The thermal environment in the wind comprises highly ionized atoms, some of which have been found to be directly indicative of the stellar wind phenomenon. Among these are C IV, Si IV, and N V, all of which are addressed in this study. When examining a spectrophotometric image of a luminous star in the ultraviolet region of 1000 to 1800 angstroms, one observes strong absorption lines as a result of these ions. This suggests that light from the stellar photosphere is being scattered out of the line of sight by these ions in the expanding wind envelope of the star. For some stars, there is also increased flux above the blackbody continuum, centered on the rest wavelength, which is called the “emission lobe.” The emission lobe is caused by two photons that have been scattered toward the observer by the wind envelope surrounding

the stellar photosphere. The absorption and/or emission features together are the “line profile,” examples of which are shown in Figure 1. When there is both emission and absorption present, it is said to be a “P Cygni profile,” named after the first star that was observed to have such a profile.

Figure 1. UV spectrophotometric image of C IV absorption in HD 159176



By studying the line profiles of hot stars, we can deduce certain things about the stellar winds. One can also see from the spectrophotometric images that the absorption lines for these ions are blue Doppler-shifted from their rest wavelengths, indicating an outflow from the star. By examining the extreme Doppler-shifting in the line profiles, we can get an idea of the terminal velocity of the winds. As the winds are accelerated and begin to move away from the surface of the star, the density of the wind decreases, and thus the amount of absorption decreases. We can deduce that the fastest winds are absorbing light from the star near where the line profile rejoins the continuum. We take this wavelength to be the greatest-shifted Doppler wavelength to determine the terminal velocity of the winds. Thus, we have evidence for the radiatively driven stellar wind model, and by examining these profiles, we are examining the wind itself. These ions become indicators and tracers of the stellar winds of hot stars.

The radiatively driven stellar wind model depends on the line opacity of elements in the star's atmosphere. That is, light emitted from the photosphere of the star is absorbed and scattered at certain discrete wavelengths by elements in the atmosphere of the star. Because of the high luminosity of O and B stars, there is sufficient photon density to provide a bombardment of a specific wavelength that results in a net transfer of momentum to the atom, thereby exciting an outward accelerating wind flow. The line opacity is progressively Doppler-shifted, exposing the faster moving shell of the wind to a fresher supply of photons at shorter and shorter wavelengths. This results in the rapid acceleration of the wind to very high speeds (Cassinelli, 1979).

In this study, we have primarily focused on hot binary star systems. As one would expect, in such systems one deals with two separate wind envelopes, one for each star. This can be particularly interesting in examining how the winds interact and how our view of them changes as the system rotates.

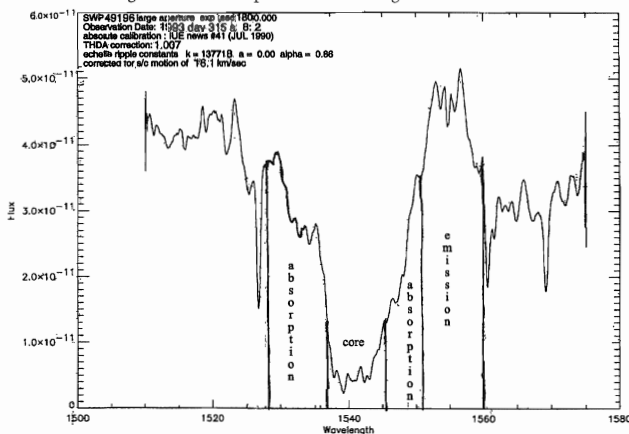
This study was undertaken to investigate what information about the wind envelope could be discovered in the light curves for certain bandpasses for each binary system. To accomplish this, the line wind profiles were divided into several narrower bandpasses and light curves for each of these bandpasses were then generated. Light curves were also generated for a 20-Å wide bandpass in the continuum, which served as a control to indicate no wind effect. These assortments of light curves were then compared to each other and to the continuum. The bandpasses used consisted of the entire line profile, the entire absorption portion of the profile, the core of the absorption, and the emission lobe. The absorption bandpass refers only to the part of the line profile that exhibits absorption of light, and the core bandpass is a narrow bandpass that is taken near the bottom of the absorption line. The emission bandpass is the region of increased flux above the continuum adjacent to the absorption.

The particular binary systems that have been chosen for study are Y Cygni, Pi Scorpii, LZ Cephei, CW Cephei, LY Aurigae, EM Carinae, HD 159176, and AO Cassiopeiae. Data in the form of a number of separate spectrophotometric images taken for these stars were obtained by the International Ultraviolet Explorer (IUE) spacecraft and downloaded from the NASA archives. The images were viewed and the light curves were generated and plotted using Interactive Data Language (IDL) routines.

DATA

Once images were downloaded from the IUE archives, a representative set of images for each star was examined in order to determine the wavelength intervals of the bandpasses of interest, namely the entire profile, absorption, core, and emission. The images were viewed and printed using IDL, and the bandpass intervals were determined by hand. This was done for C IV and Si IV in each star, and N V in stars where an N V absorption was present (Figure 2). For control and comparison purposes, a bandpass of 1450–1470 Å in the continuum was chosen. This region was found to be devoid of any strong absorption lines and thus by looking at this region, we are seeing the photosphere of the star and not the stellar wind.

Figure 2. C IV line profile for LY Aurigae

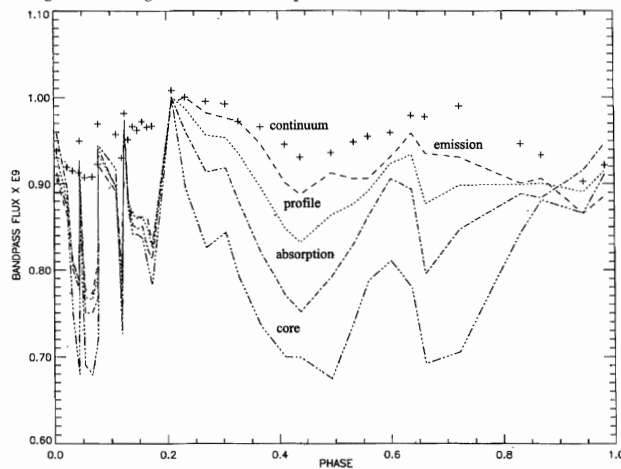


Phase data for each available image of each star were obtained from various tables of data found in the literature for Y Cyg, HD 159176, CW Cep, and AO Cas. Phases were calculated for each image available for Pi Sco, EM Car, LY Aur, and LZ Cep using ephemeris for those stars found in the literature. This process was expedited with a simple program written in Mathematica, which calculated each individual phase given ephemeris and the time and date the image was taken.

Using the wavelength values determined for bandpass intervals and given the color excesses of each star, an IDL routine was utilized to integrate the flux in each separate bandpass in each star for each available image. This has been done for each star.

This data was then utilized to plot normalized light curves for each star. One set of light curves was plotted for each of the selected tracer ions in each star and compared to the continuum. This was accomplished by using another IDL program that made use of data generated by the previous IDL routine to calculate the integrated bandpass flux. This program essentially plotted flux versus phase for each bandpass specified and compared this to the continuum light curve. An example of these plots is shown in Figure 3.

Figure 3. N V light curves for LZ Cep



For each star, a separate normalized light curve juxtaposing the core and continuum bandpasses was plotted. Such curves are useful in comparing the size of the wind envelopes between each star in a binary system. Terminal velocities for the winds of each star were calculated using the Doppler equation. The rest wavelength for the lower wavelength doublet of each tracer ion was taken from text values (Striganov et al., 1968). The Doppler shift was measured from the lowest measurable wavelength in the absorption of each line profile examined. The terminal velocities for each tracer ion in each star are summarized in Table 1.

Table 1: Terminal Velocities in km/s for ions in the stellar winds

Star	C IV	Si IV	N V
Y Cyg	1.97E+03	1.02E+03	
EM Car	3.33E+03	5.93E+02	
Pi Sco	1.78E+03	1.24E+03	
LY Aur	4.10E+03	2.53E+03	
CW Cep	4.23E+02	1.67E+03	
AO Cas	2.55E+03	1.23E+03	2.38E+03
HD 159176	3.52E+03	5.93E+02	2.13E+03
LZ Cep	1.59E+03	5.93E+02	2.62E+03

ANALYSIS OF DATA

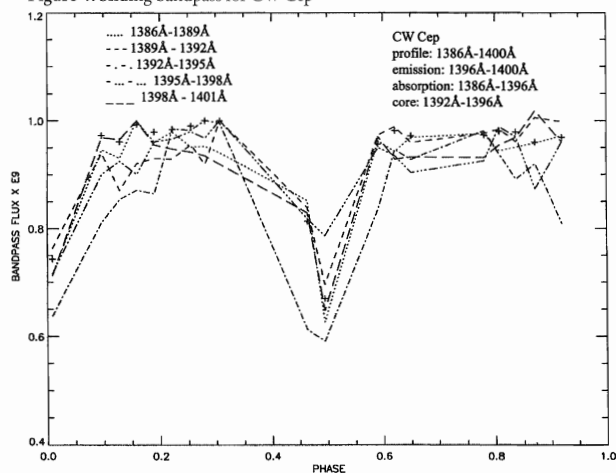
The first step taken in attempting to analyze the data gathered is to look for trends in the normalized light curves. One of the immediately obvious trends one notices is that the bandpasses examined tend to have a certain set order in the normalized light curves. This is most apparent at and around $\phi = 0.50$. Good examples of this are in the Si IV light curve of EM Car, the C IV light curve of HD 159176, and the N V light curve of LZ Cep. In each of these graphs, it is obvious that the emission light curve deviates the least from the continuum and the profile second least. The core light curve deviates the most from the continuum, and the absorption light curve, which contains the core, deviates less than the core but more than the entire profile. This draws attention to the two extremes — the emission and the core.

Photons in the emission bandpass come toward the observer both from the direct line of sight between the observer and the photosphere, and from the wind envelope around

the photosphere. This means that when one looks at a star with a significant emission, one sees flux forward-scattered toward the observer along the line of sight, as well as flux side-scattered from the region of the wind around the edge of the photosphere. The emission light curve deviates least from the continuum light curve because most of the emission results from light scattered by the winds close to the photosphere of the star.

It is significant to find out exactly which part of the line deviates the most from the continuum. Intuition might suggest the core, but to be sure, a sliding bandpass flux was taken over the Si IV profile in CW Cep. That is, the flux was integrated in bandpasses of 3-Å intervals over the entire Si IV line profile, and the normalized light curve was plotted in comparison to the continuum (Figure 4). The light curve indicates that the greatest deviation from the continuum is in a bandpass of 1392 Å-1395 Å, and this corresponds almost exactly to the core of the Si IV profile in CW Cep.

Figure 4. Sliding bandpass for CW Cep



Another such sliding bandpass was done for the C IV line profile in EM Car. At first, an attempt was made to split the bandpass evenly into five segments, each at a 6-Å interval. Unfortunately, the results proved to be useless. A 6-Å width is not precise enough because of overlapping in the line profile. At the same time, too small a width will yield too much

quantum noise. It was resolved to use a 3-Å interval and simply make two separate graphs of five light curves each, plus the continuum. Though it is much harder to see in the interval from 1530 Å to 1545 Å, it becomes more apparent in the light curves for the interval from 1545 Å to 1560 Å that the light curve that deviates most from the continuum most directly corresponds to the core bandpass.

A third such sliding bandpass integration was applied to the C IV line profile in Y Cyg. This time, bandpasses of 2 Å were chosen over only the core bandpass. The light curve that deviates most from the continuum is exactly in the middle of the core. This means that indeed the greatest amount of absorption by the wind that is uncontaminated by emission can be found in the core of the absorption, and thus by observing the light in the core bandpass, we are looking almost entirely at the wind as an envelope eclipsing the star behind it, as opposed to the photosphere. Conversely, when one observes the bandpass defined by the continuum, one is looking at the photosphere and not the wind.

By examining the core bandpass and comparing it to the continuum, it is possible to compare the effects of the wind to a bandpass of the photosphere that is unaffected by the wind. To do this, for clarity, one plots the core light curves versus the continuum normalized light curves alone and examines how the core diverges from the continuum. By this, some insight into the size of the wind envelopes around each star in the system is gained.

One common trend found in the core light curves was the tendency for the normalized core light curve to drop in flux at an earlier phase than the continuum light curve, and rejoin the continuum light curve at a later flux. Excellent examples of this can be found in the Si IV light curves for EM Car and the C IV light curves for LZ Cep. Judging by the core light curve alone, the primary star appears to be larger, attenuating light from the secondary star for a longer time than what is indicated by the continuum light curve.

This effect is the result of the wind of the primary star eclipsing the secondary star before the photosphere's eclipse. Thus, one property of interest that can be determined from these light curves is the relative sizes of the wind envelopes around each star in a binary system. This can be determined qualitatively based on the assumption that a larger wind envelope will absorb more light. The earlier the attenuation of light becomes apparent in the core light curve, and the greater the deviation of the core light curve from the continuum light curve, the larger the wind envelope.

Upon examining the core and continuum light curves for a star such as Y Cyg, one can see that the core light curve deviates only slightly from the continuum around $\phi = 0.50$, and even less around $\phi = 1.0$ and $\phi = 0.0$. The core light curve does not indicate attenuation of light from the secondary star much earlier than the continuum light curve. This suggests that while a stellar wind exists around the primary star in Y Cyg, it is small, and even smaller in the secondary star of this system.

In the C IV normalized light curves for LZ Cep, there is a very significant deviation from the continuum light curve in the core light curve, and the core light curve exhibits attenuation of the light of the star behind it well before the continuum light curve when the primary star is eclipsing. However, there is very little deviation when the secondary star is eclipsing the primary. The wind envelope of the primary star is so large that it is eclipsing the secondary star well before the photosphere of the primary star is not eclipsing the secondary star.

Different binary systems will eclipse differently depending on how they appear to an observer on Earth. For example, while an observer on Earth sees the primary star in the Y Cygni system almost completely eclipse its secondary star at $\phi = 0.5$, the primary star in HD 159176 does not appear to move directly in front of the secondary star at all from the same observer's point of view (Pachoulakis, 1996). This tells us something about the winds of HD 159176, however.

Upon examining the light curves for HD 159176, even though the stars themselves do not appear to eclipse, there is a distinct decrease in normalized flux in the continuum around $\phi = 0.5$. This can be seen clearly in the normalized light curves for the C IV absorption in HD 159176. This merely results from ellipsoidal variation in the stars. More interesting is a trend in the core light curve best seen in the C IV light curves. The core light curve does indicate significant attenuation of light from the secondary star near $\phi = 0.5$. This indicates that the winds of the primary star indeed eclipse the winds of the secondary star, even though the photospheres do not eclipse.

The Si IV light curve for HD 159176 appears to be less drastic than the light curves of C IV and N V. In fact, it appears that the core light curve for Si IV does not diverge much at all from the continuum. The reason for this can be deduced by looking at the line profile for the Si IV absorption in HD 159176. One can plainly see that the absorption is very weak in this bandpass, and thus there may be little Si IV to speak of in the winds. This occurs because HD 159176 is so hot that most of the Si IV has been ionized to Si V. Unfortunately, Si V has no absorption lines in the range of the IUE (Pachoulakis, 1996).

Another set of core and continuum light curves of some interest are those for EM Car. In the Si IV light curves, one can see that the wind envelope for the primary star is quite significant, while the wind envelope for the secondary star is much smaller. This is not nearly as interesting, however, as a sharp and sudden decrease in flux around $\phi = 0.65$. The presence of this sudden decrease in flux is confirmed in the C IV light curve. This sudden decrease in flux may be the result of a dense clump of matter in the star absorbing light from the photosphere. It is impossible to be sure of its cause from the light curves alone, however, and further investigation into this localized phenomenon would have to be conducted to glean more information.

Some difficulty in examining and drawing conclusions from the light curves lies in the

presence of noise in many of the images. The noise is caused by line saturation, and made analysis of stars such as AO Cas and LY Aur very difficult. In some images, as a result of unreddening, the flux in the core of certain bandpasses will actually drop below zero. Consequently, the detected flux represented in the normalized light curve is actually caused by quantum noise in the detector and may appear highly erratic.

SUMMARY

The atmosphere around a hot O- or B-type star is subject to incredible amounts of radiation pressure. That is, the luminosity of the star is so great that the transfer of momentum from photons to atoms in the atmosphere causes the atoms in the atmosphere to accelerate to high velocities. The result is a stream of hot ionized gasses moving away from the star in all directions. Such an outflow of gasses is called a stellar wind. In binary star systems, there may be as many as two wind envelopes—one for each star. To study these winds, an examination of certain absorption line profiles in the UV spectrum of the stars was undertaken. The SWP portion of the UV spectra obtained from the IUE spacecraft exhibits strong absorption lines resulting from C IV, Si IV, and N V. These ions are known tracers and indicators of the winds.

A line profile caused by the wind may have an absorption feature as well as an emission "lobe." The emission is symmetrically positioned about the rest wavelength of an ion. It is produced by photons that are scattered toward the observer by the wind material surrounding the star, and photons being forward-scattered by the wind within the column directly along the line of sight toward the surfaces of the star. Most of this scattering occurs where the wind is densest—near the photosphere. The absorption feature is a dip in continuum flux that gradually approaches the continuum again toward the short wavelength end of the line profile. The emission overlaps the absorption, filling it in to some degree.

As ions in the wind accelerate radially away from the star, the mass density of the wind decreases. Consequently, the outer, faster moving parts of the wind envelope produce less and less absorption the farther it is from the photosphere. Since the outer parts of the wind are moving toward the observer with increasing speed, their absorption is progressively Doppler-shifted to shorter wavelengths. In the line profile, we can see that the wind that absorbs the least light—the wind of least density—absorbs light at a wavelength at the point where the absorption rejoins the continuum. Using this shifted wavelength and comparing it to the rest wavelength of that particular ion, the terminal velocity of the wind can be found using the Doppler equation.

Since different parts of the line profile are produced by different parts of the wind, the profile has been divided into several narrower bandpasses: core, absorption, emission, and whole-line profile. These are defined for each tracer element in each star along with a continuum bandpass. The continuum bandpass ideally contains no absorption lines produced in the wind. The continuum is representative of light from the photosphere of the star. In order to examine absorption caused by the wind without the interference of the emission, a bandpass at the bottom of the absorption feature, or “core” bandpass, has been defined.

For each bandpass, the integrated flux in that bandpass is calculated for each available image for that star. The integrated flux is then plotted versus phase for the purpose of seeing how the flux under each bandpass changes over the orbital period of the binary star system. The resulting plot is called a “light curve.” Light curves formed for the flux in the core bandpasses have been compared with light curves of the integrated flux in a continuum bandpass to distinguish wind effects from photospheric effects.

It has been found that the emission light curve almost always diverges less from the trend of the continuum light curve than the other bandpasses. This occurs because most

of the emission comes from light scattered toward the observer by winds close to the photosphere. The core light curve tends to diverge the most from the continuum.

By examining the core bandpass, one is seeing the attenuation and eclipsing effect of a wind envelope around a star, and only the wind envelope. Because the absorption features of the line profile are deep, the net integrated flux in the core bandpass is small. This results in a light curve for the core bandpass that is very noisy for some stars that have nearly saturated lines.

One would predict that the denser the winds and the larger the wind envelope, the broader the eclipse and attenuation portion of the core light curve. That is, a large wind envelope for a star in a binary system will attenuate the other star in the system before the photosphere of its star eclipses the photosphere of the second star. This makes the star appear somewhat larger than it actually is. Hence, one may get an idea of the size of the wind envelope of a star by comparing the light curves of its core absorption for tracer elements in the winds to the continuum light curve. A compilation of the results of this research is presented in Table 2.

The light curve of CW Cep shows well-defined changes in the continuum flux, which is known to be the result of eclipsing photospheres. The core bandpass indicates a modest wind envelope that is approximately the same size for each star. This is because the core bandpass closely follows the trend of the continuum light curve. A similar situation is found in Y Cyg, though the core versus continuum bandpasses in Y Cyg indicate a larger wind envelope for both stars. In Pi Sco, the wind lines closely follow the trend of the continuum light curve. The absorption lines are rather weak because Pi Sco is relatively cool, and the core light curves may be misleading because of an unfortunate lack of available data points.

In the light curves for HD 159176, the core light curve indicates much earlier attenuation and eclipsing than the continuum light

curve. The case is similar for LZ Cep. In each of these systems, the primary star is made to look larger when its wind envelope attenuates light from the secondary star well before the continuum light curve indicates eclipsing of the photospheres. The core bandpass light curve in EM Car does not diverge quite so much from the continuum light curve as that of either HD 159176 or LZ Cep. Also, the core light curve in EM Car does not indicate attenuation of light from the secondary star as early as those of HD 159176 or LZ Cep. This indicates a significant wind envelope around EM Car, but not so large as those of HD 159176 or LZ Cep. There is also a significant wind envelope around the secondary star, but it is not nearly as large or dense as that of the primary star.

The light curves for AO Cas are plagued by nearly total saturation in the core bandpass of its tracer elements. Indeed, the light curves are erratic because of quantum noise in the detector. Though the continuum light curves are much cleaner in LY Aur, line saturation and a lack of reliable data points result in nearly unintelligible light curves.

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Table 2

Star	Primary Wind Envelope	Secondary Wind Envelope	Noise Level
HD 159176	Large	Large	High
LZ Cep	Large	Small	Medium
EM Car	Medium	Small	Medium
Y Cyg	Small	Small	Low
CW Cep	Small	Small	Low
Pi Sco	Small	Small	Low
LY Aur	Unknown	Unknown	High
AO Cas	Unknown	Unknown	High

Regulation of the Epithelial Sodium Channel by Sodium 4-Phenylbutyrate in Cystic Fibrosis Epithelial Cells

ABSTRACT

The cystic fibrosis transmembrane conductance regulator (CFTR) decreases the activity of the epithelial sodium channel (ENaC). However, in cystic fibrosis, there is a deletion of phenylalanine at position 508 of CFTR causing a mutant form ($\Delta F508$ -CFTR) that is retained in the endoplasmic reticulum. Treatment of IB3 cells (containing $\Delta F508$ -CFTR) with sodium 4-phenylbutyrate (4PBA) results in the expression of $\Delta F508$ -CFTR on the plasma membrane. However, it is unknown whether repaired $\Delta F508$ -CFTR is capable of all regulatory functions that are attributed to wild-type CFTR. To determine this, the effect of 4PBA treatment on the expression of ENaC in IB3 cells was studied. It was determined that the α and γ ENaC subunits are present in IB3 cells at the mRNA level by using quantitative RT-PCR with primers designed for the three subunits of ENaC and an internal standard. Similar experiments were performed using primers designed for β ENaC, but results were inconclusive. To determine the influence of 4PBA on the expression of these subunits, IB3 cells were treated with 0-5mM 4PBA for two days in culture prior to RNA extraction. RT-PCR was again performed and results indicate that 4PBA increases the expression of α and γ ENaC at the mRNA level. These data may suggest that repaired $\Delta F508$ -CFTR does not regulate ENaC in the same way as wild-type CFTR, but further analysis on the effect of 4PBA on the activity of ENaC must be performed.

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INTRODUCTION

Cystic fibrosis (CF) is the most common life-threatening autosomal recessive genetic disorder in Caucasians. It is characterized by defects in epithelial ion transport in intestines, lungs, sweat glands, and pancreas. CF is caused by mutations in the cystic fibrosis transmembrane conductance regulator (CFTR), which functions as a cAMP regulated calcium channel in the apical membrane of epithelial cells. Along with its role as a chloride channel, CFTR also interacts with and regulates other ion-channel proteins. The most common mutation, $\Delta F508$, results from the deletion of phenylalanine at position 508 of the protein and is present in approximately seventy percent of CF patients. $\Delta F508$ -CFTR undergoes aberrant intracellular trafficking characterized by its retention in the endoplasmic reticulum and premature degradation. It is possible, through the use of different pharmaceutical agents, to correct the aberrant intracellular trafficking and restore functioning $\Delta F508$ -CFTR to the plasma membrane.

One potentially promising therapy is sodium 4-phenylbutyrate (4PBA), a butyrate analogue that is known to regulate gene patterns of expression. 4PBA has been approved for pharmacological use as a waste nitrogen scavenger in patients with urea-cycle disorders, where it has a different mechanism of action. 4PBA corrects the $\Delta F508$ -CFTR trafficking defect and restores CFTR function in cultured CF airway epithelial cells (Rubenstein, Egan, and Zeitlin, 1997). It was also tested in $\Delta F508$ homozygous CF

patients and caused a small improvement in the chloride conductance in their nasal epithelial cells consistent with improved CFTR function (Rubenstein and Zeitlin, 1998). The mechanism by which 4PBA exerts its effects is currently not known.

Although 4PBA repairs the intercellular trafficking defect and restores $\Delta F508$ -CFTR to the cell surface, it is not known whether the repaired mutant CFTR is capable of all regulatory functions that are attributed to wild-type CFTR. Wild-type CFTR regulates a number of cellular ion conductances including Na^+ and HCO_3^- . CFTR regulates Na^+ conductance by interacting with the epithelial sodium channel, ENaC. This is a tetrameric channel composed of three homologous subunits termed α ENaC, β ENaC, and γ ENaC, with predicted channel stoichiometry of two α , one β , one γ (Canessa et al., 1994); (Firsov, et al., 1998); (Kosari et al., 1998). Like CFTR, ENaC is expressed in the apical plasma membrane of various epithelial tissues, including airway and kidney, where it has an important role in determining epithelial fluid volume and composition by regulating Na^+ uptake.

CFTR and ENaC have close interregulation; wild-type CFTR decreases the activity of ENaC and conversely, ENaC increases the Cl^- transport activity of wild-type CFTR (Ismailov et al., 1996); (Jiang et al., 2000). In CF airways lacking CFTR function, ENaC is hyperactive (Mall et al., 1998). This hyperactivity of ENaC may lead to viscous secretions in the CF airway because the increased Na^+ absorption causes decreased volume of airway fluid. It is not known whether repaired $\Delta F508$ -CFTR will interact with and regulate ENaC, as does wild-type CFTR, and vice versa. Our working hypothesis is that repaired $\Delta F508$ -CFTR will regulate ENaC in the same way as wild-type CFTR. The goal of this project was to determine the effect of 4PBA on ENaC expression and activity and to assess the interrelationship between ENaC and repaired $\Delta F508$ -CFTR. Our data suggest that 4PBA increases the

expression of ENaC in cells containing $\Delta F508$ -CFTR.

MATERIALS AND METHODS

Cell culture

IB3-1 cells were grown on uncoated tissue culture plasticware at 37° C or 25° C as noted in a 5% CO_2 incubator. Standard growth medium was supplemented LHC-8 (Biofluids, Rockville, Maryland) (Rubenstein, Egan, and Zeitlin, 1997). T84 cells were grown on uncoated tissue culture plasticware at 37° C in a 5% CO_2 incubator. Standard growth medium was DMEM (GIBCO BRL) supplemented with 5% fetal bovine serum (Sigma Chemicals, St. Louis, Missouri) and 100 U/ml penicillin-streptomycin (GIBCO BRL Gaithersburg, Maryland). Cells for control experiments were cultured under these routine conditions. Treated cells were grown in standard growth medium supplemented with 4PBA at the concentrations indicated in a 5% CO_2 at 37° C.

Western Blot

Whole cell lysates were prepared by solubilization of cultured cells with 2% SDS at 70° C. Protein concentration was determined using the BioRad assay reagents with bovine plasma γ -globulin as a standard (Bio-Rad Laboratories, Hercules, California). Equal amounts of protein per sample were resolved on a 7.5% SDS polyacrylamide gel. Proteins were transferred to nitrocellulose and washed in buffer (0.15 M NaCl, 30 ml 10% Tween 20, 0.01 M Tris HCL) five times. The ENaC protein was detected using a rabbit antibody specific for α ENaC as primary antibody at a dilution of 1:2500 in incubation buffer (wash buffer containing 0.4% BSA at 4° C) with gentle rocking overnight. Primary antibody was detected with donkey anti-rabbit IgG horseradish peroxidase conjugate at a dilution of 1:5000 in incubation buffer for one hour at room temperature. Detection of immunoreactivity was performed using the ECL chemiluminescence reagent (Amersham) and fluorography.

RNA Extraction and cDNA synthesis

Total RNA was prepared from control and treated cells using the RNeasy RNA isolation reagent (Ambion Inc., Austin, Texas) according to manufacturer's protocol. 2 µg of total RNA were electrophoresed on a 2% agarose gel containing ethidium bromide to analyze RNA quality. RNA reverse transcription was performed using 2 µg of total RNA, 0.5 µg of oligo dT (15) primer (Promega Corp., Madison, Wisconsin), and 300 units of Moloney Murine Leukemia Virus Reverse Transcriptase (Promega) according to manufacturer's protocol.

Polymerase Chain Reaction (PCR)

5' and 3' primers designed for the three subunits (α , β , γ) of ENaC were used to determine the expression of each subunit as shown in Figure 1. The primers led to a PCR product size of 424 bp for α , approximately 400 bp for β , and 197 bp for γ . In order to quantify PCR results and compensate for tube-to-tube variability, Ambion's β -actin internal standard kit was used. β -actin primers produce a PCR fragment of 294 bp. PCR was carried out according to manufacturer's instructions in a volume of 50 µl, including 3 µl of RT mixture, 2 µl of each forward and reverse primer, 4 µl of β -actin internal standard in the established ratio (8 µl was used in reactions with β and γ ENaC primers because of the small amount of β -actin primer in the mixture), and 2.5 units of TAQ polymerase (Takara). A water control (lacking the RT mixture) was performed. As a positive control, PCR was performed with plasmid DNA encoding relevant portions of the ENaC subunits. Reactions were denatured at 94° C for five minutes, followed by 40 polymerization cycles of denaturation at 95° C for 45 seconds, annealing at 55° C for 45 seconds, and extension at 72° C for one minute, 30 seconds. A final elongation step took eight minutes at 72° C. To determine linear range of polymerization, aliquots of 4 µl were taken every three cycles (beginning at cycle 18). PCR products were electrophoresed on 1.5% agarose gel containing ethidium bromide.

Gels were visualized under UV light and photographed. Densitometric analysis of these images was performed with Alpha Imager software Version 4.0 (Alpha Innotech, San Bernando, California).

Cloning of ENaC PCR fragments

DNA was extracted from agarose gel slices containing PCR products for α , β , and γ ENaC using the QIAquick Gel Extraction Kit (Qiagen). The PCR fragments were cloned into the pCR2.1 vector followed by transformation into One Shot competent cells (TA Cloning Kit; Invitrogen, San Diego, California). Transformations were plated on LB plates containing 100mg/ml ampicillin, 100 mM IPTG, and 40 mg/ml X-Gal. This allowed for blue/white selection of colonies containing the insert. White colonies were selected and grown overnight in 5 ml Lurea Broth containing ampicillin (100mg/ml). Plasmid DNA was prepared using QIAprep Spin Miniprep Kit (Qiagen) and analyzed for the presence of the PCR product through restriction enzyme analysis with EcoRI. DNA containing the insert was sequenced by the Children's Hospital of Philadelphia's Nucleic Acid/Protein Core to confirm sequences derived from α , β , and γ ENaC. These sequences were identical to published sequences of ENaC.

Figure 1: 5' and 3' primer sequences for α , β , γ ENaC

Subunit	3'Primer	3'Primer
α ENaC	5'ATTCTGAGTCTCC CTCTGTCACGA3'	5'GCCTTGGTGTGA GAAACCTCT3'
β ENaC	5'AAGAATCAGCAGC CAATAACATCG3'	5'CATCCGATCACC CTCACTG3'
γ ENaC	5'CTGCTCTGTTGTC TGCATCATC3'	5'TTGAAAGTGGGT AGGCATCGTCTA3'

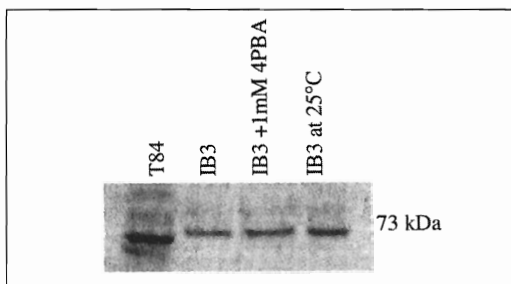
RESULTS

α ENaC is present at the protein level in IB3 cells +/- 1 mM 4PBA, T84 cells, and IB3 cells grown at 25° C.

IB3 cells are bronchial epithelial cells containing the Δ F508 mutation, while T84 cells are intestinal epithelial cells with wild-type CFTR. In order to study the effect of 4PBA on the expression of ENaC in these cell lines, it had to be determined if ENaC was present in these cells. To determine this, a western blot using a rabbit antibody specific for

α ENaC was performed on whole cell lysates of IB3 cells +/- 1 mM 4PBA, T84 cells, and IB3 cells grown at 25° C. IB3 cells grown at 25° C were used because at 25° C the CFTR protein appears on the cell surface. ENaC is a 73-kDa protein. As shown in Figure 2, α ENaC is present in all lanes. This data suggests that ENaC is expressed at the protein level in these cell types.

Figure 2: Expression of α ENaC in lysates from various cell lines/conditions. Whole cell lysates were prepared with SDS as described in methods. Total protein was resolved on a 7.5% SDS-polyacrylamide gel. Proteins were electrophoretically transferred to nitrocellulose and immunodetection of α ENaC was performed as described in methods. ENaC, a 73 k-Da protein, is expressed in all lanes.



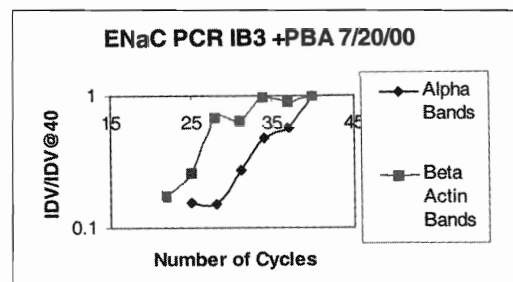
α and γ ENaC are present at the mRNA level in IB3 and T84 cells +/- 1 mM PBA.

To assess the expression of ENaC at the mRNA level in IB3 and T84 cells, PCR using primers designed for the three subunits of ENaC was performed (Figure 1). 5 μ l of PCR product was electrophoresed on a 1.5% agarose gel stained with ethidium bromide and visualized under UV light. This produced bands of the expected size when using the α and γ primers and 40 cycles of polymerization. There were no bands resulting from the β primer at 40 cycles. A PCR reaction was performed using the β ENaC primer for 30 cycles and then aliquoting 3 μ l of this reaction into a new PCR mix and performing 30 more cycles of polymerization. This produced a band of approximately 400 bp in the lane using cDNA from T84 cells treated with 1 mM PBA.

In order to quantify PCR results, Ambion's Beta-Actin Internal Standard kit was used. This kit uses competitors, specially modified primers (with the same sequence as β -actin primers) that cannot be extended. Thus, it is possible to adjust the ratio of β -actin primers

to competitors to create a signal that is similar to the expected PCR product. Each ENaC subunit was found to have a different optimal ratio of β -actin primer to competitor because of the different expression of each subunit. These optimal ratios are for α 3:7, β .25:9.75, and γ .75:9.25. Through the use of this kit, it was possible to determine the linear range of each PCR reaction. The linear range is defined as the point at which the amplification efficiency is at its maximum and remains constant over a period of time. Determining linear range was accomplished by performing PCR under normal conditions, but aliquoting 4 μ l of PCR product every three cycles. These samples were electrophoresed on a 1.5% agarose gel and densitometry was performed using Alpha Imager software. The cycle number versus the integrated density was plotted in Figure 3. This reaction is in the linear range between cycle 27 and 33. Thus, an optimal number of cycles for α ENaC and β -actin primers would be approximately 30 cycles. Unfortunately, because of time constraints, this linear range analysis was performed only using the α primers and the optimal number of cycles was not determined until after further analysis.

Figure 3: Determining linear range of PCR reaction using α ENaC and β -actin primers. PCR was performed as described in methods. 4 μ l of PCR product was aliquoted every three cycles beginning at 16. 5 μ l of product was electrophoresed on a 1.5% agarose gel and densitometric analysis was performed. The cycle number versus the integrated density value at 40 cycles was plotted on a log plot. The linear range for this reaction is approximately 30 cycles.



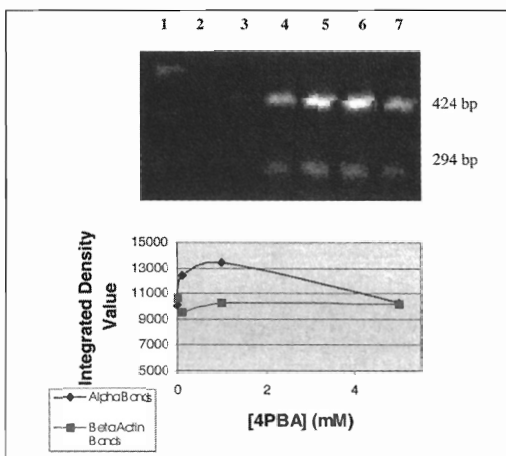
4PBA treatment results in increased α ENaC mRNA expression.

In order to assess the effect of 4PBA on α ENaC, we constructed a concentration curve using 4PBA. Cells were treated with 0.1 mM 4PBA,

1 mM PBA, 5 mM PBA, and control conditions. RNA was extracted from these cells and cDNA was synthesized. This cDNA was used in PCR reactions as previously described using α ENaC primers. These primers produced a 424 bp fragment. In order to quantify results, a β -actin internal standard was also run. This produced a fragment of 294 bp. After PCR was performed, 5 μ g of the results were run on a 1.5% agarose gel stained with ethidium bromide as seen in Figure 4A. Results were quantified using Alpha Imager software to perform densitometry (Figure 4B). The integrated density value of the β -actin bands remains constant, independent of the concentration of 4PBA used. The integrated density value for IB3 cells grown without 4PBA and those treated with 5 mM 4PBA is almost identical. However, there is an increased integrated density value for those cells treated with 0.1 mM and 1 mM PBA. This suggests that treating IB3 cells with 4PBA at low concentration increases the expression of α ENaC mRNA.

Figure 4A: PCR using α ENaC primers was performed using cDNA synthesized from RNA from IB3 cells treated with increasing concentrations of 4PBA. 5 μ l of product was electrophoresed on a 1.5% agarose gel. Lane 1: 100 bp marker. Lane 2: Negative control (H_2O). Lane 3: α ENaC Plasmid DNA. Lane 4: IB3 control. Lane 5: IB3 treated with 0.1mM PBA. Lane 6: IB3 treated with 1 mM PBA. Lane 7: IB3 treated with 5 mM PBA.

Figure 4B: Densitometry of PCR performed on cDNA synthesized from total RNA extracted IB3 cells treated with increasing concentrations of 4PBA and α ENaC primers. As the integrated density value of the β -actin bands is constant, there is an increase in the density of the α ENaC bands in the presence of 1 mM and 0.1 mM 4PBA.

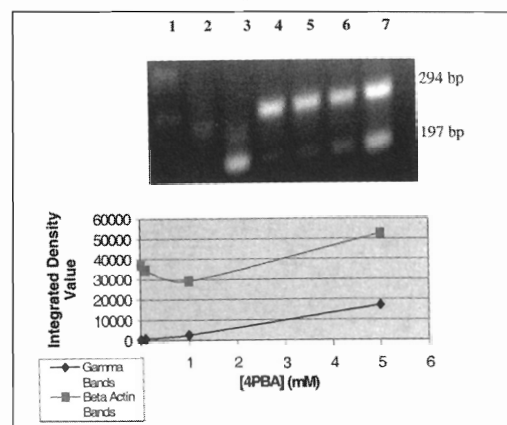


4PBA treatment results in increased γ ENaC expression ($n = 1$).

In order to assess the effect of 4PBA on the expression of γ ENaC in IB3 cells, PCR was performed using the same concentration curve that was discussed in the α ENaC results. This included IB3 cells grown in control conditions, and cells treated with 0.1 mM, 1 mM, or 5 mM 4PBA. PCR was performed using cDNA synthesized from these cells, γ ENaC primers and β -actin internal standards. The results were electrophoresed on a 1.5% agarose gel that was stained with ethidium bromide and visualized under UV light. The expected bands of 294 bp for β -actin and 107 bp for γ ENaC were observed as seen in Figure 5A. Densitometry using Alpha Imager software was performed. This shows a dramatic increase in the intensity of the IB3 cells treated with 5 mM 4PBA band as seen in Figure 5B. Although the intensity of the β -actin bands is not exactly constant, it does not indicate an increase in the concentration of the cDNA in this lane. Therefore, we can consider that 4PBA increases the expression of γ ENaC at high concentrations.

Figure 5A: PCR with γ ENaC primers was performed using cDNA synthesized from RNA extracted from IB3 cells treated with increasing concentrations of 5PBA. 5 μ l of sample was electrophoresed on a 1.5% agarose gel. Lane 1: 100 bp marker. Lane 2: Negative control (H_2O). Lane 3: γ ENaC Plasmid DNA. Lane 4: IB3 control. Lane 5: IB3 treated with 0.1mM PBA. Lane 6: IB3 treated with 1 mM PBA. Lane 7: IB3 treated with 5 mM PBA.

Figure 5B: Densitometry of PCR performed on cDNA synthesized from total RNA extracted IB3 cells treated with increasing concentrations of 4PBA and γ ENaC primers as discussed in methods. As the integrated density value of the β -actin bands is constant, there is an increase in the density of the γ ENaC bands in the presence of 5 mM and 4PBA.



DISCUSSION

This experiment demonstrates that the IB3 cell line is the appropriate cell line for these studies, because it establishes the presence of the α and γ subunits of ENaC in IB3 cells at the protein level. Because these cells also contain $\Delta F508$ -CFTR, they are ideal for the study of interactions between repaired $\Delta F508$ -CFTR and ENaC. The T84 cell line is also an appropriate cell line to use for comparison. Because T84 cells contain wild-type CFTR, the interactions between wild-type CFTR and ENaC can be studied and compared to the interactions between repaired $\Delta F508$ -CFTR and ENaC. This is a very important comparison because it allows the T84 cells to be used as a control in experiments. Experiments were performed using T84 cells, but because of time constraints results were inconclusive.

The data presented in these experiments suggest that 4PBA increases the expression of α ENaC at the mRNA and possibly the protein level in IB3 cells. It also appears to indicate that γ ENaC mRNA expression is also increased through 4PBA treatment. This seems contrary to expectations. Because wild-type CFTR downregulates the expression of ENaC, it was assumed that repaired $\Delta F508$ -CFTR would do the same. This increase in ENaC expression may suggest that repaired $\Delta F508$ -CFTR does not act in the same regulatory manner as wild-type CFTR. However, the mechanism of this interaction is unknown. It is possible that it is not the repaired $\Delta F508$ -CFTR that increases the expression of ENaC, but that 4PBA interacts with ENaC and directly increases its expression. Since 4PBA is known to regulate gene transcription (Rubenstein, Egan, and Zeitlin, 1997), it may be increasing the transcription of the α and γ ENaC genes. Further studies must be performed to determine the mechanism of action.

The interactions of 4PBA with β ENaC were also studied, but no conclusions could be drawn. PCR experiments using primers designed for β ENaC were inconclusive. This may suggest that β ENaC mRNA is present in IB3 cells at very low levels that cannot be

quantified using PCR. It may also suggest that the primers that were designed to amplify the β ENaC region were not appropriate and should be modified. As a last resort, it may be possible that β ENaC is not present in IB3 cells. Further studies must be performed to determine if the subunit is present in IB3 cells before the effect of 4PBA on its expression can be measured.

All things considered, this study may suggest that repaired $\Delta F508$ -CFTR does not interact with and regulate ENaC in the same manner as wild-type CFTR. Treatment of IB3 cells with 4PBA is expected to downregulate the expression of ENaC. However, this preliminary study indicates that 4PBA increases ENaC's expression, rather than decreasing it. This increase in ENaC expression may lead to problems with using 4PBA as a treatment for CF. While repaired $\Delta F508$ -CFTR is present on the cell surface and chloride conductance is re-established, if its downregulation of ENaC is not restored it may not make a significant change in the CF patient's status. Treatment with 4PBA that results in increasing the expression of an already hyperactive ENaC could possibly turn out to be more of a problem than an advantage to patients. However, the effect of 4PBA on the activity of ENaC is unknown. It is possible that although repaired $\Delta F508$ -CFTR increases the expression of ENaC it may also decrease its function. Further studies must be conducted before any conclusions can be drawn.

In conclusion, we demonstrate that 4PBA increases the expression of the α and γ subunits of ENaC at the mRNA level. These data conflict with the hypothesis that repaired $\Delta F508$ -CFTR will act as wild-type CFTR and downregulate the expression of ENaC. Future studies must be conducted to determine the mechanism of action of this interaction and the effects of 4PBA treatment on the activity of ENaC.

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Analgesia in Veterinary Medicine: A Retrospective Study of Postoperative Pain Management in a Canine Thoracotomy Model

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ABSTRACT

In the investigation of postoperative pain management following a thoracotomy in *Canis familiaris*, physiological parameters were evaluated to determine which analgesic protocol, morphine; morphine and bupivacaine; or morphine, bupivacaine, and transdermal fentanyl; was most effective in minimizing postoperative pain. The canines in this study were given postoperative analgesics in three protocols before, during, and after surgery. Following surgery, the canines were monitored postoperatively at 0-4 hours, 8, 10, and 20 hours for heart rate, temperature, respiratory rate, pulse quality, urine and fecal output, and overall responsiveness. These evaluations were converted to a subjective pain score. Groups A, B, and C were each composed of eight dogs and received the same preoperative analgesics. Only Group C received a transdermal fentanyl patch preoperatively. Groups B and C both received intrapleural bupivacaine via a chest tube before the thoracic incision was closed. Six to eight hours after the preoperative doses, Group A received 1.0 mg/kg morphine, Group B received 1.0 mg/kg morphine along with a 0.25% bupivacaine nerve block, and Group C received a single dose of morphine. Six to eight hours following these doses, Group A again received morphine, Group B received bupivacaine, and Group C received no additional analgesic. However, there is no statistically significant difference between the three protocols in preventing postoperative pain at 0-4, 8, and 20 hours. The results of this preliminary study indicate that

all three protocols are effective in a postoperative pain-management strategy; however, Protocol C may provide optimal analgesia in a unique manner.

INTRODUCTION

In pharmaceutical investigations, many factors heighten the probability of a favorable outcome. In those facilities that use animals as their primary research models, one of the most important endeavors is to provide the research animal with maximum comfort and care. This ensures the animal's health during the period of research. The research animal's comfort is particularly important during an invasive or major surgical procedure. Thus, successful pain management requires knowing the type of surgical procedure to be performed as well as patient characteristics that may influence the pain-management protocol (Carpenter, 1997). To ensure a rapid recovery period, it is relevant to note that a major surgery requires a more aggressive and complete pain management for optimum analgesia, or pain suppression, than does a minor surgery (Carpenter, 1997).

The invasive procedure addressed in this study is known as the thoracotomy, with the canine as the research model. The thoracotomy is a procedure in which a postero-lateral incision is made through the chest to the dorsi muscle fibers. Once the split segments of muscle are retracted, a rib is chosen for entry into the thoracic cavity (Sadighi et al., 1998). This procedure allows for the manipulation of the viscera in the thoracic cavity,

especially the heart. In the context of this experiment, the canine heart was accessed via the thoracic incisions, and a pacemaker was strategically placed on the heart in order to quantify and measure heart function. Vascular access ports were also utilized in order to deliver preliminary pharmaceuticals efficiently through the bloodstream. These techniques allowed researchers to test preliminary, undisclosed pharmaceuticals that target congestive heart failure. Thus, the successful recovery of the canine from the thoracotomy is a primary concern for the research scientist who plans to use the animal weeks or months in the future to perform further trials. More importantly, however, one is ethically obliged to provide maximum comfort to the research animal that has been used to further scientific knowledge.

One means of encouraging a rapid recovery from the thoracotomy procedure is to study the effectiveness of various analgesics to suppress pain over a specified interval of time. Previous studies suggest that minimizing pain does, in fact, speed the healing process (Rodriguez et al., 1996). In this experiment, three commonly used analgesics were the focus of the study: morphine, bupivacaine nerve block, and fentanyl. Three groups of eight canines were subjected to a thoracotomy and given different pain-management protocols before, during, and after surgery. In this study, the task at hand was to evaluate retrospectively the effectiveness of each analgesic in suppressing the pain response following surgery. Subjective observations of physiological parameters, such as heart rate, respiratory rate, urine and fecal output, and overall responsiveness of the canine, were converted to an objective pain score using subjective readings as a reference point (Firth et al., 1999). Mean pain scores ranging over the specified time interval were then compared among the three protocols. The results of this study indicate that although all three protocols successfully maintained pain at a minimum level, one approach has a unique attribute that may be

helpful to the veterinary care group in an animal research environment.

METHODS

Three groups of eight dogs, labeled A, B, and C, first underwent the thoracotomy procedure. The specific thoracic procedure, however, is beyond the scope of this study, as analgesia was the focal point of the investigation. The three groups received the same preoperative medications, anesthetic induction agent, and anesthetic maintenance component. The preoperative medications included 2 mg/kg of morphine and 0.02 mg/kg of atropine. Thiopental was the anesthetic induction agent, and isoflurane inhalant was the anesthetic maintenance component in the three groups. All experimental groups also received a 0.25% bupivacaine nerve block prior to surgery. Group A received the block just prior to the surgical incision at rib spaces 4, 5, and 6 with the incision made at rib space 5. Groups B and C both received the block earlier than Group A, just prior to the surgical preparation of the skin, and at more rib spaces, 3 through 7, with the incision made at rib space 5. Prior to the incision, only the dogs in Group C received a fentanyl transdermal patch (50 mg/hr) on the inner thigh. Groups B and C also received intrapleural bupivacaine via a chest tube just before the thoracic incision was closed.

Immediately following the surgery, all three groups received acetylpromazine intramuscularly at a dose of 0.5 mg. Six to eight hours after the preoperative medicinal doses, Group A received 1 mg/kg of morphine intramuscularly and Group B received 1 mg/kg of morphine intramuscularly along with a 0.25% bupivacaine nerve block. The nerve block was delivered via pre-placed catheters at rib spaces 3 through 7. Group C received an additional 1 mg/kg intramuscular morphine dose at this time. Six to eight hours after these initial post-operative analgesic dosages, Group A again received 1 mg/kg of morphine intramuscularly, Group B received 0.25% bupivacaine nerve block via the previously mentioned pre-placed

catheters, and the dogs in Group C were monitored for proper fentanyl patch placement and adherence.

The following morning, eight to 10 hours after the last post-operative analgesic dose, only Groups A and B received 0.01 mg/kg of buprenorphine intramuscularly. By contrast, the canines in Group C were monitored only for proper fentanyl patch placement in the 72 hours following the initial patch placement.

Thus, the canines in this study were given a series of analgesics before, during, and after their recovery from surgery. After the surgery, the canines were recovered with the appropriate analgesic protocols and monitored at times 0, 1, 2, 3, 4, 8, 10, 12, and 20 hours. Physiological parameters measured included heart rate, body temperature, respiratory rate, urine and fecal output, pulse quality, and overall responsiveness. The subsequent subjective postoperative observations were noted and converted to an objective score using The University of Melbourne Pain Scale (Firth and Haldane, 658). The postoperative pain scale that was used in this study was divided into two main categories: physiological data and subjective data. Physiological data included comparing the three groups' heart and respiratory rates to those of a control group. The preprocedural control ranges for heart and respiratory rate were determined by measuring these parameters in six age- and sex-matched canines that did not undergo the thoracotomy procedure. This group then provided the control ranges for these two parameters. Parameters for the preprocedural control ranges were determined for heart rate and respiratory rate in six control canines. In conjunction with the aforementioned pain scale, an increase in heart rate of >20% or >118 beats per minute was given a pain score of 1; >50% or >148 bpm, a pain score of 2; and >100% or >197 bpm, a pain score of 3. Additionally, increase in respiratory rate parameters of >20% or >26 was assigned a pain score of 1; >50% or >32, a pain score of 2; and >100% increase or >43, a pain score of 3. Body temperature and

salivation were also included under the physiological data category in the pain scale. Subjective data included response to palpation of the surgical site, general activity, mental status, posture, and the presence or absence of vocalization.

For each of the above categories, a pain score was determined based upon the observation of each canine that underwent the invasive surgery. The maximum total score that a dog could receive for all categories combined was 27. The higher the total score, the greater the degree of postoperative pain; the lower the total score, the lower the degree of postoperative pain experienced by the canine. Each canine was evaluated using this pain scale at hourly intervals postoperatively for the first four hours. After this, they were evaluated at 8, 10, 12, and 20 hours postoperatively.

RESULTS

Based on the preliminary study comparing analgesia Protocols A, B, and C, all were effective in preventing postoperative pain at hours 0-4, 8, 12, and 20 hours, but there was no statistically significant difference between the three protocols in preventing postoperative pain at hours 0-4, 8, 12, and 20. Important to note in Table I is that the frames under the 12-hour interval contain no mean pain score for Groups A and C because subjective observations were not recorded in the overnight hours following the thoracotomy (Table I). Therefore, the data for the 12-hour period in Protocol C were not included in the statistical analyses.

Table I. Mean Pain Scores for Protocols A, B, and C

	0hr	1hr	2hr	3hr	4hr	8hr	10hr	12hr	20hr
Group A	2.00	3.57	3.43	3.85	3.00	5.50	4.85		4.62
Group B	2.25	2.87	2.87	2.12	3.60	4.60	7.25	4.00	4.87
Group C	1.88	1.88	4.13	4.75	3.50	3.40	3.83		4.00

Interestingly, at 10 hours post-surgery, there is a statistically significant difference between Protocol A, involving repeated doses of morphine, and Protocol B, which included doses of morphine and bupivacaine nerve block at more rib spaces than Protocol A, with Protocol A being slightly better at providing

analgesia (Table I). The mean pain score for Protocol A at 10 hours is 4.85 ± 1.86 (Tables I and II) compared to that of Protocol B at 10 hours that is 7.25 ± 1.04 ; therefore, the mean pain score in Protocol A is significantly lower ($p = 0.02$) (2 ANOVA two-way statistical analysis was utilized in the investigation).

Table II. Standard Deviation Table for Mean Pain Scores in Protocols A, B, and C

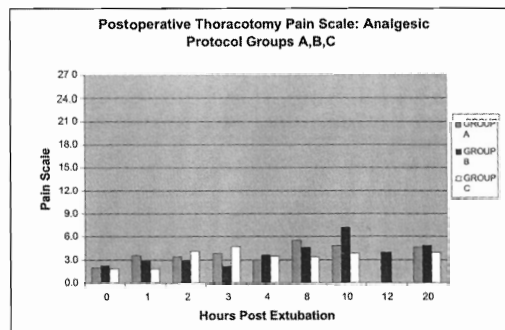
	0hr	1hr	2hr	3hr	4hr	8hr	10hr	12hr	20hr
Group A	1.41	3.10	2.82	2.73	2.83	2.12	1.86		1.41
Group B	1.28	2.10	1.64	1.13	1.15	1.53	1.04	1.00	2.36
Group C	0.83	1.36	2.59	2.87	1.76	1.14	2.14		1.31

At 10 hours, moreover, there is a statistically significant difference overall between the mean pain score of Protocol C, which is 3.83 ± 2.14 and the combined mean pain scores of Protocols A and B. In this analysis, the analgesic effects of the fentanyl patch in Protocol C were slightly better than the combined analgesic effects of the morphine and bupivacaine doses of Protocols A and B ($p = 0.0037$). Additionally, in comparing the mean pain score of Protocol C with that of Protocol B, the fentanyl patch in Protocol C was again a slightly better analgesic agent than the combined morphine/bupivacaine doses ($p = 0.0018$). However, compared to Protocol A at 10 hours, the analgesic effects of Protocol C revealed no significant difference.

As time progressed following the thoracotomy, each analgesic protocol was unique in its pattern of reducing pain at specific intervals. In Protocol A, pain suppression was at its minimum at eight hours, with a mean pain score of 5.50 ± 2.12 indicating the manner in which morphine operates at the physiological level in the organism (Figure 1). Following this 8-hour interval, pain subsequently decreased again as a result of the follow-up doses of the morphine analgesic. Additionally, in Protocol B, the trend is such that the mean pain scores on average increased from 0 to 8 hours with the highest mean pain score at 10 hours. After the 10-hour demarcation period, the pain scores indicate a sharp decrease in pain felt by the research animal (Figure 1). Lastly, Protocol C indicated staggered pain suppression results

which are supported both by the method of morphine administration followed by the placement of the fentanyl patch and the effectiveness of fentanyl at the physiologic level at a specified time period. Thus, in this protocol, pain suppression was at a minimum immediately after surgery and in the following hour. The pain felt by the animal then increased from two to three hours after the thoracotomy. This increase was then followed by another pattern of increasing pain and finally decreasing pain (Figure 1).

Figure 1. Hours Post Extubation vs. Mean Pain Scores for Protocols A, B, and C (each bar represents the mean pain scores for Protocols A, B, and C)



When the mean total pain scores of the animals under study were compared to those obtained from a study in the literature using the same pain scale, there was no significant difference (Firth and Haldane, 1999). This is notable because the canines in the study from the literature underwent an ovariohysterectomy, or spay, which is a much less invasive procedure than the thoracotomy. The focal point of the study, nevertheless, is at the 10-hour time interval that indicates the analgesic activities of morphine, morphine/bupivacaine, and fentanyl at the physiological level and their usefulness in preventing pain during the overnight hours in an animal research facility.

DISCUSSION

In the preliminary investigation of postoperative pain management in a canine thoracotomy model, the usefulness of three different analgesic protocols was analyzed; the analysis pointed to an effective, preliminary pain-management strategy aimed at decreasing

the pain experienced by the research animal following an invasive procedure. Important to the discussion is the manner in which the experimental analgesics work at the physiological levels and their unique effect on minimizing pain.

In Protocols A, B, and C, morphine sulfate was utilized both before and after surgery. During the investigation, it was administered alone postoperatively in Protocol A, or combined with another analgesic in Protocols B and C. In all three protocols, morphine acted as an opioid agonist, which induced an increase in serotonin synthesis, a neurotransmitter responsible for the analgesic effect within the body (Lumb et al., 1996). When choosing an optimum pain-management strategy, however, it is necessary to account and adjust for the subsequent effects of the analgesic outside of its pain-suppressing capability. Morphine sulfate, in addition to minimizing pain, causes central respiratory depression and may contribute to postoperative hypoventilation instead of improving ventilation (Conzemius et al., 1994). Thus, the pain-management strategy in Protocol B may be especially effective in suppressing pain and ensuring proper respiratory function following the thoracotomy. Bupivacaine, used along with morphine in Protocol B, has been documented to increase ventilation following surgery. In fact, ventilation is improved by the use of bupivacaine more so than when morphine is used alone (Pascoe et al., 1993). On the physiological level, bupivacaine nerve block, which is used along with morphine in Protocol B and morphine and fentanyl in Protocol C, provides selective analgesia to the intercostal incision, which provides effective short-term analgesia. Important to note, however, is that this intercostal local anesthetic does not block nociceptive input from the entire surgical site, but only the surgical incision (Conzemius et al., 1994). Therefore, the usefulness of morphine in Protocol A and morphine and fentanyl in Protocol C is further emphasized. The combined use of bupivacaine for early analgesia and morphine for

more prolonged analgesia has been advocated to provide better pain suppression than either drug alone affords (Egger et al., 1998).

Interestingly in the investigation, the comparison of the analgesic effects of Protocols A and B show no statistically significant difference in decreasing pain except at the 10-hour time interval. At this period, morphine minimized pain more efficiently than the combination of morphine and bupivacaine (Table I). One possible explanation for this analgesic behavior may be that the second postoperative dosage of morphine alone in Protocol A was more effective than Protocol B because of the interaction between morphine and bupivacaine in Protocol B. In both cases, however, pain was minimized more efficiently following the thoracotomy than after a less invasive ovariohysterectomy using the same subjective pain scale (Firth et al., 1999). Perhaps a tradeoff occurred at the physiological level. For example, pain scores are lower in Protocol B during hours 0-3 and 8 following the thoracotomy (Table I). Respiratory rate increase was included in the subjective evaluations, and since respiratory rate did not significantly increase with the use of bupivacaine in Protocol B, the overall pain scores were lower during the time that bupivacaine was effective. However, bupivacaine is only a short-term analgesic; as its effectiveness waned, it may have taken longer for the postoperative doses of morphine to work because of the interaction with the residual bupivacaine. In Protocol A, morphine stood alone as the effective analgesic. However, an increase in respiratory rate was a consequence of this protocol, for the mean pain scores in Protocol A during postoperative hours 0-3 and 8 were higher than those in Protocol B (Table I). Again, an increase in respiratory rate in the hours immediately following surgery is positively correlated with a higher total pain score. Thus, it can be concluded that a third analgesic may be needed in order to counteract nociception as bupivacaine levels decreased in the body, and morphine was left to act as the sole analgesic. The use of two or

more analgesics produced better pain relief than a single medication or administrative route (Carpenter, 1997). This effect is best illustrated with the results obtained in Protocol C, using the transdermal fentanyl analgesic (Table I).

In previous studies, it has been found that the fentanyl analgesic is 50 to 100 times more potent than morphine, and it is rapidly metabolized in the body (Egger et al., 1998). However, fentanyl does not reach optimum activity until 10 to 12 hours after patch placement, in this case, on the inner thigh of the canine. Experimental results are congruous with the theory of fentanyl activity, for the mean pain score of Protocol C at the 10-hour interval following surgery showed a statistically significant lower trend than the combined score for Protocols A and B (Figure 1). These results indicate that fentanyl is useful in combating pain following an invasive surgery such as the thoracotomy. In an animal-research environment, fentanyl ensures an effective pain-management strategy during the overnight hours. The drug is designed to be constantly released into the systemic circulation for up to 72 hours following administration (Egger et al., 1998).

In the investigation, Protocol C has a statistically significant advantage over Protocol B, possibly because of the physiological interaction between morphine and bupivacaine in Protocol B. As bupivacaine levels decreased locally, morphine was left alone to suppress pain. Possibly, subsequent postoperative doses of morphine may not have been as effective as a result of any reaction with residual bupivacaine. Further study is needed to indicate if and how morphine and bupivacaine analgesics interact at the physiological level.

Overall, fentanyl in Protocol C did not appear to have any statistically significant effect on pain suppression except at 10 hours, when blood plasma concentrations of the analgesic increased (Figure 1). The results of the study indicate that a combination of morphine, bupivacaine, and transdermal

fentanyl is a useful postoperative pain-management strategy following an invasive thoracotomy procedure. In future experiments, pain scores may be lowered if the fentanyl transdermal patch is applied 24 hours before surgery (Egger et al., 1998). Through use of the fentanyl transdermal patch in concert with bupivacaine and morphine, pain may be minimized and respiratory rate optimized immediately off the surgical table. Thus, the third analgesic, fentanyl, may be necessary to magnify the analgesic response.

Furthermore, it is important to mention the use of atropine sulfate and acepromazine maleate as preoperative drugs, both of which are not used for analgesic effect. Prior to surgery, atropine was administered along with the preoperative dose of morphine in order to decrease oral, pharyngeal, and respiratory-tract secretions. Use of atropine also doubles the period of anesthesia in canines (Lumb et al., 1996). Therefore, atropine aids in maintaining anesthesia and is a key preoperative measure. Additionally, in each of the three protocols, acepromazine maleate was administered along with the key analgesic postoperatively as a tranquilizer. Acepromazine relieves anxiety following surgery, prevents licking, and prepares the animal for examination (Lumb et al., 1996). Thus, both of these drugs were not included in the analysis of pain management.

Ultimately, in order to ensure proper care of the animal, pain assessment should be frequent and can be accomplished using a verbal description scale. Recognizing that pain is important enough to be measured and recorded is the first step in improving pain management (Carpenter, 1997), and in this investigation, a multi-analgesic regimen proved to be the most effective strategy to combat pain during an invasive surgery. In future experiments, instead of using control ranges, preoperative heart rates, respiratory rates, temperatures, etc., can be used for comparison before and after surgery on each dog further to reduce error. Additionally, blood gas analysis and pulse oximetry can be

implemented in order to measure the usefulness of bupivacaine in maintaining an adequate respiratory rate. Finally, different plasma concentrations and patch sizes of transdermal fentanyl may be studied to evaluate which concentration is most effective for the longest period following the thoracotomy.

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Amplification of Microsatellite Loci from Museum Specimens of Cervid Antler

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ABSTRACT

The purpose of this study was to determine if amplifiable DNA could be extracted and isolated from museum samples for experimentation. Antlers from *Odocoileus virginianus*, procured from the New Jersey State Museum, via David Parris, were analyzed. Three samples collected in 1981, numbered B-344, B-345, and B-346, were used. Approximately 0.25 grams of material was cut from each antler, and DNA was extracted and isolated using procedures outlined in Boom et al., 1995 and Villarreal et al., 1996. The DNA was then amplified through polymerase chain reaction using five sets of cervid microsatellite primers developed by DeWoody et al., 1995 (Cervid 1-4 and Cervid 14). Our results show that the DNA extracted was of the purity and length necessary for PCR amplification. We were also able to demonstrate considerable polymorphism within the white-tailed deer population sampled.

INTRODUCTION

Information can be gathered about an existing population by examining the frequency of certain alleles present within the population. Genetic material is readily extracted, isolated, and amplified from soft tissue for such purposes. Museum archives often contain vast libraries of biological specimens, but most contain little if any soft tissue preserved in its natural state. This study was performed in order to determine if viable genetic material could be gathered from these samples in the absence of soft tissue. This would allow studies

to be performed on populations long extinct. The information gathered can be used to determine the extent of heterozygosity, and therefore fitness, of a population over time. This preliminary study was performed on shed cervid antler, collected and catalogued in 1981, by the New Jersey State Museum.

METHODS AND MATERIALS

A 0.25-gram sample was cut from each antler. The samples were then crushed into smaller fragments and incubated in L6 Buffer [98% guanidine thiocyanate and 2% Triton X-100 in 0.01 M Tris (pH 6.4), 0.036 M EDTA (pH 8.0)] at 65° C for 30 minutes, followed by 37° C for 30 minutes. All insoluble materials were then removed by centrifugation. The samples were then extracted with an equal volume of phenol:chloroform:Isoamyl alcohol (49.5:49.5:1), followed by extraction with an equal volume of chloroform:Isoamyl alcohol (24:1). The DNA was precipitated by the addition of two volumes of ice-cold absolute ethanol, pelleted by centrifugation, air-dried, and dissolved in 450 µl TE 8 (Tris EDTA pH 8). The DNA was then reprecipitated by the addition of 50 µl of 5 M NaCl and 1 ml of ice-cold absolute ethanol, washed with 70% ethanol, pelleted, and dried as above. The resulting pellet was then dissolved in the minimum amount of water necessary (Boom et al., 1990). A 1:200 dilution of the final samples was then prepared for spectrophotometric analysis. DNA concentration was determined, and a PCR working dilution (40 ng/µl) was prepared. PCR was performed

under the conditions outlined in Table 1 and products were run out on a 4% NuSieve Agarose gel. PCR was then again performed using chemiluminescent-labeled primers. Primers were labeled using Gene Images AlkPhos Direct labeling reagent. DNA was transferred from the gel to a nylon membrane by vacuum. The membrane was then exposed to diagnostic film. DNA obtained from preserved porcupine skin (NJSM *Erethizon dorsatum* sample #65, 1978) is used throughout the experiment for comparison.

Table 1: PCR conditions were as follows:

2.5 mM dNTPs	0.5 μ l
Ammonium sulfate	0.5 μ l
10x buffer #12	2.5 μ l
Taq polymerase (5 μ l)	0.2 μ l
Forward primer (20 μ M)	0.65 μ l
Reverse primer (20 μ M)	0.65 μ l
Water	15.0 μ l
DNA (40 ng/ μ l)	5.0 μ l
Total reaction volume	25.0 μ l

Thermal Cycling Conditions:

Initial 5-minute denaturation at 94° C followed by 35 cycles of:

94° C - 1 minute (denaturation)

60° C - 1 minute (annealing)

72° C - 1 minute (extension)

Soak at 4° C

RESULTS AND DISCUSSION

The DNA extracted and isolated from the antler samples proved to be of considerable concentration. Purity tended to vary from sample to sample. Some proteins and organic materials were present in the final sample, but DNA-to-contaminant ratio remained fairly high (see Figure 1). The DNA samples collected were in fact of the purity necessary for PCR amplification. DNA was successfully amplified from each sample for all five microsatellite loci tested.

Polymorphism within the sample population was demonstrated (see Figure 2). This technique may prove useful in performing population studies using only museum specimens as the sample population. A preliminary trial in using chemiluminescent-labeled probes was performed in an attempt to gain better resolution and specificity. A strong signal was detected for two of the three deer sampled. Only cervid 1 primers were tested and results are inconclusive (see Figure 3). Future studies include the use of radioactively labeled microsatellite probes,

Figure 1: Absorbance profiles of samples extracted and isolated from museum cervid antlers

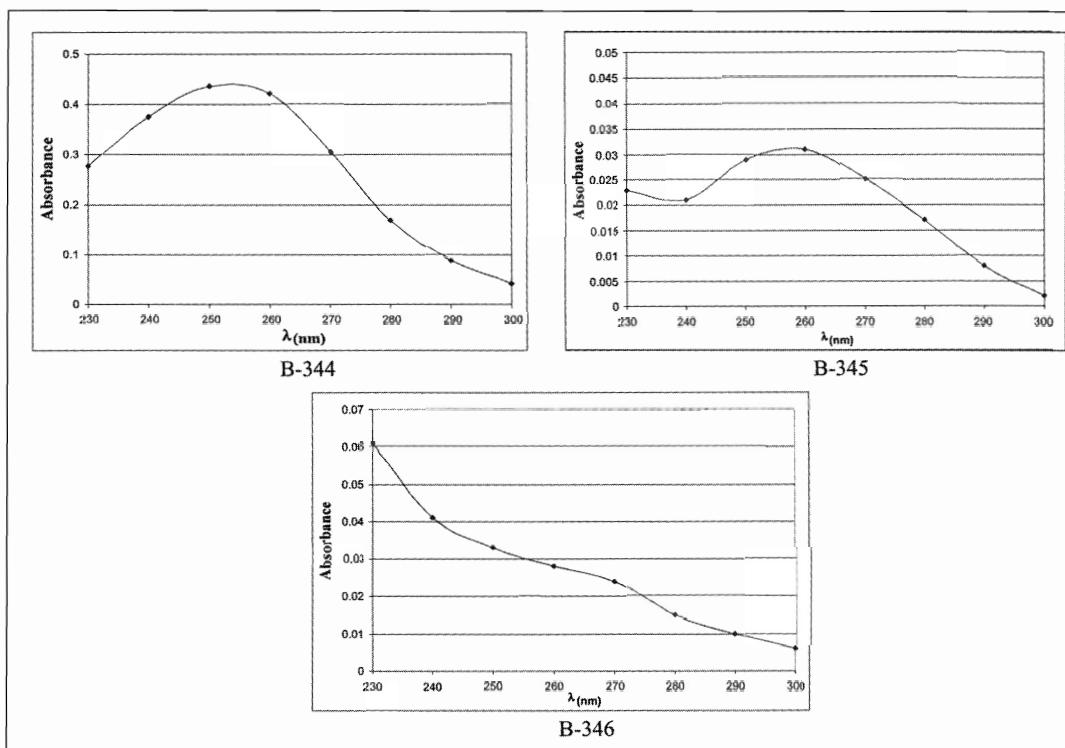
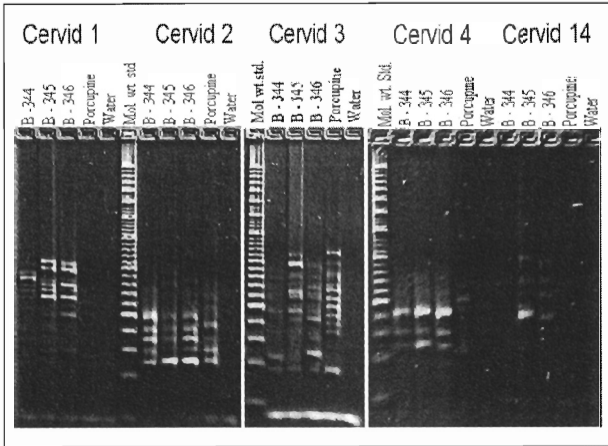
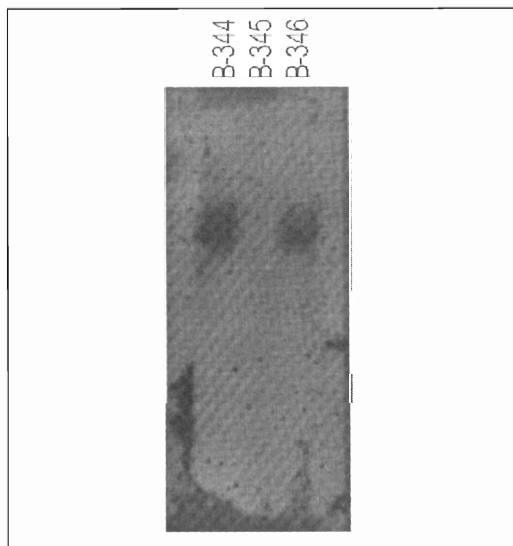


Figure 2: The PCR products from deer B-344, B-345, B-346 were run on a 4% NuSieve 3:1 Agarose gel. Each sample was tested for amplification by cervid 1, cervid 2, cervid 3, cervid 4, and cervid 14 microsatellite primers. The gel images were enhanced with a contour filter. DNA standard represents 20 bp units.



and experiments performed on similar species, such as caribou. The possibility of using this technique to measure genetic variation and population fitness within an extinct population will ultimately be investigated.

Figure 3: Cervid 1 primers were conjugated with Alkaline-Phosphatase Chemiluminescent labels and PCR was performed using the protocol previously described. Samples were then vacuum-transferred to a nylon membrane. Detection was performed using CDP-Star detection reagent and the membrane was exposed to diagnostic film. One-hour exposure shown.



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Polyadenylation Status of a Zebrafish RNA, zDAZL, Does Not Change During Early Development

G. J. Porreca,
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Faculty Sponsor:
Professor M. L. O'Connell,
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ABSTRACT

In many species, early embryogenesis is regulated by maternal gene products placed in the egg during oogenesis. Many of these maternal gene products are maternal mRNAs whose translation must be specifically and temporally regulated. In several species, including mouse and *Xenopus*, cytoplasmic polyadenylation is used as a method of translational control for select maternal mRNAs. By this mechanism, a change in poly-A tail length determines translational activity such that a short poly-A tail represses the translation of an mRNA, and elongation of the poly-A tail triggers its translation. This work was part of a screen for translational control via cytoplasmic polyadenylation in maternally provided mRNAs of the zebrafish, *Danio rerio*. The poly-A tail length of the zDAZL mRNA at various developmental time points was studied using a PCR-based assay. Results indicate that zDAZL is not subject to regulation via cytoplasmic polyadenylation during early development, as a result of the presence of a poly-A tail of constant length.

INTRODUCTION

Temporal translational regulation of maternally provided mRNAs is necessary for successful development of an embryo. Cytoplasmic polyadenylation has been determined, in several species including mouse (Stutz et al., 1998) and *Xenopus* (Simon et al., 1996), to provide one means for selective activation or de-activation of translation. This mechanism is responsible for controlling the

synthesis of key regulatory proteins in several species, such as bicoid and Toll in *Drosophila* (Salles et al., 1994), and cyclin B in *Xenopus* (Simon and Richter, 1998). Factors within the oocyte act to change the length of the poly-A tail of specific mRNAs, with shortening leading to repression of translation, and lengthening leading to activation (Huarte et al., 1992).

The polyadenylation status of an mRNA can be determined by a PCR-based assay using cDNA produced by reverse-transcription of total RNA using an oligo(dT) reverse primer. If the poly-A tail of an mRNA is relatively short, the oligo(dT) will tend to anneal to the same location on every copy of the mRNA, yielding a population of cDNAs having fairly constant length. Conversely, if the poly-A tail is long, cDNAs of varying lengths, corresponding to the high number of locations along the tail to which the primer can anneal, will result (Salles et al., 1992). The cDNA of the mRNA of interest is amplified by performing a PCR reaction with a forward primer specific to a sequence in its 3' UTR, and a reverse primer that preferentially anneals to the 3' end of the poly-A tail.

The purpose of the experiment presented here was to determine whether the zDAZL mRNA is subject to translational control via cytoplasmic polyadenylation in the zebrafish, *Danio rerio*. zDAZL is a maternally provided homologue of the DAZ gene family which is required for gametogenesis in *Drosophila* (Eberhart et al., 1996) and mouse (Ruggiu et al., 1997), and is expressed in the gonads in

humans (Shan et al., 1996) and *Xenopus* (Houston et al., 1998). It has been shown to be localized to the vegetal pole in zebrafish during early embryogenesis, and subsequently to travel toward blastomeres in cytoplasmic streams (Maegawa et al., 1999). zDAZL was chosen for the screen of mRNAs which exhibit this control mechanism because it is maternally provided, and serves a putative function of importance in the developing embryo. Results indicate that the poly-A tail of the zDAZL transcript is a consistent, short length during the period of development studied, and thus is not subject to this mechanism of control during that time.

MATERIALS AND METHODS

Zebrafish embryos were reared at 28°C under standard conditions, collected at artificial dawn, and staged according to Westerfield (1995) at five time points, corresponding to the 2-cell, 256-cell, high, sphere, and dome stages. Total RNA was then extracted from the embryos and purified using an RNA purification kit (Stratagene, Inc). The presence of RNA after purification was ascertained by formaldehyde gel electrophoresis.

PolyA+ cDNA was synthesized for the entire population of RNA present at each time point, according to Salles et al. (1992). Oligo p(dT)12-18 was allowed to anneal to the poly-A tails of all mRNAs present, at 42°C, and ligated together with T4 DNA ligase. The temperature was then lowered, and anchorT was added, which annealed to the remaining stretch of free adenine residues (less than 12 nt long) at the 3' end of the tail, to create a reverse primer for the subsequent PCR reaction.

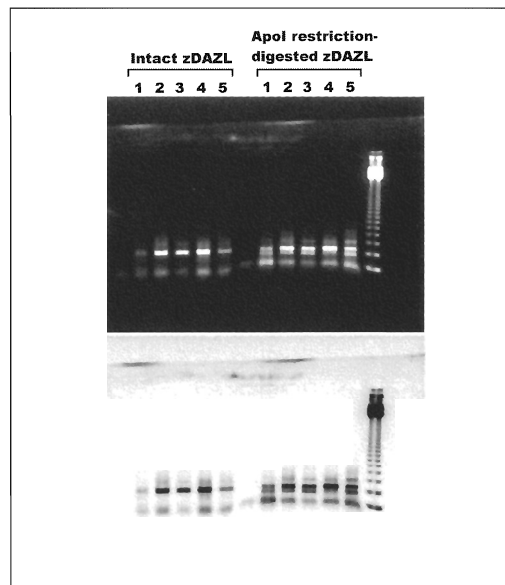
PCR was conducted on the five samples and a control, using a 22-mer found in the 3' UTR of the zDAZL mRNA (GGGGGACACATTCATCAGATTC) as the forward primer, and anchorT as the reverse primer. Following the PCR, a restriction digest was performed using the ApoI restriction enzyme to verify the identity of the product; the 3' UTR of the zDAZL transcript contains one

ApoI restriction site 57 basepairs from the 5' end of the PCR product. The sizes of both the intact zDAZL 3' UTR+poly-A tail and the restriction fragments were determined using standard agarose gel electrophoresis with ethidium bromide staining.

RESULTS

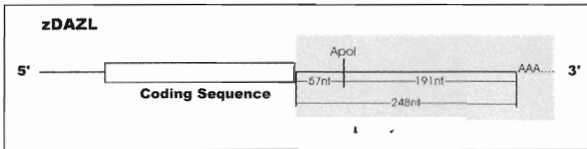
The RNA extraction procedure successfully yielded RNA at all five time points. Figure 1 shows two distinct bands in each lane, corresponding to the 18S and 28S ribosomal RNAs at each stage. While there is variability in the yield of RNA (note the relative high concentration of RNA in lanes 2 and 4), all samples yielded intact RNA.

Figure 1. Formaldehyde gel showing the presence of two ribosomal RNAs at each developmental stage. Differences in relative brightness of bands correspond to differences in concentration of isolated RNA.



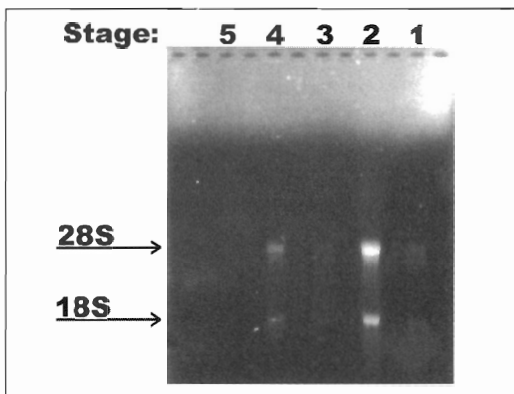
Poly-A+ cDNA was prepared from all samples using 1:1 of RNA. By this procedure, developed by Salles et al. (1992), the entire poly-A tail of all mRNAs is reverse-transcribed, along with a good portion of the 3' UTR. Therefore, the cDNA used in subsequent PCR reactions can be used to measure the length of the poly-A tail of a given mRNA.

Figure 2. Agarose gel showing both intact zDAZL 3'UTR PCR products and restriction-digested products, as labeled. Lanes 1-5 correspond to developmental stages 2-cell, 256-cell, high, sphere, and dome, respectively. In both sets, the PCR products at each developmental stage are of approximately equal size, roughly 275bp. Note the lack of product, as expected, in the control lanes, located in the lane to the left of lane 1 in each set.



zDAZL during early embryogenesis, PCR was performed using the forward primer specific to a sequence in the 3' UTR of the zDAZL transcript. PCR products were obtained for each of the five whole cDNA populations, as indicated by the presence of bands in each of the five lanes labeled "Intact zDAZL" on the gel in Figure 2. The most abundant product in each lane, corresponding to the single band, is roughly 275 bp in size, when compared to the molecular weight standards. This length is consistent with the presence of a short poly-A tail of approximately 25 bp in length (see Figure 3). The smear visible above each band is indicative of a small population having longer poly-A tails.

Figure 3. Schematic diagram of the zDAZL mRNA, with location of ApoI restriction site in the 3' UTR shown. Gray rectangle indicates the portion of the transcript present as poly-A+ cDNA, and amplified by PCR. Any variability in length of the PCR product, therefore, is a result of variable poly-A tail length. Not drawn to scale.



In order to verify the identity of the PCR products, a restriction digest using the ApoI restriction enzyme was performed. These products are labeled "ApoI restriction-digested zDAZL" in Figure 2. The presence of an extra row of bands indicates a successful restriction digest for each of the developmental stages studied. Furthermore, the sizes of the bands for the restriction-digested products correspond to the expected fragment sizes of 57 bp and 191 bp that would be produced by a restriction digest of the 3' UTR of the zDAZL transcript, as shown in Figure 3. The presence of bands in the restriction digest lanes of equal size to those in the undigested lanes suggests that not all of the DNA in each lane was digested.

DISCUSSION

The presence of PCR product of consistent length across the five developmental stages studied is indicated by bands corresponding to the same size in each lane on the gel. The size of the product, approximately 275 bp, indicates the presence of a poly-A tail approximately 25 bp long at each stage. Since the length does not change over the course of development studied, and since such a change in length is indicative of translational control via cytoplasmic polyadenylation, it is reasonable to conclude that zDAZL is not subject to this mechanism of control during the early stages of development.

The presence of zDAZL gene product during these developmental stages has not been ascertained. Therefore, several explanations for the observed pattern exist. Since translation can occur with a poly-A tail length as short as 30 nt, the mRNA could be expressed constitutively during early development, and not be subject to any form of control. Alternately, control may be effected spatially, via localization, rather than temporally. As was previously noted, Maegawa et al. (1999) have shown the transcript to travel in cytoplasmic streams. Lastly, although transcriptionally inactive during early embryogenesis, zDAZL may in fact become polyadenylated,

and expressed, during a later period of development, after the dome stage.

The screening of maternally provided mRNAs undertaken by this lab has found two RNAs that are regulated by cytoplasmic polyadenylation during early development (ElrA and tpt), and five mRNAs, now including zDAZL, that are not. These findings indicate that cytoplasmic polyadenylation is in fact a selective mechanism for translational control in zebrafish, consistent with its known role in other species.

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Conference Proceedings

Listed below are abstracts of student-faculty collaborative work presented at regional, national, and international conferences.

Henry F. Fradella, Michael R. Carroll, Ryan A. Melendez, and Edward Chamberlain,
The College of New Jersey
 (Henry F. Fradella, Faculty Sponsor)

Sexual Orientation, Justice, and Higher Education: Student Attitudes Towards Gay Civil Rights and Hate Crimes

Presented at the American Society of Criminology annual meeting, San Francisco, CA, November 15, 2000

The researchers sought to identify which factors contributing to homophobia in the law appeared to play a role in college students' conceptualizations of homosexuality and in particular, attitudes toward specific "gay rights." A quantitative content analysis of media coverage of anti-gay hate crimes in the two years before and after the death of Matthew Shepard was conducted. After documenting increases ranging from a low of 64% in certain newspapers to a high of 1543% in magazines and journals, a series of semi-structured interviews with college freshmen and seniors was conducted. The results were compared and contrasted not only in an attempt to see if increased media attention had changed these students' perceptions of gay rights, but also to uncover the basis of their perceptions regarding specifics of gay rights issues ranging from gay marriage and homosexuals' participation in the military, to anti-gay crimes of violence and living with gay friends and family members. Overall, students were generally supportive of gay rights in the abstract and with regard to various particular rights, but differences

in both gender and level of education were manifest. The policy implications for both the legal system and for teaching at the undergraduate level are explored.

Henry F. Fradella, and Michael R. Carroll,
The College of New Jersey
 (Henry F. Fradella, Faculty Sponsor)

Abracadabra, Inmate Style: The Power of "The Magic Words" in Section 1983 Prisoner Civil Rights Litigation

Presented at the American Society of Criminology annual meeting, San Francisco, CA, November 18, 2000

Recent literature on prisoner civil rights litigation has called into question the validity of the alleged frivolous nature of such lawsuits. The Prisoner Litigation Reform Act of 1996 decreased the number of Section 1983 filings by prisoners, but did not address the overwhelming number of prisoner lawsuits that are non-frivolous as a matter of law, but are found to lack substantive merit upon final adjudication. Using qualitative content analysis and discourse analysis, this study explores the nature of such lawsuits and concludes that artful pleading by inmates is responsible for the problem. The socio-legal and public policy implications for the findings are discussed.

Malinda Wolfgang,

The College of New Jersey

(*Blythe Hinitz, Faculty Sponsor*)

*Margaret Naumburg and Caroline Pratt:
Similar Progressive Educators*

Presented at the annual conference of the New Jersey Association for the Education of Young Children, Somerset, NJ, October 13, 2000

Margaret Naumburg is a woman who was active in the Progressive Movement in education. She was a teacher of young children from 1914-1916. When The Children's School was founded, she became an administrator. She was very active in the Progressive Movement as a whole, and associated with Caroline Pratt, whose school she considered the only other true progressive school of the time. This research project examines the backgrounds, interests, and philosophies of these two women and the curricula taught in Naumburg's Walden School and Pratt's City and Country School. The striking parallels that this study discusses help to explain why Naumburg considered Pratt the only other "true progressive" of the time.

The information provided in the presentation draws chiefly upon archival material and educational literature of the Progressive period, supplemented by current literature. Sources of the archival material include the Margaret Naumburg Papers at the Department of Special Collections, Van Pelt-Dietrich Library Center, University of Pennsylvania; the City and Country School and Caroline Pratt Archives at City and Country School, New York; and the Teachers College Archives, at Columbia University, New York. The presentation is interactive, consisting of four sections: principles of the Progressive Movement; Margaret Naumburg's educational background, philosophy, and curriculum at Walden School; Caroline Pratt's educational background, philosophy, and curriculum at City and Country; and a concluding section on why Naumburg considered Pratt the only other "true progressive."

Stephanie Loh,

The College of New Jersey

(*John C. Pollock, Faculty Sponsor*)

*An Analysis of the Challenger Explosion
Through the Eyes of the Media*

Presented at the annual convention of the National Communication Association, Atlanta, GA, November 3, 2001

The Challenger explosion was one of the more significant events in recent American history. As such, it is only natural that the event demanded and received extensive coverage by the media. While television provided coverage of the event and its aftermath, time and space limitations did not allow the medium to examine the event fully. The major newsmagazines, such as *Time*, *Life*, and *Newsweek*, which treated the story more extensively, were instrumental in influencing public perception. Moreover, these sources provided answers to the public about the causes of the disaster. By treating the event in simple language and setting it in the context of the space race, blame was lifted from NASA. In addition, the characterization of Christa McAuliffe as a cultural symbol that all could aspire to become, took focus off the technical reasons for the disaster. Even months after the disaster, when NASA admitted its mistakes to a national commission, the newsmagazines that did cover the story stressed the importance of continuing space-shuttle flights. The long-term implications of this study suggest that the public should be cautious of placing great faith in the media's understanding of an event.

Dana Drag and Lorraine Juzwick
The College of New Jersey
 (Deborah Knox, Faculty Sponsor)

*Cluster Computing: Development of a
 Small-Scale Cluster and Learning Modules
 for Undergraduates*

Presented at the Consortium for Computing
 in Small Colleges, Middlebury College,
 Middlebury VT, April 20-21, 2001

In both industry and at research facilities
 around the world, the demand for supercom-
 puting power is widespread. However, such
 power is tremendously expensive, and there-
 fore available primarily to national labs, large
 companies, and large research universities.
 Fortunately for those at smaller institutions,
 through the use of clustered computing one
 can achieve near supercomputer performance
 on affordable and regularly available PCs.
 The research goals for our project involved
 building a small-scale cluster, learning both
 implementation and application levels of
 clustered networking, and creating a refer-
 ence for undergraduate computer scientists
 interested in this topic.

The hardware implementation of the
 cluster uses a small number of Pentium
 computers that were donated by The
 College. Red Hat Linux (6.2) was the operat-
 ing system selected to run on the cluster,
 because of its popularity as a choice for
 clusters. The clustering software that runs
 parallel programs on the cluster is called
 MPI (Message Passing Interface). MPI is a
 library of C or C++ routines to aid in get-
 ting low-level hardware to implement ideas
 at a higher abstraction.

This cluster-computing project was
 designed to produce a tutorial to guide other
 undergraduates interested in this discipline.
 The tutorial is a combination of guidelines,
 details of problems experienced and subse-
 quent solutions, and a glossary to define
 new terms. In addition to the tutorial, lab
 exercises to be used in support of CS courses
 were created. The six-node cluster that was
 developed will be used in the future by the

computer science department for labs or to
 support other undergraduates interested in
 an independent study.

Gregory Evans, Anthony Guinta, Rebecca
 Pearson, Michael Perticari, Kim Reeves,
 and Jessica Walker
The College of New Jersey
 (P. Andrew Leynes, Faculty Sponsor)

*Event-Related Potential Measures of the
 Revelation Effect*

Presented at the Annual Meeting of the
 Cognitive Neuroscience Society, New York,
 NY, March 25, 2001; the Annual Meeting
 of the Eastern Psychological Association,
 Washington D.C., April 21, 2001; the 16th
 Annual Lehigh Valley Undergraduate
 Psychology Conference, Allentown PA,
 April 28, 2001

Asking people to discover the identity of a
 recognition test probe prior to making a
 recognition judgment tends to increase the
 number of old judgments for both targets and
 lures. This effect, referred to as the "revelation
 effect," has two viable theoretical explana-
 tions. Some hypothesize that this discovery
 process increases the familiarity of items,
 thereby making the discovered test probes
 seem old. Others suggest that the discovery
 process causes people to adopt a more liberal
 decision criterion. In the present experiment,
 we recorded event-related potentials (ERPs) in
 an attempt to disambiguate these two theoret-
 ical explanations. The effects of familiarity
 have been observed in an old/new ERP effect
 localized over frontal electrode sites. Thus, we
 expected to find differences in this compo-
 nent if discovery affected familiarity levels.
 Conversely, more complex effects were expect-
 ed if revelation influenced the decision
 processes. The ERP effects elicited by intact
 and discovered words were analyzed in a
 within-subjects design. The data appear to
 support the liberal decision criteria position.

Gregory Evans, Anthony Guinta, and Michael Perticari

The College of New Jersey

(P. Andrew Leynes, Faculty Sponsor)

The Effects of Leading Questions on Judgments of Source and Event-Related Potentials (ERPs)

Presented at the Annual Meeting of the Eastern Psychological Association, Washington D.C., April 21, 2001

Participants studied words from two different sources (i.e., seen or heard). In order to investigate the effects of decision processes on event-related potentials (ERPs), participants completed two separate source memory tests that contained leading questions (cf. Marsh & Hicks, 1998). On one test, the question "was the item seen?" led people to inspect memory for visual characteristics, whereas the question "was the item heard?" on the other test directed people to inspect memory for auditory characteristics. ERP effects were similar to previous investigations of source memory that have implicated right frontal regions in source-monitoring processes. However, ERP data suggest that the left frontal regions were recruited when the question led participants to inspect memory for characteristics not present in the memory trace. Thus, the data add to a growing body of literature that suggests left frontal areas also support some memory retrieval processes.

Jennifer Affrime, Neil Albert, Joshua Breunig, Alyssa Cairns, Anthony Guinta, Rebecca Pearson, Michael Perticari, and Kim Reeves

The College of New Jersey

(P. Andrew Leynes, Faculty Sponsor)

Minimizing the Influence of Test Modality on Judgments of Source: An Event-Related Potential Investigation

Presented at the Annual Meeting of the Eastern Psychological Association, Washington D.C., April 21, 2001; the 16th Annual Lehigh Valley Undergraduate Psychology Conference, Allentown PA, April 28, 2001

Previous studies of source memory have found that judgments of modality and event-related potentials (ERPs) are affected by the modality of the test probe. However, proponents of the source-monitoring framework (SMF) contend that source judgments can be based on many different kinds of memory characteristics. In the present experiment, the modality of the source was varied (i.e., words were either read silently or heard), but the two sources also differed in cognitive operations engaged during study. Test modality was found to have a smaller effect on source monitoring when cognitive operations could be used to support source judgments. ERPs recorded during the test also suggested that the additional memory characteristics improved source monitoring.

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