

THE COLLEGE OF NEW JERSEY

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JOURNAL OF STUDENT SCHOLARSHIP

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VOLUME 1  
APRIL 1998

THE COLLEGE OF NEW JERSEY

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**Journal of Student Scholarship**

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## Preface

*This premier edition of *The College of New Jersey Journal of Student Scholarship* is a tribute to the work and quality of our students and is a tangible example of the effects of providing our students with a top quality education. We do this by maintaining our commitment to students, engaging them in the learning process in and out of the classroom. The College values what we call *Scholarship in Support of Teaching* and recognizes the important role faculty play as role models of what it means to be engaged in scholarly inquiry. Increasingly, students and faculty collaborate on a wide range of scholarly and research projects, some of which result in published papers. Many of our students have been successful in presenting the results of their collaborative work with faculty at regional and national professional conferences where they receive deserved recognition. The apprenticeship that students receive will serve them well, beyond their years at *The College of New Jersey*.*

*The impetus for launching *The College of New Jersey Journal of Student Scholarship* came from a desire by the faculty to recognize students' efforts and to promote further student/faculty projects. While the faculty have been mentors, inspiring and encouraging the work represented in this journal, the students have responded to the challenges of their mentors not only by mastering their subject matter but, also, by applying impressive skills of analysis and presentation. The work of mentors and their protégés exemplifies the best of the educational process, and the articles in this journal—representing a wide range of disciplines and approaches—show just how rich the results of that mentor-protégé relationship can be.*

*The College of New Jersey's Vision Statement describes us as a "community of learners and scholars." I am proud to say that this inaugural issue of *The College of New Jersey Journal of Student Scholarship* demonstrates our passion and commitment to realizing this vision.*

*Dr. Anne V. Gormly  
Acting Vice President for Academic Affairs*



*From the Editor*

*Several faculty and administrators have been meeting for the past year to explore our common interest—supporting and encouraging the connection between student learning and faculty scholarship. When our meetings first began, we envisioned this journal, *The College of New Jersey Journal of Student Scholarship*, as a dream for the future. With the support and encouragement of Anne Gormly and the Academic Affairs staff, the journal became a reality more quickly than we had ever imagined. I am proud to have played a role in bringing the exciting scholarship of our students to the TCNJ community in the form of a scholarly journal.*

*The *Journal of Student Scholarship* joins our other student publications in providing a venue for students to share their ideas and their work. It was created to supplement, not replace, *The College's* other vehicles for expression. The *Journal* publishes work that represents scholarly and creative discovery—including, but not limited to, empirical investigations, literary analysis and criticism, historical commentary, and philosophical theory.*

*Our early ambitions to attract “a few good articles” for the first volume were far exceeded. Nearly thirty student papers were submitted for consideration. Every submission was an example of the high quality of the scholarship of our students. Our faculty’s dedication and skill in nurturing the talents of these young scholars was clearly evident in every paper we received. In the end, we were forced to make some very difficult choices about which articles to include in the premier issue. We sought to include the articles that best exemplified the quality of discovery, and we tried to preserve a balance—in so far as possible—between the disciplines.*

*The articles chosen represent the outcomes of independent study projects, internships, senior culminating experiences, honors theses, and “regular” courses. The work ranges from projects independently conceived by students and presented to their faculty sponsors at the end of a project or a course to year-long collaborations between student and faculty researchers (the latter type of article includes the faculty collaborator as one of the authors). The style of each article is appropriate to the discipline it represents. As a whole, *The Journal* mirrors the variety and breadth of our students’ work.*

*This is a student journal, not a collection of reports of professional scholarship. As such, it provides a training ground, a foundation, and a first example of what *The College's* students will accomplish in their professional and scholarly futures.*

*I offer my thanks to everyone who participated in getting this first issue to press, especially the student authors, faculty sponsors, and reviewers. I extend my greatest appreciation to my Associate Editor, Dr. William DeMeritt, and to Dr. Anne Gormly who knew before anyone else that this would work.*

*It is my hope that future editors of *The College of New Jersey Journal of Student Scholarship* will see this premier issue as a starting point, a good solid foundation, and an impetus to continue *The Journal* as an indispensable tradition.*

*Dr. MaryAnn Baenninger  
Editor*

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# Palladium Catalyzed Arylation and Amination

Michael P. Cassidy and  
Georgia M. Arvanitis  
*The College of New Jersey*

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Dr. Georgia Arvanitis,  
*Chemistry Department*

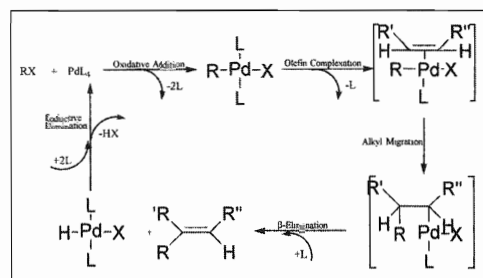
## ABSTRACT

Cinnamaldehyde, methyl cinnamate, and cinnamic acid are synthesized using a Pd-catalyzed coupling reaction. The reactions utilized a cyclic acetal protecting group to protect the aldehyde during coupling. Attempts are also made to prepare 4-octylaminopyridines using the same conditions.

## INTRODUCTION

In the early 1970s, R. F. Heck reported that aryl, methyl, and carboxyalkyl derivatives of group VIII metal salts reacted with olefins to produce the corresponding substituted olefins.<sup>1</sup> At that time, such transformations were only attainable by the use of alkylmercuric halides, thus highlighting the synthetic importance of Heck's discovery. These reactions proceed via the mechanism shown in Scheme 1. It involves the *in situ* formation of a palladium (0) phosphine complex which undergoes oxidative addition of the halide. Upon exposure of this compound to an alkene, olefin complexation occurs, forming a  $\pi$  palladium complex. Alkyl migration occurs, inserting the alkyl or aryl group into the less substituted carbon of the double bond. The last step is  $\beta$ -elimination of a proton on the newly coupled product, which reforms the olefin, and then HX is reductively eliminated and removed from solution by a base, reforming the palladium (0) phosphine complex.

At first, aryl or alkyl bromides required harsh reaction conditions,<sup>2</sup> whereas iodides required milder conditions. The conditions



Scheme 1.

used for iodide transformation are harsh enough for certain side reactions to occur. For example, if an  $\alpha,\beta$  unsaturated aldehyde or ketone is used as the olefin, because of the delocalization of the  $\pi$  electrons over three atoms, polymerization can very easily occur. The synthesis of substituted  $\alpha,\beta$  unsaturated aldehydes or ketones via this method is very difficult, if not impossible.

T. Jeffery discovered a milder, two-phase reaction that employs a phase transfer catalyst to couple alkyl or aryl iodides and alkenes using palladium as a catalyst.<sup>3</sup> The research surrounding this reaction did not mention the use of bromides. He did, however, synthesize cinnamaldehyde in 90% yield using iodobenzene and acrolein. We seek to use an *acetal* protecting group in tandem with modified Jeffery conditions to couple

*Author's Note: This paper was completed in partial fulfillment of the requirements for RSCH 400—Student-Faculty Research. Michael P. Cassidy is a chemistry major at The College of New Jersey. Dr. Georgia M. Arvanitis is an Associate Professor in the Chemistry Department at The College of New Jersey. This work is part of Dr. Arvanitis' ongoing research program.*

an  $\alpha,\beta$  unsaturated aldehyde to an aryl bromide to synthesize cinnamaldehyde using mild conditions.

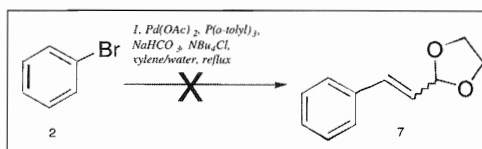
As a corollary, Buchwald and coworkers have reported the amination of alkyl and aryl halides as well as triflates using conditions similar to Heck's.<sup>4</sup> The conditions were created knowing that Heck arylations using aryl triflates have been shown to proceed in non-polar solvents such as toluene when chelating phosphines were employed.<sup>5</sup> Buchwald employed 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl (BINAP) as the chelating phosphine with sodium *t*-butoxide as a base in toluene to achieve substituted amines from aryl triflates.<sup>6</sup> Since 4-alkylaminopyridines have recently been identified as powerful antimicrobial agents,<sup>7</sup> they are of particular interest; current syntheses of these molecules involve the use of high-pressure hydrogenation apparatus. We also attempt a route to these compounds from 4-bromopyridine and the corresponding primary amine using our modified Heck conditions.

Here we report the successful arylation of a protected  $\alpha,\beta$  unsaturated aldehyde to form cinnamaldehyde as well as the attempted amination of 4-bromopyridine.

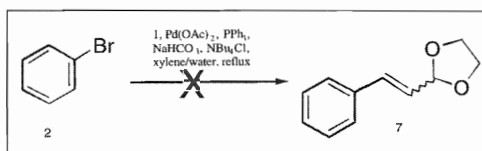
## RESULTS AND DISCUSSION

**Reaction Conditions.** After retrosynthesis of cinnamaldehyde, the reaction would require the use of the acetal of acrolein. Initial attempts at the reaction using Jeffery's conditions of 2-vinyl-1,3-dioxolane **1** with bromobenzene **2** in lieu of iodobenzene (Scheme 2) afforded no product, even after several days of reaction. After a review of Heck's conditions, we decided to try this reaction with **2** (Scheme 3), but to no avail. After a series of reactions involving the variation of olefin and solvent, we still had isolated a maximum of only 8% yield of cinnamaldehyde **8**. We turned back to Jeffery's conditions, to see if they were reproducible. Initially, we had problems with keeping the palladium from precipitating out as palladium metal, but this was solved by careful

degassing of solvents and reagents and the use of argon instead of nitrogen. Jeffery had reported 94% yield of methyl cinnamate **6a** from iodobenzene **4** and methyl acrylate **5a** (Scheme 4). We achieved 60% yield (by GC/MS) of **6a** using the same conditions. We also investigated synthesizing cinnamic acid **6b** from acrylic acid **5b**.

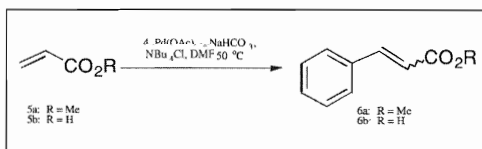


Scheme 2.

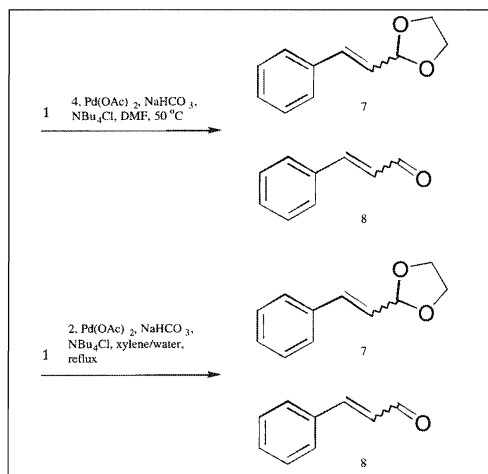


Scheme 3.

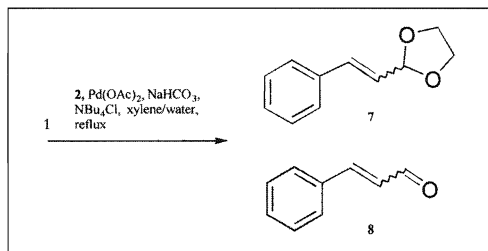
Attempts to perform this transformation using **2** were unsuccessful, and in our efforts we also found that phosphine ligands of any kind were detrimental in the case of aryl iodides, probably due to steric factors. We then attempted the reaction of **4** with **1** again with no phosphine using Jeffery's conditions. This provided us with a mixture of 2-(2-phenylvinyl)-1,3-dioxolane **7** and cinnamaldehyde **8** (Scheme 5). This reaction was done in DMF, which provided some difficulties in that it was difficult to remove after the reaction had taken place. Heck had reported the use of nonpolar solvents such as xylenes and toluene, so we tried this reaction with a xylenes-water system, and had comparable results. This system also proved effective for the reaction of **2** with **1** to give a mixture of **7** and **8** in a yield of 49.9% (Scheme 6). A list of all of the reactions and results is shown in Table 1.



Scheme 4.



Scheme 5.



Scheme 6.

**Effect of Phosphine.** According to table 1, there was a definite correlation between the phosphine and the arylation reaction's success. In the case of aryl iodides, the iodide cannot coordinate to the palladium if there is a phosphine present because the iodide is inherently large and diffuse, although it is effective as a leaving group. There is too much steric crowding around the palladium, and thus no reaction occurs. For bromides, the phosphine is necessary to stabilize the alkylpalladium halide complex that forms; however, it appears that the use of a chelating ligand such as DPPE hinders this reaction as well. The other correlation that we noted was that the amount of conversion seemed to be proportional to the cone angle of the ligand. When triphenylphosphine was used, less conversion was noted than when tri(*o*-tolyl)phosphine was used, which has a larger cone angle. Therefore, we determined the best choice for a phosphine ligand seemed to be tri(*o*-tolyl)phosphine, which is monodentate, and has a large cone angle.

**Palladium-Catalyzed Aminations.** Our first attempt to synthesize 4-octylaminopyridine 11 from octylamine 9 and 4-bromopyridine 10 (Scheme 7) was unsuccessful. Buchwald had only experimented with one primary amine in his studies on palladium-catalyzed aminations, and only reported 40-50% yield compared to the 90+% yield in every other reaction he reported. We suspected that elimination was occurring because of the presence of the *t*-butoxide ion. Alkylpalladium compounds readily eliminate in the  $\beta$  position, so this could have been accelerated by the strong base.

Our first attempts at modification were to use the modified Jeffery conditions that were used to synthesize cinnamaldehyde. As we followed this reaction with TLC, we saw the appearance of a new spot after several hours, but after working the reaction up, we wound up with no product. We also used another amine, cyclohexylamine 12 to try to synthesize 4-cyclohexylaminopyridine 13, but although by TLC a new spot appeared even faster than on the previous plate, we were unable to isolate anything from this reaction (Scheme 8). One reaction of particular interest was the last reaction tried before the end of the semester using the same conditions that were successful in synthesizing cinnamaldehyde (Scheme 9). Although we have not concluded exactly what our product is, a solid was isolated which shows peaks on <sup>13</sup>C NMR that correspond to the pyridyl and alkyl regions of the spectrum. An APT <sup>13</sup>C NMR comparing the product to supposed authentic 4-octylaminopyridine was inconclusive because the supposed 4-octylaminopyridine has no peaks in the pyridyl region. More study is required into this reaction. One other reaction was performed, using a ligand with a smaller cone angle (tri(*n*-butyl)phosphine) to try to reduce the amount of elimination that we believed was occurring on the metal. No data has been collected on this reaction at this point.

**Construction of Calibration Curves.** In the midst of trying to determine yields, we

constructed two calibration curves. The first (Figure 1) involves the determination of the yield of methyl cinnamate.

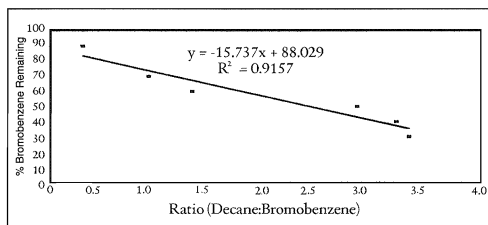


Figure 1.

A number of solutions representing various ratios of decane: bromobenzene were prepared and injected into the GC/MS. The ratio of peak area of decane: peak areas of bromobenzene were determined for each injection, and the % consumption of halide was plotted versus ratio. The other calibration curve was constructed in the same fashion except using 4-*t*-butyltoluene as an internal standard and bromobenzene as the halide (Figure 2). These curves were used to determine the yields reported in Table 1.

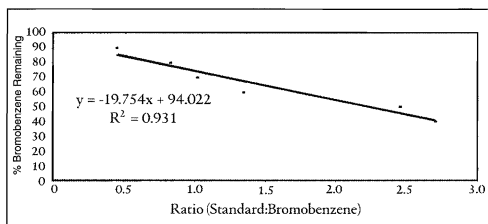
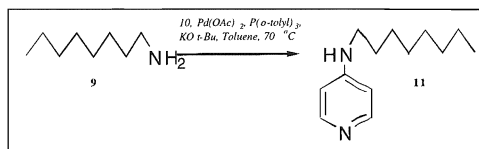


Figure 2.

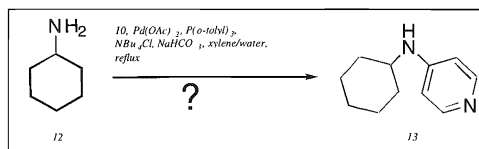
Halide	Olefin	Phosphine	Temp	Base	Quat	Solvent	Yield
PhBr	2-vinyl-1,3-dioxolane	PPh <sub>3</sub>	r.t.	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	MeCN	N.R.
PhBr	2-vinyl-1,3-dioxolane	PPh <sub>3</sub>	150	TEA	-	xylenes	N.R.
PhBr	2-vinyl-1,3-dioxolane	PPh <sub>3</sub>	80	TEA	-	MeCN	N.R.
PhBr	Acrylic acid	PPh <sub>3</sub>	150	TEA	-	xylenes	~8%
PhI	Methyl acrylate	-	r.t.	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	MeCN	N.R.
PhI	Methyl acrylate	-	50	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	DMF	N.R.
PhBr*	Methyl acrylate	-	50	NaHCO <sub>3</sub>	-	DMF	N.R.
PhI	Methyl acrylate	-	50	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	DMF	~60%**
PhBr	Vinyl acetate	DPPE	100	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	xylene/H <sub>2</sub> O	N.R.
PhBr*	Methyl acrylate	PPh <sub>3</sub>	50	TEA	-	DMF	N.R.
PhI	Methyl acrylate	TCP	50	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	DMF	N.R.
PhI	Methyl acrylate	-	35	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	DMF	2-27%**
PhI	Methyl acrylate	-	50	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	DMF	58.8%**
PhBr	2-vinyl-1,3-dioxolane	P(o-tolyl) <sub>3</sub>	100	NaHCO <sub>3</sub>	NBu <sub>4</sub> Cl	xylene/H <sub>2</sub> O	49.9%**

\*CuI on alumina added  
\*\*By GC/MS  
TEA=triethylamine  
TCP=tricyclohexylphosphine  
DPPE=1,2-bis(diphenylphosphino)ethane

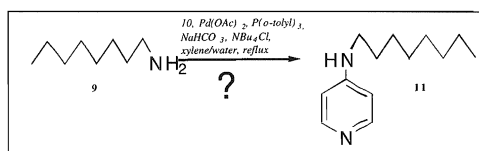
Table 1.



Scheme 7.



Scheme 8.



Scheme 9.

## CONCLUSION

Cinnamaldehyde has been successfully synthesized using a cyclic acetal protection group. Cinnamic acid and methyl cinnamate were also successfully synthesized. We have shown that the removal of the abundance of delocalized  $\pi$  electrons from  $\alpha,\beta$ -unsaturated aldehydes and ketones enables these usually unfavorable substrates to be used in Pd-catalyzed coupling reactions and are easily removed by mild acidic conditions.

We also attempted the synthesis of alkylaminopyridines using a modification of Buchwald's Pd-catalyzed amination reaction. Although at this time it is unknown if this method worked, we believe that with further exploration, this reaction could be a reality.

## EXPERIMENTAL

Unless otherwise noted, all reactions were performed in oven dried glassware under an atmosphere of argon or nitrogen (specified). All TLC eluents were 3:1 Hexane: Chloroform. 2-vinyl-1,3-dioxolane, octylamine, tri(o-tolyl)phosphine, tetrabutylammonium chloride hydrate, triethylamine, triphenylphosphine, potassium t-butoxide, acrylic acid, methyl acrylate, iodobenzene, vinyl acetate, 4-bromopyridine, 4-*t*-butyl-

toluene, decane, tri(n-butyl)phosphine, were purchased from Aldrich. Bromobenzene was purchased from B&A. Sodium bicarbonate was purchased from MCB. Palladium (II) acetate was purchased from Acros.

**General Arylation Procedure:** 10 mmol of halide is added to 10 mL of xylenes in a 50-mL RB flask. 10 mL of distilled water is added, followed by 25 mmol of  $\text{NaHCO}_3$ , 12 mmol of olefin, and 2.8 mmol of  $\text{NBu}_4\text{Cl}$ . This mixture is degassed with Argon for ten minutes. A solution of 0.1 mmol of  $\text{Pd}(\text{OAc})_2$  and 0.3 mmol of  $\text{P}(\text{o-tolyl})_3$  is prepared in 500mL of degassed xylenes. This mixture is agitated, and then degassed with Argon for ten minutes. The palladium solution is then added to the reaction mixture, and the reaction mixture is held at reflux under Argon for two days. GC/MS is used to follow and quantify the reaction. If isolation is desired, the reaction mixture is filtered through Celite and then alumina. The resulting two-phase system is washed three times with 50/50 HCl/water, and then the organic layer is dried with  $\text{MgSO}_4$ . The solvent is evaporated *in vacuo* with minimum heat affording the product.

#### Amination Reaction (General Method).

4 mmol of amine is added to 5 mL of xylenes, followed by 5 mL distilled water, 1 mmol of halogenated pyridine, and 6 mmol of  $\text{NaHCO}_3$ . This solution is degassed for ten minutes with argon. A separate solution of 0.05 mmol  $\text{Pd}(\text{OAc})_2$  and 0.15 mmol  $\text{P}(\text{o-tolyl})_3$  is prepared in 500mL of xylenes and degassed with argon for ten minutes. The solutions are combined and held at reflux under Argon for one day. The solution is separated, the organic layer is evaporated *in vacuo*, and the resultant crystals are triturated with hexanes to give the product.

#### ACKNOWLEDGMENTS

I extend my heartfelt thanks to Dr. Georgia Arvanitis, Dr. Michael Berardini, Diana Johnson, Chris Masterson, Rich Mayo, Brian Falcone, Dr. David Hunt, and the rest of the chemistry department at The College of New Jersey. Without everyone's collaborative help, this project would have been much more difficult to complete.

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# Metalation Reactions of 3,5-Dichloro-N,N-diethylbenzamide

Maria Demas and Lynn Bradley  
The College of New Jersey

Faculty Sponsor:  
Dr. Lynn Bradley

## ABSTRACT

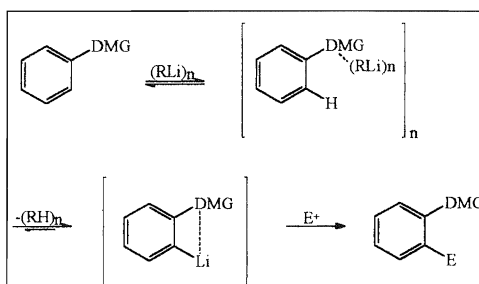
The competing influences of regiocontrol of the diethylamido and chloro functional groups were examined in the metalation reactions of 3,5-dichloro-N,N-diethylbenzamide. The compounds, 3,5-dichloro-4-methyl-N,N-diethylbenzamide and 2,6-dichloro-4-N,N-diethylamide benzoic acid, were synthesized by reacting 3,5-dichloro-N,N-diethylbenzamide with butyllithium (BuLi) followed by iodomethane (CH<sub>3</sub>I) and carbon dioxide (CO<sub>2</sub>), respectively. The observed site of metalation was controlled by the chlorine substituents, rather than the amide substituent. The products were characterized using silica-gel TLC, Varian Gemini 300MHz <sup>1</sup>H-NMR spectroscopy, and mass spectroscopy (MS).

## INTRODUCTION

Regiospecific preparation and modification of polysubstituted aromatic molecules present fundamental problems in both industrial and academic laboratories. Many modern pharmaceutical and agrochemical synthetic targets are benzenoid or incorporate key aromatic or heteroaromatic groups.<sup>1</sup> There have been numerous studies done to introduce a variety of functional groups into aromatic compounds for the purpose of drug activity modification. Introduction of these groups may occur via classical electrophilic substitution.

Heteroatom-directed *ortho*-lithiation is an established synthetic procedure for introducing these functional groups into an aromatic ring. The relative ability of a substituent to

direct metalation can be interpreted as a combination of inductive and complexation effects.<sup>2</sup> The DoM (directed *ortho*-metalation) process for this study was a three step process (Scheme 1).<sup>3</sup> First, the (RLi)<sub>n</sub> aggregate coordinates to the DMG (directed metalating group). In a second step, deprotonation occurs to give the *ortho*-lithiated species. Finally, the reaction with the electrophile yields the desired alkylated product.



Scheme 1. General directed *ortho*-metalation process.

This type of process has been used for a variety of pharmaceutical applications. For example, through a sequence of metalations and alkylations, using *t*-BuOK/*n*-BuLi for deprotonation, the one pot synthesis of 2-(4-isobutylphenyl) propanoic acid (ibuprofen) from *p*-xylene has been achieved in 52% yield. This process has also been used to protect other functional groups.

*Author's Note:* This paper was completed in partial fulfillment of the requirements for Chemistry 499—Independent Study. Maria Demas is a chemistry major at The College of New Jersey, and Dr. Lynn Bradley is an Assistant Professor in the chemistry department at The College of New Jersey. This work was completed as part of Dr. Bradley's ongoing research program.



Perhaps one of the most important applications of this process is in agricultural research, where the need to discover effective insect repellents that are also safe for humans remains a chief goal. McCabe, et. al., have reported that ring substituted diethylbenzamides can be used in the synthesis.<sup>4</sup> N,N-diethylamides and N,N-diethylbenzamides are among some very effective mosquito repellents, yet the latter was found to be somewhat irritating to human skin. It would therefore be advantageous to introduce new groups onto benzene, while still utilizing the effects of the N,N-diethylamide group. This would be done in hopes of finding a safe, effective repellent. Unfortunately, because only a small number of compounds ever exhibit desired activity, it is necessary to synthesize a large variety of candidates. Extensive screening is then carried out in an attempt to isolate any active compounds.

The anomaly of the reaction studied here is that under normal electrophilic substitution conditions, the amide group is a very powerful *ortho*-director, while chlorine is only very weakly *ortho*-directing as well as deactivating. Beak and Brown have specifically demonstrated the ability of tertiary amides to direct metalation adjacent to the substituent.<sup>2</sup> In the reaction of N,N-diethylbenzamide, the use of CH<sub>3</sub>I as the electrophile produces the *ortho*-substituted species in 77% yield.<sup>1</sup> Furthermore, in 1,3-dihalogenated benzenes only 1% of substitutions occur at the C<sub>2</sub> position.<sup>5,6,7</sup> Combining the amide and the chlorine substituents, it has been shown that in 3-chloro-N,N-diethylbenzamide, metalation occurs in the C<sub>2</sub> position with 95% regioselectivity and in 80% yield. The metalation reactions of *ortho*-, *meta*-, and *para*-chloro-N,N-diethylbenzamides with *sec*-BuLi/TMEDA followed by CH<sub>3</sub>OD at -100°C have yielded the *ortho*-substituted products in 87%, 80%, and 85% yield, respectively.

Based on the above data, it would be expected that substitution would be controlled by the amide and would predominantly occur adjacent only to this substituent.

It is very unexpected for metalation/alkylation to occur *para* to the amide in 3,5-dichloro-N,N-diethylbenzamide. However, alkylation at the *para* position was observed for the reactions studied in this project.

#### EXPERIMENTAL

In an attempt to not only synthesize the product, but also to optimize yield and purity, a series of reactions was performed varying the nature of the alkyllithium base, the solvent, and the electrophile. All reactions were carried out at -78°C, in an anhydrous, inert nitrogen (N<sub>2</sub>) atmosphere using a three-necked roundbottom flask equipped with a magnetic stir bar and a cold temperature thermometer. All reactants were placed in a Dewar flask and stirred at a quick, steady rate. All additions were made using a dry needle and syringe.

For the standard additions of Scheme 2, Methods A-E, the 3,5-dichloro-N,N-diethylbenzamide was dissolved in solvent [tetrahydrofuran (THF) or diethyl ether (Et<sub>2</sub>O)] and tetramethylethylenediamine (TMEDA) (except Method A). The corresponding BuLi was added dropwise and stirred for 30 minutes. Methyl iodide was then added slowly. The solution was brought to room temperature (RT) and stirred for 1 h.

For the inverse additions of Scheme 2, Methods F-J, a solution of 3,5-dichloro-N,N-diethylbenzamide dissolved in solvent (THF or Et<sub>2</sub>O) was added dropwise to a 1:1 TMEDA: BuLi complex, and allowed to react for 30 minutes. The appropriate electrophile, CH<sub>3</sub>I or CO<sub>2</sub>, was then slowly added while the solution was brought to RT, and allowed to react for 1 h.

The mixtures obtained from Methods A-H were extracted with water followed by ethyl acetate (EtOAc). The organic layer was saved and extracted with sodium hydroxide (1M NaOH) followed by hydrochloric acid (2M HCl). The mixtures obtained from Methods I and J were extracted first with water and Et<sub>2</sub>O. The water layer was saved, and acidified with 2M HCl. The resulting mixture was again extracted with ether, and the organic layer was saved.

The organic layers from all reactions were then dried over anhydrous magnesium sulfate ( $\text{MgSO}_4$ ), and concentrated on a rotary evaporator to a golden oil (Methods A-H) or crystals immersed in a golden oil (Methods I and J). All products were separated and purified using silica-gel column chromatography or prep TLC, using 9:1 (v/v) hexane:EtOAc as eluent. All products were characterized using silica-gel TLC (9:1 hexane:EtOAc),  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ), and MS. A table of reactants is listed below (Table 1), which includes the general molar ratios used:

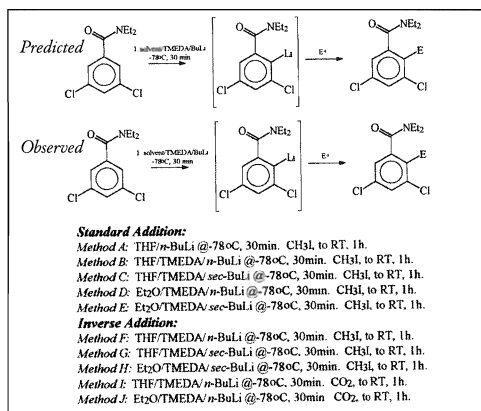
Table 1: Table of Reactants

	MW (g/mol)	mmol	density (g/mL)	mL or g
3,5-Dichloro-N,N-diethylbenzamide	246.14	1.00	—	0.246 g
THF	72.10	—	0.8892	5.0 mL
$\text{Et}_2\text{O}$	74.12	—	0.711	5.0 mL
TMEDA	116.21	1.20	0.770	0.181 mL
n-BuLi (1.6 M in hexanes)	64.06	1.20	0.769	0.750 mL
sec-BuLi (1.3 M in cyclohexanes)	64.06	1.20	0.769	0.923 mL
$\text{CH}_3\text{I}$	141.94	1.50	2.280	0.0934 mL
$\text{CO}_2$	44.01	1.50	1.35	0.0660 g

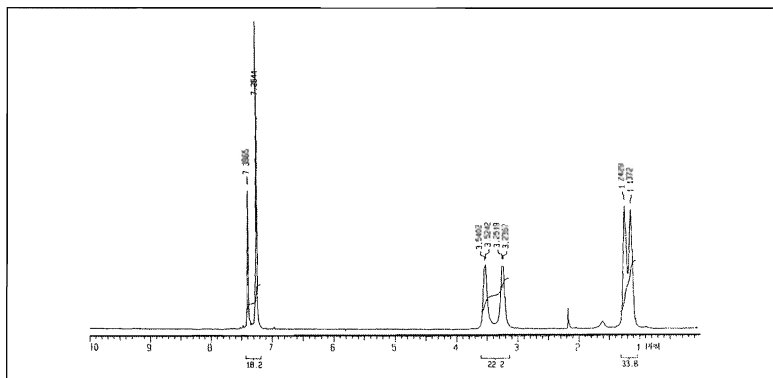
In all cases, excess BuLi was added. The highly reactive metalating species is partially consumed by the solvent, even at  $-78^\circ\text{C}$ .<sup>3</sup> Therefore, an excess was needed to produce the dianion that reacts with the electrophile to yield the desired product.<sup>2</sup> Excess electrophile was added as well to ensure reaction with the benzamide. The predicted and observed reaction schemes are shown below.

## DATA AND RESULTS

Because the yields were low, they have not been reported, but will be reported when all conditions have been optimized. Low yields were possibly attributed to the poor stirring that occurred in most reactions. Also, in Methods I and J, incorrect molar ratios were used with respect to the electrophile; therefore the reaction did not react to completion. The  $^1\text{H}$  NMR spectra (Figs. 2-5) of Methods B, E, F, and I can be found on the attached pages. These are illustrative of the best and worst reactions. All other schemes yielded similar spectra with regard to purity. The  $^1\text{H}$  NMR spectrum (Fig. 1) of the starting material, 3,5-dichloro-N,N-diethylbenzamide, has also been included for comparison.



Scheme 2. Metalation Reactions of 3,5-dichloro-N,N-diethylbenzamide.

Figure 1.  $^1\text{H}$  NMR of 3,5-Dichloro-N,N-diethylbenzamide.

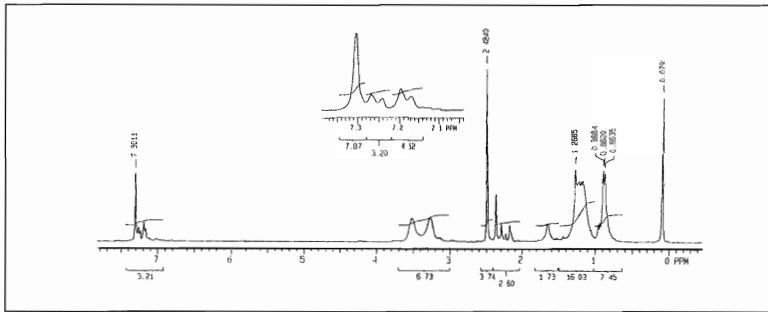


Figure 2. Method B <sup>1</sup>H NMR.

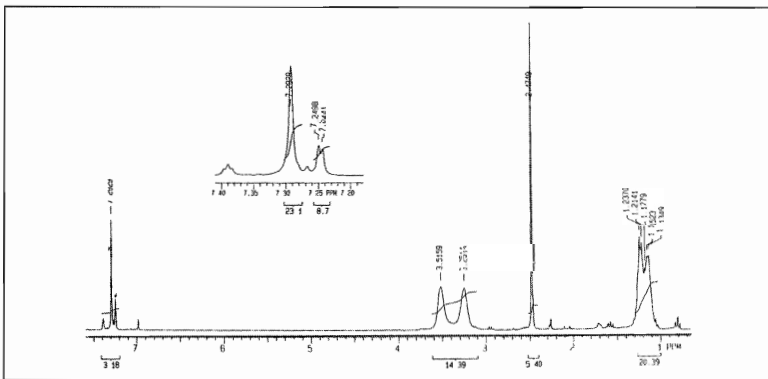


Figure 3. Method E <sup>1</sup>H NMR.

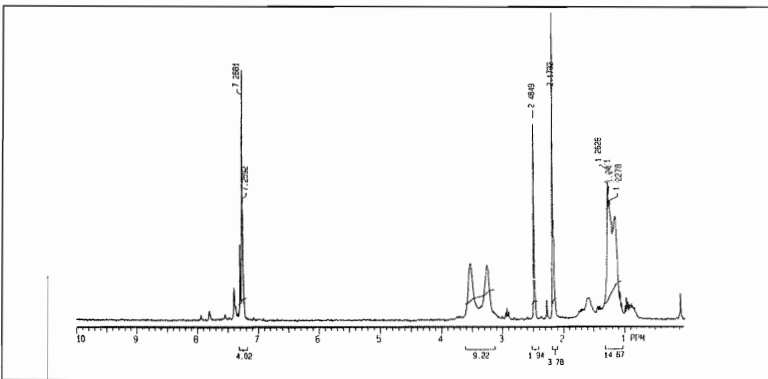


Figure 4. Method F <sup>1</sup>H NMR.

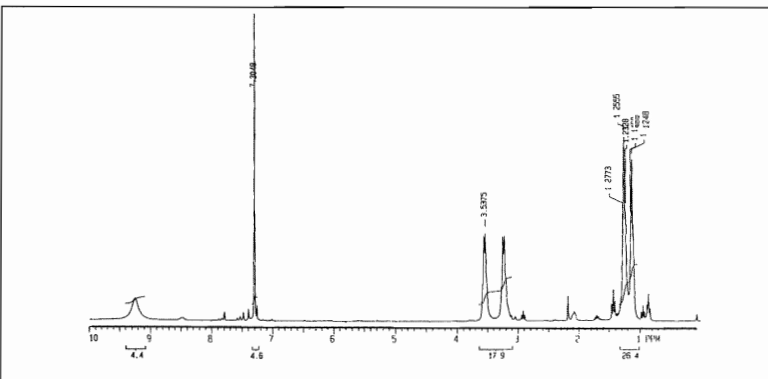


Figure 5. Method I <sup>1</sup>H NMR.

## DISCUSSION

Our results indicated that TMEDA was necessary for metalation to occur. Tetramethylethylenediamine is known to break up  $(n\text{-BuLi})_6$ , which makes the  $n\text{-BuLi}$  more reactive. Tetrahydrofuran (Fig. 6) does not effectively bind to Li to fully break up this hexamer. Tetramethylethylenediamine (Fig. 7), though, is a bidentate ligand, and when used in coordination with THF, more of the  $n\text{-BuLi}$  is freed from the aggregate. It has been observed that with organolithium/TMEDA bases, the tertiary oxamides are more effective as *ortho*-directors than any other noncarboxamido directing group.<sup>2</sup>

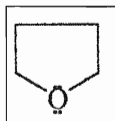


Figure 6. THF.

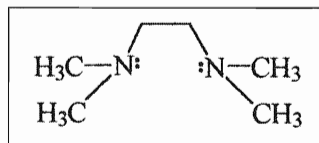


Figure 7. TMEDA.

Methods B-J were all successful in synthesizing the desired product, though some were more favorable than others. When  $\text{CH}_3\text{I}$  is used as the electrophile, the  $^1\text{H}$  NMR spectrum should show a peak around 2.4 for the methyl group, and a single peak in the aromatic region indicating that the only two protons left on the ring are equivalent. When the electrophile is  $\text{CO}_2$ , the  $^1\text{H}$  NMR spectrum should show a peak around 9-10 for the  $\text{COOH}$  group, and a single peak in the aromatic region again indicating that the only two protons left on the ring are equivalent. To varying degrees of purity, this is exactly what was observed.

Comparatively speaking, Methods B-D, G, H, and J were only marginally successful. The desired peaks did appear on the  $^1\text{H}$  NMR spectra, but there was also a great deal of alkylated material upfield, indicating that many undesired side reactions were occurring simultaneously. For example, in Method

B, when  $n\text{-BuLi}$  was used in the reaction sequence, the corresponding valerophenone (Fig. 8) was isolated as the major by-product. This indicated that  $n\text{-BuLi}$  acted as a nucleophile rather than a base. The  $^1\text{H}$  NMR spectrum of Method B is shown in Fig. 2.

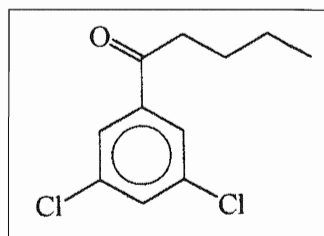


Figure 8. 3,5-Dichlorovalerophenone.

When the conditions were modified in Methods E, F and I, the product was isolated in much higher purity. The  $^1\text{H}$  NMR spectra (Figs. 3-5, respectively) still indicate alkylated material upfield, but the amount of side products decreased significantly.

For the standard additions employed in Methods A-E, the two main factors that affected purity were the choice of solvent and alkyllithium base. In Method E, the use of  $\text{Et}_2\text{O}$  as the solvent clearly enhanced the purity of the product. It gave a considerably less alkylated crude product, and an even more pure product after the column was performed. The  $^1\text{H}$  NMR spectrum (Fig. 3) of Method E clearly illustrates this. This solvent effect may be due to the fact that at increased temperatures THF has a tendency to decompose to  $\text{H}_2\text{C}=\text{CH}_2$ . Also, the fact that THF is cyclic, while diethyl ether is bent may have an effect. While the electron lone pairs on THF are more available, because of its bulky structure THF may not be able to effectively solvate the benzamide, leaving much more of the benzamide unreacted. Diethyl ether, however, can surround the molecule more effectively. This allows more of the 3,5-dichloro-N,N-diethylbenzamide to be freed up for the reaction.

The switch to *sec*-BuLi also enhanced the purity of the product. The  $^1\text{H}$  NMR spectrum of Method E (Fig. 3) again indicates that while there were still some minor

impurities in the fraction, the predominant component was 3,5-dichloro-4-methyl-N,N-diethylbenzamide. This correlates well with previous observations that *sec*-BuLi acts as a stronger base compared to *n*-BuLi, while *n*-BuLi acts as a more potent nucleophile attacking at the carbonyl, thereby affording addition products (e.g. valerophenone).<sup>2</sup>

The most successful reactions (Methods F-J) were observed when inverse addition was employed. Inverse addition of the base allows the highly exothermic reaction to be more controlled and assures that less base is consumed by the solvent. Complexation effects are also thought to play a role. By adding the benzamide dropwise, it is more completely attacked by the BuLi, whereas in standard addition, the BuLi may attack some sites, and not others, leaving the necessary site often untouched. Inverse addition, therefore, provides greater opportunity for reaction with the electrophile. The <sup>1</sup>H NMR for Method F and Method I (Figs. 4 and 5) clearly indicate the purity of the products obtained.

## CONCLUSION

The efficiency of lithiation of tertiary benzamides is a function of the solvent, organolithium, complexing agent, temperature, order of addition, and substituents on the amide nitrogen. The optimum conditions are reported to be slow addition of the amide in dry THF to a slight excess of 1:1 *sec*-BuLi/TMEDA complex in THF at -78°C.<sup>4</sup> The optimum conditions observed in our experiments were slow addition of the amide in THF to a slight excess of 1:1 TMEDA/*n*-BuLi complex (Methods F, I) and slow addition of *sec*-BuLi to the amide in Et<sub>2</sub>O (Method E).

In the future, several modifications will be made to the reaction procedure. These modifications include temperature, solvent, alkyllithium base, and electrophile variation. Unfortunately, the use of a higher reaction temperature to promote lithiation not only partially consumes the base, but has also been shown to promote benzyne formation. Perhaps a colder reaction temperature

will have to be used.<sup>2</sup> Alkyllithium base modification could include using *tert*-BuLi, or using the alkyllithium base in conjunction with something else. For example, the combination of butyllithium and potassium *tert*-butoxide has been shown to give virtually instantaneous metalation of fluorobenzene.<sup>2</sup> These modifications will be made in an effort to optimize yield and purity, to introduce various functional groups onto the aromatic ring, and to possibly identify the mechanism of the reaction.

## ACKNOWLEDGMENTS

The first author would like to thank Dr. Lynn M. Bradley and Dr. David A. Hunt, American Cyanamid Corporation.

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# An Assessment of Human Impact on the Coral Reefs of the Admiral Cockburn Land and Sea National Park

## ABSTRACT

This study was performed with the objective of initiating a long-term assessment of human impacts on the health of coral reefs in the Admiral Cockburn Land and Sea National Park, South Caicos, Turks and Caicos Islands (TCI). Since a study of this type has never been performed in the area, the data compiled served as a baseline to be built upon in future studies. Through the use of line intercept transects and quadrat mapping of The Arch, a local SCUBA site located in East Bay and Admiral's Aquarium, a shallow patch reef off Long Cay, data were obtained which showed the percentages of living and nonliving benthic cover of these areas. This information will be useful in detecting any significant changes over time. Sediment traps were deployed at various locations within the park including The Arch and Admiral's Aquarium in order to gauge sedimentation and turbidity in the water column. Methodologies of these types were implemented to show the impacts of human endeavors on coral reefs within the park. Additionally, manta towing, an aquatic surveying technique, and exploratory diving were conducted to locate potential new dive sites in hopes of alleviating stresses imposed on the few existing ones. Admiral's Aquarium was found to contain the highest percentage of live coral, but coral species were more diverse at The Arch. The most abundant species at both locations was found to be *Montastrea annularis*. Although sediment traps were deployed at these two

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sites, the research team opted not to collect them but rather to retrieve two that had been deployed at the West Dock, a docking facility belonging to The School for Field Studies where its boats are kept. This decision was made because of the brevity of the time the traps were allowed to collect sediment. The West Dock received the most stress of all the areas where sediment traps were deployed and was therefore expected to collect the largest quantity of sediment. Initial observations of the others revealed negligible results. In an attempt to alleviate stresses on impacted coral reefs, five new SCUBA sites on the windward side of Long Cay and new snorkel sites between Six Hills Cays and Middleton Cay were identified. Although currently reefs in South Caicos are considered pristine, with an anticipated rise in tourism this condition needs to be maintained as well as monitored to differentiate between normal fluctuations in reef health and impacts brought on by anthropogenic sources (Rogers *et al.*, 1994). This study successfully implemented that much needed monitoring process.

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*Author's Note: This report was submitted in partial fulfillment of the requirements for Biology 397—Biology Internship, coordinated by Dr. W. S. Klug, The College of New Jersey. The work was completed at The School for Field Studies, Center for Marine Resource Studies, South Caicos, Turks and Caicos Islands, British West Indies, under the supervision of Drs. Phil and Julia Davies. The program provider was Dr. Valerie Brady. Jacqueline Gill is a biology major at The College of New Jersey.*

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## INTRODUCTION

Aside from the aesthetic appeal of Caribbean coral colonies which inevitably attract the curiosity of man, coral reefs provide pivotal biological functions for their surrounding ecosystems which most often go unobserved by the human eye. Corals are living habitats for numerous aquatic organisms, in particular vulnerable juveniles whose survival from voracious predators is dependent upon a secure habitat. Additionally, the tough skeletal structures characteristic of reef building corals buffer surrounding systems from destructive weather patterns and wave action. While reefs show resilience toward such natural stresses, the effects of continuous human interaction with coral reefs are sometimes detrimental to the colony's overall health and can only be repaired over long periods of uninterrupted time. Due to the interdependence of coral reefs with surrounding organisms, a loss of one will result in the disturbance of the natural balance of the others.

The geographic position of TCI, due north of Haiti, and South East of the Bahamas Islands, serves to make tourism its number one industry. The increase of development in service of this industry is likely to increase the anthropogenic impacts to its coral reefs in the near future. This study assessed the impact of human activity on the overall health of coral reefs in the Admiral Cockburn Land and Sea National Park. Such activities result in the disturbance of sediment. Adverse sedimentation effects to reef ecosystems have two primary human causes: disturbance of already present sediment, particularly from the fins of divers and snorkelers or boat anchors, and the introduction of new sediment primarily from construction and development. In order to determine the cause of disturbed sediment, the recreational user group was identified as well as monitored through log sheets given to Club Carib, the only local dive resort on South Caicos. Through the use of sediment traps deployed at various recreational and industrial sites, baseline data on sediment levels

were obtained. Methods were implemented to monitor the progression of the health of the reef. These include the use of line intercept transects and quadrat mapping to estimate the percentage of benthic cover including the varying species of coral. In addition, surveys of potential new dive sites were conducted based on a number of criteria such as aesthetic value, distance from shore, depth, and user level (i.e. novice, intermediate, advanced, expert). Such new sites would alleviate the stress that the current ones receive from constant use by man.

Due to the brief time length of this study, no definitive conclusions regarding long-term, adverse, anthropogenic effects were reached. However, baseline data concerning the current health of the coral reefs of the Admiral Cockburn Land and Sea National Park were established.

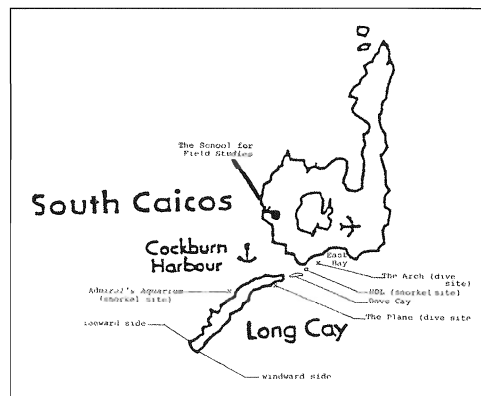


Figure 1. South Caicos, Turks and Caicos Islands.

These data will be further built upon by future researchers in order to obtain conclusive results that could be utilized to benefit the economy and livelihood of South Caicos.

## MATERIALS AND METHODS

### Manta Towing and Exploratory Diving.

Manta towing was performed with the intent of locating potential new dive sites. This technique is useful for observing and surveying large areas of ocean. Its benefits are its simplicity and efficiency. In addition, it is extremely economical. Manta towing can be performed in remote areas and can determine

the effects of large scale disturbances and population changes in ocean communities.

A manta board allows two people to hold on by use of indented hand grips. The observers, equipped with snorkel gear, are pulled while holding onto the board. The board is attached to the boat by means of an 18m line with two buoys at 6m and 12m positions. These are used by the observers to estimate visibility. The force from the speed of the boat pulls the performers horizontally. By placing their faces into the water, the observers are able to examine what lies on the ocean floor. The board is directed to descend or ascend by pushing or pulling the front of the board respectively while being towed by the boat. Proper hand signals are given to a spotter at the stern of the boat; these in turn are relayed to the boat driver. These signals allow the boat to speed up, slow down, stop, or change direction.

Manta towing was used to survey the reef region within the park over a three day period from June 19 through June 21, 1997. The regions surveyed were those around Long Cay and Dove Cay (Fig. 1) and the region around The Arch. A GPS (Global Position System) fix was taken each time a potential new dive site was located.

When deeper areas needed to be surveyed and manta towing was not feasible, exploratory SCUBA dives were conducted on July 7, 1997 between 2:30 and 6:30 P.M. When a site of interest was located, a diver pulled on a line attached to a Surface Marker Buoy (SMB). This would alert researchers on the boat to take a GPS reading. They also noted any landmark that would make relocation of the site easier. Each potential new site was critiqued for aesthetic qualities, user level, accessibility, and possible mooring locations. A similar procedure was performed by free divers within the areas of Middleton Cay and Six Hills Cays except that an SMB was not used because of the shallowness of the water.

**Line Intercept Transect.** The Line Intercept Transect method, performed at

The Arch and Admiral's Aquarium, was used for the purpose of estimating the percentage of ocean floor covered by varying benthic elements. This along with mapping data from the quadrats will be analyzed in the future so that the health of the reef, measured by growth and destruction patterns, can be monitored.

A 50m long transect line was laid across a portion of the selected site. The line was subdivided into 10m sections. One diver was responsible in each subdivision for recording either the coral species or benthic component and its length under the transect tape. The designated categories were live hard coral recorded to species level, rubble including dead coral, sand, macroalgae and other sessile life such as sponges, sea fans, etc.

**Quadrats.** The quadrat method (English *et al.*, 1994) was used to establish baseline data for monitoring changes likely to occur over time in the sessile reef community at the two dive sites. This technique was used in conjunction with the Line Intercept Transect placed at The Arch and Admiral's Aquarium for use in assessing the overall health of the reef.

A 1x1m quadrat was constructed from PVC tubing and fishing line. At each of the two dive sites, twenty quadrats in total were mapped. Four different quadrat surveys were taken along each 10m section of the Line Intercept Transect. In order to map a quadrat, the constructed device was placed over the designated region. On an underwater slate, the diver noted what percent of the quadrat was filled with the following elements: live hard coral, macroalgae, rubble, sand, and other sessile life. The percentages of the different categories were determined by assessing the number of 10 x 10 cm squares each covered in a 1x1 m quadrat. The quadrats at both sites were mapped by ten surveyors on June 30, 1997.

**Sediment Traps.** In order to calculate the sedimentation rates currently experienced at local dive sites and at the main shipping dock, ten sediment traps were constructed



and deployed at various locations within the park. Each trap comprised three replicate collectors with fitted baffles and caps in a wooden holder attached to a thin PVC tube. The design was similar to that described by English *et al.* (1994). Two sediment traps were deployed at each of four dive sites, chosen on the basis of diver/snorkeler use and at a nearby docking facility subject to much shipping traffic. Chosen dive sites were: The Arch, The Plane, Admiral's Aquarium, and HDL (Fig. 1).

Of the two traps deployed at The Arch, one was placed in a sandy patch directly under "the arch" (a natural coral formation) off-center, to prevent diver interference, and the other was placed ten meters away in an area of similar composition to allow for comparison. Both were placed at a depth of fourteen meters. The Plane traps were deployed at a similar depth, with one being placed in a sandy area at the end of the wreck, where divers exit, and the other near the base of the mooring, a short distance away. At Admiral's Aquarium, one trap was placed in sand about one meter from a station of the snorkel trail and the other approximately half way along the major patch reef. Both were located about one meter from coral heads and at a depth of approximately three meters. The two traps deployed at HDL were similarly positioned but in water five meters deep. In the shipping area, one sediment trap was placed directly between West Dock and the loading dock, and the second deployed further out from the pier at the south end, under the major shipping channel. This trap was set in a sand patch within a seagrass bed approximately five meters from the shore. Except for the West Dock traps, which were set one day later, traps were deployed on June 24, 1997 between 2:00 and 7:00 P.M. To secure each trap, an 80 cm long rebar was hammered into a suitable sandy area until only 20 cm remained visible. The sites were then abandoned for 45 minutes to allow any disturbed sediment to settle, after which time the traps were placed on the rebar poles and caps were

removed. The two traps from the West Dock were collected on July 3, 1997 between 11:30 A.M. and 1:00 P.M. The remaining eight traps at the dive sites were not retrieved at that time but rather were left to be collected at a later date when significant levels of sediment could have accumulated. The contents of each collector were filtered through fine-grade coffee filters and thoroughly rinsed with fresh water to remove salt. The dry weight of each sample was obtained after being totally dehydrated in an oven at 90°C for 2.25 hours.

## RESULTS

### Manta Towing and Exploratory Diving.

The manta towing conducted on June 19 covered the northern windward area off Long Cay. The depth averaged fifteen to twenty meters and horizontal visibility exceeded eighteen meters. Oktas, a measure of cloud cover, were 2/8.

The same area was surveyed on the following day. Depth, visibility, and oktas were as before. The Dove Cay area was also surveyed on this day with the depth ranging from three to five meters.

On June 21, the leeward side of Long Cay was surveyed at depths averaging three to five meters. Visibility was fair and oktas were 4/8. No potential new dive sites were identified using the manta towing techniques. The exploratory SCUBA diving and free diving identified five potential new dive sites all on the windward side of Long Cay. Shallower snorkel sites were identified in the waters between Six Hills Cays and Middleton Cays. GPS readings were taken to record the position of the sites.

**Line Intercept Transect.** The results of this methodology are summarized in (Fig. 2a, 2b, 2c). It was found that at The Arch, rubble occupied the majority of the transect with 54.1% coverage. Rubble was found only on 17% of Admirals' transect. In addition, the largest percentage of coverage at Admiral's was live coral with 47.8% of the fifty meter transect, which compares to only

28.2% at The Arch. Macroalgae occupied 25% of the transect at Admiral's while it only covered 6.1% of the total transect at The Arch. Concerning the variety of coral species, The Arch was found to be the more diverse of the two sites with fourteen versus seven coral species. Diversity was also shown through the abundance of sessile organisms. Ten percent of The Arch's transect was devoted to sessile life as opposed to only <1% at Admiral's. *Montastrea annularis* commonly known as Boulder Star Coral, was the most abundant coral species at both sites.

**Quadrats.** Figure 4 summarizes the results of the quadrat mapping. The Arch showed twice as much rubble cover as Admiral's. The mean live, hard coral cover was approximately equal at both sites. Admiral's Aquarium had 30% more sand than The Arch. The percentages of both macroalgae and other sessile life were quite low for the two sites.

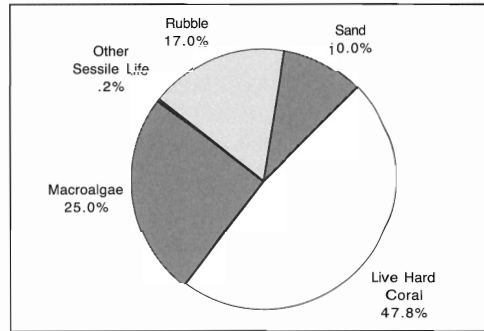


Figure 2b. Admiral's: Pie chart showing percentage area of benthic cover.

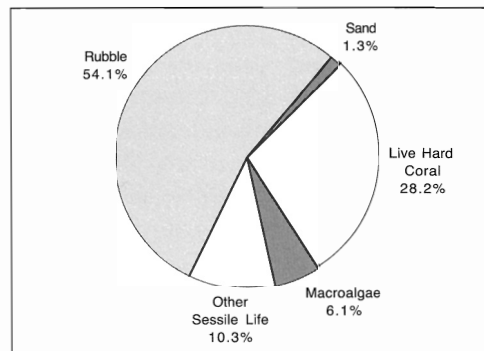


Figure 2c. The Arch: Pie chart showing percentage area of benthic cover.

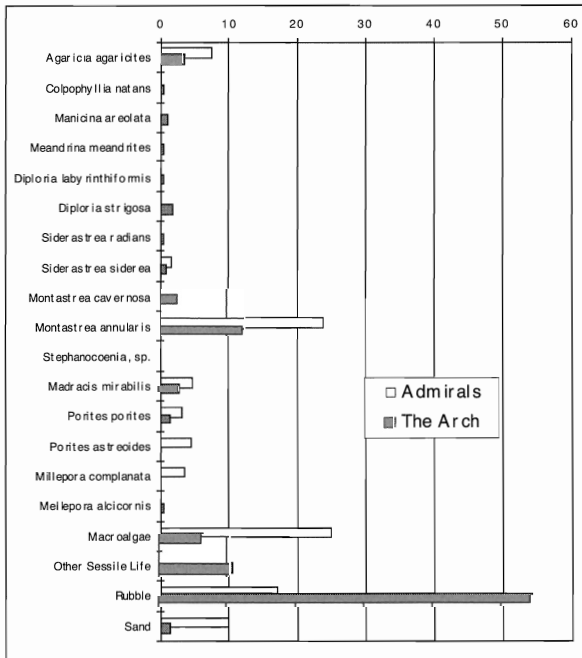


Figure 2a. Percentage cover of coral species and substratum components at two sites: Admiral's and The Arch.

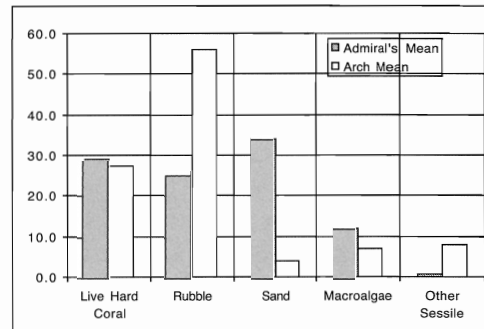


Figure 3. Mean percentage cover of five benthic categories at The Arch and Admiral's Aquarium, as determined from twenty different quadrats at each site.

**Sediment Traps.** Only two sediment traps were collected in order to obtain baseline data as well as to allow the remaining eight traps adequate time to collect significant amounts of sediment. Table 1 summarizes the results. The sedimentation rate was calculated using the following formula (Rogers et al., 1994):  $Sediment\ Rate = \frac{No.\ of\ days \times \pi \times r^2}{No.\ of\ days}$ , where  $r$  = radius of collector in cm = 2.5 cm, and No. of days = 8.

Table 1

Sediment Trap	West Dock Location	Weight of Sediment (g)	Rate of Sedimentation $\text{g}/\text{cm}^2/\text{day}^{-1}$
Trap C			
Collector 1	West End	10	0.064
Collector 2	West End	9	0.057
Collector 3	West End	9	0.057
Trap D			
Collector 1	South End	5	0.032
Collector 2	South End	4	0.025
Collector 3	South End	4.5	0.029

The rate of sedimentation in Trap C was approximately double that of Trap D.

## DISCUSSION

Despite their lifeless appearance, corals are themselves living organisms. Furthermore, corals are intricate ecosystems acting as dwelling places for fishes, marine creatures, and plants. The interdependence between such organisms and corals creates a natural, delicate equilibrium which can be easily disturbed and disrupted.

The stresses encountered by coral reefs stem from two sources: nature and man. Natural conditions such as storms, wave action, and exposure due to low water levels pose threats to the health of coral reefs. However, due to the slow nature of a coral's growth, it will take long periods of uninterrupted time for a reef to fully recover. Under ideal growth conditions, a coral will grow less than one inch per year (Humann, 1993). If a stress is too severe, a coral reef can be completely destroyed (Wilkinson, 1992).

Often worse than the stresses imposed by nature are those imposed by man. Stresses to coral reefs are increasing and persist with continued use of oceans. Shipping, anchor damage, diving, pollution, and blast fishing are among anthropogenic effects which negatively impact coral reef ecosystems. It is estimated that by the year 2050, 70% of all reefs will be completely destroyed (Nash, 1996).

Although humans impact coral reefs in numerous ways, J. T. Tilmant (1987) believes there are three major concerns: boating impacts, diver impacts, and fishing impacts. Effects from boats and larger ships include anchor damage and pollution. Fuel pollution contaminates surrounding waters and dis-

rupts biological processes of its ecosystems. Divers, both SCUBA and snorkelers alike, cause physical damage to reef communities by kicking, holding onto or standing on corals. Also, divers are a disturbance to marine organisms dwelling within the corals. Fishermen not only destroy the physical nature of coral reefs with the use of their gear, they also impact community structure and survival by removing key predators (Tilmant, 1987).

The extent to which corals sustain physical damage is strongly dependent upon their size, morphology, and sturdiness. For example, the *Acropora* species, a highly branched variety, are extremely susceptible to breakage (Riegle & Riegle, 1995). There are three types of *Acropora* corals in the waters of the TCI. Mound corals such as the species *Montastraea annularis* and brain corals are able to withstand physically damaging conditions better because of their unobtrusive shape (Liddle & Kay, 1987).

An additional impact of human activity on coral reefs is sedimentation effects. As sediment such as sand is kicked up from the ocean floor, it becomes suspended in the water column. Water clarity decreases and so does the amount of light, required for photosynthesis, that will penetrate the water. As sediment settles out, a certain amount will inevitably come to rest on coral heads. This "chokes them" by prohibiting them to feed (Humann, 1993). In order for a coral to remove the sediment, it must expend a large quantity of energy which it now cannot use for growth and reproduction (Riegle & Riegle, 1995).

As with physical damage, the extent of sedimentation effects is also dependent upon morphology. Mound or boulder and brain corals will accumulate more sediment buildup than a branching or plate coral from which sediment will fall.

Yet another human-created problem that impacts coral reef ecosystems is eutrophication. In such a case, an overabundance of nutrients enters the water column. Bacteria

will deplete the oxygen supply and thereby limit the amount available for corals. Sewage discharge from desalination plants and other industrial activities has the ability to affect the salinity and temperature of the water. Corals have an optimum temperature (70-85° F) and salinity range in which they can survive (Humann, 1993). Any deviation from these standards hampers successful growth of corals.

The use of reefs is increasing each year. Most of this use however is applied to a small number of popular reefs (Hawkins & Roberts, 1994). Because no knowledge of a recreational carrying capacity for reefs is known, methodologies are needed to assess reef health and to anticipate the amount of recreational use which can be tolerated by a coral reef. This is often difficult to measure because only after carrying capacity has been exceeded can the optimum tolerance level be determined (Agardy, 1997).

The TCI hosted 87,794 visitors last year, of which only 1% visited South Caicos (Tourist Board, 1997). With plans for hotel development in South Caicos to be completed by December, 1997 the diving industry will inevitably increase. The hotel, High Point, will accommodate 500-750 guests. Club Carib, currently the only hotel on the island hosted only 100 guests for the entire year of 1996. South Caicos is one of the best dive areas in all of the TCI (Cummings & Cummings, 1993). However at present, the limited number of dive sites on South Caicos is congested. With only four mooring buoys currently in the waters of the park, coral reefs suffer from excessive use and subsequent anchor damage. Addition of both mooring buoys and new dive sites would alleviate some of the current pressures applied to South Caicos' reefs. An integral part of this study was the search for potential new sites. Club Carib has recently undergone management changes and the new manager is unfamiliar with the waters of South Caicos. Subsequently Club Carib was awaiting results of this study as they were

willing to deploy additional mooring buoys at new sites. If a reef were to become overexploited, the buoy could be relocated to allow the area some chance to recover.

This study was conducted over a period of one month (June 11-July 10, 1997) with the objective of initiating a long-term assessment of human impacts on the health of coral reefs of South Caicos. Data obtained were used to establish a baseline upon which later researchers will add as they continue to monitor the progress of the reefs' health. Currently, findings show the condition of coral reefs in South Caicos to be pristine. Stresses from diving and boating are not presently severe, but with the construction of High Point in progress and the anticipated rise in tourism, this may very well change. South Caicos is marketed purely for its dive sites. With a monitoring system in place any changes in reef health such as coral growth and destruction patterns as well as sedimentation levels and effects could be observed.

The manta tow technique was utilized with the intention of locating appealing new dive sites. However the technique proved ineffective due to the depth of the surveyed waters and the inexperience of observers. The great water depth as well as the speed of the manta board hindered effective determination of interesting new dive sites. Consequently, exploratory SCUBA and free diving were used as an alternate technique which produced better results. Five SCUBA sites were located on the windward side of Long Cay. Depending on the maximum depth of the dive, the user level of the sites was assessed and ranged from beginner to advanced. These sites were chosen because they were beautifully panoramic and within ten minutes of Cockburn Harbour and because available sandy patches would allow the placement of mooring buoys.

Possible snorkeling sites were located within the more shallow waters between Six Hills Cays and Middleton Cay but offered less potential because of their greater distance from Cockburn Harbour and their

lack of a suitable location for mooring buoys. Currently, there are very few snorkel sites which are actively used. These sites were visited by 1,832 snorkelers within a three month period (Center for Marine Resource Studies, Unpublished, 1997).

Data obtained from the line intercept transects established the foundation for assessing what living and non-living matter covered the ocean floor. Long-term monitoring of this type will detect any significant losses of coral life. Differences in the variety and number of species recorded were not reflective of differences in anthropogenic factors. More shallow waters are known to be less diverse in coral structure because of the greater amount of impact they receive (Floor, 1992). The Arch is home to fourteen different coral species while Admiral's only houses seven species. The greatest diversity is located at a depth of fifteen to twenty meters (Floor, 1992). Admiral's Aquarium, being a more shallow reef (3-5m) than The Arch (15-20m), showed less biodiversity as seen in the percent coverage portion of Figure 3. This neither makes The Arch healthier nor enables the determination of specific anthropogenic impacts. Each site must be monitored both long-term and individually in order to detect any deviation from the baseline data. Over equivalent time periods, the exact methods from this study should be used on the same sites to continue the accumulation of data. Observers should be knowledgeable in native coral species to ensure proper identification.

Likewise the quadrat technique was used to determine the amounts of benthic cover lying on the ocean floor. This method enabled a more significant area outside the line intercept transect to be assessed. Again, percentages determined are not indicative of the types of anthropogenic impacts inflicted upon the reefs. The presence of more algae at Admiral's Aquarium could be explained by its depth. The more shallow reef receives more sunlight than the deeper Arch. This would result in an increase in algae growth.

In order for this data to be replicated, the quadrats will have to be placed in the exact area where they were originally positioned. The probability of this occurring is unlikely. The placement of permanent quadrats would be more effective for accurate data keeping.

The results obtained from the sediment traps in the park represent the first estimates of sedimentation rates to be obtained for South Caicos. The sediment traps chosen to be collected and deployed at West Dock were impacted most in the short period from deployment to collection. Intermittent observations on the ocean floor of the deployed sediment traps at the dive sites led the research team to conclude that collection of these traps and subsequent analysis of their contents would have yielded negligible and insignificant results. The area of the West Dock was determined to be the most highly stressed because of the amount of boat and ship traffic it received in such a short time. The remaining eight sediment traps were left for collection at a later date by another research team.

Traps C and D, those retrieved, were positioned at the west and south ends of the West Dock. Although large vessels passed over both traps, twice the amount of sediment accumulated in Trap C by the west end. The discrepancy in the weight of the sediment may possibly be caused by the boats' docking in close proximity to Trap C. This would presumably result in increased wave action and more sediment disturbance. In addition, this area is subject to more recreational impact, such as swimming with and without fin. This in turn may have a greater effect on sediment accumulation in the trap.

A difference in sediment coloration was also noted between the contents of Traps C and D. Trap C contained soot colored sediment, while Trap D contained sediment that was buff colored. The presence of seagrass beds, which are known to produce dissolved and particulate organic matter, (Phillips & Menez, 1988) may account for the sediment color difference. In order to be certain, chem-

ical analysis should be performed to determine the organic composition of the sediment. Seagrass beds near Trap D also promote sediment consolidation and therefore cause less sediment resuspension, resulting in reduced amounts of sand in the trap. Seagrass beds also stabilize and hold sediment even through the worst weather patterns (Phillips & Menez, 1988).

The remaining eight traps not retrieved for use in this paper will be analyzed in future studies and will provide valuable baseline data on current sedimentation levels at popular dive sites. More data will be compiled in the future in hopes of making definite conclusions about diver impact on sedimentation rates.

In order for the pristine reefs of the Admiral Cockburn Land and Sea National Park to be sustained for use in the future, anthropogenic impacts need to be assessed as well as reduced. Acquiring baseline data on current reef conditions is the first step toward such processes. At this time there is no definitive link between human activities and amounts of rubble and sediment within a given reef. However precautionary measures should be taken to reduce any type of negative anthropogenic effect.

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# Platinum DMSO Complexes with Amine Ligands: A Study of Solvent Induced Isomerization

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## ABSTRACT

This research involved the preparation of platinum (II) complexes of the type trans-[Pt(DMSO)Cl<sub>2</sub>(am)] where DMSO is dimethyl sulfoxide and am is an amine. These complexes were studied by <sup>1</sup>H and <sup>195</sup>Pt NMR in order to 1) determine the effects of solvent on trans to cis isomerization and 2) obtain the reaction rates of isomerization.

## INTRODUCTION

It was serendipity that led Barnett Rosenberg to the identification of cisplatin and to the subsequent investigation of this compound as an anti-cancer agent. Rosenberg was conducting experiments on cellular division. In 1962, he noted that an electric field generated between two platinum electrodes inhibited the division of bacterial cells.<sup>1,2</sup> Hydrolysis at the electrode released platinum into the growth medium allowing the metal to react with chloride and ammonium ions.<sup>1,2</sup> The resulting square-planar complex, cisplatin (*cis*-diamminedichloroplatinum(II)), was responsible for the inhibition of cellular division due to its interaction with DNA.<sup>3</sup>

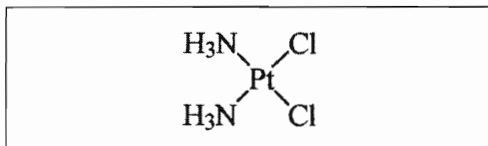


Figure 1. Cisplatin (*cis*-diamminedichloroplatinum(II)).

Cisplatin displays similar activity against certain cancerous cells. It is used chiefly in

the chemotherapeutic treatment of testicular and ovarian tumors.<sup>4</sup> Unfortunately, patients suffer from severe toxic side effects. For example, renal toxicity has been noted in 28 to 36% of patients treated with a single dose of 50mg/M<sup>2</sup>.<sup>5</sup> Other adverse reactions include nausea, vomiting, nephrotoxicity, ototoxicity, myelosuppression, neurotoxicity and bone marrow toxicity.<sup>5,6,3</sup> The second limitation to cisplatin's efficacy is that certain cells exhibit resistance (intrinsic or acquired) as a result of transport, intracellular detoxification, chromatin binding, and DNA repair mechanisms.<sup>4</sup>

In an effort to eliminate the difficulties associated with the use of cisplatin, current research is geared toward developing less toxic analogs that sidestep cellular resistance mechanisms. Alternate platinum compounds that have been developed include ammine/amine platinum(IV) dicarboxylates and 1,2-diaminocyclohexane (DACH) platinum(IV) complexes.<sup>3,4</sup> Platinum(II) dimethyl sulfoxide (DMSO) complexes with amine (am) ligands are yet another option. The complexes used

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in this research were of the type  $\text{trans-[Pt(DMSO)Cl}_2(\text{am})]$ . Various amine ligands were reacted with  $\text{K}[(\text{DMSO})\text{PtCl}_3]$ . Due to the trans-directing ability of DMSO, the ligands reacted to form the trans isomer.

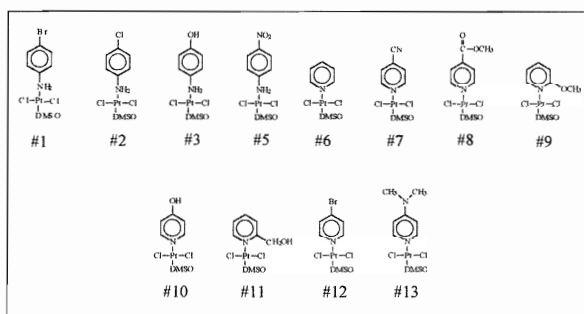


Figure 2. The complexes used in this experiment (with number designations).

## EXPERIMENTAL

**Synthesis of  $\text{K}[(\text{DMSO})\text{PtCl}_3]$ .**  $\text{K}_2\text{PtCl}_4$  (3.00mmol) was dissolved in 20mL of water. An equimolar amount of previously prepared  $(\text{DMSO})_2\text{PtCl}_2$  was added to the  $\text{K}_2\text{PtCl}_4$  solution. This mixture was allowed to stir vigorously for approximately one week. During this time, many color changes were observed: orange  $\rightarrow$  yellow  $\rightarrow$  yellow with black film  $\rightarrow$  olive green. (The solution grew darker because the pH was too basic. This was not a fatal mistake and can be corrected in future syntheses by monitoring pH.) Placing the reaction flask on a heating mantle returned the solution to a golden hue. The hot solution was filtered via gravity filtration, frozen at  $-80^\circ\text{C}$  overnight, and freeze dried for two days.

**Synthesis of 4-Bromopyridine Complex (#12).** This complex required a two-phase reaction. Step One: The ligand, purchased from Aldrich as 4-bromopyridine hydrochloride, was free-based. After the ligand (2.57mmol) was dissolved in water, sodium bicarbonate (7.71mmol) was slowly added. Three successive extractions with 20mL of dichloromethane were performed. To minimize the amount of  $\text{K}[(\text{DMSO})\text{PtCl}_3]$  required for the second phase of the reaction, the organic layer was brought up to 50mL

with  $\text{CH}_2\text{Cl}_2$  using a volumetric flask. Step Two: From the 50mL of base, 25mL were transferred to a round bottom flask.  $\text{K}[(\text{DMSO})\text{PtCl}_3]$  (1.2mmol), dissolved in 10mL of water, was added to the flask and the two-phase reaction was stirred violently using a stir plate. The organic layer became increasingly yellow over time. After approximately ten hours, stirring was stopped and the organic layer was separated and dried over  $\text{Na}_2\text{CO}_3$ . Gravity filtration removed the drying agent, and the filtrate was allowed to evaporate. The resulting crystals were well-formed, yellow needles. The purity of this complex has yet to be determined.

### Synthesis of All Other Complexes.

$\text{K}[(\text{DMSO})\text{PtCl}_3]$  (0.5mmol) was dissolved in water. The amine ligand (0.5mmol) was dissolved in ethanol. It was necessary to use heat while stirring in order to achieve complete dissolution. The ligand solution was added, dropwise, to the  $\text{K}[(\text{DMSO})\text{PtCl}_3]$  solution leading to a yellow precipitate. After stirring for six hours, the solid  $\text{trans-[Pt(DMSO)Cl}_2(\text{am})]$  product was isolated by filtration. The product was washed successively with water, ethanol, and finally ether.

**Spectroscopy.**  $^1\text{H}$  NMR and  $^{195}\text{Pt}$  NMR spectra were obtained on a Gemini 300MHz NMR. Standard parameters were used. Approximately 10mg of complex was dissolved in 600-700 $\mu\text{L}$  of DMSO.

For complexes containing arylamine ligands, spectra were taken at 30 minute intervals for a total of 8.5 hours. For complexes with heterocyclic amine ligands, spectra were taken at increments of 15 minutes (x 4), 30 minutes (x 2), and 60 minutes (x 11) for a total of 13 hours.

Spectra for the  $^{195}\text{Pt}$  kinetic runs were taken at increments of 10 minutes (x 5), 15 minutes (x 4), 30 minutes (x 4). Each spectrum had an acquisition time of 5.1 minutes.

## RESULTS AND DISCUSSION

When dissolved in excess DMSO, an equilibrium was reached between the prepared trans complexes and their cis isomers.



DMSO induced isomerization because of its high coordinating ability to platinum.<sup>7</sup>

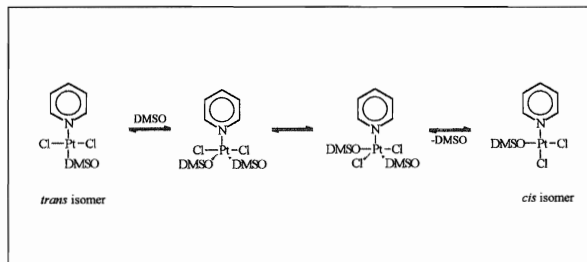


Figure 3. Solvent induced isomerization of the pyridine complex (#6) in DMSO.

<sup>1</sup>H NMR spectra were taken at defined intervals over time to monitor trans to cis isomerization. Figure 4 labels the different types of hydrogens and their corresponding peaks for each isomer of the pyridine complex (#6).

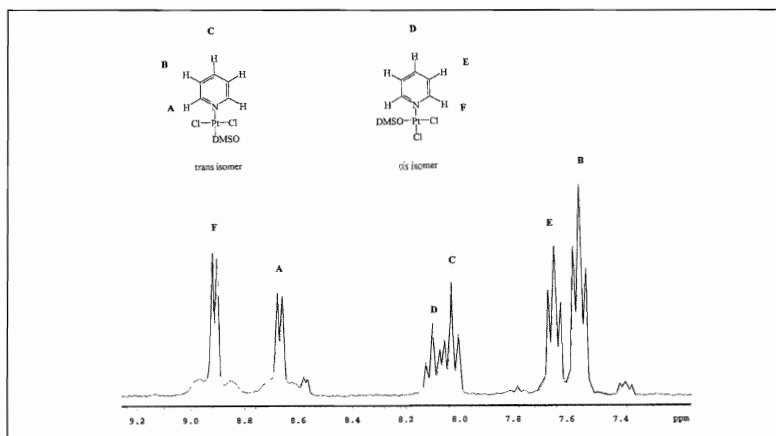


Figure 4. Magnified region of <sup>1</sup>H NMR spectrum of complex #6 in DMSO at 13 hours.

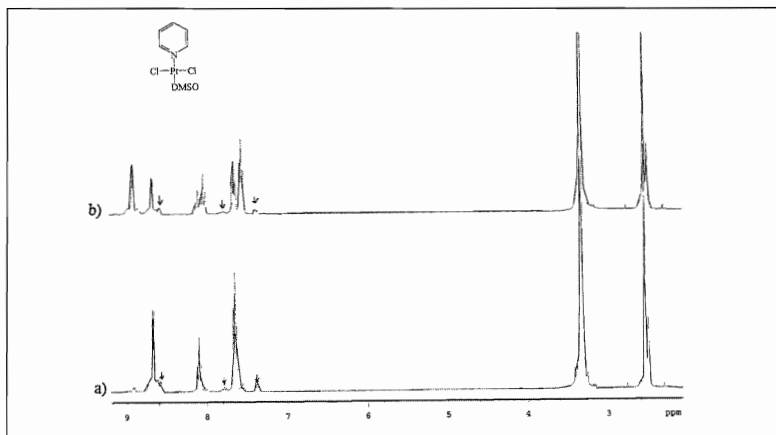


Figure 5. <sup>1</sup>H NMR of pyridine complex (#6) at a) 0 hours and at b) 13 hours. The arrows indicate the presence of free ligand.

The initial and final spectra for the pyridine complex (#6) is presented in Figure 5. It is clear that over time the peaks between 7ppm and 9ppm doubled, indicating the appearance of a second isomer.

The arrows are pointing out the peaks belonging to free ligand. When dissolved in DMSO, the ligand is labilized by the solvent leading to the appearance of free ligand. These peaks do not change over time. In general, complex lability depends on the strength of the amine-platinum bond.

Integration values taken from these spectra allowed for the construction of plots of ln [concentration] versus time. Solvent participation leads to pseudo first order kinetics, producing linear plots.

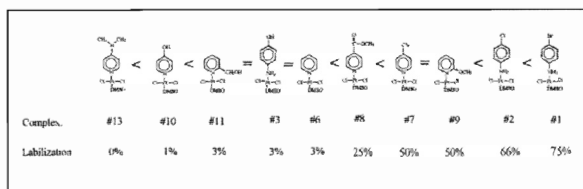


Figure 6. Complexes in order of percent labilization (approximate values) expressed as a ratio of free ligand to *trans* isomer. For example, when dissolved in DMSO, a  $^1\text{H}$  NMR of complex #7 revealed peaks of equal height for the *trans* isomer and for the free ligand.

From these graphs, it was possible to ascertain the rate constant,  $k$ , which is equal to the slope of the line. The rate constant was of interest because it reflects the rate of isomerization. Comparing the rate constants revealed a pattern among the complexes.

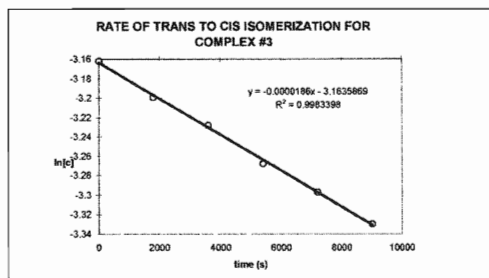


Figure 7. Graph of  $\ln[c]$  vs. time for the 4-aminophenol complex (#3).

Considering that all of the complexes had the same structure except for the amine ligand, variations in rate were attributed to the ligands' properties. The basicity of the ligand (expressed in terms of the  $\text{pK}_a$  of the ligand's conjugate acid) was of primary concern. Figure 8 shows the  $\text{pK}_a$  values for the complexes that produced  $k$  values. In general, complexes with less basic ligands had higher rates of isomerization (and vice versa). For example, 4-cyanopyridine has the lowest  $\text{pK}_a$  and complex #7 had the fastest rate of isomerization. Following the same trend, 4-aminophenol has the highest  $\text{pK}_a$  and complex #3 had the slowest rate of isomerization.

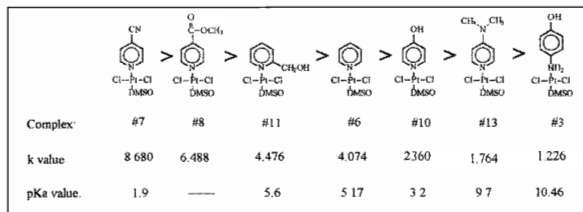


Figure 8. Comparative rates of isomerization ( $k$  values expressed in  $10^{-3} \text{ min}^{-1}$ ). Each  $\text{pK}_a$  value is for the dissociation of the ligand's corresponding conjugate-acid ammonium ion.

A second trend involved the electron withdrawing nature of the ligand. As the ligand's electron withdrawing ability increases, so does the rate of isomerization. This occurs because pulling electron density away from Pt makes it easier for the solvent to attack and induce isomerization.

The ligand *trans* to the substitution site also influences the rate of isomerization. This is known as the *trans* effect. If a ligand "prefers" to have chlorine opposite itself in the molecule, then an incoming solvent molecule will be forced out of the *trans* position, encouraging the *cis* configuration.

In contrast to the typical isomerization reactions, the 2-methoxypyridine complex (#9) behaved anomalously. Its  $^1\text{H}$  NMR was difficult to interpret, so a  $^{195}\text{Pt}$  NMR kinetic run was performed. The results from this kinetic run suggested the involvement of a long-lived intermediate. As shown in Figure 9, it was clear that the *trans* isomer was present in the first spectrum ( $t = 0$ ), but it disappeared almost immediately. Interestingly, the *cis* isomer was not detected during the entire kinetic experiment. Instead, there was an upfield peak which we have assigned as  $[(\text{DMSO})_2\text{PtLCl}]^+$ . To date, attempts to isolate this complex have failed and, in fact, only the *cis*-2-methoxypyridine isomer can be obtained. Similarly, the 4-chloroaniline complex (#2) and the *p*-nitroaniline complex (#5) produced substantial  $[(\text{DMSO})_2\text{PtLCl}]^+$  peaks.

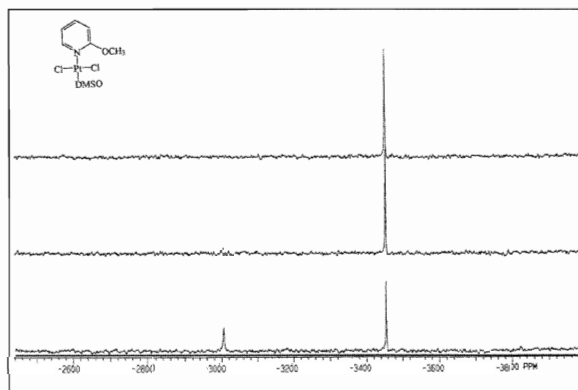


Figure 9.  $^{195}\text{Pt}$  arrayed spectra of the 2-methoxypyridine complex (#9) in DMSO.

## CONCLUSION

The rates of isomerization for various pyridine and aniline complexes have been measured and are generally related to the  $pK_a$  of the ligand. In addition, this research provided a useful means of preparing the cis isomer from the trans isomer in the case of pyridines.

We plan to carry out in vitro assays in order to assess the anticancer activity of the complexes involved in this study. Furthermore, gel electrophoresis studies will be used to examine their DNA binding properties. Finally, the kinetics of isomerization of the complexes which form cationic intermediates will be determined. Attempts to isolate the cations will be made.

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# Chronic Cocaine Exposure Causes Increase in Population Spike Amplitudes in CA1 Pyramidal Cells of the Rat Hippocampus

## ABSTRACT

Long-Evans rats were treated for five to seven days with cocaine and lidocaine. Population spike amplitudes from the CA1 pyramidal cells of the hippocampus were then measured. Lidocaine treated rats did not show any increase in population spike amplitude relative to the control group. However, pyramidal cells from cocaine treated rats yield population spikes of significantly higher amplitudes than the control group. It is possible that an increase in the excitability of neurons may cause this increase in population spike amplitude.

## INTRODUCTION

Chronic cocaine exposure has been observed to produce increased levels of locomotor activity (Schuster and Fischman, 1977), abnormal visual tracking behavior (Post et al, 1976), and sensitization (Post and Rose, 1976). Synaptic responses (observed in the form of population spikes) have indicated that chronic prenatal cocaine exposure may cause hyperexcitability in CA1 neurons of the hippocampus (Baraban and Schwartzkroin, 1997). However, the changes in synaptic electrophysiological properties due to chronic cocaine exposure of the neurons of the hippocampus of a fully developed rat are unknown.

Cocaine is known to produce two acute effects. First, cocaine produces a local anesthetic effect by inhibiting sodium channels (Ritchie and Greene, 1980). Second, cocaine blocks the re-uptake of monoamine neurotransmitters (such as dopamine, serotonin,

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and norepinephrine (Roberts, 1992) causing a psychostimulant effect. A known effect of chronic cocaine exposure is that it increases the sodium currents of neurons (Zhai, Wieland, and Sessler, 1997). Cocaine may alter or interact with NMDA receptors of neurons (Karler and Calder, 1992, Rockhold et al, 1991; Wilkin and Tortella, 1991; Itzhak and Stein, 1992) after both acute and chronic exposure.

Changes in the electrophysiological properties of the pyramidal cell layer of the CA1 region of the hippocampus were studied in mature Long-Evans rats (which were chronically exposed to cocaine). It was found that chronic cocaine exposure altered the electrophysiological properties of the CA1 pyramidal cells. In particular, rats treated chronically with cocaine yielded population spikes of greater amplitude than the population spikes of the rats of the control group.

In order to determine if changes in population spike amplitudes were related to cocaine's local anesthetic properties, a group of rats was chronically treated with lidocaine, a widely-used anesthetic and antiarrhythmic (Moe and Abildskov, 1970). Population spike

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*Author's Note: This report was submitted in partial fulfillment of the requirements for Biology 397—Biology Internship, coordinated by Dr. W. S. Klug, The College of New Jersey. Steven Kikolski is a biology major. This work was completed under the direction of Dr. Frances Sessler at the Department of Neurobiology and Anatomy, MCP/Hahnemann School of Medicine, Allegheny University of the Health Sciences, 3200 Henry Ave., Philadelphia, PA 19129, U.S.A.*

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amplitudes which were recorded in hippocampal slices of rats treated with lidocaine were not significantly different from those recorded in the control group.

The experiment was done on the CA1 pyramidal cells of the hippocampus for a number of reasons. First, the CA1 neurons of the hippocampus was a good region of the brain to study because the cell bodies are easily visible, which allowed for easy placement of the recording electrode. Also, use of the hippocampus provided a good pathway for stimulating the CA1 cells. Finally, the results of the present study may be compared to results of other, similar experiments since they have typically involved the hippocampus, as well.

#### MATERIALS AND METHODS

Long-Evans rats (150-200g) were divided into three experimental groups (cocaine, lidocaine, and control) and were injected (i.p.) with their respective treatments for five to seven days. Cocaine was administered at a concentration of 45mg/Kg and lidocaine was administered at an equivalent concentration of 70mg/Kg. Responses indicating behavioral sensitization were observed in the cocaine treated rats including locomotion and stereotypy (repetitive sniffing and movement of the head and limbs). One half of the control rats received injections of saline (.9%) and the other half did not receive any injection. Results from the two control groups showed no statistical difference, thus, they were combined into one large control group for data treatment.

On the final day of treatment, rats were given one last injection of their respective treatment to minimize withdrawal effects. Once the acute effects of the treatment wore off (which took approximately two hours), the rats were lightly anesthetized using Halothane (5%) and then immediately decapitated. Following decapitation, the brain was removed and immersed in ice-cold (4 C), oxygenated artificial cerebrospinal fluid (ACSF) consisting of (in mM) NaCl 124, CaCl<sub>2</sub> 2.4, KCl 5, KH<sub>2</sub>PO<sub>4</sub> 1.25, MgSO<sub>4</sub> 1.3, Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub> .048, glucose 10, and NaHCO<sub>3</sub> 26.01. No

more than three minutes was allowed to pass from the time of decapitation to the time when the brain was immersed in ACSF; this was to prevent death of cells. The brain was then dissected and hippocampal slices with a width of 425  $\mu$ m were obtained using a tissue chopper. The slices (n=4-7) were placed in an oxygenated (95% O<sub>2</sub>/5% CO<sub>2</sub>) chamber and were perfused with ACSF (32 C); the slices were left undisturbed for 30 minutes to allow the cells to regain stability.

Electrical stimulation of CA1 region pyramidal cells was evoked orthodromically using a bipolar electrode made with silver wire coated with Teflon. The stimulating electrode was placed in the CA3 region to stimulate the CA1 region via fibers connecting the two regions; the position of the stimulating electrode was held constant in each experiment. Stimulation was performed at a frequency of 0.05-0.2 Hz, using a pulse duration of 0.1-0.2 msec. Cells were stimulated at an intensity between 10-600  $\mu$ A at increments of 10-20  $\mu$ A.

Population spikes (somatic field potentials) from pyramidal cell bodies of the CA1 region were recorded extracellularly using glass-microelectrodes (2-5 M $\Omega$ ) filled with 2M NaCl. Figure 1 is a diagram of the circuitry of the hippocampus and shows the placement for both the recording (Re.) and stimulating electrode (St.) (Joy et al, 1995). The recording electrode was placed in the pyramidal cell layer in a position (varying from experiment to experiment) which provided the best results. Slices yielding a population spike of at least 4mv at maximum response were considered healthy. Slices that did not fit this criteria were discarded.

Six responses were taken per slice at each increment of stimulus intensity and averaged. Amplitudes of the population spikes were measured from the negative peak to the positive peak to determine any change in neuron excitability between control and experimental groups. The method used for measuring population spikes is illustrated in Figure 2 (Doller and Weight, 1985).

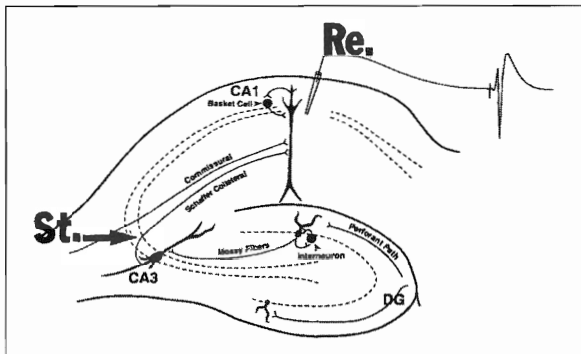


Figure 1. Diagram of the Circuitry of the Hippocampus Showing Positions of Recording (Re.) and Stimulating (St.) Electrodes.

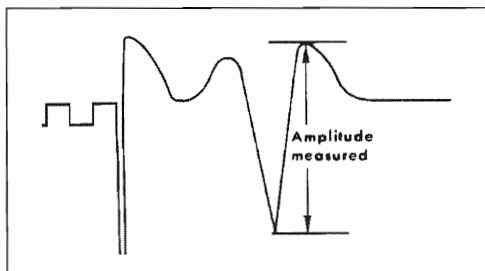


Figure 2. Method Used for Measuring Population Spikes.

## RESULTS

Slices derived from control animals ( $n=33$ ) required an average minimum stimulus intensity of  $53.94 \mu\text{A}$  ( $\pm 4.10 \mu\text{A}$ ) to present a minimum response and a stimulus of  $317.27 \mu\text{A}$  ( $\pm 13.01 \mu\text{A}$ ) to produce a maximum response. Slices from rats treated with cocaine ( $n=26$ ) required an average minimum stimulus intensity of  $46.30 \mu\text{A}$  ( $\pm 3.74 \mu\text{A}$ ) and a stimulus intensity of  $297.78 \mu\text{A}$  ( $\pm 15.59 \mu\text{A}$ ) to achieve a maximum response. Tissue slices from animals exposed to lidocaine ( $n=19$ ) required a minimum stimulus intensity of  $48.95 \mu\text{A}$  ( $\pm 4.32 \mu\text{A}$ ) to produce a response and a stimulus intensity of  $357.89 \mu\text{A}$  ( $\pm 22.47 \mu\text{A}$ ) to produce a maximum response. These values were within the accepted range for healthy slices.

Electrophysiological changes due to chronic cocaine and lidocaine exposure were investigated by examining changes in population spike amplitude relative to the control group. Results of the experiment are presented in Figure 3; amplitude of average responses (in millivolts) is plotted against

the common log of various levels of stimulus intensity.

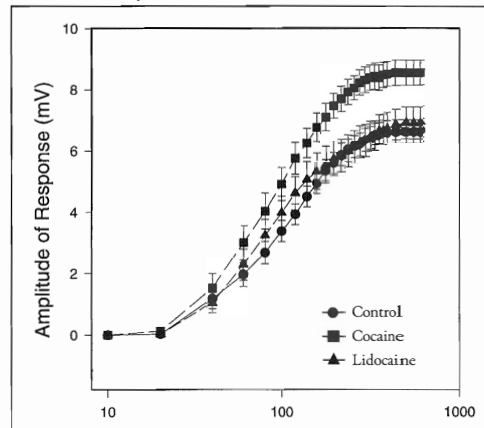


Figure 3. Log Stimulation Intensity  $\mu\text{A}$ .

The amplitude of the responses of control and lidocaine treated animals were not statistically different. However, the responses derived from cocaine treated animals were significantly different from responses of control and lidocaine treated animals. At maximum stimulus intensity, slices from cocaine treated animals yielded an average response of  $8.56 \text{ mV}$  ( $\pm 0.40 \text{ mV}$ ); lidocaine treated animals yielded an average response of  $6.95 \text{ mV}$  ( $\pm 0.51 \text{ mV}$ ) and animals of the control group yielded an average response of  $6.67 \text{ mV}$  ( $\pm 0.38 \text{ mV}$ ).

Slices from cocaine treated animals also presented differences in population spike amplitudes at levels below maximum intensity (which is also demonstrated in Figure 3). Using analysis of variance (ANOVA), it was determined that significant differences in population spike amplitudes between control animals and cocaine treated animals occurred at stimulation intensities that were equal or greater than  $80 \text{ mA}$ .

## DISCUSSION

Population spikes are due to a change in voltage in the extracellular space caused by the simultaneous firing of a group of neurons. If the neurons of an area are more easily excited (require a lower level of stimulus to fire) then a given level of stimulus will

recruit more neurons to fire. As more neurons fire, the voltage change becomes greater, thus, the amplitude of a population spike increases. Using this logic, it was hypothesized that the occurrence of greater amplitudes of population spikes in rats treated chronically with cocaine was a reflection of the increase in excitability of the CA1 pyramidal cells.

Lidocaine is a widely used anesthetic and antiarrhythmic (Moe and Abildskov, 1970) that inhibits sodium channels, thus preventing a neuron from firing. Cocaine also produces an anesthetic effect by inhibiting sodium channels. Chronic treatment with lidocaine did not increase the amplitudes of population spikes in the CA1 pyramidal cells of the rat hippocampus. Thus, it is unlikely that the local anesthetic properties of cocaine were responsible for the increase in population spike amplitudes.

It is possible, however, that cocaine's effect on monoamine neurotransmitters could increase the excitability of the neurons. However, the degree to which this property of cocaine affects population spike amplitudes still needs to be determined. This could be accomplished by treating rats chronically with other drugs (such as flouoxetine, which blocks the re-uptake of serotonin) known to block the re-uptake of specific neurotransmitters and then recording population spikes in the hippocampus of such rats. These results could then be compared with the results obtained from the control group and the cocaine treated group to determine which neurotransmitter (if any) or group of neurotransmitters are involved in the increase in the excitability of CA1 neurons when the re-uptake of these neurotransmitters is blocked.

Another way that cocaine may produce changes in electrophysiological properties is through a mechanism by which cocaine interacts with NMDA receptors. It has been shown that NMDA receptor blockers (MK801, APV) can prevent the convulsive and lethal effects of a lethal dose of cocaine

(Karler and Calder, 1992; Rockhold et al., 1991; Witkin and Tortella, 1991). Also Karler and Calder (1992) found that antagonists of the NMDA receptor can block the locomotor stimulation associated with exposure to cocaine. In addition, antagonists of the NMDA receptor have been found to block the sensitization to the toxic effects of cocaine (Itzhak and Stein, 1992).

Changes in electrophysiology due to cocaine's interaction with NMDA receptors could be examined by recording the population spikes of hippocampal slices of both cocaine-treated and control rats. An NMDA receptor blocker (mixed with ACSF) could then be exposed to the same hippocampal slices and population spikes could be recorded again. The changes in population spike amplitude after the NMDA receptor blocker has been applied could then be examined. The effect of the NMDA receptor blocker on population spikes of cocaine treated rats would then be compared to its effects on the population spikes of control rats.

Chronic cocaine exposure may increase population spike amplitudes because of a phenomenon observed in an experiment done by Zhai, Wieland, and Sessler (1997). The study investigated the effects of chronic cocaine intoxication on sodium channel function and found that chronic cocaine exposure was correlated with an increase in sodium currents. This may have been due to modification of sodium channels caused by a compensatory mechanism or an increase in sodium channel density. A greater number of sodium channels or sodium channels with a lower threshold could increase the excitability of a neuron.

## CONCLUSION

When rats were exposed chronically to cocaine, pyramidal cells of the CA1 region of the hippocampus produced population spikes that had significantly greater amplitudes than those of the control group. This was likely attributed to an increase in excitability of these cells. Lidocaine did not

increase population spike amplitudes. Thus, it is not likely that the increase in excitability was due to cocaine's local anesthetic effect.

#### ACKNOWLEDGEMENTS

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# The Impact of Fire on Selected Small Mammal Species In the Pine Barrens of New Jersey

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## ABSTRACT

Small mammals' responses to fire can vary from initial annihilation with rapid recovery, to long-term disappearance in species. This affects not only small mammal populations and activity ranges, but can impact predators that feed on these animals. In April 1995, a wildfire burned 20,000 acres of Ocean County Pinelands. A project was designed to determine the impact of fire on resident small mammals. This was done through the use of drift fences and live trapping. The two most common species caught were the white-footed mouse (*Peromyscus leucopus*) and the red-backed vole (*Clethrionomys gapperi*). Because these two species were the most commonly captured mammals, they served as the focal point of this study. The results of 2,083 trap nights indicated that *P. leucopus* showed no preference for burned or unburned habitats. Conversely, *C. gapperi* showed a clear preference for unburned areas, specifically the upland forest area. Additionally, *C. gapperi* appeared to exhibit a more patchy distribution in preferred habitats than *P. leucopus*.

## INTRODUCTION

Protective cover and food are necessary for survival, establishment of home range size, breeding, and competition. Fire can create a loss of protective cover and loss of food source for many small mammals. These losses cause either short or long-term alterations to daily life depending on the species affected. Recovery of small mammal populations

as a result of fire can range from several months to a year or more, depending on the species and their nutritional and cover needs (White, 1961; Tester, 1965; Beck and Vogl, 1972; Krefting and Ahlgren, 1974; McMurry and Lochmiller, 1996). Ultimately this impacts not only small mammal populations, but also on the predators that prey upon them.

Several papers have reviewed the effects of fire on small mammals. These papers, ranging from prairie to deciduous forest fire studies, have shown a general fire-negative response in several small mammals immediately following a fire (Cook, 1959; Clark and Kaufman, 1990). The goal of this project was to assess the impact of fire on small mammals in the New Jersey Pine Barrens. Population densities, fitness, and home range sizes were targeted as a method of fire assessment. Studies such as this can aid in understanding what impact controlled burning may have on small mammals as individual species and small mammals as a prey.

## MATERIALS AND METHODS

**Study Area.** The study was performed in the vicinity of Bamber Lake, Ocean County, New Jersey. The New Jersey Pine Barrens is categorized as lowland and upland communities.

*Author's Note:* This work was completed in partial fulfillment of the requirements for Biology 499—Independent Study, under the supervision of Dr. Howard K. Reinert, Biology Department. Gylla MacGregor is a 1997 graduate of The College of New Jersey and is now a graduate student at Clarion University in Pennsylvania.

The lowland areas include swamp forests, small marsh communities (Foreman, 1979), and low level flatlands cut by streams and shallow valleys (Harshberger, 1970). Upland communities are pine forests and pine-oak forests (Harshberger, 1970; Foreman, 1979). A detailed description of the Pine Barrens' vegetation and climate can be found in Harshberger (1970) and Foreman (1979).

**Sampling.** In April 1995 approximately 20,000 acres of New Jersey Pine Barrens in Ocean County were burned. Live trapping was performed on 13 localities in four separate habitats and represented both burned and unburned areas. These habitats consisted of both upland forests and wetland communities common to the area. The lowland habitats sampled included swamps and shrubby wetlands.

Sampled unburned habitats contained vegetation typically described in Harshberger (1970) and Foreman (1979). Habitat 1, the white cedar (*Chamaecyparis thyoides*) swamp contained an understory dominated by mountain laurel (*Kalmia latifolia*). Some blueberry (*Vaccinium atrococcum*, *V. corymbosum*) was also present. The ground cover was a dense, well-distributed layer of moss (*Sphagnum*). The dominant hardwood tree in the broadleaf swamp (Habitat 2) was swamp red maple (*Acer rubrum*), with pitch pine (*Pinus rigida*) intermixed. The understory consisted of blueberry (*Vaccinium vacillans*), sheep laurel (*K. angustifolia*), and maleberry (*Lyonia ligustrina*). Spangum mosses were the common ground cover. Habitat 3, the open-canopied shrubby wetland, contained various species of blueberry (*V. vacillans*, *V. corymbosum*), sheep laurel (*K. angustifolia*), and gallberry holly (*Ilex glabra*). An occasional scrub oak (*Quercus ilicifolia*) was also found in the wetlands. Pitch pine (*P. rigida*) was the only overstory tree species. A ground layer of downy hudsonia (*Hudsonia ericoides*) was also abundant in the shrubby wetland grids. The fourth habitat, the upland forest, was dominated by a pitch pine (*P. rigida*) overstory. The most frequent

understory vegetation in the upland forest consisted of scrub oak (*Q. ilicifolia*), black jack oak (*Q. marilandica*), blueberry (*V. vacillans*, *V. corymbosum*), and dwarf huckleberry (*G. dumosa*). All vegetation was identified through the use of descriptions in Harshberger (1970), Foreman (1979), Petrides (1986), and Boyd (1991).

Post-fire re-growth varied among the habitats. In the lowlands, the burned shrubby wetland community had some live pitch pine (*P. rigida*) overstory trees although in general these trees were smaller in DBH than the unburned areas. A slightly higher proportion of sheep laurel (*K. angustifolia*) to blueberry (*V. corymbosum*) was also present in these areas. Regeneration in the shrubby wetland was, in general, quite thick. Regeneration in the burned cedar swamp was poor at the time of trapping. Plant recovery in the burned cedar swamp was represented mainly by blueberry (*V. vacillans*) and mountain laurel (*K. latifolia*); almost all of these plants were low in height (<0.50 meters). The burned hardwood swamp had abundant post-fire regeneration dominated by tall (>1 meter) blueberry (*V. vacillans*) and huckleberry (*G. fondosa*) plants and large ferns (*C. asplenifolia*, and *P. aquilinum*) and grasses.

In the uplands, many of the larger pitch pines (*P. rigida*) were showing re-growth indicating a high survival rate of larger trees. Changes could be seen at the understory level, however, due to the creation of a more open canopy following the fire. Understory regeneration allowed for more blueberry (*V. vacillans*, *V. corymbosum*) than observed in the unburned pitch pine forest. Oak (*Q. ilicifolia*, *Q. marilandica*, and *Q. prinoides*) and blueberry (*V. vacillans*, *V. corymbosum*) plants were also taller in the burn than those found in the unburned pitch areas.

In each of the 13 sampling sites, Sherman Live Traps were placed at 10-meter intervals in grids covering 2,000 square meters. Traps were placed near trees or large understory vegetation within 1 meter of grid intersections. With the exception of the burned

cedar swamp, burned broadleaf swamp, and unburned broadleaf swamp Grid A, all grids consisted of the same 5x4 trap design. Due to the elongated and narrow nature of habitats following the stream, the above mentioned broadleaf swamp grids consisted of 3x7 and 3x13 grids respectively. The burned cedar swamp consisted of a 5x4 grid, but the shape was not rectangular. Grid intersections were labeled using an alphanumeric system, with the long side of the grid represented by a letter and the short side represented by a number. Grids were laid out using a Suunto site compass and a Ranging 100 Optical Tapemeasure.

Point quarter sampling (Brewer and McCann, 1982) was performed in each grid for each trap location. This was to provide data for replicate grid comparison. The data for each trap site in each grid was condensed for single trap data of average diameter at breast height (DBH) for overstory, average DBH for understory, average distance to overstory vegetation, and average distance to understory vegetation. For example, four data points for overstory DBH were taken for Trap 1 at Grid X. These four points were averaged together creating a single data point for Trap 1 at Grid X. Vegetation type was logged as percent of each species represented for the four points.

A Taylor Sybron Maximum/Minimum thermometer was hung on a tree in each grid during the trapping period. Each morning, prior to checking traps, high/low temperatures from the previous night and day were recorded and the thermometer was then reset for the next recording period. Rain was frequent during the trapping period; however rainfall amounts were not recorded.

The sampling period covered a potential 2,300 trap nights running from June 3 and July 26, 1996. Grids were trapped for two five-night trapping periods providing a total of 10 trapping nights for each grid. This was consistent for all grids with the exception of the burned and unburned cedar swamp, burned broadleaf swamp, and unburned

broadleaf swamp Grid A. Trapping was arranged so that both a burned and unburned representative of each habitat was trapped at the same time. Trapping began with the pitch pine forest, followed by the cedar swamp, broadleaf swamp, and shrubby wetland. This sequence was determined by the order in which the grids were located and established. A minimum of one week was allowed between the first five trapping nights and second five trapping nights in each grid. This one-week break was to encourage natural foraging and exploratory behavior that might otherwise have been altered due to bait trapping.

Traps were baited with a 50/50 mixture of peanut butter and rolled oatmeal. Traps were locked in an open position for two consecutive nights prior to trapping. Trapping took place immediately after the two-night acclimation period and continued for five consecutive nights. All traps were checked each morning between 0700 and 1100 and were set for the next trapping night at that time.

Two drift fences (Zappalorti and Torocco, 1995) were operated during 1995 and 1996. The drift fences were constructed with a 91-meter nylon silt fence stapled to wooden stakes. Sixteen 5-gallon buckets were placed in the ground at 10-meter intervals—eight on each side of the fence. One additional 5-gallon bucket was placed at each end of the fence for a total of 18 drift fence traps. Holes were punched in each bucket for water drainage. Sphagnum moss was placed in each bucket to provide both cover from the sun and to retain some moisture. The drift fences were in both burned and unburned locations. The first drift fence was located in the burned wetland adjacent to the burned cedar swamp. This drift fence was operated in 1984, 1995, and 1996, thus providing both pre and post fire data. The 1995 dates of operation for this first drift fence were from May 16 to November 3. The 1996 drift fence dates of operation were from June 3 to August 21. The second drift fence was located in the pitch pine uplands. This upland

drift fence was operated from May 16 to November 3, 1995 and from June 3 to August 21, 1996. During the 1996 season, both drift fences were checked daily between 0700 and 1100 hours.

**Collection of Animals.** Small mammals captured by trapping were transferred from the trap into a 1/2 gallon zipper freezer bag. Species, sex, and weight ( $\pm 0.5$ g) were recorded in addition to length of hind foot, body, tail, and ear ( $\pm 0.5$ mm). Pelage was used to identify sub-adults from adults.

The trap number was recorded at the time of capture. Disturbed (sprung) traps without a mammal inside were also recorded and subtracted out of the total traps available for animal captures. When all pertinent data were collected, each animal was marked by toe clipping (Waichman, 1992) and released at the location of capture. Mammals caught in the drift fence were recorded by species and bucket number prior to their release on the side of the fence opposite from point of capture. Toe clipping was not performed on drift fence captures.

Dead animals were retained for study skin mounts. Museum specimens were deposited in the collection of the biology department of The College of New Jersey.

**Statistical Analysis.** Population estimates were obtained using the Schnabel method of population estimation with the Poisson distribution (Krebs, 1989). Biomass was calculated as the mean body mass (in grams) per hectare. Analysis of variance (ANOVA), using Systat, was employed to examine intraspecific and interspecific differences in population densities, habitat use, and burned versus unburned area use. One way ANOVA (Model I) was used to compare mass and length, both overall and for animals utilizing burned versus unburned areas. A Tukey post hoc test of means was used to identify specific areas of variation in all ANOVAs that came up significantly different.

Chi-square analysis (Brewer and McCann, 1982) was used to look at capture ratios of males to females for a species. Cormack's Test

for Catchability (Krebs, 1989) was used to determine the extent of equal catchability among the sexes.

Trap success was calculated as the number of captures divided by the total number of traps minus 1/2 the number of sprung traps (Ruffer, 1961). The corrected trap success formula allows for randomly sprung traps and assumes they were sprung at an arithmetic rate. Biomass was calculated as the mean body mass (in grams), per hectare.

Principal component analysis was used to reduce the number of variables from the point quarter sampling data among habitats to three principal components. A minimum of 50% of the variation among habitats was targeted for the first three principal components. Variables used in the analysis were those most common among the different habitats (Table 9). Once three principal components were determined, replicate grids were tested against each principal component using 95% centroids and comparing the central axis of each centroid. Ninety-five percent centroids were also used to compare burned versus unburned grids.

## RESULTS

**Small Mammals.** A total of 122 small mammals representing four species were caught in live traps during 2,083 trap nights yielding an overall trap success ratio of 5.56%. Small mammals captured in live traps during the sampling period were *Peromyscus leucopus* (n=98), *Clethrionomys gapperi* (n=22), *Tamias straitus* (n=1), and *Blarina brevicauda* (n=1). *P. leucopus* and *C. gapperi* were the focal point of all data analysis because of their large sample size.

*P. leucopus* was found in all sample grids and showed no significant difference ( $F_{s(1,14)} = 0.209, P > 0.05$ ) in population size for burned or unburned area use. In addition they were generally distributed among all study grids. *C. gapperi* was captured only in unburned habitats, and reflected a patchy distribution based on sporadic captures in replicate grids. For example *C. gapperi* were

captured in one pitch pine grid but not in the replicate grid. Additionally, in both unburned shrubby wetland grids, *C. gapperi* were caught only in traps nearest the stream and in no other traps. In habitats where both *P. leucopus* and *C. gapperi* were caught, there was no significant difference ( $F_{s(1,8)}=0$ ,  $P>0.90$ ) between their population densities of these two species (Figure 1). Biomass (grams/hectare) was also not significantly different between *P. leucopus* and *C. gapperi* ( $F_{s(1,8)}=0.004$ ,  $P>0.90$ ).

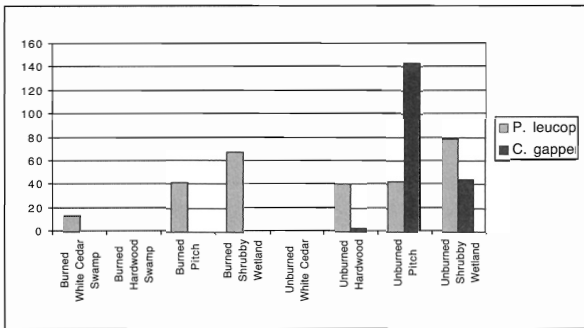


Figure 1. *C. gapperi* and *P. leucopus* population densities for each habitat where estimates were obtained. 95% confidence intervals are indicated.

**Peromyscus Leucopus.** A total of 98 mice (61 male, 37 female) were captured. Twenty-four mice were positively identified as sub-adult based on coat color. In all grids combined, 59 mice were recaptured one or more times. Twenty-five mice (13 male, 2 sub-adult; 7 female, 3 sub-adult) were captured four or more times in different traps. Three unmarked mice escaped prior to recording body measurements. Cormack's test for catchability indicated all mice were equal in catchability ( $z = -0.05973$ ). A chi-square analysis showed a strong male biased capture ratio of nearly 2:1 ( $\chi^2=3.84$ ,  $df=1$ ).

Two pitch pine grids—one burned and one unburned—were trapped in both 1995 and 1996 as indicated in Table 1. The pitch pine population estimates for 1996 were consistent with a trapping period conducted in August, 1995 as indicated in Table 1. The 1995 trapping period was operated for four consecutive nights.

Table 1. *P. leucopus* population estimates per hectare by grid for each habitat, burned and unburned. Coverage is for the 1995-1996 trapping periods.

Habitat/Type	Total Trap Nights	Population Estimate/Hectare	Population Low/Hectare	Population High/Hectare
Burned White Cedar Swamp	43	12.5	4.7	490.2
Burned Hardwood Swamp	41	2 Caught - no recaptures		
Burned Pitch Pine - A*	199	28.6	17.8	59.1
Burned Pitch Pine - B	200	50.5	30.1	113.2
Burned Shrubby Wetland - A	198	80.7	58.2	125.2
Burned Shrubby Wetland - B	196	39.8	29.7	61.5
Unburned White Cedar Swamp	43	1 recapture from burned Cedar Swamp		
Unburned Hardwood Swamp - A	175	22.0	11.4	80.5
Unburned Hardwood Swamp - B	194	42.2	30.8	64.3
Unburned Pitch Pine - A*	200	25.4	15.8	52.6
Unburned Pitch Pine - B	200	58.3	35.1	159.8
Unburned Shrubby Wetland - A	200	47.5	36.1	69.2
Unburned Shrubby Wetland - B	194	106.1	80.0	153.3
*1995 - Burned Pitch Pine	97	49.8	31.8	96.9
*1995 - Unburned Pitch Pine	100	60.4	42.4	208.1

An analysis of variance revealed that male and female *P. leucopus* were not significantly different ( $F_{s(4,89)}=0.724$ ,  $P>0.50$ ) in habitat utilization. A one way analysis of variance (Model I) indicated a significant difference in male mass ( $F_{s(4,56)}=5.80$ ,  $P<0.001$ ) and body length ( $F_{s(4,55)}=4.52$ ,  $P=0.003$ ) between burned and unburned grids. A Tukey's a posteriori test of means indicated that male mass in the unburned pitch was similar to the unburned maple, however different than masses in burned areas, or the unburned shrubby wetland. Male mass tended to be highest in the unburned pitch, (Mean=23.4g., S.E.=1.37, n=11), and lowest in the burned pitch (Mean=16.8g., S.E.=1.23, n=12) and burned shrubby wetland (Mean=17.9g., S.E.=0.777, n=17). Male mass in the unburned pitch also tended to be higher than that of the unburned shrubby wetland (Mean=17.9g., S.E.=0.508, n=14). A Tukey's a posteriori test of means indicated male body length differences existed between the burned shrubby wetland versus unburned shrubby wetland, and the unburned hardwood swamp versus unburned shrubby wet-

land. Body length tended to be greater in the unburned shrubby wetland (Mean=8.4g., S.E.=0.434, n=14), and lower in the burned shrubby wetland (Mean=7.9g., S.E.=0.172, n=17) and unburned hardwood swamp (Mean=7.9g., S.E.=0.142, n=7).

There was no significant difference for female body length among burned and unburned areas ( $F_{s(6,29)}=1.190$ ,  $P=0.339$ ); however mass was significantly different ( $F_{s(5,31)}=3.91$ ,  $P=0.005$ ) between burned and unburned grids. A Tukey's a posteriori test of means indicated that the difference in female mass was due to the difference between the burned cedar swamp, and the burned shrubby wetland, unburned hardwood swamp, and unburned pitch. Mass was lowest in the burned cedar swamp (Mean=12.5g., S.E.=1.702, n=4) and highest in the unburned pitch pine (Mean=22.5g., S.E.=1.52, n=6).

*Clethrionomys Gapperi*. *C. gapperi* was trapped in all unburned areas excluding the white cedar swamp; only one was captured in the hardwood swamp. As seen in Table 2, the presence of *C. gapperi* populations was patchy. There were no captures in hardwood swamp B nor pitch pine grid A. The burned lowland drift fence contained the only captures of *C. gapperi* among the burned habitats.

Table 2. *C. gapperi* population estimates per hectare per grid for each burned and unburned habitat. Coverage is for the 1995-1996 trapping periods.

Habitat/Type	Total Trap Nights	Population Estimate/Hectare	Population Low/Hectare	Population High/Hectare
Unburned Hardwood Swamp - A	175	2.5	0.94	98.0
Unburned Hardwood Swamp - B	194	0	0	0
Unburned Pitch Pine - A	200	0	0	0
Unburned Pitch Pine - B	200	143.3	64.3	1,211.2
Unburned Shrubby Wetland - A	200	7.5	2.8	294.1
Unburned Shrubby Wetland - B	194	47.7	28.8	130.9
*1995 - Unburned Pitch Pine - A	100	Caught 2 - no recaptures		

Out of the 22 voles captured, 11 were male and 11 were female; two were positively identified as sub-adult based on coat color. In all grids combined, six were recaptured one or more times. Cormack's test for

catchability indicated all voles were equal in their catchability ( $z=-0.23821$ ).

Population estimates for these areas are indicated in Figure 1 and Table 2.

Neither male nor female *C. gapperi* showed a significant difference in habitat use ( $F_{s(1,20)}=1.286$ ,  $P>0.05$ ). Male mass was significantly different ( $F_{s(1,9)}=16.57$ ,  $P=0.003$ ) in the pitch pine habitat compared to the shrubby wetland habitat. Mass was higher in the pitch pine (Mean=20.8g., S.E.=0.401, n=6) and lower in the shrubby wetland (Mean=17.8g., S.E.=0.663, n=5). Body length was also significantly different for males ( $F_{s(1,9)}=15.16$ ,  $P=0.004$ ), being higher in the pitch pine (Mean=8.8 cm, S.E.=0.197, n=6) than the shrubby wetland (Mean=7.9 cm, S.E.=0.116, n=5).

Females had no significant differences in mass ( $F_{s(2,8)}=0.621$ ,  $P>0.05$ ) or body length ( $F_{s(2,8)}=2.186$ ,  $P>0.05$ ) for either habitat. Mean mass for females was 18.1 grams (S.E.=1.604, n=11) and mean body length was 8.3 (S.E.=0.325, n=11).

**Drift Fence.** In 1984, *S. cinereus*, *P. leucopus* and *C. gapperi* represented the majority of lowland drift fence captures (32.9%, 25.8%, and 11.7% respectively). This trend was similar to the 1995 period in which *S. cinereus*, (32.19%), *P. leucopus* (10.24%), and *C. gapperi* (9.27%) were the most common small mammals captured. At this same location in 1996, *C. gapperi*, *M. pennsylvanicus* and *P. leucopus* were the most commonly captured small mammals (21.28%, 21.28%, and 17.02% respectively). In the upland drift fence, *S. cinereus*, *P. leucopus*, and *C. gapperi* again were the most common small mammals captured in 1995 (28.95%, 22.81%, and 14.03% respectively). In 1996 the most commonly captured small mammals in the upland drift fence were *P. leucopus* (41.38%), *C. gapperi* (21.84%), and *M. pinetorum* (12.64%). Field observations and additional drift fence observations during the 1996 period revealed that additional small mammals were also present at the study site (*Sylvilagus floridanus*, *Zapus hudsonius*, *Tamiasciurus hud-*

*sonicus*, *Sciurus carolinensis*, *Scalopus aquaticus*, *Mustela frenata*, *Mephitis mephitis*, *Didelphis virginiana*, and *Procyon lotor*).

**Habitats.** High and low temperatures were recorded daily at each grid during the trapping period. Daily temperatures had a low mean of 12.7° C (S.E.=0.719, n=20) and a high mean of 37.8° C (S.E.=0.952, n=20). Temperature was not recorded during the 1995 trapping period.

A principal components analysis (PCA), based on three principal components, described 50.32% of the variance among all trapping grids. The component loadings used were overstory: pitch, maple, cedar; and understory: pitch, oak, maple, sheep laurel, mountain laurel, and blueberry. Additional components were the distance to overstory and understory and the DBH of overstory and understory. The first principal component described the pitch pine forest and the cedar swamp at opposite extremes. The second principal component described the open habitat (widely spaced trees and sheep laurel) of the shrubby wetland and at the opposite extreme, a denser habitat represented largely by blueberry. Along similar lines, the third principal component described the hardwood swamp and the white cedar swamp at opposite ends of the spectrum. Burned and unburned habitats were not identifiable among the first three principal components.

Ninety-five percent centroids used to compare the accuracy of replicate grids showed significant overlap for principal components 1, 2, and 3 for the unburned shrubby wetland. Additionally there was significant overlap for principal components 1, 2, and 3 for the burned shrubby wetland. The burned pitch pine forest showed significant overlap only for principal component 1 and 3. No other replicate grids indicated overlap in any of the three principal component factors.

The 95% centroid was also used in a comparison of burned against unburned grids. In an overall comparison of burned against unburned areas, the 95% centroid presented no significant overlap for the three princi-

pal components. Clustering can be seen, however, for principal component 1 and 3. Among all habitat types, the pitch pine burned and unburned grids were the only grids with significant overlap along the principal components.

## DISCUSSION

Both habitat structure and food availability can influence *P. leucopus* and *C. gapperi* in their presence and use of burned and unburned areas. Given the potential negative effects of fire on key resources, the high abundance of *P. leucopus* in both burned and unburned areas was a significant finding in this research and is supported in other studies (White, 1961; Tester, 1965; Beck and Vogl, 1972). *P. leucopus* achieved high densities in the burned site as early as August 1995, five months following the fire. An additional key finding was the apparent lack of *C. gapperi* in trap operated burned areas, their presence in the burned drift fence area, and overall patchy distribution. The avoidance of burned areas by *C. gapperi* has been reported (Krefting and Ahlgren, 1974; Kirkland, et al., 1996), although a presence in burned areas has also been recorded (White, 1961; Beck and Vogl, 1972).

Habitat structure was considered the first key requirement for *P. leucopus* and *C. gapperi*. In reviewing the data collected, statistically there was little difference between burned and unburned grids. Although litter layer was not recorded and would clearly indicate a component of structural difference, in general any structural changes that occurred as a result of fire were subtle and not critical to the presence of some species of small mammals. High population densities of *P. leucopus* in both burned and unburned areas reflect this lack of critical structural changes. Leaf litter was minimal to non-existent based on visual observations, and the lack of *C. gapperi* could reflect this difference between burned and unburned areas.

The appearance of *P. leucopus* in burned areas may indicate greater adaptability to the



smaller vegetative and structural differences in burned and unburned areas (Tester, 1965; Beck and Vogl, 1972). Structure has been recorded as playing a role in *P. leucopus*' visual navigation, and *P. leucopus* will often use trees and logs during movement through a forest (Barry and Francq, 1980; Douglass and Reinert, 1982; McMillan and Kaufman, 1995). Although the pitch pine trees were altered during the fire, most of these potential navigational tools remained standing and available to *P. leucopus*.

The impact of fire on vegetative cover and leaf litter appeared to play a more important role in the movements of *C. gapperi*. Any subtle differences between burned and unburned habitats may be more critical for these rodents (Merritt, 1987). A lack of litter layer in the burned areas would create a loss of travel runways and could be the primary cause for the lack of *C. gapperi* captures in the trap grids.

Food resources are also altered by fire both positively, through an increase in grasses and forbs (Beck and Vogl, 1972), and negatively, through a loss of seeds and nuts (i.e., scrub oak nut production was not observed in burned areas in 1996). Some plants, such as lowbush blueberry, are unaffected by irregular fires in the New Jersey Pine Barrens (Buell, 1953). Accordingly, if structural requirements are sufficient, the lack of severely altered food sources may lessen the effects of fire for some animals. Blueberry plants (lowbush and highbush) were abundant and bearing fruit in burned grids. Huckleberry, fungi, and insects were also frequently located. Grasses were present although not consistently present in all burned grids. Given the high amount of insects, seeds, and fruits in the diet of *P. leucopus* (Merritt, 1987), food availability is possibly the main reason for successfully maintained populations of *P. leucopus* in burned habitats. *C. gapperi* has a diet similar to *P. leucopus*; however *C. gapperi* also eats green vegetation and fungi (Merritt, 1987). Competition for the summer fruits could be an additional reason for the absence of *C.*

*gapperi* in burned trap grids. Although *C. gapperi* was captured in the burned area drift fence, interspecific competition with other animals (e.g., *P. leucopus*, *M. pennsylvanicus*) may prevent *C. gapperi* from re-establishing themselves in burned areas so soon following a fire. *M. pennsylvanicus*, generally absent in this section of the Pine Barrens (personal communication, H. Reinert), represented a significant percentage of burned lowland drift fence captures.

Fruits, however, present an important dietary difference between burned and unburned areas. This causes differences in the health of the small mammal population. Oak nuts were not observed in burned areas although pinecones were often found. These pinecones were mixed in quality from obviously burned to mildly burned. Since nuts and seeds generally contain more fat than fruits (Martin, et al, 1961), the abundance of fruit is not enough to create an optimal foraging habitat. This can be seen in the comparison of mouse sizes in the burned versus unburned grids. Mice in burned areas were generally smaller than those captured in unburned areas. Size differences for burned versus unburned areas is considered a result of both younger mice being forced into the less desirable habitat, and adult mice foraging for lower quality food resources.

In general, population densities for both species were higher than what has been reported (Merritt, 1987; Terman, 1993), and the strongly male biased capture ratio for *P. leucopus* reported in this study is not unusual (White, 1961; Barry and Francq, 1980; Terman, 1993; Kirkland, et al., 1996). Male *P. leucopus* might be more inquisitive of traps, or spend more time foraging and searching for mates which would increase their likelihood of being captured. Population estimates for both species were limited in some areas however. Opossums were a constant problem in the cedar swamp, stealing bait and springing traps. This resulted in reduced rodent captures that would prevent accurate tabulation of population densities.



Population densities are similar for *P. leucopus* and *C. gapperi* and range from about 1-38/ha (Merritt, 1987). The population density of *P. leucopus* in this study is consistent across grids, with 95% confidence intervals fairly tight thereby implying accuracy in the estimated *P. leucopus* populations for this section of the Pine Barrens. *C. gapperi*'s patchy distribution and broad confidence intervals make the population estimates for this species somewhat suspect. Additionally, the patchy distribution and its implications should not be overlooked. *C. gapperi* may exist in burned areas, as indicated in the burned drift fence data, and the established grids may have missed these sporadic populations.

*P. leucopus* and *C. gapperi* were found to share all unburned habitats, and were captured even at the same trap site, although a higher percentage of *P. leucopus* to *C. gapperi* captures were obtained as is supported in other research (Beck and Vogl, 1972; Kirkland, Snoddy, and Amsler, 1996). This indicates two possible scenarios: activity periods were different between the species, and food resources were sufficient to support both species. Abundant resources and *C. gapperi*'s patchy distribution may be enough to allow for shared habitats.

In Connor (1953), overall species diversity showed *P. leucopus* to be the most prevalent animal followed by *S. cinereus*, and *C. gapperi*. Zappalorti et al. (1984) found *S. cinereus*, and *P. leucopus* to be the most numerous animals caught respectively. In this study, *P. leucopus* continued to be the most common animal captured in the drift fences, suggesting their overall dominance in the Pine Barrens for small mammals of comparable size. The shift in dominant species captured in the burned lowland drift fence may again reflect individual species' response to fire.

In conclusion, the 1995 wildfire seems to have had no obvious impact on *P. leucopus*; however *C. gapperi* appears to show a fire negative response at one year following the fire. *P. leucopus* in burned areas, although not generally as large in size as those in the

unburned areas, are successfully surviving, utilizing their habitat, and increasing in numbers. The durability of *P. leucopus* in a habitat generally considered less desirable is beneficial for predators that depend on small mammals for food. A fire such as the Ocean County burn in 1995 can destroy established foraging areas of many predators. Any negative effect of fire on small mammals can create a devastating domino effect up the food chain. The rapid return of species such as *P. leucopus* to burned foraging grounds is critical in minimizing changes in normal predatory activity. The New Jersey Pine Barrens has both endangered and non-endangered species. Understanding the effects of fire on small mammals is critical in areas where prescribed burning is used to maintain a habitat, or where wildfires are a frequent threat.

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## Two Models of Fungicide Activity: Differences in Antifungal Activity and Proper Application of Two Contrasting Commercial Fungicide Types in Field Evaluations

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### ABSTRACT

Apple scab is one of the most economically damaging agricultural diseases, occurring wherever apples are grown, and causing crop losses of 70% or greater when uncontrolled. A variety of techniques and materials are available for the control of apple scab, the most commonly used technique being the use of fungicidal applications. However, overuse of these chemicals may lead to the development of fungal strains resistant to the fungicide, so it is important to continually develop new fungicides with novel modes of action. This study assesses the effectiveness of two fungicides, representing two unique anti-fungal mechanisms, through field trials covering two commonly used application schedules. BAS-490F, a quasi-systemic fungicide, was found to be more effective when applied before an inoculation (infection) event, while flusilazole, a systemic fungicide, was found to be more effective when applied after an inoculation event. Both fungicides were found to be equally effective when applied repeatedly over a ten-day between treatment application schedule during periods of heavy infection within the orchard.

### INTRODUCTION

Commercial apple producers worldwide face a number of potentially destructive pathogens, the most economically destructive of which is *Venturia inaequalis*, the cause of the common apple scab disease. Apple scab is the most economically important apple disease in northeastern North America, Europe, South

America, and Asia. It can be found wherever apples are grown, can cause crop losses of 70% or greater in uncontrolled conditions (Jones and Aldwinckle, 1990), and affects all species of apples (genus *Malus*) (Agrios, 1988).

The primary effect of apple scab is reduction of fruit quality; secondary effects include: reduced fruit size, reduced duration of harvest storage before spoiling occurs, premature fruit drop, reduction of functioning leaf surface area, defoliation, and poor bud development for the following year (Agrios, 1988). Infection can be observed on all leaf, stem, and fruit bearing portions of the apple tree, and is recognized by velvety brown to olivecolored lesions covering much of the surface of an infected plant (Jones and Aldwinckle, 1990).

Leaf and fruit lesions become apparent in the late spring, usually 8-15 days after infection of plant tissue by ascospores of *V. inaequalis*. Spores of this fungus are wind-borne, and rely on cool temperatures and high humidity for infection of plant tissue. Upon infection, the spores generate fungal tissue between the outer cell wall and cuticle of the host. After the development of healthy fungal mycelia, enormous amounts of reproductive conidia are formed, which constitute the visible manifestations of infection (Agrios, 1988).

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Proper control of such diseases consists of a combination of four control methods: regulatory, cultural, biological, and chemical. Regulatory control, such as quarantine and plant certification, seeks to exclude the pathogen from host contact. Cultural methods consist of agricultural techniques that seek to avoid the pathogen. Biological methods, such as the development of resistant cultivars and microorganisms antagonistic to the pathogen, seek to protect the host. Finally, chemical methods, such as insecticide, herbicide, and fungicide sprays, seek to protect the host and kill the pathogen (Walther, 1997).

Examples of all four types of control exist for the apple scab disease. Regulatory quarantines can be set up for severe infection, and international traffic of infected fruit is banned. Culturally, methods of orchard sanitation prevent the formation of overwintering bodies, and proper spacing of trees in an orchard facilitates air flow and rapid drying. Biologically, many cultivars have been genetically engineered for resistance to apple scab (Jones and Aldwinckle, 1990). Of all these methods, however, the most commonly known and employed manner of controlling apple scab is through chemical sprays (Agrios, 1988).

Due to the severe economic impact of apple scab, and the common usage of chemical applications, it is critically important to develop effective fungicides and spray techniques to battle both the apple scab fungus and the eventual development of pathogen resistance to a particular fungicide.

Currently effective, marketed fungicides against apple scab are captans, ethylene bis-dithiocarbamates, benzimidazoles, ergosterol biosynthesis inhibitors, and dodine (Jones and Aldwinckle, 1990). The most commonly employed spray techniques are: residual sprays, applied seven days before a likely infection; protectant sprays, applied 15 days before infection; curative sprays, applied after infection but before symptoms are evident; and eradicated sprays, applied after the appearance of symptoms (Kohls, 1997). This investigation will assess and compare the

effectiveness against apple scab of residual and curative sprays of the commercial fungicides flusilazole, a triazolebased fungicide, and BAS490F, commonly known as kresoxim methyl.

## MATERIALS AND METHODS

In order to test both the curative and residual properties of the two compounds, flusilazole and kresoxim methyl, two distinct trials were set up under identical conditions in the same orchard. The only difference between the two was that the curative trial involved postinoculation applications of the experimental compounds, while the residual trial involved experimental applications before inoculation events. Compounds were tested on the Nured Jonathan variety of apple (*Malus sylvestris var.domesticus*), which was selected because of its susceptibility to the apple scab disease.

**Orchard Conditions.** The orchard was structured around a trellis system, with one trellis row consisting of 19 heavy logs, approximately .25m in diameter, placed 6.1m apart, with 4.75m between each row. One orchard panel consisted of the space between two logs, and held two trees, spaced evenly within each panel. Each tree received a particular experimental treatment, and thus was considered to constitute an individual experimental plot. The curative trial used three complete trellis rows, and the residual trial used two, with the trees of the end panels for both trials being skipped, since these trees would be more open to wind currents, and would receive an abnormally high level of infection from the wind-borne spores. Two steel cables were placed along the length of the rows, at heights of 0.6m and 1.2m above the ground, to provide secure attachment for scaffold limbs. Limbs and nonfruit bearing suckers extending above the second wire were pruned, leaving adequate foliage for the tests, while avoiding overgrowth and elevated leaf density.

**Inoculation.** Infection of leaves by *Venturia inaequalis* relies heavily on the pres-

ence of moisture on the leaf surface, and the success of the trial is dependent upon complete and thorough infection of the orchard. A mist irrigation system was installed in the orchard to ensure that inoculation events would be followed by an extended period of wetness. The mist system was operated through the use of a battery-operated timer, which was set to mist the apple foliage for a duration of ten seconds every five minutes for a 48 hour period following an inoculation event. The system was inactivated prior to experimental applications, or during naturally rainy periods.

To infect the trees, conidial suspensions were prepared and applied directly onto the young leaves of the orchard in the late spring. The necessary suspensions are prepared from cultures of *Venturia* maintained on apple seedlings in a greenhouse or growth chamber. Leaves of infected seedlings are cut off and shaken in a solution of .05% Tween 20 (polyoxyethylene sorbitan monolaurate) in deionized water in order to shake loose and separate spores from the fungal mycelia. Tween 20 acts as a nonionic surfactant that is used to facilitate the suspension of the largely hydrophobic spores in water. The resulting suspension is filtered through cheesecloth to remove any vegetative fungal material from the conidial suspension, and diluted with .05% Tween 20 in water until the concentration of spores reaches 2,000,000 conidia/mL as determined by a hemacytometer. Approximately 100150 mL of suspension may be derived from 12 infected seedlings. This suspension is often frozen to be rethawed and utilized as needed.

This suspension is sprayed using a Solo™ backpack sprayer, with speed of application and nozzle choice selected to ensure even distribution of inoculum. Inoculations were performed on five separate occasions, once for the curative trial on 5/25/97, and four times for the residual trial, with inoculation events occurring on 5/13/97, 5/19/97, 5/25/97, and 6/2/97. Inoculation events were chosen to coincide with cool, naturally rainy

weather when possible, and fungal maturation was supplemented by the activation of the mist system in order to provide heavy infections. Each inoculation event applied 100150 mL of suspension per tree, and the repeated inoculations of the residual trial ensured heavy infection over the length of this longterm trial.

**Plot Randomization.** Before any experimental applications were made, each orchard plot was assigned a specific experimental treatment randomly through the use of an inhouse field trial manager computer program. Randomization was performed under a randomized complete block design (RCBD) system. The orchard was divided into four blocks, with each block containing the entire set of treatments for the experiment, in order to control for the effects an expected infection gradient fueled by prevailing WestEast winds across the orchard.

**Curative Trial.** For the curative trial, both experimental compounds were placed in a treatment schedule so that each compound would be sprayed over a set of predetermined intervals past an inoculation event, and each interval length would be reflected in a specific treatment number. Treatments for both compounds were applied either 52 hours before inoculation, or 20, 31, 44, 53, or 77 hours after the inoculation event of 5/25/97. Both treatments were applied at manufacturer's suggested rates, with flusilazole applied at 2.50 gm/HL, and BAS490F applied at 7.50 gm/HL.

**Residual Trial.** The residual trial was set up with each treatment sprayed according to the same schedule; it was a simple comparison of efficacy between Flusilazole and two formulations of BAS490F. Flusilazole was applied at the rate of 2.50 gm/HL, and BAS490F was tested at the rates of 5.00 and 7.50 gm/HL.

**Experimental Application.** Sprays were applied in the field using a John Deere 2355N tractor, with a customfitted spray platform attached to the rear hitch of the tractor. This spray platform utilized com-

pressed air to propel experimental compounds from 3L storage containers through a boom shaped like an inverted "U." The tractor was driven so that the trees passed through the center of the inverted "U", thus ensuring thorough and even coverage of foliage on both sides of the tree. The air compressor is regulated to pressurize the lines and remains at a constant setting throughout the length of the trial, but as the experiment progressed, the foliage grew and increased its surface area, so the amount applied to the leaves had to be subsequently increased. This required the use of two different spray nozzles and tractor speed settings. For the residual trial, the first two applications were performed early on the mornings of 4/27/97 and 5/5/97. They were sprayed with a 8002VS tip at 345 KPA, delivering 333.3 L/Ha with a constant tractor speed of 2.29 sec/plot. The next two applications were performed on 5/18/97 and 5/28/97, and used a 8004VS tip, which delivered 666.6 L/Ha at a speed of 2.34 sec/plot. The final application occurred on 6/8/97, and utilized the same 8004VS tips as the previous two applications, but delivered 1000 L/Ha at a speed of 3.5 sec/plot. All applications were performed between 6:00 A.M. and 7:30 A.M., to avoid the slight winds that usually arrive by midmorning and last through the late afternoon. If strong enough, these winds can blow the spray onto adjacent plots, creating an overspray condition that can threaten the accuracy of the results.

Since the curative trial applications were scheduled within a few days of each other, there was no need to adjust the spray volume to compensate for foliage growth. As a result of the consistency of applications in this trial, a singlenozzled handheld CO<sub>2</sub> sprayer was used for these treatments. All plots were sprayed with a D433 nozzle at a rate of 16.19 sec/plot at a pressure of 275 KPA, discharging 666.6 L/Ha, at a rate of 1.48 L/min. As with the residual trial, all applications were performed in the early morning or early evening to avoid windy conditions.

**Disease Assessment.** Disease assessments are performed at the first sign of disease in the untreated check, and repeated every two to four weeks. Five to ten terminals per plot are tagged, and approximately ten day-old leaves are rated subjectively by a trained evaluator according to the percentage of leaf area infected. The evaluator is trained to be an objective judge of disease severity through the use of computer-run disease assessment software programs, and treatment cards are pulled from the field during assessments in order to eliminate bias. Assessments are entered on a field data recorder and downloaded directly into the field manager program, which performs statistical analyses and transformations. For these trials, a NewmanKeuhls range test and ANOVA were performed with significance levels set at 95%.

## RESULTS

Observations of disease severity were made for the curative trial on three separate occasions: 6/09/97, 15 days after inoculation and upon the first visible signs of disease; 6/16/97, 22 days after inoculation; and 7/01/97, 38 days after inoculation. Observations of the residual trial were made on two occasions: 6/10/97, eight days after the final inoculation; and 7/14/97, 42 days after the final inoculation. It was discovered that plots 214 and 222 in the curative trial contained trees of a different cultivar than the rest of the trial, so data from these plots were ignored in the statistical analysis of observations.

**Curative Trial.** Ten subsamples were rated on each tree in the curative trial in the field, and the statistical analysis program assigned a value of percent disease severity for each tree or plot by determining the mean of the ten subsamples. A value of percent disease severity for each treatment in that particular rating was assigned by determining the average of the means of the four plots in the treatment. Significance of results was determined by analysis of the assigned value for each treatment as compared to the assigned disease severity value for the untreated plot.

The results from the rating of 6/09/97 (see Table 1) show significant difference from the untreated check for all treatments. The 52 hour flusilazole and 77 hour BAS490F treatments do appear to show slightly increased levels of disease severity even though they are not statistically different from the others when compared to the severity of the untreated check.

Mean of individual trees (% leaf area infected)					
	Block 1	Block 2	Block 3	Block 4	Mean of blocks
Flusilazole -52 hours	2.00	3.40	3.00	1.80	2.6****
20	0.30	0.00	0.00	0.00	0.08****
31.00	0.00	0.20	0.00	0.10	0.08****
44.00	1.10	0.70	0.20	0.60	0.64****
53.00	0.30	0.10	0.30	0.20	0.27****
77.00	0.30	N/A	0.10	0.60	0.33****
BAS-490F -52 hours	0.00	N/A	0.00	0.00	0****
20.00	0.00	0.10	0.00	0.10	0.05****
31.00	0.20	0.00	0.20	0.10	0.13****
44.00	0.70	0.00	0.10	0.30	0.28****
53.00	0.50	0.10	0.10	0.50	0.3****
77.00	2.40	3.50	0.10	0.20	1.55****
Untreated	29.70	45.00			37.5*

f-value treatment = 17.569  
 f-value block = 1.590  
 lsd = 5.366  
 standard error = 2.539

significance of treatment = 95%  
 significance of blocking = ns  
 c.v. of experiment = 7.2%

\* (Stars are used to indicate levels of significant statistical differences from the untreated check. The value for the untreated plots will be in the category with stars, so it will always have one star. The greater the number of stars, the greater the difference is compared with the untreated plots. A value for an experimental treatment will be significantly different from all other experimental treatments with a different number of stars. This system will be used for all following tables of data.)

Table 1. Curative Trial Observations - 6/09/97.

The observations of 6/19/97 (see Table 2) show a slight increase in disease severity for most plots, but with a marked increase in severity for the flusilazole 52 plot, and BAS490F 31, 44, 53, and 77 plots. In the ten days between the first two observations, the values for these plots have risen enough to be statistically significant from the other experimental plots.

Mean of individual trees (% leaf area infected)					
	Block 1	Block 2	Block 3	Block 4	Mean of blocks
Flusilazole -52 hours	3.70	5.00	2.80	1.90	3.35****
20.00	0.10	0.00	0.00	0.00	0.03****
31.00	0.70	0.00	0.00	0.10	0.19****
44.00	0.70	0.30	0.10	3.30	1.10****
53.00	0.10	0.10	0.00	0.00	0.05****
77.00	0.20	N/A	0.00	0.20	0.13****
BAS-490F -52 hours	0.10	N/A	0.00	0.30	0.13****
20.00	0.20	2.40	1.00	1.90	1.38****
31.00	2.60	2.20	2.00	3.10	2.65****
44.00	9.60	7.50	2.40	8.00	6.88****
53.00	32.70	4.70	7.50	12.60	14.38****
77.00	9.00	21.50	7.50	14.40	13.10****
Untreated	30.50	52.00			42.5*

f-value treatment = 13.709  
 f-value block = 2.631  
 lsd = 7.591  
 s.e. = 3.757

sig. treatment = 95%  
 sig. block = ns  
 c.v. experiment = 59%

Table 2. Curative Trial Observations - 6/19/97.

In the sixteen days between the second and third observations, the values for all treatments increased, but the most dramatic increases occurred for the flusilazole 52 treatment, and almost all of the BAS490F treatments (see Table 3; Fig. 3). Most of the flusilazole treatments in this observation, with the exception of the 52 hour application exhibit similarly low levels of severity, but the BAS490F treatments have begun to show a definite positive correlation between disease severity and interval between inoculation and application.

Mean of individual trees (% leaf area infected)					
	Block 1	Block 2	Block 3	Block 4	Mean of blocks
Flusilazole -52 hours	8.90	7.10	3.50	10.30	7.45****
20.00	0.90	1.70	0.80	1.20	1.17****
31.00	2.20	2.20	0.40	2.80	1.90****
44.00	1.20	0.30	5.10	2.50	2.28****
53.00	0.90	2.00	2.70	0.40	1.50****
77.00	0.20	N/A	1.60	0.20	0.67****
BAS-490F -52 hours	0.70	N/A	0.70	1.70	1.05****
20.00	1.40	6.50	5.80	5.40	4.78****
31.00	4.80	4.40	7.30	9.20	6.48****
44.00	15.60	11.00	3.70	14.80	11.28****
53.00	31.50	3.20	13.30	19.40	16.85**
77.00	18.50	21.20	16.00	22.70	19.6**
Untreated	28.00	37.50			32.83*

f-value treatment = 13.053  
 f-value block = 3.038  
 lsd = 6.091  
 s.e. = 3.432

sig. treatment = 95%  
 sig. block = 95%  
 c.v. experiment = 45%

Table 3. Curative Trial Observations - 7/1/97.

**Residual Trial.** The statistical analyses performed for this trial were similar to the ones used for the curative trial, except that 15 subsamples were taken for the first observation on 6/10/97, and 20 subsamples were taken for the second observation on 7/14/97. The observation of 6/10/97 (see Table 4), yielded no significant differences between the three treatments, and all were strongly different from the untreated values.

Mean of individual trees (% leaf area infected)					
	Block 1	Block 2	Block 3	Block 4	Mean of blocks
Untreated	42.10	28.10	28.90	13.30	28.13*
Flusilazole 2.5 g/HL	1.10	0.30	0.60	0.90	0.72****
BAS-490F 5.0 g/HL	1.30	0.60	1.60	0.60	1.05****
BAS-490F 7.5 g/HL	0.30	0.10	0.90	N/A	0.42****

f-value treatment = 10.185  
 f-value block = 0.185  
 lsd = 8.134  
 s.e. = 3.980

sig. treatment = 95%  
 sig. block = ns  
 c.v. experiment = 55%

Table 4. Residual Trial Observations - 6/10/97.

Data from the second observation (see Table 5) show a marked increase in disease

severity for all treatments, but no treatment is statistically different from any other, although the 7.5g/HL BAS490F treatment shows a slight but statistically insignificant increase in control when compared to the 5.0g/HL BAS490F treatment.

Mean of individual trees (% leaf area infected)					
	Block 1	Block 2	Block 3	Block 4	Mean of blocks
Untreated	29.50	32.50	31.20	29.60	30.73*
Flusilazole 2.5 g/HL	10.20	1.70	5.40	2.20	4.91*****
BAS-490F 5.0 g/HL	9.10	4.10	4.10	7.85	6.29*****
BAS-490F 7.5 g/HL	4.60	1.80	6.80	N/A	4.45*****

f-value treatment = 20.455      sig. treatment = 95%  
 f-value block = 1.077      sig. block = ns  
 lsd = 3.849      c.v. experiment = 23%  
 s.e. = 2.780

Table 5. Residual Trial Observations - 7/14/97.

**SUMMARY**

Overall, the curative trial (see Fig. 1) exhibited excellent control by all treatments at the first observation. However, as time went on, it became apparent that, although the flusilazole applications that occurred after the inoculation event remained at nearly the same degree of effectiveness, the flusilazole treatment that was applied before inoculation became gradually less and less effective. The BAS490F treatments showed roughly the opposite: poorer disease control at longer intervals between inoculation and application as well as poorer disease control over time.

The residual trial (see Fig. 2) showed equal levels of disease controls for all treatments initially as well as over time, even though disease levels rose for all treatments over time.

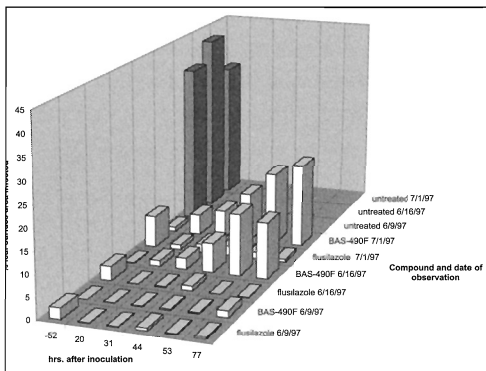


Figure 1. Combined Curative Trials.

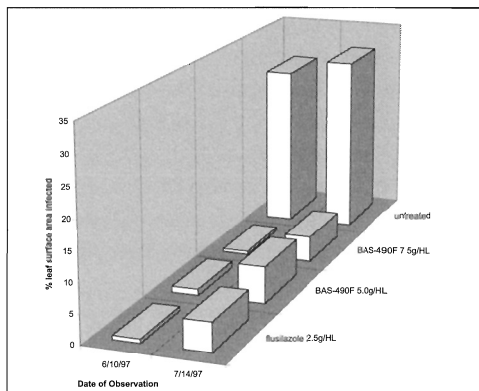


Figure 2. Combined Residual Trials.

**DISCUSSION**

Although the residual trial's specific protocol failed to illustrate any significant differences between the protective abilities of the two compounds in question, the curative trial did succeed in demonstrating some unique differences between flusilazole and BAS490F. The curative trial was set up in such a way as to measure fungicidal activity of the two compounds in a situation where the compound was applied before inoculation, as well as a number of different situations where the inoculum was supplied before the fungicide. Furthermore, the trial consisted of one application only, which allowed each compound's activity to be monitored over time. These two features, different application time vs. inoculation event scenarios and the ability to track an individual application over time, brought out strong differences between the two compounds, differences that can be explained by looking at their unique molecular modes of action.

It is important to keep in mind that most commercial fungicides are more properly fungistats than fungicides. Instead of killing fungal cells outright, they provide some sort of molecular block that will deprive the fungus of a nutrient or enzyme necessary for growth and reproduction. In this state, fungal material may remain perfectly alive, but unless either the block is removed by some means or an alternative pathway around the



block can be utilized by the fungus, the fungal cells will not be able to grow and develop any further than they already have at the time of fungicide application.

Flusilazole (1 [[bis(4fluorophenyl)methylsilyl]methyl]1H 1,2,4triazole), provides a block by inhibiting ergosterol biosynthesis. It binds tightly to C14 demethylase, altering the enzyme's conformation, and making it unavailable for use by its intended substrate. This block of an important pathway deprives the fungus of production of a necessary constituent of its cell walls. This fungicide is systemic, meaning that upon application, it will readily diffuse and stay within the tissue of the leaf itself, making it more resistant to washoff than if it coated and remained on the outside of the leaf (Tomlin, 1994).

BAS490F, or kresoxim methyl (methyl(E)-methoxyimino[a(otolyoxy)otoly]acetate, blocks fungal growth by inhibiting mitochondrial electron transport at the cytochrome bc1 site (Gold, 1997), disrupting ATP production. Kresoxim methyl is a quasi systemic fungicide, diffusing over the leaf surface in the vapor phase and settling down on the leaf surface as a particulate deposit after drying. Only a small portion of the compound is taken up by the outer layers of plant tissue as this process occurs (Gold, 1997). In effect, this compound does little to harm a fungus that has already infected plant tissue, but provides a barrier which the fungus finds difficult to penetrate as it attempts to spread or to send out sporebearing bodies. Since this compound remains on the surface, it is susceptible to washoff, hydrolysis, UV degradation, and any other chemical or mechanical degradation factors over time (Meister, 1997).

With the mode of action of these two compounds in mind, it is much easier to interpret the results of this trial. The ability of flusilazole to resist wear, as compared to BAS490F's tendency to diminish in activity over time, can be understood in terms of flusilazole's systemic, degradation resistant qualities, compared to BAS490F's tendency to remain on the leaf surface, vulnerable to wear.

Another inconsistency between the two chemicals is flusilazole's relatively weaker performance compared to BAS490F in the 52 hour applications. Flusilazole did extremely well when applied after inoculation, but before inoculation, it did not perform quite as well. Clearly, something must have happened to the applied flusilazole in the 52 hours between application and inoculation. Flusilazole is reluctant to breakdown and degradation—its performance over time elsewhere in the trial demonstrates that—so this is not a likely explanation. The most plausible answer is that flusilazole must slowly be taken up and bound strongly to a component of the plant cells. Since no fungal material is present in the 52 hour application, all of the applied flusilazole is available to be taken up and held by the plant tissue. When the inoculum is finally applied, the areas where flusilazole has been held and inactivated by the plant are now vulnerable to infection and spread of fungal material.

In a contrasting situation, BAS490F was most effective when applied 52 hours before inoculation, and decreased in effectiveness as the interval between application and infection increased. In order to understand this, it is helpful to picture BAS490F as a degradable barrier between leaf tissue and the environment. In order to infect the leaf and to flourish, the fungus must penetrate this barrier twice, once as a spore to infect, and once as mature mycelium to spread and reproduce. The barrier is strong at first, but over time, it degrades, providing more and more holes for the fungus to exploit. When BAS490F is applied before inoculation, the fungus must pass through the barrier twice, but when the inoculum is applied first, no barrier exists and the spores are free to infect the plant tissue without having to pass through a barrier. Since in this situation, the fungus will be able to infect the plant at will and need only wait for a hole in the barrier to open and exploit, the probability of disease occurrence is much higher. As the interval between inoculation and application

increases from 20 hours to 72 hours, more spores have time to infect leaf tissue before the chemical barrier is applied. If more spores infect the plant, the likelihood is greater that one of those spores will be able to exploit a spot where the chemical defense has been degraded and weakened.

The weakness in the curative trial is that it involves only one application. Most commercial farmers will not simply wait for an infection to present itself in their orchard; instead they will employ a series of maintenance sprays at regular intervals in order to ensure maximum protection for their orchard. It was this type of fungicide usage that the residual trial was intended to mimic. Applications were performed on a ten-day between-treatment schedule amid numerous inoculations and heavy potential for infection. When an infection eventually did take hold in the orchard, the results indicate that the ten-day schedule of application essentially nullified any of the weaknesses of the two chemicals that the curative trial made evident. Repeated applications ensured that even if the plant held some of the flusilazole and nullified some of its activity, or if some of the BAS490F wore off of the leaf surface, enough flusilazole would remain available and unbound in the leaf tissue, and enough BAS490F would be present on the leaf surface to prevent strong infection and high disease severity.

Of commercial interest to the farmer as well as the manufacturer, the BAS490F application with 2.5 g/HL less active ingredient held up well in comparison to both the flusilazole and more concentrated BAS490F application. To the farmer, the less concentrated application would mean less cost per acre, and to the manufacturer, the less concentrated application would mean reduced production costs, for results that show no statistically significant differences in comparison to the more expensive application.

To the scientist, these two trials point out a number of interesting differences between the field performance of flusilazole and BAS490F.

These differences can largely be explained by an examination of their modes of action, but more work is necessary to determine what exactly happens to flusilazole when it is taken up by plant tissue and how long before an infection period BAS490F can be sprayed before it loses its effectiveness. More work is also needed to validate or to offer an alternative explanation to the one put forth in this paper concerning the barrierlike activity of BAS490F. Scientifically, many variables remain to be explored; to the farmer, however, much practical knowledge can be gained. If a farmer should decide to only spray once near a likely infection event, it would be better for him to spray before the likely event if he plans to use BAS490F, and better to spray soon after the likely infection event if he should decide to use flusilazole. If the farmer should decide to spray preventatively on a regular schedule, he is free to use either flusilazole or BAS490F as he chooses. The similarity of effectiveness between the two compounds in the residual trial is encouraging, since the farmer is able to use either without great loss to his crop, and is free of a reliance upon just one effective compound that can easily lead to overuse of that compound and the development of resistance to that compound within his orchard.

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# Investigation of the Interactions Between Platinum Compounds and Plasmid DNA

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## ABSTRACT

Cisplatin is a platinum based complex that has demonstrated antitumor activity in testicular and ovarian tumors as well as cancers of the head and neck.<sup>1,2</sup> Cisplatin binds to DNA in a way that disrupts the helical structure,<sup>2,3,4,5</sup> thereby killing rapidly dividing tumor cells. However, cisplatin has also proven to have harmful side effects<sup>1,2</sup> and, in some cases, no anticancer impact at all.<sup>1,3,5</sup> In search of a drug with the same or better efficacy but less toxicity than cisplatin, the interactions between three novel platinum complexes and DNA were studied. The goal of the study was to find a compound that would distort the conformation of plasmid DNA (pUC-19) at a lower concentration than cisplatin. In order to visualize the extent to which the platinum molecules were binding to the DNA, competition assays were performed between the compounds and a restriction endonuclease for the platinum binding sites. The restriction endonuclease, SmaI, recognizes a unique sequence in pUC-19 that contains a dinucleotide sequence to which platinum complexes bind. The results of the assays were analyzed by agarose gel electrophoresis. Of the three novel platinum compounds studied, one behaved similarly to cisplatin but did not distort the DNA at a lower concentration than cisplatin.

## INTRODUCTION

Cis-diamminedichloroplatinum, otherwise known as cisplatin, has been used extensively

as a chemotherapy drug ever since its approval from the Food and Drug Administration in 1979.<sup>1,2,3,6</sup> The platinum based drug is well known for its severe side effects, including vomiting, kidney poisoning, loss of feeling in the hands and feet, and inner ear problems.<sup>1,2</sup> Although cisplatin has successfully been used to fight ovarian and testicular cancer and cancers of the head and neck,<sup>1,2</sup> it has been known to fail in treatment.<sup>1,3,5</sup> For these reasons, a less toxic and more efficient platinum based drug has been sought; however, none has been found.<sup>1,3</sup>

The exact mechanism for cisplatin's mode of action is still not completely understood. It is largely believed that cisplatin is cytotoxic because it binds to DNA in such a way that changes the conformation of the Watson and Crick structure.<sup>2,3,4,5,7</sup> As a result, the recognition of polymerases may be prevented.<sup>3</sup> Therefore, DNA replication—and possibly transcription—inhibited, and the cell dies without reproducing.<sup>3</sup> It is also possible that the binding of cisplatin to DNA interferes with the ability of excision repair proteins to repair the DNA damage<sup>1,5</sup>. The distorted

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helix around the area of platinum binding resembles the binding site of high mobility group (HMG) domain proteins,<sup>1,5</sup> and the binding of these proteins to the DNA prevents DNA excision repair. Therefore, the cell eventually dies without reproducing.<sup>1,5</sup>

Cisplatin binds to DNA by forming either intrastrand crosslinks between neighboring purines<sup>1,2,3,5,7</sup> or to a lesser extent<sup>2,3</sup> interstrand crosslinks between guanines.<sup>2,3,7</sup> When the crosslinks are formed, the DNA helix bends and unwinds, changing its conformation.<sup>1,2,4,6</sup> The chloride ions of cisplatin (see Figure 1a) act as leaving groups and enable the platinum to covalently bind to the N7 atoms of neighboring guanines.<sup>3,6,7</sup> The ammine groups of cisplatin stabilize the reaction through hydrogen bonding with the phosphate backbone.<sup>7</sup> Replacing the chloride ions with better leaving groups may change the mechanism of cisplatin's interaction with DNA and the effect this binding has on the DNA structure.

In this study, three novel platinum compounds were analyzed and compared to cisplatin in their ability to distort the structure of plasmid DNA (small circular double stranded DNA molecules). These compounds had one of their chloride leaving groups replaced to help determine what kind of leaving group is best for the greatest DNA distortion. The study focused on the search for a compound that was successful at distorting the DNA helix at a lower concentration than cisplatin.

In addition to assaying the platinum - DNA interactions directly, the complexes were also subjected to a competition assay. The assay involved the use of restriction digest analysis to evaluate the affinity of the platinum compounds for forming intrastrand crosslinks between neighboring guanine residues and/or interstrand crosslinks between guanine residues on opposite strands (see Diagram 1).

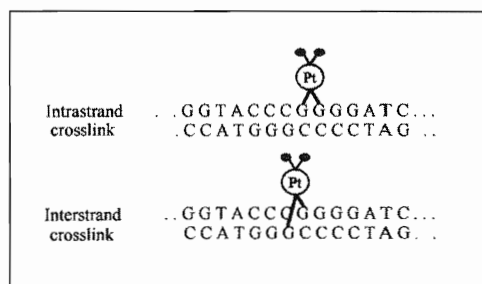


Diagram 1. Possible intrastrand and interstrand crosslinks formed by cisplatin binding to the SmaI site in pUC-19.

The restriction endonuclease, SmaI, cleaves double stranded DNA when it binds to the sequence CCCGGG; therefore, the SmaI recognition site contains both the sequence GpG and an interstrand GG. Furthermore, there is a single SmaI site in pUC-19, and so SmaI will linearize the plasmid. SmaI was therefore used to compete with the platinum compounds for binding to pUC-19.

The rationale for the competition assay is that as the concentration of the platinum compound increases, the opportunity for SmaI to find its site without a platinum molecule bound to it decreases. Therefore, at the higher concentrations of a platinum compound, the plasmid does not become linearized. The presence of linearized DNA (Form III) as well as supercoiled (Form I) and relaxed circular (Form II) DNA was detected by agarose gel electrophoresis. The results from these experiments indicate that the competition assay is an excellent straightforward assay for the analysis of platinum binding to DNA.

While all of the novel compounds bound to DNA in a similar pattern to cisplatin, none of them changed the conformation of the DNA at a lower concentration than cisplatin. The compound ethylenediamminechloro(6-phenyl-2,3,5,6-tetrahydroimidazo[2,1-b]thiazole) platinum chloride (compound B) behaved most similarly to cisplatin both in the concentration at which the first migrational change was observed and the concentration at which the compound competed with SmaI. From these results, modified platinum compounds will be constructed and tested to continue the search for a better antitumor drug.

## METHODS

**Preparation of Plasmid DNA.** Competent LE392 bacteria were transformed with pUC-19 and overnight cultures were grown. pUC-19 was purified from the cells by a miniprep procedure using phenol:chloroform extraction. The samples were subjected to a digest with RNase (1ug/uL) to further purify the DNA. The presence of the plasmid was checked by restriction digest, and the results were analyzed by agarose gel electrophoresis. The appropriate samples were chosen, and overnight cultures were prepared from the corresponding colonies. These cultures were used to do an alkali/SDS megaprep to make a large stock of pUC-19. The DNA was precipitated by LiCl precipitation, and its concentration was checked by both optical density spectrophotometry and agarose gel electrophoresis. The concentration of the pUC-19 used in the experiments was 1.1ug/uL.

**Preparation of buffers.** Two buffers were used in the platinum compound-DNA binding reaction. 100mM Tris, pH 7.1, was prepared and used in a final concentration of 25mM. 100mM NaNO<sub>3</sub> was prepared and used in a final concentration of 15mM.

**Preparation of platinum compounds.** The platinum compounds were obtained in crystalized form from Dr. G. M. Arvanitis' lab. They were dissolved in sterile distilled water and diluted to make 1x (0.084mM), 10x (0.84mM), and 100x (8.4mM) stocks.

**Standard Binding Assay.** A constant concentration of pUC-19 was incubated with nine different concentrations of platinum compounds. The concentrations ranged from 0.084mM to 8.4mM, and the platinum:DNA molar ratios for each reaction are given in Table 1. The platinum compounds and pUC-19 were incubated for 22.5 hours at 37°C. The reactions were quenched with NaCl at a final concentration of 200mM. A control was prepared as described above with the same volumes of buffer and NaCl and was incubated with the rest of the samples. The only difference between the control

and the samples was that the control was not incubated with platinum compounds. The migration of the control DNA was compared to stock DNA on an agarose gel, and the results were identical (data not shown).

**Competition Assay.** A competition was set up between the platinum molecules and the restriction enzyme, SmaI, for the availability of the GpG and GpC sequences found in the SmaI recognition site on pUC-19. One half of each sample prepared in the standard binding assay was subjected to a restriction digest with SmaI from New England Biolabs for two hours at room temperature. The buffer used in the reaction was NE buffer 4 (1x). A control for the restriction digest was prepared by subjecting half of the binding assay control to a digest with SmaI. The migration of the linearized control DNA through an agarose gel was no different than stock DNA cut with SmaI (data not shown).

**Agarose Gel Electrophoresis.** Sample buffer containing bromphenol blue and 6% glycerol was added to both cut and uncut reactions, and the samples were applied to a 1% agarose gel in 1x TBE buffer. The samples were separated by electrophoresis for five hours at 80 constant volts. The gel was stained with ethidium bromide (0.5mg/mL) on a rocker for 20 minutes and viewed under UV light.

## RESULTS

Agarose gel electrophoresis was used to detect migrational changes caused by the distortion of the DNA structure. A diagrammatic representation of typical results is shown in Diagram 2.

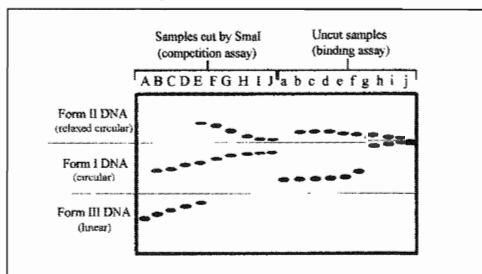


Diagram 2. Gel layout.

As illustrated in Lanes a through j, the supercoiled, circular form (Form I) of plasmid DNA becomes unwound when a platinum compound binds to it; as a result, the DNA migrates through the gel matrix slower than a plasmid with no platinum bound (Lane a). As the concentration of platinum is increased, the migration of Form I continues to decrease. Form II or relaxed circular DNA migrates slower than Form I, but as the concentration of platinum increases, so does the migration of Form II. Therefore, as the concentration of platinum is increased, Form I and Form II appear to migrate toward one another, until they eventually comigrate. After this point, Form I begins to positively supercoil and increase in migration. In the competition assay, represented by Lanes A through J, Form III (linearized) migrates faster than Form I and decreases in migration as the concentration of platinum is increased. However, as explained above, Form III should only be present at the lower concentrations of platinum because not enough platinum is present in order to block the recognition site of SmaI.

The results for the experiments with cisplatin are shown in Figure 1.

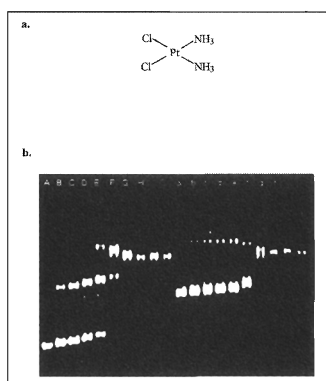


Figure 1. Incubation of *cis*-diamminedichloroplatinum and pUC-19. a. *Cis*-diamminedichloroplatinum (cisplatin). b. Electrophoretic analysis of the incubation of cisplatin and pUC-19. Samples were applied to the gel as described in the Gel Layout at the platinum: DNA ratios specified in Table 1.

Figure 1a is the molecular structure of cisplatin. Figure 1b is the agarose gel of the competition and binding assays of cisplatin and pUC-19. The samples were applied to the gel at the platinum: DNA molar ratios described in Table 1.

Lane	Ratio
A/a	0
B/b	0.00878
C/c	0.0235
D/d	0.0441
E/e	0.0878
F/f	0.235
G/g	0.441
H/h	0.807
I/i	1.01
J/j	1.91

Table 1. Platinum: DNA molar ratios.

Lane A contains linearized pUC-19 used for comparison. The competition assay, which is represented in Lanes B-J, shows Form III DNA in lanes B-E. By a platinum: DNA molar ratio of 0.235 (Lane F), Form III is no longer present. Lane a is supercoiled DNA that was not incubated with cisplatin. The binding assay is represented in Lanes b-j. At the same ratio as the competition assay, 0.235, there is a substantial change in migration of Form I DNA. Note that in lanes H, I, J, h, i, and j the migrations of Form I and Form II appear to have leveled off.

Figure 2a is the molecular structure of *Cis*-diamminechloro(4-methylpyridine)platinum nitrate (compound A).

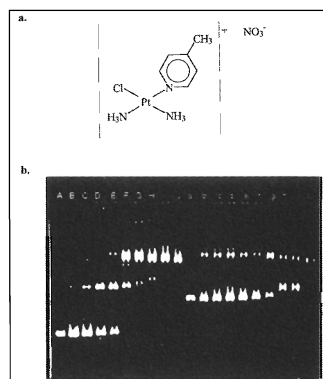


Figure 2. Incubation of *cis*-diamminechloro(4-methylpyridine)platinum nitrate and pUC-19. a. *Cis*-diamminechloro(4-methylpyridine)platinum nitrate (compound A). b. Electrophoretic analysis of the incubation of compound A and pUC-19. Samples were applied to the gel as described in the Gel Layout at the platinum: DNA ratios specified in Table 1.

Figure 2b is the agarose gel of the competition and binding assays of compound A and pUC-19. The samples were applied to the gel at the platinum: DNA molar ratios described in Table 1. Lanes A and a contain DNA that was not incubated with compound A. Like

cisplatin, compound A causes Form III DNA to disappear at a ratio of 0.235 in the competition assay. Unlike cisplatin, however, the decrease in migration of Form I and the increase in migration of Form II in the binding assay is much more gradual. The migrations do not appear to level off at the highest concentrations. The migrational change of the supercoiled DNA does not occur until Lane h (ratio of 0.807).

Figure 3a is the molecular structure of ethylenediaminechloro(6-phenyl-2,3,5,6-tetrahydroimidazo[2,1-b]thiazole)platinum chloride (compound B).

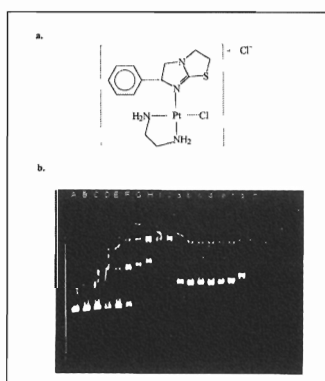


Figure 3. Incubation of ethylenediaminechloro(6-phenyl-2,3,5,6-tetrahydroimidazo[2,1-b]thiazole)platinum chloride and pUC-19. a. Ethylenediaminechloro(6-phenyl-2,3,5,6-tetrahydroimidazo[2,1-b]thiazole)platinum chloride (compound B). b. Electrophoretic analysis of the incubation of compound B and pUC-19. Samples were applied to the gel as described in the Gel Layout at the platinum: DNA ratios specified in Table 1.

Figure 3b is the agarose gel of the binding and competition assays of compound B and pUC-19. The samples were applied to the gel at the platinum: DNA molar ratios described in Table 1. Lanes A and a contain DNA that was not incubated with compound B. Form III DNA is not present at a ratio of 0.441 in Lane G of the competition assay between compound B and SmaI. Likewise, the first decrease in migration of Form I in the binding assay occurs in Lane g at the same ratio of 0.441.

Figure 4a is the molecular structure of *Cis*-diamminechloro-(3-iodoaniline)platinum nitrate (compound C).

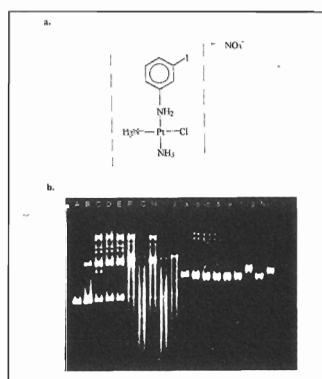


Figure 4. Incubation of *cis*-diamminechloro-(3-iodoaniline)platinum nitrate and pUC-19. a. *Cis*-diamminechloro-(3-iodoaniline)platinum nitrate (compound C). b. Electrophoretic analysis of the incubation of compound C and pUC-19. Samples were applied to the gel as described in the Gel Layout at the platinum: DNA ratios specified in Table 1. (NOTE: The decrease in migration of Form I in Lane g is due to the concentration of compound C being slightly higher in this lane than it should have been for the ratio of 0.441. Subsequent testing showed that at the correct ratio for Lane g, Form I does not decrease in migration.)

Figure 4b is the agarose gel of the binding and competition assays of compound C and pUC-19. The samples were applied to the gel at the platinum: DNA molar ratios described in Table 1. Lanes A and a contain DNA that was not incubated with compound C. Like cisplatin and compound A, Form III DNA is not present in Lane F at a ratio of 0.235. The binding assay shows that Form I does not have a significant conformational change until a ratio of 1.01 in Lane j. The decrease in migration of Form I in Lane g is due to the concentration of compound C being slightly higher in this lane than it should have been for the ratio of 0.441. Subsequent testing showed that at the correct ratio for Lane g, Form I does not decrease in migration (data not shown).

## DISCUSSION

The results of the standard binding assays and the competitions assays give insight into how cisplatin and the novel platinum complexes bind to DNA. At a platinum: DNA ratio of 0.235 (Figure 1b, Lane F), cisplatin prevents SmaI from recognizing its site, hence Form III is no longer visible starting in Lane F. Likewise, at the same ratio in the uncut samples (Figure 1b, Lane f), Form I begins a substantial decrease in migration,

indicating that at this concentration the structure of the DNA is severely altered. Because in Figure 1b, Lanes H, I, J, h, i, and j show a leveling off of the migrations of Form I and Form II, the DNA is probably completely saturated by cisplatin at these concentrations. No more cisplatin can bind to the DNA, and the unwound structure does not positively supercoil.

Like cisplatin, compound A causes Form III DNA to disappear in Lane F (Figure 2b) at a molar ratio of 0.235. Unlike cisplatin, however, the decrease in migration of Form I and the increase in migration of Form II are more gradual and do not level off at the highest concentrations. This indicates that compound A, while binding to DNA enough to prevent SmaI from cutting, is not saturating the DNA at these concentrations. The major conformational change of supercoiled DNA does not occur until the one of the highest concentrations in Lane h (Figure 2b). This indicates that compound A has to be present in high concentration in order to demonstrate the same effect as cisplatin. In another test (data not shown) higher concentrations of compound A were incubated with pUC-19, and the DNA became saturated at a ratio of 1.91 (same as Lanes J and j above).

Unlike cisplatin and compound A, compound B prevents SmaI from recognizing its site at the molar ratio of 0.441 (Figure 3b, Lane G) as indicated by the disappearance of Form III in this lane. The uncut samples exhibit a decrease in migration at the same ratio (Figure 3b, Lane g), showing that at 0.441 the DNA structure is highly distorted. This pattern of Form III disappearance and Form I decreasing in migration at the same ratio is similar to cisplatin. However, the migration of Form I and Form II do not level off, indicating that like compound A, compound B does not completely saturate the DNA molecule at these concentrations.

Compound C blocks SmaI from binding to its site at a molar ratio of 0.235 as do cisplatin and compound A. The uncut samples show that compound C does not begin to

alter the DNA structure until the ratio of 1.01, as shown by the decrease in migration of Form I in Lane i. Since Form I does not start to significantly change in migration until the highest concentration of compound C (Lane j), it is unlikely that the DNA is saturated at this ratio.

Compound A and compound C both prevent SmaI from binding at a molar ratio of 0.235 but do not cause Form I to decrease in migration until higher concentrations. A possible explanation for this behavior is that Compound A and Compound C have higher affinities for the GpG and interstrand GG sites on pUC-19 than cisplatin and compound B. This would explain why compounds A and C do not completely saturate the DNA at high concentrations and cisplatin and compound B do. Cisplatin and compound B bind to other sites besides the GpG sequence, and therefore more molecules of these compounds can bind to the DNA at lower ratios than the molecules of compound A and compound C. Hence, of the three novel compounds, compound B was the most effective in distorting the DNA at low concentration (platinum: DNA molar ratio of 0.441). Cisplatin, however, is the most effective at distorting and completely saturating the DNA at the lowest concentration (ratio of 0.235) of all the compounds.

In the future, other novel cisplatin derivatives will be tested by the methods described in this study. In addition, transplatin, a close relative of cisplatin, will be studied. Surprisingly, transplatin and other platinum derivatives in the *trans* conformation have not demonstrated the same toxic effects in the cell as cisplatin, and are regarded as having no antitumor activity.<sup>3,7</sup> Transplatin may not be active because it binds to DNA differently than cisplatin and its derivatives. It is possible that DNA repair mechanisms are not blocked when transplatin binds to DNA.<sup>3</sup> Knowledge about the nature of transplatin's interaction with DNA could lead to a better understanding of the binding mechanism that results in toxicity, and



hence, to the construction of new prospective drugs. Preliminary studies have begun on transplatin including the competition assay with SmaI. The results thus far have shown that the migrational changes of the DNA induced by transplatin are comparable to cisplatin as well as the disappearance of linearized DNA. This, at first, may seem surprising; however, a plausible explanation can be made. Transplatin is known to bind to DNA by interstrand crosslinks between a guanine residue and its complementary cytosine.<sup>3,7</sup> Since the SmaI site is CCCGGG, both transplatin and cisplatin may compete with SmaI equally. Further analysis of the interaction between these compounds and different DNA sequences should allow us to test this hypothesis.

In addition to the above studies, the competition assay would be applied to other binding sites on the plasmid. For example, since cisplatin favorably binds to neighboring purines,<sup>1,2,3,5,7</sup> using restriction enzymes that recognize sites containing GpA or ApA can test for the affinity of the platinum compounds for these sites in comparison to GpG. As was seen with compounds A and C, the platinum compounds may be more or less specific in their choice of nucleotide binding. The competition assay can also be used to distinguish between GpG crosslinks and interstrand GG crosslinks. Using different restriction enzymes in a competition assay to make a comparative analysis of the results should provide a rapid means for testing how novel platinum compounds differ in their binding mechanisms. Since the distortion of the DNA helix can imitate binding domains of cellular proteins (thereby preventing the recognition of excision repair enzymes),<sup>1,5</sup> knowing where the platinum binds may be used to figure out how the DNA structure is changed. Knowing the specificity of a compound for binding DNA can lead to the construction of new compounds to be used in cancer therapy.

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# Rational Repression: The Ideologies Behind Argentina's "Dirty War"

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## ABSTRACT

This paper discusses the political, social, and economic ideologies of state terror in Argentina during the period of 1976-1983. It begins by explaining the political motives and psychological manipulation, which led to eventual military rule in Argentina. The seizure of power and the actual reign of terror are then discussed in detail. The effects of military rule on the population are portrayed through the words of political leaders, military victimization of so-called "subversives," and references to nationalism as the probable cause of both the beginning and the end of the "Dirty War." The paper concludes by discussing the fall of the military government and its implications both then and now.

## IDEOLOGIES FOR REPRESSION

According to historian Ernest Renan, members of a nation must consent freely both to live together and to acknowledge their common past. Such actions require the people to exercise their own free will. Recently, that exercise was outlawed by a military government in Argentina. The Argentine nationalist movement entitled *El Proceso de Reorganización Nacional*—the *Process of National Reorganization*—took place during the late 1970s and early 1980s. Despite enthusiastic promotions of democratic ideals prior to the movement, only the wills of the movement's military leaders were ever considered during this period of state terror. Those behind the movement were determined to reconstruct

Argentina *their way*, fully prepared to achieve their ends through whatever means necessary. Thus, whereas a normal democracy places political power into the hands of the people, this government actually took power from them. The *Proceso* movement, also known as the "Dirty War," is considered nationalist because leaders sincerely believed that their ideas would best serve Argentina. However, in doing so, they failed to consider any consequences other than those which they envisioned as the keys to a new and improved Argentina. As the public's will was essentially "disappeared" from the scene, military repression resulted in massive suffering by the people. The Argentine National Commission on the Disappeared uncovered the fates of close to nine thousand people reported missing during the period, and it believes that the actual number of people who "disappeared" is much higher due to unreported incidences (*Nunca Mas* 5). This paper discusses the historical background of the "Dirty War" and its implications for both the people of Argentina and the nation as a whole. It also analyzes the various political, social, and economic ideologies that provided military leaders with motives for their actions.

In order to understand fully the impact of the *Proceso* movement on Argentina, the

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political rationale adopted prior to the movement must be discussed. Originally adopted by the military to keep Peronists from power and prevent Communism from entering Argentina, the National Security Doctrine of 1955 had three main provisions. The first involved national security and economic development, stating that one could not be accomplished without the other. The second portrayed Communism as a threat to the Western world. Any internal conflicts with Western ideologies—"subversion," as the doctrine states—were considered threatening to national security and could not be tolerated. The third awarded the military the right to judge civilian governments and overthrow those failing to meet military standards (Rock 195). In short, the doctrine "perceives the Armed Forces as the last bulwark of morality against the ethical decline of civilian power and its behavior in government, as the only body capable of maintaining ideological strength" (*Nunca Mas* 444).

Internal political conflicts, such as the guerrilla movements during the 1970s, set the stage for military intervention in defense of the nation as it had been outlined in the National Security Doctrine. Conflicts escalated between various factions of the Argentine political stage, including political parties and guerilla movements. The military became extremely critical of the civilian government, constantly criticizing its efforts because it could neither stabilize the economy nor end these conflicts (Rock 223). As the military prepared to solve Argentina's problems itself, military leaders began a campaign to persuade the public that the Armed Forces were entirely within their rights to take such action. From their perspective, the population needed to see that the military was performing its civic duty, a duty that would benefit the entire nation. For this to occur, the military needed the public's support—not its help (Taylor 306-8).

In its public relations campaign, the military used the media to construct a socially masculine image of itself, thus portraying

itself as an Argentine hero and the only possible answer to the nation's problems (Taylor 309). At the same time, the rest of the population was appropriately feminized by becoming a mere onlooker; in effect, military ads and pronouncements "disappeared" Argentines from having any say in its actions (314). People were unknowingly coerced into "welcoming" military action as a change for the good of the nation (310).

For example, an ad was placed in *La Nacion*, Argentina's principal newspaper, just days before the coup. It featured a drawing of one young and innocent-looking soldier against a black background. Unbeknownst to the public, several subtle messages were intentionally encoded within the ad. For instance, the ad was drawn rather than photographed so that the viewer would see a civil conflict as no more than a possibility. The text on the poster read: "YOU'RE NOT ALONE... your nation stands behind you" in boldface letters (Taylor 312-3). Ads like these and other propaganda were used to portray the military's actions as a civilly backed rescue operation rather than a greed-inspired military coup (314-5). People sympathized with the ads, yet they were unable to see that the military had duped them into sympathizing with its own cause. Through such propaganda, the military heavily influenced the public's way of thinking, convincing it that the military's way of handling the situation was best. At the same time, the military withheld the true nature of its plans until it had acted on them.

In 1974, Juan Peron died while serving his second term as Argentine president. His second wife, Isabel, succeeded him as the first woman president in Latin America. However, she proved unable to correct Argentina's problems (Alexander 351). Guerilla movements became even more widespread, and the economy worsened. When the military decided that Isabel was incapable of solving Argentina's problems, it removed her from power on March 24, 1976 (*Nunca Mas* 1). General Jorge Rafael Videla

of the army, Admiral Emilio Eduardo Massera of the navy, and Brigadier Orlando Ramon Agosti of the air force resumed command and were collectively known as the first military *junta*, thus beginning the *Proceso de Reorganizacion Nacional* as it was named by the new leaders (Norden 50). On the day of the coup, this new government installed military officials in most of the significant government positions (Rudolph 206). Its major goals were to “eliminate the roots and acts of guerrilla warfare (subversion), institute a traditional code of morality, and boost the economy” (Norden 55).

The following day, the *junta* explained and justified its actions by revealing its plan to the Argentine people via a national radio broadcast:

This decision is aimed at ending misrule, corruption, and the scourge of subversion, but it is only directed at those who are guilty of crimes or abuse of power. It is a decision for the fatherland and does not suppose, therefore, to discriminate against any civic group or social sector whatsoever (Loveman and Davier 196).

Here, General Videla, now the president, announces to the nation that any measures taken by the new military government were meant only to benefit the “fatherland.” He also predicts the eventual formation of a “vigorous, organized, and unified society... spiritually and culturally prepared to forge a better future” (200-1). In fact, the *junta* declared itself “the supreme organ of the Nation” in an attempt to establish itself as a “model of leadership: male, measured, mature, and responsible, as opposed to Isabelita, who was female, hysterical, unqualified, and out of control” (Taylor 315). Furthermore, the *junta* stressed the country’s apparent unity, deciding on the public’s behalf that the *Proceso* should—and would—receive their backing (318).

Why was this reference to national unity so important? Nationalist sentiments on the

part of the public were seen by the *junta* as vital to the success of the *Proceso* movement. Leaders might have perceived nationalism as the driving force behind successful ideological change, and they would have had good reason for thinking so. “Underlying [nationalism] is the natural human desire to belong to a society... In the 20th century [nationalism] has proved far more powerful than religious ties or such ideologies as Communism or socialism” [“Nation”]. This was most evident during the reign of Adolf Hitler in Nazi Germany, when the quest for a utopian German population took precedence over the personal beliefs and values of individuals. Nationalism was first evident during the American and French Revolutions, when people united against a common enemy in a universal fight for their freedoms. Since then, it has been an extremely powerful political, social, and emotional force in history.

In addition to its impacts worldwide, the considerable influence of nationalism on Argentine history looked very attractive to the military in their quest for the “compliance” of the population. Consequently, speeches by Argentine military leaders constantly included efforts to portray the Argentine people as a single entity. Through this, the *Proceso* could be advertised as an ideological battle which the citizenry would support, fight, and eventually win. If the public saw this as a fight for the universal betterment of citizen life, the *junta* could more easily achieve its ideological goals without encountering massive resistance. For example, the radio broadcast of the *junta* just after the coup emphasized that the citizens needed to play a key role if the government was to work to better their lives. It stated that “all the representative sectors of the country ought to feel clearly identified with and committed to the common undertaking that will contribute to the greatness of the fatherland” (Loveman and Davier 197). In a separate speech, new president Videla explained that the *Proceso* would require all Argentines to sacrifice but also to have total confidence

in the government's efforts to improve society, all the while stressing that "the only beneficiary" of those efforts was Argentina itself (199). With these words, the war against Argentine subversion began; a war which would see thousands of people victimized and "disappeared" by the military for reasons which many today might consider incredibly trivial.

So what exactly defined "subversion," that mysterious phenomenon which the military was willing to eliminate completely by whatever means necessary? According to Videla, subversion was defined by the *junta* as "a global phenomenon that... based on philosophical or ideological assumptions, tries to penetrate within a population to subvert its values, create chaos, and through these means assume power violently" (Pion-Berlin, *Victims* 70). Videla also labeled a "subversive" as "anyone who opposes the Argentine way of life" (quoted in Pion-Berlin, *National* 401). These two definitions were extremely vague on what was considered subversive, yet they were just as intolerant of it as the National Security Doctrine. As the military ruthlessly caused the "disappearances" of thousands who somehow fit these definitions, fear arose among the remainder of the population for their own lives. The apparent lack of a pattern to the terror, as well as the words of the *junta* stating that no specific group was targeted, made it impossible for Argentines to predict who would be the next victims (*Alexander* 68).

However, contrary to the words of the *junta* just after the coup, the military did target several groups within the population as being subversive. Historian David Rock believes that the military sought a population with specific morals and values: "The generals drew on the Nationalist eschatology to portray themselves as Christian Commanders leading a struggle to extirpate the heretics and convert the unbelievers" (*Rock* 227). When the Argentine National Commission on the Disappeared tried to determine who, how, and why certain groups

were victimized, it was threatened by officials claiming that they were "saving the country and its Western, Christian values. In reality they were responsible for dragging these values inside the bloody walls of the dungeons of repression" (*Nunca Mas* 5). Such statements imply that the military was trying to establish a good and decent rationale for actions that internally echoed no such intent. The military's only interest through these contradictory policies was to coerce the population into agreeing with their views: "...the *junta* perceived a great and insurmountable distance between itself and its political foes—one that could not be easily bridged through negotiation or compromise" (Pion-Berlin, *National* 398).

Soon after the coup, *Cabildo*—a right-wing Nationalist magazine which had been banned from 1974 to June 1976—published a list of words which it believed showed evidence of "ideological subversion." For example, the word "consensus" was said to "deify public opinion," elevating it to heights that the military could not allow. Also, the word "couple" was believed to encourage extramarital relations, a huge offense to Christians. These ideas implied that the military did not focus just on the guerrillas but rather on the entire population. As *Cabildo* stated, the *junta* wished to destroy not only the guerrillas but also the causes of their existence—namely, to shatter the "habits of mind and secular and relativist values that guerrillas lived by" (*Rock* 226-7). These were a few of the ideologies which the *junta* may have exaggerated but nevertheless perceived as direct threats to its views and as an internal danger to national security.

In addition to the National Security Doctrine, the economic ideologies of the *junta* were a major factor behind the military's actions. The military believed that the state was too heavily involved with economic policy, that the government had become too protective of workers' rights, and that government spending should not exceed national income (Pion-Berlin, *Victims* 72).

Hence, after the coup, the *junta* took a non-nationalistic approach to the economy, stressing privatization and exposing the labor market to global competition. Believing that labor was responsible for high inflation and Argentina's other economic problems, the military made plans to eliminate labor's dependency on the government—directly attacking the efforts of former president Juan Peron to support laborers' rights (Pion-Berlin, *National* 395). This was intended to serve as a sort of "punishment" for organized labor (Pion-Berlin, *Victims* 73). The irony of these actions is that they in no way coincided with the ideological nationalism the *junta* had supported and emphasized so greatly in its speeches and declarations.

Eventually, the military targeted labor and trade unionists both politically and as victims of torture and repression (Pion-Berlin, *Victims* 73). After the *junta* resumed power, the Economics Ministry announced that arbitrary dismissals of workers in the public sector would be permitted, a declaration overtly opposing a Peronist law which stated that workers could only be released for job-related reasons. Secret documents of the *junta* revealed that industrial trade unions, particularly the larger ones, were more heavily victimized because they were perceived as the biggest threat to the proposed free-market economy (75-9). Of the disappeared persons reported to the Argentine National Commission on the Disappeared, almost a third were "blue-collar workers" (*Nunca Mas* 368). To cripple the power of large trade unions, the military would assassinate leading unionists. This resulted in the silence of other union members, fearing that they would be next if they ever became as outspoken as their late colleagues (82).

Another group that the military targeted was the press. Special attention was paid to the words of journalists because they were the major links between the actions of the *junta* and the ears of the public. General Ramon Campos, who often spoke on behalf

of the *Proceso* government, believed that journalists had to be stopped from "taking positions that threatened the prevailing institutions" (*Rock* 227). The Argentine National Commission on the Disappeared agreed, citing this and one other main reason for the desire of the *junta* to "disappear" journalists:

Those responsible for the repression saw journalists as a threat to the consensus that was meant to exist for the government's highly controversial and compromising actions. Journalists were also seen as a threat to the secrecy that was meant to surround the illegal, repressive system of disappearances, which was aimed at paralyzing the nation with fear (*Nunca Mas* 363).

On the day of the coup, the *junta* made it clear that anyone who in any way disrupted or badmouthed the Armed Forces' efforts to defeat subversion would be imprisoned. The military later resumed control of the Argentine Journalists' Federation, censoring all major news media throughout the nation so as to prevent any bad publicity from spreading internationally. Books were even stolen from Argentine libraries and later destroyed (*Nunca Mas* 363).

"A terrorist is not just someone with a gun or bomb, but also someone who spreads ideas that are contrary to Western and Christian civilization" (quoted in Pion-Berlin, *Victims* 79). This quote of President Videla helps to explain why those in education were also targeted and labeled by the military as the sources of subversive ideologies (*Rock* 229). In a military report entitled "Evolution of Terrorist Delinquency in Argentina," the Ministry of Education under former president Juan Peron was blamed for pressuring teachers to educate Argentina's youth on Marxism. From elementary school through college, students were exposed to these ideologies (Pion-Berlin, *Victims* 79).

To end this, the *junta* took educational matters into its own hands by appointing all education officials itself. Professors,

desperately trying to keep their jobs by staying on the new administrators' good sides, taught only the facts and stopped preaching "foreign" ideologies such as Marxism to students. The *junta* took advantage of this "self-censorship" and used the system to encourage its own values of a Christian, family-oriented, and "compliant" lifestyle (79).

Although teachers' unions were smaller than those of industrial trade, 40% of teaching unionists were "disappeared" as opposed to only 16% of manufacturing unionists (77).

Other groups were also victimized for various reasons. Lawyers, particularly those who defended subversives or supported laborers' rights, were commonly "disappeared" because anyone who defended such ideas was assumed to believe them himself (*Nunca Mas* 412-3). Psychologists and psychoanalysts were targeted because of the influences that they could have on people's minds. The *junta* saw their professions as similar to those of Church officials. Supporting this view, Cabildo stated that psychoanalysts had been plotting to "destroy Christ's concept of the family" (*Rock* 228). Another unlikely group targeted was architects. This group was victimized in part because of its association with the Peronists. Also, the *junta* saw architects as responsible for the "physical environment of subversives" and would not allow their efforts to reinforce subversive ideals in any way (229). When the families of all of these "disappeared" consulted human rights organizations for help and support, the *junta* simply demanded that these organizations surrender any information they had regarding individual cases. The military searched the headquarters of several major organizations, seizing anything that they could find which could possibly work against their efforts (*Nunca Mas* 420-1).

By the end of 1979, the "Dirty War" had been declared a success by the *junta*. The guerrillas were no longer a problem, but the population—with the exception of the Mothers of the Plaza De Mayo—now had a tremendous fear of both the military and the

government (*Alexander* 445). General Leopoldo Galtieri, in a speech to the nation during 1980, reinforced what the *junta* had said from the very beginning of the *Proceso* movement. He denied military involvement in the disappearances and implied that the military felt sympathetic toward their loved ones. In addition, he stated that "national unity" and the "political will" of the government to help its people would usher in a new period of Argentine history (*Loveman and Davier* 202-4). President Videla announced that the construction of a democracy would soon begin, but an economic recession slightly delayed his plans (*Rudolph* 246).

After Videla retired in March 1981, army commander General Robert Viola became the new civilian president. Eventually, Viola came to be greatly distrusted by the navy and various other military officials because he was extremely open to the opinions of political parties and other "civilian politicians" (*Rudolph* 247). When the *junta* announced a year later that Viola had stepped down for "reasons of health," Galtieri assumed the presidency (248). What he inherited was somewhat different from the fear-stricken Argentina that Videla had ruled. By this time, the Mothers of the Plaza De Mayo had attracted more followers, and the general population was finally beginning to break its silence. People were growing tired of waiting for answers from the government regarding their loved ones who disappeared, and they wanted both answers and justice (*Alexander* 176).

Galtieri realized that his government could be in serious trouble. Unless he found a way to quickly mobilize popular support, he and his associates would not have enough public backing to win elected offices in a few years (*Rudolph* 249). So, he devised a plan, which he felt would encourage, rather than coerce, feelings of nationalism within the people of Argentina. If the plan was successful, and the people were on his side, it would greatly improve his chances to stay in power. His plan was to regain for Argentina the

Malvinas (A.K.A. Falkland) Islands, directing the Armed Forces to retake the islands by force from Great Britain between August and September of 1982. When Galtieri noticed the public's growing impatience with the government, he decided to move the attack to April 2 (*Rudolph* 249).

Retaking the islands proved to be a success in public relations, but only temporarily. The movement did indeed receive a great deal of "popular enthusiasm" largely because Argentines had always felt that these islands—controlled by Britain since 1833, yet just off Argentina's eastern coast—should belong to Argentina in the first place. This inspired the nationalism on which Galtieri had counted, and it gave him and his government a temporary reprieve from the economic and social problems for which they had been blamed. However, when Galtieri recaptured the islands, he failed to consider several important factors. For instance, Argentina received no international support for its actions, despite having expected significant backing by several nations. Heavily depended-upon support from the United States did not materialize, despite Argentina's support of Ronald Reagan's Cold War revival. Also, the British refused to allow the islands to fall into Argentine hands. As efforts of Argentine negotiators to hold off British attacks failed, reinforcements were sent to recapture the islands for the British. Within a matter of days, the Argentine military was humiliated by the British forces, and the Malvinas were once again under the control of Great Britain (*Halperin-Dhongi* 359).

As suddenly as it had appeared, the support that Galtieri had roused from the Argentine people vanished. The nationalism, which he had inspired, turned against him. People became angry about the loss, and complaints progressed from the pain of economic turmoil to the need for "a new beginning" in Argentine history, a beginning not orchestrated by a military takeover (*Dhongi* 359-60). The Mothers of the Plaza De Mayo

continued to attract more followers, and Galtieri and the military soon agreed to the return of civilian rule as long as the now-weakened armed forces were once again restored to their former strength (*Rudolph* 250). National elections were held in 1983, and the winner by a significant majority was Raul Alfonsin, an outspoken Argentine human rights activist and harsh critic of the military's economic and repressionist policies. With Alfonsin's promise to redemocratize Argentina, true civilian rule had been reestablished for the first time since 1976 (*Alexander* 14-5).

Now that the military had been ousted from power by popular demand, the *Proceso* movement could be seen for what it really was: a failure. "The military had failed at government, failed at external war, and failed at convincing the civilian population of the legitimacy of their methods in the internal war" (*Norden* 76). Since the military had now lost all of its political credibility, critics placed political responsibility where many believed it should have been left in the first place: in the hands of the politicians themselves. Once Alfonsin was in power, the National Security Doctrine was revised accordingly to accommodate this criticism. The military's role in government became one of subordination rather than superiority, as it would no longer have the right to judge and overthrow civilian governments (77). Democracy and human will were once again dominant in Argentina.

Throughout this democratization, the military repeatedly denied any wrongdoing during the "Dirty War." Finally, in 1995, army Chief of Staff General Martin Balza admitted that the military had "employed illegitimate methods, including the suppression of life, to obtain information." This greatly displeased Argentina's current president, Carlos Menem, who praised the efforts of the military during that period and then attempted to forget it altogether (*Sims* A5).

Having effectively "disappeared" the public will from the picture, the Argentine



military had organized and executed one of the most vicious periods of state terror in Latin American history. Military leaders had ignored the wishes of the public, enforcing their ideologies through whatever means necessary and later watching their efforts crumble. Argentina's current leaders have chosen to forget this ghastly period in order to preserve the unity of the nation, but Argentina's current population refuses to allow it to die. The people remember their loved ones, those who suddenly "disappeared" during the *Proceso* movement. This makes for an interesting paradox regarding the construction of a nation. It is crucial to forget that which tears a nation apart, yet what tears it apart may also be what ultimately establishes a sense of unity: *nationalism*.

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## Comparing City Characteristics and Nationwide Coverage of the 1997 Hong Kong Handover: A Community Structure Approach

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### ABSTRACT

The handover of Hong Kong to the People's Republic of China is one of the most complex political stories in recent times. Questions regarding political ideology and ethnic identity grew as the July 1, 1997 deadline approached. Coverage of the handover in the media varied as greatly as did the feelings among an American public that sensed economic, political, and cultural ties with Hong Kong. For this reason, it is important to use media coverage as a tool for examining the handover. This study examined coverage of the handover in twenty newspapers from around the country. The articles were surveyed and coded according to slant (favorable, unfavorable, or balanced/neutral) and were calculated using Spearman Rho correlations. These correlations were compared with aggregate data using the City Characteristics approach. The findings led to a number of interesting and significant points. Included in the findings were significant data linking high levels of devotional reading with positive coverage of the handover. In addition, significant links were found between high income (\$100,000/year) and negative coverage. This study examines the possible reasons behind these links and makes suggestions for further research.

### INTRODUCTION

July 1, 1997 brought to an end one of the most fascinating and controversial political struggles in recent history. The British colony of Hong Kong, one of the most

important economic and cultural cities in Asia, was given back to the People's Republic of China after one hundred and fifty-six years of imperial rule. Lifelong British subjects suddenly became citizens of one of the last Communist nations in the world. In terms of political jockeying, however, the handover was anything but sudden.

The return of Hong Kong to mainland China appears on the surface as a black and white struggle of political, moral, and economic ideologies. The loss of the Soviet Union as the symbol of the Communist world and ideological counterpart of the United States during the 1980s left a void in the minds of many Westerners. China, the only prosperous Communist state left in the world, was seen by many as the heir apparent to the role of political enemy of the United States. A history of extensive and systematic use of oppression and violence by Chinese leaders like Mao Zedong and Deng Xiaoping and recent incidents like the Tiananmen Square massacre also heavily shaped the world-wide perception of the People's Republic of China. Amnesty International human rights violation notices, the arguments against extending China's most favored nation trading status (based on human rights abuses), and increased awareness of Tibet's status all pointed to China as the new "evil empire."

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The question about the impact that China's economy would have on the economy of Hong Kong was clouded by the recent opening of China's market to foreign businesses under Deng. The disparity between China's tolerance of free trade and intolerance of free thought poses serious questions about whether or not the competition necessary to sustain a successful capitalist economy will be allowed to continue under Chinese rule. Will China abuse the immense wealth that Hong Kong possesses or will it utilize the many multinational businesses to further solidify itself in the global marketplace? The many questions that come with such a dramatic change are bound to create immense interest around the world.

The way that Americans react to this story gives tremendous insight into modern society and biases. American interest in the handover of Hong Kong is based in a number of different areas. Some see this as an economic issue that will have lasting repercussions into the next century. Some have strong reactions due to religious and ethical beliefs. Others have a vested interest since their families come from China. It is obvious that there are more issues in question than sovereignty over a small former colony. There exists a clash of cultures, ideologies, and opinions that offers a sense of confusion regarding who is "right" and who is "wrong," or even if there is a "right" and "wrong." As we shall see, public perception of the handover of Hong Kong will vary greatly. Since it is obvious that this variance will rely largely on the life experiences and prejudices of the publics, it is logical to assume that the citizens of one locale will hold vastly different opinions of the handover than those in other locales. Factors such as economic status, belief system, and ethnic identity will vary from one city to another and will play a role in creating the public's perception of important news stories such as the handover. It may be that the only true consensus is that it is an event that will have long term and profound implications.

#### A REVIEW OF COMMUNICATION LITERATURE: A RESEARCH GAP

Upon review of several major communication journals, little information was found on the subject of the handover of Hong Kong from Great Britain to China. *Communication Research, Communications Studies, Critical Studies in Mass Communications, Communication Quarterly, Journal of Applied Communication, Research, Journalism & Mass Communication Quarterly*, and *Communication Abstracts* entries between 1991 and 1995 provided few articles containing relevant subject matter on Hong Kong. Multiple key word searches were performed including: Hong Kong; China; Human Rights; Transition; International Business; and Land Rights. While articles were retrieved with these key words, a vast majority focus on either business communication or the role of mass media in Far Eastern countries. One particular article from *Journalism & Mass Communication Quarterly* discusses press coverage of the Tiananmen Square massacre, the 1989 incident which clearly exhibited human rights violations on the part of the Chinese government. Zhang and Krauss (1995) write:

Images of Tiananmen Square received and inspired global responses. The United States, Canada, Australia, Japan, The European Community, and some international organizations applied various economic and political sanctions against the Chinese government. The Communist countries of Yugoslavia, Vietnam, and the Soviet Union also expressed their shock of the military suppression. China was isolated in the international community. (p. 412)

The Tiananmen Square incident seriously damaged other nations' views of the Communist People's Republic of China (PRC). While this massacre is not the focus of this study, the impact of the event has significant implications for the controversy surrounding Hong Kong's transition to Chinese rule. Human rights violations and other forms of governmental suppression are major areas of concern for the people of Hong Kong.

Another article, taken from *Communication Quarterly*, examines essential communication issues facing Hong Kong during its period of transition. While the article primarily discusses the difference in dialects and ethnic identities of the people of Hong Kong and mainland China, it does touch upon the political impact of the territory's transition once it is under Chinese sovereignty. Pierson (1992) claims:

Putonghua (the language) and the radically different political culture of mainland China, will be challenging the hybrid Hong Kong Chinese culture and the dominance of Cantonese. Although the outcome is far from certain, it is likely that there will be a significant shift in language loyalties as a result of the territory's political changes. (p. 382)

While Pierson maintains a relatively neutral view of the handover, he makes it clear that communication problems are foreseeable between China and Hong Kong, which could conceivably lead to a less than harmonious period of transition.

#### COMMUNITY STRUCTURE APPROACH

Newspapers have long been regarded as the most complete and valuable sources of information. Not as transient as television or radio broadcasts, the newspaper is seen as having more weight when it comes to shaping the agenda and influencing the opinions of its readership. It has the time and space to go into much more detail and cover a larger number of subjects than other media news outlets can. Newspapers are widely acknowledged as the place to go for an individual or organization that wants to shape public perception on an issue. But to understand what determines the attitude and stance that a particular newspaper will take, we have to look at papers as less of an idealized disseminator of information and more of a practical and rational business.

The operation of newspapers according to the market model allows for a number of logi-

cal points that are useful to our study. Simple economics dictates that a business can not continue to exist unless consumers purchase its product. The obvious product in the case of a newspaper publisher is the daily edition that is delivered to homes and newsstands. There is, however, a less apparent product that the newspaper is selling. The editorial content of the newspaper, the topics and stories that the paper devotes space to and the way in which those articles are biased, must coincide with the mores and opinions of its readership. A paper that does not connect with readers will not survive long.

In order to remain economically viable and prominent in the minds of the readers, newspapers must present stories in a way that does not conflict with public opinion. We see that there is a double filter, the reporter and the editors, through which news must pass. With these conditions in mind, we can see that the community structure approach is a useful tool when analyzing media coverage on a particular topic. If it is possible to determine through pre-existing data what characteristics a region possesses, we can begin to interpret why a story was covered the way it was. The metropolitan nature of newspaper circulation allows researchers to clearly define the intended audience and pinpoint relationships between demographic and aggregate data and newspaper coverage. The community structure approach utilizes and advances the work of Tichenor, Donohue & Olien (1973, 1980); Pollock, Robinson & Murray (1978); Dearing & Rogers (1992); Pollock, Awrachow and Kuntz (1994); Pollock, Coughlin, Thomas & Connaughton (Winter 1996); and Pollock, Kreuer & Ouano (1997). Scholarly research has, in the past, examined diverse issues such as *Roe v. Wade* (Pollock, Robinson, & Murray, 1978) and the announcement that basketball star "Magic" Johnson was HIV positive (Pollock, Awrachow, & Kuntz, 1994) by using the community structure method.

## HYPOTHESES

To examine effectively the city characteristics that guided the newspaper coverage of the 1997 Hong Kong transition, five cluster groups will be tested: education and awareness, ethnic identity, occupational status and privilege, belief system, and media saturation. Hypotheses, and their logical derivation, will be described in turn. Citations in parenthesis following each topic refer to the sources used to obtain demographic data to subsequently test each hypothesis.

### Education and Awareness Level.

Spearman Rho calculations on the data used in this study show a high level of correlation between cities with high percentages of individuals possessing 16+ years of education and people employed in professional positions ( $r=.7737$ ;  $p<.005$ ). Although not necessary for a professional career, this indicates that there is a significant relationship between college education and the number of individuals occupying a professional position. These careers offer the people an opportunity to be greater informed regarding international affairs in general (Pollock, Kreuer & Ouano, 1997; Pollock, Shier & Slattery, Winter 1995) and China in particular. The lives of these more educated people could be more greatly influenced by the changes in Hong Kong. Their decision regarding the handover will be shaped by the effects of social, economic, and political changes that would theoretically occur due to the handover.

Those people with four or more years of college education will have a better opportunity to be informed about China, the takeover and the history of the British occupation of Hong Kong. Hong Kong, previously a democratic state, could face major obstacles when returned to the People's Republic of China. A major power in trade and business, Hong Kong may be abused by China in an effort to take advantage of the financial resources. The more highly educated will be more familiar with incidences of human rights violations and the confrontation in Tiananmen Square.

H1- The higher the percentage of people within a city who have had 16+ years of education, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

China has frequently been the center of international controversy. Long before the news of the transition began, China was accused of many human rights violations, including the incident in Tiananmen Square. Those people who report being interested in current affairs and politics will most likely have a higher level of awareness of China and its history of human rights violations. People with an avid interest in current events and politics will be more likely to remember the violations China has committed in the past and will be less likely to favor the transition.

H2- The higher the percentage of people interested in current affairs and politics in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

China is a large country and is rich in a number of resources. Many of these resources have applications in the expanding world of science and new technology. After the takeover, these improved resources will be readily available to the scientists of Hong Kong. This positive aspect of the handover would create a more favorable view of the handover as a whole.

H3- The higher the percentage of people with an avid interest in science and new technology in a city, the more favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

Avid readers are more likely to possess a more well-rounded and well-educated view of the situation in China. They understand the history of China and the possible consequences of the handover, and would consequently be less likely to hold a favorable opinion of the handover.

H4- The higher the percentage of avid readers in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

**Ethnic Identity.** Members of ethnic or immigrant groups will share somewhat similar views regarding the situation that faces Hong Kong. Immigrants have often attempted to distance themselves from the political or social climate abroad by coming to the United States. People who have shown their dissatisfaction with the state of affairs in the past will apply these feelings to the current situation (Pollock, Kreuer & Ouano, 1997).

H5- The higher the percentage of Asian individuals in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

H6- The higher the percentage of Chinese speaking individuals in a city, the less favorable the coverage of the Hong Kong handover (1990 Census of Population).

H7- The higher the percentage of foreign born citizens in a city, the less favorable the coverage of the Hong Kong handover (Hall & Gaquin, 1997).

**Occupational Status and Privilege.** People earning more than \$100,000 per year will be less likely to favor the transition because many of these individuals are employed in businesses that may be adversely effected by any negative results of the handover. These are often the same people who possess the income to hold bonds and stock in companies which may be affected. The prospect of significant financial loss will cause these individuals to give a more guarded or negative outlook on the handover.

H8- The higher the percentage of people earning \$100,000+ per year in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

H9- The higher the percentage of people holding stocks and bonds in a city, the less

favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

People working as professionals have a steady income which predisposes them to possessing knowledge regarding the world around them. They are more likely to be able to afford a subscription to a newspaper and would therefore be more aware of the current state of affairs in the world. Furthermore, their jobs could conceivably be adversely effected by any dramatic changes resulting from the Hong Kong transition to the People's Republic of China's rule.

H10- The greater the percentage of professionals in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

People living below the poverty level do not have much of an opportunity to make themselves aware of current events (Pollock & Robinson, 1977). They do not have the resources to spend on media consumption and they would therefore be ignorant of China's history of human rights violations. In addition, the takeover of the Hong Kong economy by China would have little effect on their financial situation.

H11- The greater the percentage of individuals living below the poverty level in a city, the more favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

Those people who are employed in the area of manufacturing often work for companies that could be affected by the transition. The motives of the government of the People's Republic of China are unclear regarding the tremendous financial resources located in Hong Kong. Concerns regarding the restrictions that may be placed on Hong Kong's businesses, which have enjoyed an extremely open market in the past, may cause manufacturing employees to be wary of economic developments after the China takeover.

H12- The greater the percentage of workers in manufacturing industries in

a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

**Belief System.** People who possess strong religious or spiritual beliefs are often concerned with the impact of current events on religious freedoms around the world (Pollock & Robinson, 1977). Communist regimes have traditionally been extremely intolerant of religious freedoms, particularly when organized religion is involved. People interested in religion and spirituality, particularly those who are members of groups that have traditionally been persecuted, will be fearful of any attempt by China to curb religious freedoms in Hong Kong. This fear would translate to a negative outlook on the handover of Hong Kong.

H13- The higher the percentage of Jewish individuals in a city, the less favorable the coverage of the Hong Kong handover (Singer, 1997).

H14- The higher the percentage of Catholic individuals in a city, the less favorable the coverage of the Hong Kong handover (Foy & Avato, 1997).

H15- The higher the percentage of Baptist individuals in a city, the less favorable the coverage of the Hong Kong handover (Kurian, 1994).

H16- The higher the percentage of devotional readers in a city, the less favorable the coverage of the Hong Kong handover (Lifestyle Market Analyst).

**Media Saturation.** The amount of media to which the public is exposed has been shown to prove significant when using the community structure approach (Pollock, Awrachow & Kuntz, 1994; Montero, 1995; Pollock, Sheir & Slattery, 1996). This is due in large part because media outlets, particularly those utilizing viewer or listener feedback, provide a forum to share ideas and opinions. Radio stations are among the most effective means of sharing personal view-

points with a large number of listeners. The bias among AM talk radio shows toward a more conservative position would skew the attitude of individuals against the handover. The frequency of instances of the negative opinion being expounded on the radio would cause an overall bias toward an unfavorable view of the handover.

H17- The higher the number of radio stations in a city, the less favorable the coverage of the Hong Kong handover (Fischer, 1990).

## METHODOLOGY

Twenty newspapers, each representing a separate major metropolitan area, were surveyed for content regarding the handover of Hong Kong to the People's Republic of China. The search, which utilized the DIALOG Classroom Instruction Program, was conducted by using keywords such as "Hong Kong" and "handover" and approximately twenty of the longest articles from each newspaper were collected. Articles and editorials that appeared from January 1, 1996 through November 1, 1997 were retrieved and coded. The newspapers were chosen in order to provide a diverse cross-section of the United States so that a variety of demographic groups would be represented. The sample was comprised of:

*The Atlanta Journal/Constitution*  
*The (Baltimore) Sun*  
*The Boston Globe*  
*The Albany Times Union*  
*The Charlotte Observer*  
*The Chicago Tribune*  
*The Cincinnati Post*  
*The (Denver) Rocky Mountain News*  
*The Detroit Free Press*  
*The Houston Chronicle*  
*The (Memphis) Commercial Appeal*  
*The (New Orleans) Times-Picayune*  
*The Orlando Sentinel*  
*The Philadelphia Inquirer*  
*The Arizona Republic/Phoenix Gazette*  
*The Pittsburgh Post-Gazette*  
*The Portland Oregonian*

*The St. Louis Post-Dispatch*  
*The San Francisco Chronicle*  
*The Seattle Post-Intelligencer*

The articles were given two scores that would eventually be used to calculate the Janis-Fadner Coefficient of Imbalance. An attention or display score was assigned to each article based on placement, article length, headline length, and the inclusion of a photograph. The directional score was assigned through evaluation of article content. Each article was classified into one of three groups: overall favorable coverage of the story (F), overall unfavorable coverage of the story (U), and either balanced or neutral coverage of the story (N). In this case, favorable articles took an optimistic or positive stance on the Chinese takeover of Hong Kong. They stressed the future benefits of the handover and failed to significantly criticize China on a number of issues. Unfavorable coverage took a more cautious approach and stressed some of the more controversial issues involved in the event. Balanced or neutral coverage was characterized by either relatively similar amounts of both positive and negative coverage or generally unbiased coverage.

These classifications were, in turn, used to calculate the Janis-Fadner Coefficient of Imbalance for each newspaper surveyed. The Coefficient of Imbalance produced a score between +1.0 and -1.0 for each paper regarding coverage of the Hong Kong handover. In general, a positive coefficient of imbalance reflects positive coverage, a negative coefficient of imbalance reflects negative coverage. The numerical value reflects distance from the neutral. All of the articles that were gathered were graded in this manner by two of the researchers and a Holsti's Coefficient of Inter-coder Reliability was calculated at eighty percent in order to insure that the classifications were assigned consistently. The Coefficients of Imbalance for each city were calculated and were ranked so that Spearman correlations could be calculated and significance tests run to determine relationships with select demographic data.

The use of the Janis-Fadner Coefficient of Imbalance by communication scholars has been well documented. This is due, in large part, to the fact that it incorporates content analysis and quantifiable data as effectively as it does. Articles on a variety of topics that utilize this methodology have been accepted at a number of professional conferences and can be found in publications such as *Journalism Quarterly*, *The Journal of International Communication*, and *Newspaper Research Journal* (Pollock, Kreuer, & Ouano, 1997).

## RESULTS

### Janis-Fadner Coefficients of Imbalance.

There are a number of interesting results regarding the Coefficients of Imbalance that should be mentioned (see Table 1).

Table 1. Janis-Fadner Coefficients of Imbalance.

1. St. Louis	+ .2307
2. Memphis	+ .1600
3. Chicago	+ .0825
4. Seattle	+ .0534
5. Atlanta	+ .0527
6. Denver	+ .0515
7. New Orleans	+ .0488
8. Charlotte	+ .0436
9. Albany	+ .0433
10. Houston	- .0019
11. Pittsburgh	- .0102
12. Orlando	- .0346
13. Portland	- .0375
14. Boston	- .0547
15. Baltimore	- .0590
16. Cincinnati	- .0816
17. San Francisco	- .1050
18. Philadelphia	- .2105
19. Phoenix	- .2816
20. Detroit	- .3582

A number of the larger cities (with the notable exception of Chicago) seem to have fallen closer to negative than have some of the smaller cities. Since large cities often contain the highest concentration of immigrants and ethnic enclaves, it seemed that the hypotheses regarding the negative dispositions of foreign born, Asian and Chinese speaking individuals would be confirmed. In addition, a number of the "bible belt" and midwestern cities (e.g. St. Louis, Memphis, Atlanta) are found on the positive end of the scale, with St. Louis and Memphis receiving Coefficients of Imbalance of .1600 or greater.



Again, the role that religion plays in shaping the attitudes of the public appeared to be evident. There were a few instances in which regional associations could not be made. Portland and Seattle, though separated by less than two hundred miles, were separated by nine spaces according to the ranking.

**Spearman Rho Correlations.** See Table 2 for a list of the individual hypotheses, along with their respective Spearman Rho correlations and levels of significance.

Table 2. Hypotheses and Spearman Rho Correlations.

1. College Education	-.0992	>.250
2. Current Affairs/Politics	-.0541	>.250
3. Science/New Technology	-.3947	<.100
4. Avid Readers	-.3429	<.100
5. Asian Descent	-.1421	>.250
6. Chinese Speaking	-.1503	>.250
7. Foreign Born	-.1767	<.250
8. \$100,000+ income	-.3962	<.050
9. Stocks and Bonds	-.1797	<.250
10. Professionals	-.1188	>.250
11. Poverty	+.1323	>.250
12. Manufacturing	+.0098	>.250
13. Jewish	-.2692	<.250
14. Catholic	-.3722	<.100
15. Baptist	+.3278	<.100
16. Devotional Reading	+.5248	<.010
17. Radio Stations	+.2143	<.250

**Belief System Linked to Mixed Coverage.** In what was, by far, the most interesting and thought provoking finding in this study, the calculations revealed a highly significant ( $r = +.5248$ ;  $p < .01$ ) link between devotional reading and favorable coverage. Also linked to favorable coverage was percent Baptist ( $r = +.3278$ ;  $p < .10$ ). Percent Catholic ( $r = -.3722$ ;  $p < .10$ ), and percent Jewish ( $r = -.2692$ ;  $p < .25$ ) were found to be minimally related, in the negative direction, as predicted.

It was initially believed that all of the hypotheses dealing with belief systems would be negatively correlated with positive coverage of the handover. The negative correlation with Catholicism seems to be consistent with the traditional view that Catholics, more than other groups, have been the target of efforts by communist governments to eradicate the open and free practice of religion. The direction and significance of the findings regarding devotional reading and the relationships for Baptists seems, on the surface, to go against logic. Upon closer

examination, however, there seems to be a subtle relationship.

It is generally understood that some denominations of Christianity engage in more devotional reading than others. Catholics generally do not rely as heavily on the evangelical aspect of religion as do more fundamental groups such as Baptists. If we see that Baptists are more likely than other Christians to engage in devotional reading (Spearman Rho correlations between Baptists and devotional reading for the data used in the study yielded findings of  $r = .5929$ ;  $p < .005$ ), we see why both percent Baptists and devotional reading are pointed in one direction while percent Catholic correlates in another. There are also significant differences in the locations of Baptists and Catholics. Baptists live mostly in the South and would most likely be found in cities like Memphis or Atlanta, both of which exhibited favorable coverage of the handover. Catholics are more prevalent in the Northeast, in cities like Boston and Philadelphia that appear to show unfavorable coverage. What we ultimately see is a make up of both Baptists and devotional readers (of which there is much overlap), that is less critical of the Chinese government than their Catholic counterparts and that does not feel the sense of "second hand" persecution feared by Catholics.

**High Income Only Privilege Factor Linked to Negative Coverage.** As predicted, income of over \$100,000 per year correlated significantly ( $r = -.3862$ ;  $p < .050$ ) with negative coverage of the handover. It seems that there was a level of apprehension among those whose financial status may be adversely effected by drastic change in Hong Kong's economy.

**Education and Awareness Linked to Negative Coverage.** Somewhat linked to negative coverage are interest in science and new technology ( $r = -.3947$ ;  $p < .100$ ) and avid reading ( $r = -.3429$ ;  $p < .100$ ), confirming these hypotheses. Although it was originally believed that favorable coverage would correlate with interest in science and new

technology due to the potential for scientific growth, it appears that the business aspect of technology may have proven most important. Because many of the largest and most powerful companies in the world are based on technology, it is reasonable to believe that the majority of interest in the transition from a science and technology position deals with the economic aspect. Just as there was apprehension among those individuals earning over \$100,000, the people interested in technology are also interested in the bottom line.

The disparity in the levels of significance between avid readers and interest in current events may be a result of the many facets to the story of Hong Kong's reversion after a century and a half of rule. Avid readers are probably familiar with the well-documented cases of dissidents who have been subject to inhumane treatment at the hands of the government of the People's Republic of China. They have a depth of knowledge that contains a lot of information that is damning to the Chinese government and therefore would cast a negative light on the events taking place. The people interested in current events may have come to learn about the matter from television and newspapers and would not have the negative bias held by avid readers. The theme of many of the articles surveyed dealt with the seizing of Hong Kong by the British after the Opium Wars and the rightful ownership of Hong Kong by China. Although there were a number of other articles pointing out infringements on human and civil rights, there was generally even coverage regarding the right to China's claim of ownership over Hong Kong. These reports, although not enough to create a favorable bias, were prevalent enough to create a fairly unbiased story for those who gained most of their knowledge regarding the handover from the morning paper or the evening news.

**Ethnic Identity Shows Minimal Link to Negative Coverage.** Despite the significant findings regarding Asians and foreign born individuals and Beijing's bid for the 2000

Olympics (Pollock, Kreuer & Ouano, 1997), no evidence was found to link percent Asians ( $r = -.1421$ ;  $p = >.250$ ), percent speaking Chinese ( $r = -.1503$ ;  $p = >.250$ ), or percent foreign born ( $r = -.1767$ ;  $p = <.250$ ) with negative coverage. Although the results regarding San Francisco (which was among the top in all three categories) were consistent with our hypotheses, the city of Seattle (which also had significant numbers of Asians, Chinese speakers, and foreign born) seemed to create a problem with a strong correlation. Other factors, such as the heavy reliance by Seattle on the technology industry (Microsoft) and the aerospace industry (Boeing) may have played a prominent role in complicating the effect of ethnic identity on this issue. Both industries may see China as an untapped market that will be opened to the West by the free trade tradition of Hong Kong. Again, we see that money seems to trump other issues when it comes to coverage of the handover.

#### SUGGESTIONS FOR FURTHER RESEARCH

**Further Examination of the Role of Belief Systems.** The most compelling finding in this study is the highly significant relationship between devotional reading and favorable coverage. The reasoning given in this study relies on a number of generalizations that may or may not be wholly accurate. It is likely that some groups are more involved than others when it comes to devotional reading, and it would be interesting to concretely determine how Catholics, Jews, and Baptists differ in level of interest in devotional reading.

Research should be conducted regarding the nature of the coverage related to religious freedoms and the correlations with particular religions. More precise research would reveal whether, as expected, the majority of articles dealing with the Catholic church in Hong Kong contained a negative bias. Further, the identification of members of the Catholic and Jewish religion as primarily liberal should be examined to determine if there are other non-religious factors influencing the correlation.

Conversely, the recent conservative stances taken by Baptists on a number of issues should be examined further.

**Awareness, Privilege Should Be Further Examined.** The effect of interest in reading and science and new technology may have significant practical repercussions for those who act as advocates for or against the actions of the Chinese government. If links can be made between the volume of reading and awareness of human and civil rights violations by the Chinese governments, these associations would have important uses to organizations interested in furthering the cause against the government of the People's Republic of China.

The negative correlation between those who would be interested in financial matters (\$100,000+ income, interest in science and new technology) and the handover of Hong Kong warrants further research as the economic future of China and Hong Kong becomes more clear. Fluctuations in Asian stock markets during the fall of 1997 have sent shockwaves throughout the world economy. Given the volatility of today's "global economy," any losses that may occur as a result of the transition of Hong Kong businesses to Chinese economic standards could incite the sort of panic that could have far reaching repercussions.

## CONCLUSIONS

The reversion of Hong Kong to Chinese control has proven to be one of the most anticipated and feared international events of the decade. World events, throughout most of the past century, have been portrayed as ideology versus ideology, leader versus leader. The circumstances regarding the handover lack this clear sense of the forces at conflict. China no longer conforms to the public's image of a communist superpower and many of the "evils" of communism are only hinted at by the actions of the PRC government. As with the questions raised by economists and politicians, there are two main points of interest brought about by this study that have impli-

cations in the world of communication. Religious and civil freedoms and concerns regarding the future of the Hong Kong economy dominate the attention and help to shape the attitude toward the event among the media and the public. Add to this the close cultural ties between Hong Kong and mainland China and it becomes evident that there can be no single factor that will determine public or media opinion of the handover.

Turbulence in the world economy has led to early speculation that the specter of increased control looms over Hong Kong. The world of economics relies on stability for reassurance, a feeling that can never be truly guaranteed. The relaxing of controls and the opening of the Chinese market under the reforms of Deng Xiaoping have resulted in a good deal of interaction between the economy of China and that of the West. Just as the crackdown in Tiananmen Square revealed that Chinese leadership would not tolerate too much dissension regarding the push for democratization, it is conceivable that loosening of constraints on the economy may face a harsh reversion to a controlled economy if Hong Kong businesses try to exercise too much freedom. The effect that such a roll back would have on foreign investments in Hong Kong or China would be staggering. Newspapers, like any other businesses, will be prone to take a "wait and see" attitude regarding the economy at the very least. More likely, an unfavorable slant would result from the uncertainty about future developments. The cities surveyed have displayed, to some degree, that the newspapers have adopted the logical fear of businesses regarding the future of the world economy. The discourse of business in the mainstream media will become even more important as technological tools such as the Internet allow more people to become involved in investment.

Finally, the cultural repercussions of the reversion of Hong Kong to its historical owner are quite compelling. There is little debate regarding the effectiveness of Great Britain in building up Hong Kong as a world

economic power. There is also little debate over the fact that Hong Kong was one of the spoils of a war fought by Great Britain to force the Chinese government to allow British merchants to sell opium in China. Couple this controversy with the traditional link between China and Hong Kong and an effective case could be made that China has a valid claim to Hong Kong regardless of human rights or economics. So we see that there is yet another factor that must be closely examined if we are to understand the newspaper coverage of the transition.

Although the future of Hong Kong is largely unknown, the portrayal of the transition in the media has exhibited a number of definite characteristics. It is obvious that there are a number of diverse points of view that shape the nature of newspaper coverage. People use their life experiences, beliefs, and financial situation to form an opinion about the handover and the aggregate data has provided some insight into the frequency of specific characteristics in the cities surveyed. The result was a plurality of viewpoints among the articles surveyed that mirrored the diversity of the opinions and biases held by the public.

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# Byzantine Missionary Contributions to the Slavs of Eastern Europe

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## ABSTRACT

Beginning in the second half of the ninth century, Byzantium's most remarkable cultural influence was its missionary activities with the Slavic peoples. This resulted in exposure to the Classical World and a championing of native-Slavic cultural heritage. This paper will examine three distinct areas of Byzantine cultural radiation: Moravia, under the reign of Ratislav, Bulgaria under the reign of Boris, and later his son Symeon, and finally Kievan Rus' under the reign of Prince Vladimir I. Attention will also be given to a jealous and rivalrous Roman papacy and its attempt to halt Byzantine prestige and establish Latin jurisdiction in Central and Southeast Europe. The positive contributions of such individuals as Patriarch Photios, Constantine-Cyril, Methodios, Clement, Michael III, and Boris-Michael will be discussed in terms of their efforts to promote and facilitate an Eastern European Byzantine Cultural Commonwealth whose legacy was preserved long after the Turkish Conquest.

## BYZANTINE MISSIONARY CONTRIBUTIONS

A trip to Constantinople (or Istanbul, depending on one's belief) today would reveal very few indications of a great Christian capital, and the center of Eastern Orthodox teaching some 500 years ago. Emperor Justinian's Hagia Sophia, the core of Eastern Christianity, has long ceased to be a church, and though a museum today, it was converted into a mosque upon the Turkish sack in 1453. Without a

trained eye, the tourist would not be able to discern what is Byzantine, and what is Turkish. However, if the tourist were to travel west into Greece, north into Bulgaria, or northeast into Russia, evidence of a once great empire is openly displayed through architecture, religion, politics, law, and culture passed on by this long-gone age of Byzantium. George Ostrogorsky is correct when he says that Byzantine culture, in its heyday, had a great power of radiation.<sup>1</sup>

During much of its reign, the Eastern Roman Empire embraced much of the Mediterranean world and penetrated deep into the European continent. Especially during the second half of the ninth century, we can see that one of the most remarkable advances of Byzantine cultural penetration was demonstrated through intense missionary activity to the Slavic peoples.

The Byzantine Empire was regarded as the repository of civilization to the barbarian periphery. In the eyes of the East Romans, the gift of Christianity offered an introduction to an advanced life. Thus the converts integrated into the civilized *oecumene*, when the Byzantine administrative system was introduced to these emerging societies. This integration combined the best from the world of Byzantium, with the world of Slavic native heritage.

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The Byzantine missions to the Slavs are primarily associated with what many historians relate to as “Cyrillo-Methodian ideology.”<sup>2</sup> It is named after the two brothers who served as the forerunning missionaries to the Slavs, and is characterized by the translation of the Scriptures and liturgies from Greek into the vernacular Slavonic. This principle remained the distinctive characteristic of Orthodox missionary activities, as opposed to the West, which advocated only Latin as the accepted ecclesiastical language along with the traditional Greek and Hebrew. Constantine-Cyril and Methodius instead stressed that the people of various regions throughout Europe, North Africa, and Asia Minor praise God in their own language, in order to understand the Scripture. With this rule in mind, it is safe to claim that the Slavic peoples, through conversion to Byzantine Christianity, received religion and civilization from an imperial Christian power, while retaining most of their cultural heritage from ages past.

The main centers of Byzantine missionary activities begin in Moravia, a Slavic principality that gained prominence after the destruction of the Avar nation at the hands of Charlemagne. Next, we see the direct influence of Byzantine religion and secular policies successfully fused in Bulgaria under the reign of Boris I (852-89), and later under his son Symeon (893-27). Bulgaria served as the first permanent foundation of Slavic Christianity from Constantinople. Its theological seminaries were to radiate their influence into Serbia, Wallachia, Moldavia, and most importantly in 988 to Kievan Russia, arguably regarded as the heir of the Byzantine tradition after 1453. It is the three main areas of focus—Moravia, Bulgaria, and Kievan Russia—that this paper will target. Starting from the missionary works in Ratislav’s Moravia in 864, we can see the transition of Byzantine theology and government from Greek into Slavonic through the next hundred years, ending with the conversion of Vladimir’s Russia in 989. Its legacy was to remain in Eastern Europe long after

the Cross was substituted for the Crescent in Constantinople.

Beginning in the late ninth and early tenth centuries, Byzantium lost control of the Balkans after the Slavic migrations. Those Slavs that dwelled within the territories gradually reoccupied by the Byzantines became relatively Hellenized over time, and lost their Slavic roots. Those that remained outside of the direct control of Byzantium developed into independent Slavic states or joined the already existing Bulgar state. Partial reoccupation of the Balkans by the Byzantines during the Iconoclastic period demonstrated the Empire’s vitality, and created conditions for the eventual re-Hellenization of the region, as well as providing a solid foundation for the Empire’s activities beyond its borders. By encircling the outside lands with Imperial themes, and strengthening the position of bordering cities, like Thessalonika, the home of Constantine-Cyril and Methodius, Byzantium began to reassert its power, and vigorously spread its influence over the Balkan states.

But we must also be aware that at this time, almost all the Balkan lands, including the much coveted Illyricum, remained under papal jurisdiction until the beginning of the Iconoclastic Age, in the middle of the eighth century. It was only after the Iconoclastic period that the vital changes were made. The Byzantine Empire reclaimed the Hellenized regions of Southern Italy and the Balkans, after Pope Steven V recognized Pepin the Short in 751. The reclamation culminated in 800 with the crowning of Charlemagne by Pope Leo III, as emperor in the West. Therefore, the Balkan Peninsula, originally under the jurisdiction of Rome, fell, during the Iconoclastic period, together with the southern Italian regions, under the authority of Constantinople. As a result, the new lands, now under the Greek church, reached areas outside the political boundaries of the Empire. This was to prove its worth in the post-Iconoclastic period when the wave of religious missionary works began in Moravia.

The *Vita Constantini* mentions that ninth century Moravia saw the presence of Latin, Greek, and German missionaries. German priests, however, had done most of the work, since Moravia was under ecclesiastical jurisdiction of the Archbishop of Salzburg. The church services were in Latin, and therefore unintelligible to the masses, since the Slavic tongue had no written language. Joan Hussey states that even if there were an existing Slavic script, it would have been deemed impermissible for any liturgical work to be written in anything but Latin, Greek, and Hebrew<sup>3</sup>. Nevertheless, in 862, Ratislav, finding no satisfaction in his requests to the papacy for a bishop, sent envoys to Emperor Michael III in Constantinople, asking him for “a teacher capable of instructing us in the true Christian faith in our language.”<sup>4</sup> In addition, an alliance with Byzantium would be profitable, in response to an expanding Bulgaria and the ambitions of the Franks. Answering Ratislav’s request, Michael dispatched two missionaries, Constantine-Cyril and Methodius, to Moravia from 864-867.

Constantine-Cyril and Methodius were two of the Byzantine Empire’s most remarkable personalities. As philosophers and theologians, they were well versed in all secular and theological knowledge of the day. They were also men typical of the Byzantine-Slav relation of the Balkans, coming from Thessalonika, the most important city on the border of the Byzantine and Slav world. They began preaching and instructing the Moravian clergy in 864, and set up a seminary for native clergymen. The Scriptures and Service Books were translated into the vernacular, and an alphabet, to use for further translations, was invented. Called Glagolthic, it was believed to have been based on Greek minuscule and the Slavic tongue spoken in Constantine’s native Macedonia. This suggests that the Slavic books brought to Moravia were probably written for Slavs of the Thessaly and Peloponnesus provinces, rather than primarily for the Moravians.<sup>5</sup> Glagolthic was the

proto-alphabet that was to eventually become Cyrillic, associated with the Bulgarian, Serbian, and Russian languages and scripts of today. The primary reason for the new alphabet was to present a language that was *not* related to Greek, and so give the Slavic churches a sense of national identity apart from the Franks and the Latins.<sup>6</sup>

Naturally, the Frankish Church was to resist the teaching of the Scriptures in Slavic on the basis that it was a tongue foreign to the Latin and Gothic speaking Franks. Furthermore, to honor Slavonic would hurt the Frankish racial pride. However, unlike Ratislav, his successors favored Latin over Slavonic, as a chance to ascend the social levels of Frankish civilization, and please the German priests who argued that the only lawful liturgical languages were Hebrew, Greek, and Latin, the languages used on the inscriptions on the Cross. When the Frankish clergy in Rome accosted Constantine about the linguistic issue, Constantine responded by noting all the peoples north and east of the Black Sea to have liturgies in their own languages. The *Vita Constantini* provides an excellent response to this demand; it justifies the entire missionary activity of Byzantium to the Slavs: “We [Byzantines] know of many peoples who have books and who give praise to God each in its own tongue. Such peoples, it is known, are the Armenians, the Persians, . . . the Khazars, the Arabs, the Egyptians, the Syrians, and many more.”<sup>7</sup> Constantine recites Biblical passages, which defend his actions in Moravia, and call for singing praises to God in every language: “All the world worships the Christian God, therefore, let every nation praise Him in its respective language . . . in church I would rather speak five words with my mind, in order to instruct others, than ten thousand words in a [foreign] tongue.”<sup>8</sup>

The Franks wished the Moravians to remain in the Latin-speaking church, under the jurisdiction of the Archbishop of Salzburg, the spiritual head of the Frankish Church in Central Europe. In actuality, they feared that the introduction of Slavonic into Moravian liturgies



would give the people enough of an independent identity that they would reject Frankish domination, side with the Byzantines, or establish a separate sovereign state. Frankish activities in Central Europe would then be seriously weakened. It would then appear that this issue of linguistics, presented by the Germans to Constantine, was more political than ecclesiastical, since they wished the Moravians to be allied to the Carolingians.

After the death of Constantine-Cyril in February 869, Pope Hadrian II, in full support of Methodius' return to Moravia, chose a third option. He was hoping that if the Slavic churches of Moravia and Croatia could be strongly established under Roman jurisdiction, the Serbs and then the Bulgarians could also be drawn away from the Greek episcopate. He failed, however, to reckon with the Franks, who in 871, under the reign of the Moravian Svjatopulk, handed Methodius over to the Archbishop of Salzburg and incarcerated him for two years. By the time of his release, the new pope, John VIII, was against the patronage of the Slavic language in Moravia. At this point, a Frankish alliance was favored to counter the invading Huns and Saracens. It seemed more important now for the papacy to appease Germans than convert Slavs. The Moravian mission was an ecclesiastical failure for Byzantium, and by the reign of Steven V, all Slavic-speaking clergymen were expelled from Moravia.

When Methodius returned to Constantinople in 882, he was greeted warmly by Patriarch Photius, who gave him a gift of Slavonic books to be used to train Greek priests in the way of the Slavonic culture for future missionary activities. This seminary in Constantinople was one of Photius' most important contributions to efforts of the Slavic missions, and after 864, it became a refuge of Slavic priests expelled from Moravia. This seminary was to be the springboard for the next campaign, Bulgaria, which became, after the conversion of Boris I, the new promised land for pupils of Methodius to continue the work of their teacher.

Racially, the Bulgars are a Turkic people, who invaded and conquered the land inhabited by the Slavs on the Danube border. Between the seventh and ninth centuries however, they became absorbed into the Slavic population, and completely assimilated themselves in language, customs, and local institutions.

Anyone familiar with the ecclesiastical policies of Pope Nicholas I (858-67) will understand his anxiety over Bulgaria, a young and vigorous nation that occupied a part of Illyricum, a province reclaimed by Constantinople from Rome during the Iconoclastic Age. Its inhabitants were still pagans, but their conversion was inevitable. Again, papal anxieties about the conversion of the Slavs to the Latin Church returned. Had the Pope's plans succeeded, not only would the Bulgarians be converted to Roman Christianity, on the very threshold of Constantinople, but the Latin Church would have won the claim to Illyricum, a similar victory the papacy achieved with the Moravian mission. The Latins would then be in a favorable position to put any further Greek and Frankish missionary works in the Balkans in check.

The Bulgars, under Boris I, began to be interested in Christianity around 862, the same time that Ratislav of Moravia began to search for a Slavic-speaking clergy. But Bulgaria sided with the Franks against the Moravian bid for a Byzantine-based church. The Byzantine Empire saw this as a threat to their security on the northern frontier. An enemy on the threshold of the Empire was to be avoided at all costs. Under Michael III, the Empire invaded and defeated Bulgaria. The terms presented to Boris were as follows: 1) Baptism is under the Byzantine Church, 2) ecclesiastical obedience to Constantinople, and 3) withdrawal of alliances with Louis the Frank. In 864, Boris was baptized and took Michael III as his godfather. Bulgaria submitted to the Byzantine Church, but efforts to Christianize the Bulgars were not to be the same as in Moravia. Missionary activities were



not simply the teaching of the Scriptures in Slavonic to local clergymen. The Patriarchate of Constantinople wanted Bulgaria directly under their jurisdiction. An independent church, so close to the Byzantine border, was deemed impermissible.

Greek clergy poured into Bulgaria. When Boris wrote a letter to Photius to request a bishop to administer to a Bulgarian Church, the Patriarch declined, and instead explained the faith of the church, by reference to the Nicene Creed and the Seven Ecumenical Councils. Seeing his prospects for a Slavic bishop halted by Byzantium, his gaze again shifted West, and in 866 his ambassadors were in an audience with Pope Nicholas I. In addition to his request for a bishop from the papacy, he sent a list of 106 questions relating to social and religious obligations, which were part of accepting Christianity. The Pope sent two bishops, Paul of Populonia (bishop 861-77) and Formosus of Porto (bishop 864-76), along with the *Responsa ad Bulgaros*, the answers to the 106 questions. But like Photius, Nicholas too had plans for direct ecclesiastic control of the Bulgarians. Their orders were to attach Bulgaria to the Latin Church. In the *Responsa*, Nicholas answered all the questions asked by Boris, like what foods were to be abstained from during periods of fasting, whether it was still permissible to wear turbans, and whether men could still wear trousers. He also insisted that the Church, being occupied by the Roman See, shifted Constantinople back to the fourth place in the Pillars of the Patriarchates that included Rome, Constantinople, Alexandria, Antioch, and Jerusalem. In addition, a number of Greek customs were condemned, and when a set of laws was requested, the Collection of Lombard Laws was sent instead of the Justinianic Code.<sup>9</sup>

The question of whether Boris would eventually side with Rome or Constantinople was of the utmost importance for Nicholas. Previously concerned with lands within their own interests, Bulgaria became the rift that led competition between East and West

to a serious tone. The news of Boris' defection to the West sent a shockwave through the courts at Constantinople. He was well prepared for such a move, for his armies, already recovered from their defeat in 864, were stationed on the Bulgar-Byzantine border. In addition, the bulk of the Byzantine army was away at Crete, fighting the Arabs. If war and diplomacy were out of the question, the only feasible solution left would be to play the Latins at their own shrewd game—and the Byzantines were masters at being shrewd. George Every reports that the Greek missionaries expelled from Bulgaria complained about "suspicious" doctrines made by the Franks. For instance, the Franks allowed the Bulgarians to eat cheese during Lent, a sign of blasphemy to the Greeks. Secondly, Every explains Frankish behavior to be like Manichaeans since they forbade priests to marry. What was worst of all, the Franks were teaching that the Holy Ghost proceeded from the Father and the Son. Thus arose the much written *filioque* controversy, and the Photian Schism between Rome and Constantinople. This led in 867 to the first serious rift between East and West. The papacy, eager to extend Latin control into the Balkans, tried to force Byzantium to restore Roman jurisdiction over southern Italy and Illyricum through its emphasis on Bulgaria. Photius countered Latin claims by accusing them of deviation from the Nicene doctrines, with the addition of the word *filioque* to the Creed. This clear deviation from the Nicene Creed demanded action.<sup>10</sup>

A synod was summoned, and the ruling decrees were taken back to the legates, condemning these "false doctrines." Unable to accept the synod's decrees, the legates had no other choice but to return, along with the letters from Rome, to the Bulgarians. Rome's hopes of establishing a Latin dominated Balkans were crushed.

These details may seem petty to the historian today, but Dvornik points out that they should be viewed in the setting of two documents: Photius' encyclical letter to the

Eastern bishops condemning the West, and Nicholas' letter to Hincmar, Archbishop of Rheims, condemning the East. Photius' tone explains the severity of the wound the papacy inflicted on the national pride of the Byzantine people. To have the papacy set foot in the Balkans was a threat to Byzantine security. Nicholas's way of thinking allowed no compromise with the Empire. On the other hand, Nicholas never understood how vital Bulgaria was to Byzantine security, and could not understand the strong Greek reaction to his actions in the Balkans. He did see that this political rift could easily spill over into issues of dogma and further deteriorate relations with Byzantium.<sup>11</sup>

Dvornik, in his work *The Photian Schism*, claims that as long as the Bulgarians were administered by Greek clergy and remained culturally dependent on Constantinople, the danger to Byzantium of a Bulgarian Empire rising at its gates could easily be dealt with. Nevertheless, Byzantium could never tolerate the proximity of a Bulgaria drifting under the cultural influence of the Franks and the spiritual administrations of a Latin and Frankish clergy.<sup>12</sup>

The fundamental problems facing King Boris, on adopting Christianity as the state religion in 865, was that loyalty ultimately led to the emperor and patriarch in Constantinople. In addition, Rome wanted Bulgaria to serve as an outpost against the rival Greeks, as well as for ecclesiastic control of the Balkans. Boris wanted an independent church under his authority, as the only means of maintaining a viable Bulgarian state against an expanding Byzantine empire to the south and an ambitious papacy to the west. The clergy in Bulgaria spoke only Greek, a language alien to the Slavic peasants. Without understanding what the clergy was preaching, the population was no better off than when they were worshipping Perun, the Slavic pagan thunder god. Therefore, according to Browning, was it possible to enjoy the advantages of Christianity without falling under the political sway of the

Empire, and without allowing an ideology centered on Byzantium to determine the attitudes and values of Bulgarian society? Was it possible to have a Bulgarian Church, spoken in Slavic, as did the Moravians? This was a main concern for the Slavic kingdom since it was situated on the threshold of the Byzantine world, and, unlike the cases of Moravia, and later, Russia, would be directly influenced by anything permeating out of the Bosphorus.<sup>13</sup>

In 885 and 886, a group of pupils of Methodius arrived in Bulgaria, after their expulsion from Moravia. Boris welcomed this opportunity to form in his kingdom a Slavonic Church, whose clergy were native, Slavic-speaking Bulgarians, and whose ties to Constantinople would be close enough for guidance, but distant enough to avoid the Greek dominance in the clergy. The pupils, led by Clement and Naum, were warmly welcomed into Preslav by Boris, and sent to work immediately on translating the Greek Scriptures. Their first task was a rapid training of Slavonic-speaking clergy and the copying of Slavonic liturgical books. This task was given high priority by Boris, who quickly sought to replace the Greek, spoken by the clergy within his borders, with Slavonic. The alphabet provided by Constantine-Cyril, the Glagolthic, was deemed too cumbersome and unacceptable to those who could already read Greek. Though it continued to be used in Macedonia, in eastern Bulgaria it was modified into a new alphabet, Cyrillic, named after its inventor, around 893, an alphabet slightly based on Greek speaking principles. Whether this task was completed under Boris or under his son Symeon is unknown. How the translations from Glagolthic to Cyrillic were concluded is also a mystery. We can only assume, if Browning is correct, that Symeon had enough powerful patronage to find a solution. Other than that assumption, Browning has no further evidence. What we do know, is that the main centers of literary translations were at Preslav and Ohrid. The Bible, the three Liturgies of John Chrysostom, Basil, and

Gregory the Great were already translated by Cyril and Methodius. Other liturgical books, like the *Euchologian*, *Gospel Readings*, *Praxapostolos*, *Pasalter*, *Horologian*, *Triodion*, *Pentekostarion*, *Okoechos*, *Menologies*, etc. were all translated word for word in Bulgaria.<sup>14</sup> Browning further explains that the adoption of the Slavonic language for liturgical and literary use ended any remaining antagonism between old Bulgar and Slavic linguistics. It quickly led to the development of a native literate class and facilitated cultural growth within the Bulgarian state.

Though not too much focus should be given to a history of Bulgaria alone, it is interesting to note, that after the acculturation of Bulgaria to Christendom, no attempts were made to preserve any writings or legends from the pre-Christian, proto-Bulgar ages. Other than the *List of Princes*, nothing seems to have survived pagan Bulgaria. The Bulgars, according to Browning, took over the Byzantine picture of the ready-made past. By doing this, Christian elements were adopted to the word. The Hellenistic elements, however, were never successfully incorporated. That was foreign to the simple Bulgars and of no use in the new Bulgarian city of Preslav. What the Bulgarians did do, however, was create their own Christian legends, similar to those of the Greeks, by recognizing local Slavic saints in various parts of their kingdom.<sup>15</sup>

Bulgaria thus saved the legacy of Cyril and Methodius to the Slavs. Long before John Tornikios founded the Holy Monastery on Mount Athos in 979, Slavic Christian and cultural centers flourished in places like Preslav and Ohrid. Had Boris refused protection of the expelled disciples of Methodius, the Moravian mission would have been a mere episode in the annals of history, and never would have assumed the importance given to it today. As stated by Browning, "it was the reflection of the Byzantine civilization in Bulgaria that served as the model for the medieval Serbian kingdom, as well as Kievan and Muscovite Russia. It was through

the relation of Byzantium and Bulgaria that the Orthodox Slavic world was found."<sup>16</sup>

During his seven year activity at Kutmichevista, Clement gained up to 3,500 disciples who were sent to their posts in the Slavic world as readers, subdeacons, deacons, and priests. This is where the legacy of St. Cyril and Methodius was successfully transplanted from Moravia throughout Eastern Europe. Clement himself was appointed bishop upon the ascension of Symeon in 893. His legacy to the Slavs can be compared to St. Paul's legacy to the Corinthians.<sup>17</sup>

The Serbians were the first people to be influenced by Slavic Christianity radiating from Bulgaria. Partial conversions as early as under Emperor Heraclius had no lasting effects, but once the Arab siege at Dubrovnik had been lifted by the Byzantine fleet and Nikephoros Phokas in 867, and Byzantine authority was reestablished on the Dalmatian coast after the Photian Schism, Christianity fully penetrated the Southern Slavic peoples. It continued to grow in Serbia under Symeon, whose supremacy had been recognized by the Serbian prince Mutimir.<sup>18</sup>

Serbia was controlled for another three centuries either by the Bulgarians or the Byzantines, the founders of an independent Christian Serbian state Stefan Nemanja (1151-95). Like Boris I of Bulgaria, his son continued the prospect of creating a church in Serbia. His son, Ratsko, became the patron saint of Serbia, and received the name Sava as a monk. In 1217, he was consecrated by Constantinople as Archbishop of Serbia. In 1222, he crowned his brother, Stefan, as King of the Serbs. His feast day is a national holiday in Serbia, celebrated since 1595, when his relics were burned by the Turks in an attempt to stamp out Serbian patriotism.<sup>19</sup> Serbia was the first state to be influenced by Slavic Christianity from the Byzantine missions in Bulgaria, but the greatest pupil of Byzantine culture was still to come.

In 860, a new enemy, the Russians, threatened Constantinople. Though they were repeatedly pushed back into the steppe

regions, the shock was felt among the leaders of the Empire. The immediate result was to dispatch a large embassy to the court of Russia's rival neighbors, the Khazars. The Khazars and the Byzantines had cooperated previously in repelling Arab advances, and now the offer was for help in containing the Russians. More significant than the diplomacy toward the Khazars was the proposal by Patriarch Photius of converting Russia to Christianity, so as to control its churches, and ultimately its politics, as had originally been the case in Bulgaria. Clearly, Photius was an advocate of a Byzantine commonwealth.

By the tenth century, Slavic missionaries had penetrated into Russia and earned some converts, though the rulers stubbornly clung to pagan practices until the 950s. It was then that Princess Olga, credited for a rudimentary tax collecting administration, accepted baptism, and visited Byzantium.<sup>20</sup> But when it came to setting up a state church, she initially turned to the German Franks. In 959 she requested Otto I to send missionaries to Russia, but they arrived only 10 years later in the form of a common bishop, whose conditions for allegiance were no better than the Byzantines'. By that time however, most of Russia had relapsed into paganism.

Olga is credited as the first Russian leader to embrace Christianity, though it was only under her grandson, Vladimir, that the Christian faith was fully accepted into Russia. He dispatched envoys throughout Europe and Asia Minor to observe the different religions that were practiced, and report back to him. Upon returning to Kiev, the envoys were requested by Vladimir to report on their observations of religion in the surrounding lands.

When we journeyed among the Bulgarians, we beheld how they worship in their temple, called a mosque, while they stand ungirt... Their religion is no good. Then we went among the Germans, and saw them performing many ceremonies in their temples; but we beheld no glory there. Then we went

on to Greece, and the Greeks led us to the edifices where they worship their God, and we knew not whether we were in heaven or on earth. For on earth, there is no such splendor, or such beauty, and we are at a loss how to describe it. We only know that God dwells there among men, and their service is fairer than the ceremonies of other nations.<sup>21</sup>

Along with the reports of his envoys, Vladimir was told,

If the Greek faith were evil, it would not have been adopted by your grandmother Olga, who is wiser than all other men.<sup>22</sup>

As Nicholas Zernov states, the love of beauty, as had been described by Vladimir's envoys, has been one of the chief characteristics of Russian Christianity. Indeed, the Russian word for "Orthodoxy" is *Pravoslavie* which means true glory or right worship.<sup>23</sup>

The conversion of the Russians could not have come at a better time for the Empire, beleaguered by internal conflicts for the imperial throne. The Emperor Basil II's claim to power was challenged by Bardas Sclerus, brother-in-law of the late emperor John Tzimiskes, and by Bardas Phokas, nephew of the assassinated Nikephorus Phokas. Though Basil was a brilliant tactician, only external aid could save his throne. Ostrogorsky states that this is when he turned to Vladimir of Russia, who promised to send aid of 6,000 hand-picked soldiers, known as the Varangian Guard.<sup>24</sup> With the help of Vladimir, the revolt was crushed, and Basil II retained the throne. The Varangian guard remained in Constantinople as the emperors' elite shock troops, up to the fall of the Empire in 1453.

As a reward for his aid at the eleventh hour, Vladimir was promised Anna, sister of Basil II, a Porphyrogenita, as his wife, on the condition that he and his people receive baptism in the Greek Church. This was a great concession, for no Byzantine princess born in the purple had ever married a barbarian. Not even Symeon, the educated Christian

Bulgar leader that he was, ever received such a prize from Romanus I, but had to settle for marrying one of his daughters to the young Constantine VII. Russia alone was given the honor of becoming related by marriage to the legitimate imperial house. Such a marriage created wide controversy among the Byzantine elites, as well as inflicting a blow to Byzantine self-esteem: A Porphyrogenita married to a barbarian was deemed outrageous. Many felt that once the danger to the throne was lifted, this promise to Vladimir should be aborted. If Basil II ever had any notions of going back on his word, Vladimir did not. To show his determination to marry into the Byzantine imperial family, he felt it necessary to conduct raids on the Byzantine town of Cherson, on the Crimea.

Thus Basil kept his promise. Vladimir was baptized at Cherson in 988, and married Anna, sister of the Emperor Basil II. In return, the Empire was provided with valuable manpower from Russia. Upon returning to Russia, he ordered the destruction of all pagan monuments and temples. "He had Perún [Slavic god of thunder] thrown down, beaten with clubs, dragged at the horse's tail, and thrown into the Dnieper."<sup>25</sup>

The conversion of the Russians marked the greatest diplomatic triumph for Byzantium since the days of Heraclius' victory over the Persians. With the conversion of the largest and most promising Slavic peoples, the Byzantine sphere of influence expanded to an extent undreamed of by either the Greeks, the Franks, or the Latins. The new Russian Church was to be subordinate to Constantinople, and receive initial developmental growth from the Greeks for another two centuries.

Further, when the Russians converted in 988, it would be logical to assume that the missionaries also brought the official code of law in Byzantium. This was the handbook called *Prochieron*, published in the second half of the ninth century under Basil I to replace the *Ecloga*, a handbook of laws compiled under the iconoclastic emperors Leo III and his son

Constantine V in 740. This was, however, not the case in the Slavic countries. Dvornik states that it was the *Ecloga* that was presented to all the Slavic states, from Moravia to Russia, Christianized by Byzantium.

He points to evidence of this claim by explaining that the first Slavonic code of laws passed were called *Zakon sudnyi ljudem* (Juridical Law for Laymen). Studies of these sets of laws have indicated a similarity with the language used by the Byzantine missionaries Cyril and Methodius for the conversions in Moravia in 863. It contains words and expressions that would only have been known in Moravia in the ninth century, and were misunderstood by Russian scribes, who nevertheless copied the document word for word in Kiev in the tenth century. This then points to the conclusion that Ratislav sent not only for missionaries from Byzantium, but also for a set of coded laws to use for an independent Moravian state. The Emperor Michael III thus sent him the *Ecloga*, still in use in Constantinople, for the *Prochieron* had not yet been written. These laws reached Russia soon after conversion by way of Bulgaria, which had direct access to Byzantium after Boris' conversion. By means of geographical location, early Greek ecclesiastic teaching and education passed on to Symeon during his days as a seminary student in Constantinople. They were brought to Boris after the disciples of Methodius were expelled from Moravia in 885. These laws came to be used with the *Russkaya Pravda* as the first codification of Russian law, originating in the eleventh century. Therefore, the *Zakon* was incorporated into the official collection of Russian law, the *Pilot's Book* (*Kormcaja knjiga*), in force from the thirteenth century, down to present times.<sup>26</sup>

The use of Slavonic in worship and in translation of the Bible facilitated the growth of Russian culture faster, according to Zernov, than their Christian counterparts in the Latin West. In other words, in the West, Latin was used strictly in ecclesiastic and administrative documents, while a local

vernacular tongue was spoken daily by the people. However, the Slavic language introduced to the Russians was used for administrative, ecclesiastic, and local speech. The vernacular and the ecclesiastic were one and the same. Thus learning was more accessible to the Slavic peasant than to his Latin counterpart in the West. This problem in the West was only solved during the Reformation, about 600 years later.<sup>27</sup>

To demonstrate how successful tenth century Byzantine cultural influence was on Russia, the harmonious relation between the mother church in Constantinople and Russia was abruptly severed with the signing of the decrees at the Council of Florence in 1439, which united the Greek church with the Latins in the West, as a defense against the invading Turks. The Greek Isidore, Greek metropolitan of Russia, signed the decree but was rejected by his flock upon his return to Kiev in 1441 for abandoning the Eastern Church, for authority from the West. When the city ultimately fell in 1453, the Russians interpreted this as God's punishment for the sins that resulted in uniting with the Latins. They now regarded themselves as the true heirs to Orthodoxy, untouched by the invading Turks.<sup>28</sup> They put the blame on the "deviousness" of Isidore and the "betrayal" of the Greeks to the Latins. "You have exchanged light for darkness," wrote one polemicist to Emperor John VIII Paleologus, "Instead of divine law, you have received the Latin faith."<sup>29</sup>

The Russians thus exemplify the greatest beneficiaries of this tradition of Byzantine cultural influence. Following the conversion in 988, Christianity and the Slavic language were introduced into the Kievan state, and became a rich cornerstone of literature and culture for the Russians as a unifying force, as it did in Preslav for the Bulgarians in the turbulent years to come. This tradition helped to inspire Muscovy in its task of "gathering" the Russian lands. As Muscovy expanded, the Slavic language and culture, born in Moravia, eventually reached the shores of the Pacific Ocean.

With the Orthodox Slavic use of the Cyrillic alphabet, derived from modified Greek, the earliest traces of Byzantine musical traditions among the Slavs came with the missionary contributions of Cyril and Methodius in the second half of the ninth century. This, coupled with the conversion of the Russians a century later, provided definite proof of the close relationship between Byzantine religious practices and those of the Slavs.

Liturgical books demonstrate that the texts of the services are identical in meaning, the Slavic texts being exact translations from Greek into Old Church Slavonic. Furthermore, the very same musical notation that emerged in Byzantium in the mid-tenth century was in the eleventh century transmitted to the Slavs—more specifically to the Russians. This is amply documented and still, extant musical manuscripts of Kievan and Novgorodian provenance. We do not have to follow this process through the entire centuries to realize that the roots of Russian church music are to be found in the melodies of Byzantine origin.<sup>30</sup>

The religious vision, created when the Empire existed, still inspires millions. The calendar, formulated by the church, was the ultimate programming of life among the Balkan Christians. The seasonal and religious timetable was created by the Byzantines, and survived the Ottoman conquest virtually unscathed, ensuring Orthodox Christians a cultural homogeneity, as well as a strong tie to the Byzantine legacy.<sup>31</sup> The patronage of Mount Athos by Russian rulers further strengthened the island of Byzantine learning as a central meeting place and as a cultural clearing house of Byzantine religious, literary, and artistic traditions for the entire Orthodox world. It shaped and refined the Eastern Christian mind on its past traditions, as well as their enemies, the Muslims and the Catholics. The influence of Mount Athos after the fall of Byzantium was so great that it

stretched to encompass Asia Minor, Greece, Serbia, Bulgaria, Romania, and Russia.

Of all the nations that converted to Orthodox Christianity under the Byzantines, the only state to remain untouched by the Turks, and therefore left to grow under Byzantine missionary influence, was Russia. Hence the legacy of "Byzantium after Byzantium" is a different viewpoint to the Russians than to the Balkan peoples. Russian princes, after 988, viewed Rus' as a part of the Byzantine commonwealth, never as part of the Empire. The prestige of the Russian Church was great in that it represented the only administrative structure from the Byzantine Age, that spread across the entire Russian dominion. With this in mind, one can even say that the Byzantine Empire moved north after 1453, and the Tsars claimed the rightful duty to continue the authority of the Byzantine Emperors.

Since it was so, and since [the fall of Constantinople] had happened thus because of our sins [the Union of Florence], the lawless Mehmed seated himself on the Tsar's throne, the noblest of all [thrones] on earth, and they ruled the rulers of the two halves of the earth... But understand, O accursed ones. If all the signs concerning this city that were foretold by Methodius of Patra and Leo the Wise have come to pass, the last shall not be avoided but shall likewise have come to pass; for it is written 'the Russian race with its former founders [the Byzantines] shall conquer all the Mohammedans and shall receive the city of the Seven Hills with its formal lawful masters, and shall reign in it... Two Romes are fallen, but a third stands fast; a fourth there cannot be. Thy Christian kingdom shall not be given to another.'<sup>32</sup>

So we have now discussed the missionary contributions of the Byzantine Empire around the ninth and tenth century to four Slavic kingdoms. Each had its own reason

for Byzantine action. The Moravian missions were sent to help create an independent Moravian state that, allied with Byzantium, would have put the Franks and the Bulgars in check in Eastern and Central Europe, had the mission succeeded. The missionary activities to the Bulgarians initially were fostered to keep the papacy out of the Balkans, and maintain Greek ecclesiastic hegemony to a powerful state so close to the border. When an independent Bulgarian Church was created, Bulgaria became the first center of learning for Slavic Christianity, with centers at Preslav and Ohrid to provide a starting point for Slavic clergymen. Russia's conversion to Orthodoxy came as a result of Kievan beauty and awe of Byzantine religion, Slavic patronage from Bulgaria, as well as a political guarantee made by Basil II against his rivals. With the exchange of a Porphyrogennita for a division of elite troops for the emperor, Byzantium guaranteed Russia a place of greatness for ecclesiastical and administrative policies. Thus, when the Eastern Roman Empire fell, the Russians took it upon themselves to continue the Byzantine legacy to the Slavs. As mentioned at the beginning, one cannot go to Constantinople today to see the characteristics of a once great Christian Empire. But if one travels to Sofia, Belgrade, Mount Athos, Bucharest, and ultimately Moscow, one cannot hide the evidence of cultural and spiritual influences Byzantium had contributed to the rise of the respective nation states. The Byzantine imperial framework did not disappear with the fall of Constantinople in 1453. It rather, states Meyendorff, took different forms and flourished under monasticism, spirituality, and martyrdom.<sup>33</sup>

#### FOOTNOTES

<sup>1</sup>George Ostrogorsky, "The Byzantine Background of the Moravian Mission" p. 3.

<sup>2</sup>John Meyendorff, *Byzantine Theology* p. 29.

<sup>3</sup>J. M. Hussey, *The Orthodox Church in the Byzantine Empire* p. 96.

<sup>4</sup>*Vita Constantini* ch. XIV.

- <sup>5</sup>George Every, *The Byzantine Patriarchate 451-1204* p. 113, see also Robert Browning, *Byzantium and Bulgaria* p. 146, Steven Runciman, *The First Bulgarian Empire*, p. 398.
- <sup>6</sup>Rev. B.J. Kidd, *The Churches of Eastern Christendom* p. 158.
- <sup>7</sup>*Vita Constantini* chapter XVI.
- <sup>8</sup>*Vita Constantini* chapter XVI, Paul (I Corinthians 14:19).
- <sup>9</sup>Every, 114.
- <sup>10</sup>*Ibid* pp. 117-18 see also Deno John Geanakopolos, *Byzantium*, p. 5.
- <sup>11</sup>Francis Dvornik, *The Photian Schism* p. 119.
- <sup>12</sup>Dvornik, p. 212.
- <sup>13</sup>Robert Browning, *Byzantium and Bulgaria*, p. 56.
- <sup>14</sup>*Ibid*, 183.
- <sup>15</sup>Browning, 183.
- <sup>16</sup>Browning, 16.
- <sup>17</sup>George C. Soulis, "The Legacy of Cyril and Methodius to the Southern Slavs." p. 27.
- <sup>18</sup>Ostrogorsky, "The Byzantine Background of the Moravian Mission" p. 39.
- <sup>19</sup>Nicholas Zernov, *Eastern Christendom* p. 110. It is also interesting to note that the 400th Anniversary of St. Sava occurred in 1995 when the persecution of the Bosnian Muslims by the Orthodox Serbians began. The Serbian government does not hesitate to emphasize this.
- <sup>20</sup>Phillip Longworth, *The Makins of Eastern Europe* p. 280.
- <sup>21</sup>Deno Geanakopolos, *Byzantium*, "The Russian Primary Chronicle on Byzantine Liturgy", p. 190, from Serge A. Zenkovsky, ed., *Medieval Russia's Epics, Chronicles, and Tales*, New York, 1963.
- <sup>22</sup>*Ibid*.
- <sup>23</sup>Zernov, 112.
- <sup>24</sup>Ostrogorsky, *History of the Byzantine State* p. 304.
- <sup>25</sup>Kidd, p. 191.
- <sup>26</sup>Dvornik, "Byzantine Political Ideas in Kievan Russia" pp. 77-8.
- <sup>27</sup>Zernov, 114.
- <sup>28</sup>Meyendorff, *The Byzantine Legacy in the Orthodox Church*, p. 40.
- <sup>29</sup>Meyendorff, "Was there Ever a Third Rome?" pp. 48-9.
- <sup>30</sup>Milo Velimirovic, "Byzantine Musical Traditions among the Slavs" p. 95.
- <sup>31</sup>Spers Vryonis Jr., "The Byzantine Legacy in the Formal Cultures of the Balkan Peoples," *The Byzantine Tradition after the Fall of Constantinople* ed. John Yiannias p. 29.
- <sup>32</sup>Geanakopolos, *Byzantium, A Source Book for Russian History* p. 447.
- <sup>33</sup>John Meyendorff, *The Byzantine Legacy in the Orthodox Church* p. 251.

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# Translating “Real-Life” Spatial Experience into High Spatial Test Performance: Block Design and Quilt Design

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## ABSTRACT

The present study investigates whether intense experience in a specific spatial activity, quilting, has an effect on one's ability to perform significantly higher on spatial measures that are related to the skills used in that activity. Thirteen female quilters and 16 female non-quilters completed four spatial measures, the Differential Aptitude Test—Space Relations Scale, the Group Embedded Figures Test, the Vandenberg Mental Rotations Test, and the Wechsler Adult Intelligence Scale—Revised Block Design, as well as the Spatial Activity Participation and Demographics Questionnaire—Revised, a questionnaire which examined participants' involvement in spatial activities throughout their lives. It was predicted that the quilters would score significantly higher on those tests that assessed two-dimensional spatial ability—the GEFT and the WAIS-R. Results indicated that the quilters scored significantly higher than the non-quilters on the GEFT, the DAT, and the WAIS-R, but that quilters did not participate more in spatial activities (other than quilting-related activities) than the non-quilting sample. These results demonstrate that experiential factors do have an important role in the development of spatial skills and may help to explain the differences in spatial ability that exist between males and females.

## INTRODUCTION

Current research has focused on many of the controversial issues that surround spatial

ability including whether a difference between males and females actually does exist, and if this difference does exist, which factor or factors affect the development of spatial skills and the consequent difference in performance.

**Defining Spatial Ability.** A problem with research in spatial ability exists because of the lack of clear and specific definitions as to what constitutes spatial ability (Linn and Petersen, 1985). Because it is impossible to create a universally accepted definition, researchers consider the term “spatial ability” to be a label which defines a number of separate components. For example, Linn and Petersen (1985) have developed three distinct categories in order to describe the different facets of spatial ability. The first of these categories has been labeled *spatial perception*, the ability to discern spatial relationships despite the interference of distracting information.

The second category described has been named *mental rotations* and is the ability to transform or rotate two- or three-dimensional figures and objects mentally and to be able to visualize them accurately from different

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angles. Dentists use this spatial ability in their work when they maneuver mirrors around a patient's mouth and interpret these mirror images.

Finally, the last category identified by Linn and Petersen (1985) includes those tests, which require a subject to mentally manipulate and organize complex spatial information, called *spatial visualization*. Patchwork quilt makers make use of spatial visualization by mentally piecing together pieces of fabric in order to develop intricate patterns, while wasting the least amount of material possible.

Voyer, Voyer, and Bryden (1995) have refined Linn and Petersen's (1985) categorical definitions because they feel that they oversimplify the various forms of spatial ability. For instance, several tests contain elements of more than one of the categories provided for by Linn and Petersen (1985). They also consider the spatial visualization category to be a catchall category because it includes those tests which do not fit in neatly with either of the other two definitions. However, regardless of these definitional differences, researchers often compare the results of studies that have assessed different aspects of spatial ability and therefore often draw opposing conclusions about spatial ability, especially when analyzing differences in spatial ability between males and females (Voyer, Voyer, and Bryden, 1995).

**Sex-related Differences in Spatial Ability.** A majority of the research conducted on men's and women's spatial ability has found that men perform significantly better on spatial ability tests than women (Geary, Gilger, & Elliott-Miller, 1990; Linn & Petersen, 1985; Martino & Winner, 1995; Sanders, Soares, & D'Aquila, 1982). However, there is still much disagreement not only about the magnitude of sex differences in spatial ability, but also over whether these differences exist across all categorical definitions of spatial ability.

Research has shown that there are more consistent and larger sex differences in the mental rotation category than either the spatial perception or visualization categories.

Linn and Petersen (1985) report in their meta-analysis that significant differences between the sexes are found only in the areas of spatial perception and mental rotations, but that males and females find spatial visualization equally difficult. However, spatial ability differences between the sexes were large only for the mental rotations category, while they were smaller for the spatial perception category.

These basic findings were supported in Voyer, Voyer, and Bryden's (1995) meta-analysis, which reviewed 286 studies. Males significantly outperformed females on both the mental rotation tasks and the spatial perception tasks. As in Linn and Petersen's (1985) review, a significant difference between men and women's performance on spatial visualization was not found. These consistent results indicate that the greatest difference between males and females in terms of spatial ability lies in those tests, which evaluate mental rotations as opposed to spatial perception or visualization.

**Explanations for Sex Differences in Spatial Ability.** In order to account for the differences that exist both between men and women and across different types of spatial tasks, researchers have developed a number of explanations including biological and social theories, as well as theories which take into account both biological and social factors. Purely biological explanations have been attacked because of the inconsistent and unreliable reports of differences between the sexes in spatial abilities and because spatial differences between the sexes can often be eradicated or explained when participants' confidence levels are taken into account, when tests are not timed, and when participants are given training on how to manipulate objects spatially or allowed to practice spatial manipulation (Baenninger & Newcombe, 1989; Connor, Shackman, & Serbin, 1978; Duesbury & O'Neil, 1996; Goldstein, Haldane, & Mitchell, 1990).

A recent study conducted by McClearn et al. (1997) provides even more criticism for these purely biological explanations. The

influence of both genes and environmental factors was analyzed in the results of various cognitive tests taken by 110 identical twin pairs. Participants were tested in general cognitive ability, verbal ability, spatial ability, speed of processing, and memory. In all of these tests, the variance in ability was due to both environmental factors and biological factors. In fact, shared and nonshared environmental factors accounted for a total of approximately 58% of the variance for spatial ability between the twins, while heritability accounted for only approximately 32%. Given the results of this study, it is evident that environmental factors in spatial abilities need to be examined.

**Environmental and Social Explanations for Sex Differences in Spatial Ability.** Sherman's (1974) hypothesis states that instead of looking towards purely biological theories to explain spatial ability sex differences, one should look to experiential factors. His theory states that differences in spatial ability can be attributed to the fact that girls generally play with one set of toys that do not enhance spatial performance while boys play with a different set of toys that helps to contribute to spatial ability. Consequently, if both men and women were engaged in more activities that promoted spatial ability throughout their lifetimes, their spatial performance would be enhanced.

In a meta-analysis, Baenninger and Newcombe (1989) investigate Sherman's (1974) assertion that females have less spatial experience than males. Evidence indicates that there is a difference in involvement in spatial activities at an early age between the sexes. Boys are more likely to be involved in athletics and are more likely to play with toys that have spatial, mathematical, or scientific components than girls, such as building models or playing with chemistry sets. Boys are also more likely to take classes in school in mathematics and science, therefore being exposed to geometrical shapes and problems.

Tracy (1987) also conducted a study in order to examine, among other factors,

whether children's toy playing habits were related to the sex of the child and whether some children's toys fostered the development of spatial abilities more than others did. Their findings indicate that toys and games are sex-typed and that boys and girls are encouraged from a young age to play with those toys that are specific to their sex. Girls with masculine characteristics and all boys were also more likely to play with toys that promote spatial development by the manipulation of their parts through space, such as with cars and Erector sets.

These results are supported by Signorella, Jamison, and Krupa's (1989) research on the relationship between one's self-reported stereotypical masculine and feminine characteristics (as indicated by the Bem Sex Role Inventory (Bem, 1974)), one's participation in sex-typed activities and one's performance on spatial measures. These researchers found that those participants (both males and females) who rated high in masculine personality traits were more likely to take part in masculine activities and performed significantly higher on spatial measures. Conversely, those participants (males and females) who rated high in feminine traits were more likely to take part in feminine spatial activities and score significantly lower on spatial measures. The results of this study provide support for an environmental explanation of sex differences in spatial ability because masculine women received higher scores on spatial measures than feminine women.

**Effects of Training on Spatial Ability Performance.** If males and females have the opportunity to receive training or practice in a particular task, their performance on spatial ability tasks improves. In 1996, Duesbury and O'Neil conducted a study to determine whether one's ability to visualize three-dimensional objects would be improved after intensive training in manipulating both two- and three-dimensional images. Participants in treatment groups were given training in either rotational or nonrotation visualization. In the former, participants were able to

watch the changes in three-dimensional objects as they were rotated in all directions, and they were able to see what a three-dimensional object would look like as a two-dimensional object and vice versa. On the other hand, subjects who were in the nonrotation visualization treatment group could only see the different sides of a three-dimensional object in two-dimensions, but could not rotate the object from a three-dimensional view into a two-dimensional view.

Results indicated that those subjects who had received training in the rotation treatment group scored significantly higher than those subjects in the nonrotation and control groups on two out of the four tests which measured three-dimensional spatial ability. Subjects in the nonrotation group also scored higher, but not significantly higher, than those participants in the control group. These results support the theory that practice, especially practice that allows subjects see how a two-dimensional figure is related to a three-dimensional figure, will improve spatial ability. These results also coincide with Baenninger and Newcombe's (1989) meta-analysis, which concluded that not only did spatial test scores increase after training, but they increased more when the training was specific to the spatial test.

Connor, Shackman, and Serbin (1978) found results to support the claim that training improves spatial test scores and can attenuate differences in spatial scores between the sexes as well. Fifty-two boys and 41 girls in first grade were assigned to either a training or control group and were given a pretest and posttest on the Children's Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971). In comparing the posttest scores of the training and control group, it was found that children who had undergone training scored significantly higher than the children in the control group, regardless of sex. Within the training group, all of the children's posttest scores were significantly higher than their pretest scores. It was also noted that while boys scored higher than the girls on the ini-

tial pretest, the girls benefited more from the training, actually receiving scores which exceeded the scores of the boys on the posttest, but not significantly.

#### **Effects of Spatial Activity Involvement on Spatial Ability Performance.**

Baenninger and Newcombe's (1989) meta-analysis examined whether involvement in spatial activity was related to high performance on spatial measures. They found that there was a small but significant relationship between one's participation in spatial activities throughout childhood and adulthood and performance on spatial tests for both males and females. Newcombe, Bandura, and Taylor (1983) conducted an empirical study to determine whether there was a correlation between a spatial activities questionnaire that they constructed and scores on the Differential Aptitude Test (DAT). Twenty-two males and 23 females completed the 81 item questionnaire and the DAT. A significant correlation was found, indicating that those participants who had more experience in spatial activities scored higher on the DAT.

In 1993, a study was conducted by Talbot and Haude to determine whether experience in a particular spatial activity would increase one's aptitude in mental rotation. They investigated the impact of American Sign Language (ASL) in 49 hearing and two hearing impaired women on their performance on the MRT. Signing is considered a spatial activity, particularly when fingerspelling is employed. Fingerspelling is used when discussing proper names and when using words that do not have a sign. In order to fingerspell or interpret fingerspelling, one needs to be able to recognize the rapidly and subtly changing patterns that one's finger are making. The subjects in this study were split into three groups based on their experience and skill in ASL. While the first two groups were quite similar in their experience and skill in ASL, the third group consisted of women who had a great deal of experience. Results indicated that while there was no sig-

nificant difference between the first two groups in their performance on the MRT, the third group scored significantly higher on the MRT than both of the other two groups.

Although the results of Talbot and Haude's (1993) study and the results of Newcombe, Bandura, and Taylor's (1983) study indicate that experience in a large number of spatial activities or experience in a particular activity can translate into high spatial test performance, these studies do not address a correlational problem. While one's performance on a spatial measure may upon initial examination seem to be directly related to the amount of experience that the participant had in activities that have a spatial component, a researcher must consider the fact that those people who receive high scores on spatial measures may be drawn to participate in activities that have a spatial component because of a genetic factor.

This introduces development of the "bent twig" theory, a theory which takes into account both biological and environmental factors in the development of spatial ability.

**"Bent Twig" Explanation for Sex Differences in Spatial Ability.** Sherman's (1978) "bent twig" theory incorporates both biological and experiential approaches to explain the difference in spatial ability between males and females. This explanation states that boys are more likely to enter into activities and hobbies that have spatial components because of a biological predisposition for spatial ability. Furthermore, their continuous involvement in the spatial activities or hobbies sharpens their spatial skills, increasing the difference in spatial ability between the sexes. Therefore, it is the genetic factor combined with the experience in spatial activities which leads to men's higher performance on spatial measures.

Casey and Brabeck (1990) investigated this theory by comparing the spatial ability of a group of women who had both the genetic makeup as described by Annett (1985) and high spatial activity experience with the ability of women who either had only one of

these components or none at all. This study found that the women participants who had the specific genetic makeup and experience in spatial activities scored significantly higher on a spatial measure than all of the other groups of women, lending support to the bent twig theory.

The present study was conducted in order to determine the role of experience in the development of specific spatial skills as opposed to generalized superior spatial ability, therefore addressing the correlational problem. The target population of this study was a group of female quilters because quilting is an activity that is female sex-typed and requires a great deal of specific two-dimensional spatial skills in order to visualize the quilt patterns out of the pieces of material. The quilters and the normal population will be administered four measures of spatial ability—the DAT Space Relations Scale, the GEFT, the MRT, and the WAIS-R Block Design Subtest—and a questionnaire which assesses the participants' involvement in various spatial activities during childhood and adulthood. It is hypothesized that the quilters will score significantly higher on the WAIS-R Block Design Subtest and the GEFT than the normal population, but that no such difference will be found on the MRT or the DAT Space Relations Scale. This is because the former two tests assess the two-dimensional skill that is fostered in quilting. While the WAIS-R Block Design Subtest assesses a specific spatial skill which closely resembles the skill needed to construct quilt patterns, the GEFT tests one's ability to pick out specific patterns in a larger complex figure. The MRT and the DAT Space Relations Scale, on the other hand, are spatial measures which assess three-dimensional spatial ability and focus on folding or rotating a target stimulus in order to match it with a selection of other figures. There is no element in quilting that the researcher could determine which is related to the skills needed to perform above average on either of these tests. If global spatial ability was primarily biologically deter-

mined, one would expect the female quilters to be skilled at a variety of spatial tasks and score significantly higher than the normal population on all four measures of spatial ability. However, if spatial ability is fostered through experience and environmental factors, the quilters should perform significantly higher on only those tasks, which utilize those skills gained through quilting.

#### METHOD

**Participants.** A total of 28 women participated in this study. The quilting group was made up of 13 Quilters solicited from a local quilt group from Mercer County, New Jersey. The mean age of the Quilters was 54.00 years, ranging from 40 to 81 years of age. To be included in the quilting group, the participants needed to have at least two years experience in quilting. Their mean quilting experience was 12.04 years, ranging from between two and one-half to 19 years. The non-quilting group was made up of 13 females recruited from Bucks County, Pennsylvania, and three undergraduate volunteers from a public northeastern college. The mean age of this sample was 53.81 years, ranging from 39 to 78 years. One 73-year old Quilter and one 87-year old Non-Quilter did not complete all of the spatial measures and their scores were therefore not included in the final data analysis. All subjects were tested individually in either their homes, in a college library, or in their local libraries.

**Materials.** Participants were asked to complete four timed spatial ability measures and a paper and pencil questionnaire which requests demographic information and information regarding their previous spatial experience. Three of the tasks were paper and pencil tests while the fourth involved arranging blocks to match different patterns. Although the four spatial ability tests were timed, the researchers believed that time limits would negatively affect the performance of many of the participants by causing increased anxiety, particularly for the older women. These women might also score

lower because of slower cognitive and motor skills (Mazaux et al., 1995; Salthouse, Babcock, Skovronek, Mitchell, & Palmon, 1990). Because of this, the researchers gave the participants extra time to complete all of the spatial measures.

**The Differential Aptitude Test (DAT).** The Differential Aptitude Test, Form L, Space Relations Scale (Bennett, Seashore & Wesman, 1968) is a 60-item paper-and-pencil test which requires the subject to mentally manipulate objects in three-dimensional space. Each item consists of an unfolded two-dimensional pattern along with four folded three-dimensional figures. Subjects were required to mentally fold the pattern and choose the one correct folded figure, which was the same as the unfolded pattern. Subjects were given 25 minutes to complete this test. However, they were allowed an additional 10 minutes to finish if needed. Two scores were attained by counting the number of correctly answered questions. Scores could range from 0 to 60.

**The Group Embedded Figures Test (GEFT).** The Group Embedded Figures Test (GEFT) (Oltman, Raskin, & Witkin, 1971) is a paper and pencil test consisting of 18 complex figures. It has three sections: the first section contains seven simple items and is not counted towards scoring; the second and third sections each contain nine more difficult items. In this test, the subject is directed to find a simple form that is embedded within a complex figure. The simple forms are located on the back cover of the GEFT booklet. Subjects were given two minutes for the first practice section and were allowed an additional two minutes to complete any unanswered questions. Participants were given five minutes for each of the remaining two sections. If these two sections were not completed in the allotted time, participants were allowed five additional minutes to complete each section. A score was attained by counting the number of correctly-traced embedded figures in the last two sections. Scores could range from 0 to 18.

**The Vandenberg Mental Rotations Test (MRT).** The Vandenberg Mental Rotations Test (Vandenberg, & Kuse, 1971) is a paper and pencil test that consists of two sections, each with ten items. Each item contains a three-dimensional figure, followed by two correct matching figures and two incorrect distractor figures. Subjects are directed to identify the two correct figures, which are identical to the stimulus figure but are rotated in space and therefore seen from a different perspective. Participants in this study were given three minutes for each section, but were then allowed to work on the test for an additional seven minutes in each section. Subjects were given one point for each correctly selected matching figure, and to correct for guessing, half of the number of incorrectly guessed answers were subtracted from the total number of correct answers. Scores could range from -20 (signifying all incorrect items chosen) to 40 (signifying all correct items chosen).

**The Wechsler Adult Intelligence Scale-Revised Block Design (WAIS-R).** The Wechsler Adult Intelligence Scale-Revised Block Design (WAIS-R) (Wechsler, 1981) is a two-dimensional spatial test consisting of a series of nine red and white patterned designs. The participants are asked to construct the patterns which are made up of squares and triangles in varying positions using three-dimensional red and white blocks. The nine identical blocks are one inch square, each having two red sides, two white sides, and two half red and half white sides. The subject uses only four blocks and is allowed 60 seconds for the first five printed designs. The subject is given 120 seconds to use all nine blocks to construct the remaining four printed designs. Scoring for this test is based on the speed in which the subject correctly completes the block design. For the first two designs—which are primarily for practice and gaining familiarity with the blocks—a maximum of two points are awarded. For the remaining seven designs, four points are given for each design successfully completed within the time limit, plus a

maximum of three bonus points could be earned for a fast performance. Scores for this test could range from 0 to 81 points.

**Spatial Activity Participation and Demographics Questionnaire-Revised (SAQ-RD).** Participants in this study were also asked to complete the paper and pencil Spatial Activity Participation and Demographics Questionnaire, which is a revised form of Newcombe, Bandura, and Taylor's (1983) spatial activities questionnaire. The first section asks the subject to review a total of 111 activities broken down into nine categories. These categories are as follows: Outdoor Activities or Sports, Athletic Skill Activities, Arts and Crafts, Model Building and Related Activities, Puzzles, Games and Brain Teasers, Household, Repair and Skilled Activities, and Other Activities. Subjects are then asked to rank the amount of experience that they have had in each activity on a scale from 0 to 4 (0=never, 2=sometimes, 4=often) during two time periods of their life—as a child or in high school, and since high school. At the end of each section, participants are asked to add any similar activities that are related to visual perception that they have had experience in and are not included elsewhere in the questionnaire. The second section of this questionnaire consists of demographic questions such as an identifying four-digit code, sex, age, handedness, and work history.

**Procedure.** Participants were contacted by phone in order to schedule individual appointments for testing. Prior to each testing appointment, the experimenter randomized the order of administration of each of the tests.

Upon arrival at the testing location, the experimenter reviewed the purpose of the study with the participant, gave her a summary sheet, which described the experiment, and asked her to sign an informed consent form. The participant was then asked to choose a four-digit code number so that their tests and questionnaire could be identified without using their names. The four spatial tests were then administered to the



participant in random order. The instructions of the DAT, MRT, WAIS-R, and SAQ-RD were read aloud to the participants, while they read the GEFT instructions to themselves. Before starting each of the tests, the experimenter answered any questions that the participants might have had.

The experimenter also explained to the participants, as it was described in the summary sheet, that they should not feel pressured by time limits or anxious about not being able to complete a spatial task, because being faster does not necessarily mean being better. The participants were told that after the amount of time that was allotted for each test by the administration booklet was used up, they would be asked to draw a line under the last answered problem that they had completed. It was then explained that the participant would be given an additional amount of time to work on the completion of that task. The timing of these tests was done in this way because the researchers believed that the allotted time constraints would cause increased anxiety, and consequently lower test scores, especially in the older participants. These decreased scores may also be due to unfamiliarity with testing situations, attention deficits, or slower cognitive and motor skills, all common variables when older participants are studied (Mazaux et al., 1995). In fact, a study conducted by Salthouse, Babcock, Skovronek, Mitchell, and Palmon (1990) determined that increased age was negatively correlated with low levels of performance on spatial visualization tests, regardless of whether or not participants had had intensive past experiences in spatial activities and occupations.

The experimenter recorded the times of completion of all sections of the tests. When all four tests had been taken, the participant was given the option of either completing the SAQ-RD at that time or completing it later and mailing it back to the experimenter. Testing sessions lasted between approximately one and one-half hours to three hours, depending on how quickly the

participants understood and completed each of the tests. Many of the older participants and the Non-Quilters had difficulty understanding the test instructions and the actual spatial manipulation. Consequently, the researcher spent extra time working through the sample problems with the participants helping them to understand what the test was asking them to do. The duration of the testing sessions also varied because while some participants finished all of the tests under the official time limit, others used all of the additional time that was provided for them by the researchers.

**Scoring.** Once all of the participants had been tested, the experimenter scored the spatial skill tasks and reviewed the demographic questions. Two separate scores were attained for each test. The first score that was recorded was derived from the score that the participant would receive using the time allotted by the administration booklet. The second score was found by including any additional correctly answered questions in the time that was added by the experimenter.

## RESULTS

**Quilters vs. Non-Quilters.** Means and standard deviations for the four spatial measures for the Quilter and Non-Quilter Groups are presented in Table 1.

Table 1. Means and Standard Deviations for the DAT, GEFT, MRT, and WAIS-R.

Group	DAT		GEFT		MRT		WAIS-R	
	M	SD	M	SD	M	SD	M	SD
Quilter	38.23	13.58	11.31	4.73	10.19	9.15	34.69	7.73
Non-Quilter	27.31	8.81	7.66	3.67	7.50	3.92	27.77	5.74

T-Tests revealed significantly higher scores for the Quilter Group on three of the four spatial measures: DAT ( $t(24)=2.43, p=.023$ ), GEFT ( $t(24)=2.22, p=.037$ ), WAIS-R ( $t(24)=2.59, p=.016$ ). The two groups did not differ significantly on their scores on the MRT ( $t(24)=.97, p=.34$ ). T-tests for the untimed versions of the four spatial measures revealed the same pattern of results, consequently standard administration (timed) scores for the spatial measure were used for all subsequent analyses.



**Spatial Activity Participation.** The fact that Quilters performed better than Non-Quilters on three of the four spatial ability measures leaves open the possibility that Quilters are predisposed to their hobby because they have a genetic predisposition for high spatial ability. Following this logic, one would expect Quilters and Non-Quilters to show markedly different patterns of participation in spatial activity. Quilters should show high levels of spatial activity in general; if high spatial ability attracted them to quilting, high spatial ability should attract them to a variety of activities that are correlated with spatial performance. Non-Quilters, hypothetically born with lower spatial ability, should be attracted to fewer spatial activities than Quilters, and should spend less time engaged in those activities. **This, in fact, is not the case.** Only six activities (besides Quilting), out of a total of 224 (112 during childhood, and 112 during adulthood), distinguished Quilters from Non-Quilters. Four of these activities were closely associated with Quilting, and are always or sometimes engaged in during the processes of quilting. (Thus, these four differences are not due to chance variation between the groups.) Quilters spend significantly more time as adults engaging in sewing ( $t(24)=4.55$ ,  $p=.0001$ ), weaving ( $t(24)=2.95$ ,  $p=.007$ ), cross-stitch ( $t(24)=3.26$ ,  $p=.003$ ), and embroidery ( $t(24)=4.22$ ,  $p=.0001$ ), and spent significantly more time as children doing embroidery ( $t(24)=3.65$ ,  $p=.011$ ). Only two other activities separated Quilters from Non-Quilters. The former group spent more time playing basketball as children ( $t(24)=2.72$ ,  $p=.012$ ) and the latter group spent more time playing baseball as children ( $t(24)=-2.32$ ,  $p=.029$ ). It seems then that these two groups of women do not come from different populations in terms of their activity preferences, except that the Quilter Group spends significantly more time engaging in Quilting-related activities than the Non-Quilter Group. It would be nonsensical to suggest that the Quilter Group was born with higher spatial ability than the

Non-Quilter Group, but that this genetically transmitted talent only affects the participation in sewing activities, but not in a host of other spatial activities.

## DISCUSSION

The results of this study support the view that experience plays a significant role in the development of spatial ability. The quilters scored significantly higher than the non-quilting participants on three out of the four spatial measures: the DAT, the GEFT, and the WAIS-R. These results were initially surprising to the researchers because it was predicted that quilters would only outperform the normal population on those measures which assessed two-dimensional spatial ability—the GEFT and the WAIS-R Block Design Subtest. However, after careful consideration and after discussing these results with an experienced quilter, the researchers determined that quilters most likely approach the DAT in a way that taps into their quilting experience. The average person would answer a problem on the DAT by initially mentally folding the unfolded pattern to the left, and then attempting to mentally rotate and manipulate this folded object in order to match it with the folded figures to the right. On the other hand, it makes sense to postulate that quilters examine the seams of the folded figures on the right which may consist of a shaded and unshaded side. They then determine if it is possible for these seams to be made based on their mental visualization of the folded figure to the left. This visualization of seams and of patterns that make up the seams is a skill that is developed through the making of patchwork quilts.

Another explanation for this surprising discovery has to do with Linn and Petersen's (1985) descriptive categories of spatial ability. As discussed in the Introduction, their third category, entitled spatial visualization, consists of tests that require a participant to manipulate and organize complex spatial information. The GEFT, the WAIS-R Block Design Subtest, and the DAT are all included

under this category. Therefore, it would make sense to conclude that the scores of the quilters on these three tests would be comparable or higher when compared to the scores of the non-quilters.

The correlational problem (Baenninger and Newcombe, 1989; Newcombe, Bandura, and Taylor, 1983; Talbot and Haude, 1993) that has been present in much of the previous research on spatial ability has been addressed in this study to a certain extent. Experience and environmental factors did seem to play a significant role in the development of spatial ability because the quilters and non-quilters did not differ significantly in terms of their experience with spatial activity (other than quilting-related activity). If they had differed in this way, it would have been an indication that quilters could be biologically predisposed because of high spatial ability to engage in a myriad of spatial activities. This was not the case, however. Quilters have no differential predisposition to do so.

The results of this study are relevant to the debate over sex-related differences in ability (Linn & Petersen, 1985; Sanders, Soares, & D'Aquila, 1982; Martino & Winner, 1995; Geary, Gilger, & Elliott-Miller, 1990). If one can account for individual differences within sex by differences in experience, it is likely that between-sex differences can be explained in a similar fashion. Perhaps environmental factors can explain between-sex differences to an even greater extent, given the disparity in amount of spatial experience between the sexes.

Nevertheless, these results do not exclude biological influences on spatial ability, particularly as specified by the "bent twig theory." The most likely scenario is that biological and social factors interact to produce an individual's spatial profile.

This study has shown, however, that in-depth involvement in a spatial activity can improve one's spatial ability. As a result of these findings, one would hypothesize that these spatially related activities, games, toys, and education classes actually can improve children and adult's spatial ability. Therefore,

it logically follows that from a young age, children—both boys and girls—should be exposed to those activities which promote spatial ability. By encouraging girls especially to take part in activities and educational experiences (such as math and science) that do foster spatial skills, the difference between men's and women's spatial ability as measured by spatial tests may decrease.

Future research might extend the findings of this study by having participants complete a wider variety of spatial measures. While the researchers of this study included four spatial measures that equally represented two- and three-dimensional spatial problems, three of the measures ultimately fell under Linn and Petersen's (1985) spatial visualization category while only one fell under the category of mental rotations. By administering tests that fell under all three of the definitional categories, including the spatial perception category, future research on spatial skills could determine more definitively if intense experience in a particular spatial activity enhanced spatial performance in that area.

It would also be interesting to examine whether differences in skill or length of time that the participant had been quilting would translate into higher spatial performance. Based on this study, it would be logical to hypothesize that more advanced quilters would score higher than beginner quilters on those tests which tapped into the skills used in quilting. The present study could also be replicated using different populations who have also had intense experience in different spatial activities including the suggestions made.

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# Behavioral Disorders and Inclusion: A Look from Higher Education

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## ABSTRACT

A national survey of 330 college and university professors specializing in emotional/behavioral disorders was conducted. Professors were asked to indicate their theoretical orientation or conceptual model of emotional disturbance and to indicate their attitude toward the inclusion of students classified as emotionally or behaviorally disordered (EBD). Results indicate a majority of the professors prescribe to a theoretical orientation of emotional disturbance that is based on the behaviorists paradigm and an overwhelming majority of professors, although philosophically in agreement with the inclusion of students classified as EBD, view their inclusion with caution and concern. Implications of the findings and limitations of the study are discussed.

## INTRODUCTION

Our public school administrators and teachers are faced with an enormous challenge—student behavior in schools. One of the major components of this challenge is the education of students who are classified as **seriously emotionally disturbed** (SED). By the very nature of their disability these students bring unique needs and behaviors into our public schools. How these students are educated (e.g., the conceptual models or theoretical orientations that underlie the methods and strategies used in their education), and where they are educated (e.g., self-contained classrooms, resource rooms, full inclusive settings) are important matters of concern and debate among professionals in the area of “emotional disturbance.”

An understanding of **how** and **where** students classified as SED are educated may be of great importance because it may affect the quality of the education they receive and in turn the quality of their lives as healthy productive adults. Also an understanding of the **how** and **where** allows for a comparison between what is at present taking place and the existing empirical research on effective methods, strategies, and placement options for students classified as SED. Although valuable, it would be next to impossible to determine **how** and **where** such students, throughout the United States, are being educated. Therefore, this research is based on the following assumption: We tend to teach as we were taught. Specifically, individuals trained under a specific theoretical orientation concerning the nature of “emotional disturbance” (e.g., psychoeducational, cognitive-behavioral) will tend to adopt that orientation and incorporate its corresponding values, methodologies, and strategies into their own teaching. If this assumption is correct, then an understanding of how teachers of students classified as EBD are being

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trained may shed light on how their students (EBD) are being educated.

The remainder of this paper will report on: terminology and the definition of SED; prevalence of students classified as SED; the issue of how teachers of students of SED are trained; and, the results of a national survey of professors who specialize in the area of emotional disturbance and behavioral disorders.

**Terminology and Definition.** The Education of the Handicapped Act (PL 94-142) and its amendments (Individuals with Disabilities Education Act, PL 101-436) refers to students exhibiting emotional and/or behavioral disorders as **seriously emotionally disturbed (SED)**. Most professionals in the field of special education prefer the term **emotionally or behaviorally disordered (EBD)** because of its more accurate description of the socialization difficulties of children and youth with emotional problems, and its less stigmatizing label (Council for Children with Behavioral Disorders, 1987). Throughout this paper the term **emotionally and behaviorally disturbed (EBD)** will be used to describe those children and youth who fall under the federal definition of **seriously emotionally disturbed**.

EBD is defined as a condition in which behavioral or emotional responses of an individual in school are so different from his/her generally accepted, age-appropriate, ethnic, or cultural norms that they adversely affect educational performance in such areas as self-care, social relationships, personal judgment, academic progress, classroom behavior, or work adjustment (Nelson, 1993).

**Prevalence.** Lack of an effective standardized definition of EBD, difficulties in the estimation of emotional or behavioral disorders, and social and economic factors surrounding the education of students classified as EBD make it extremely difficult to estimate the prevalence of emotional or behavioral disorders in the school-age population (Kauffman, 1993). Consider the following: (1) at the federal level, reported prevalence estimates for students with EBD have

decreased over the years, going from 2 percent to 1.2 percent, to the present, where prevalence figures are no longer being reported; (2) it has been reported that up to 20 percent of children and youth may have psychological problems (Nelson, 1993); and (3) Kauffman (1993) reports that the prevalence of EBD may vary from approximately 0.5 percent to more than 20 percent of the school age population, a rather large range. Although discrepancies continue to exist as to the prevalence of students with EBD, the best available research indicates that 3 to 6 percent of the school age children and youth are in need of special education and related services due to their emotional or behavioral disorders (Kauffman, 1993; Institute of Medicine, 1989).

**Issue 1. How are students classified as EBD being educated?** Teachers specifically trained and certified in the area of special education are on the front line in working with students classified as EBD. It is their task to help educate these students so they have an opportunity to become effective and productive members of society. How special education teachers accomplish this task (the specific theoretical orientation they adopt, the strategies and methodologies used) may in large part be a function of how they themselves were trained.

Teachers of students classified as EBD attend colleges and universities to acquire their undergraduate or graduate degrees and special education certification. At present there are 316 graduate and/or undergraduate teacher preparation programs in the U.S. specifically designed to prepare teachers of emotional disturbance/behavioral disorders (Council for Exceptional Children, 1997). In general, teacher preparation programs, in their mission statements, identify a specific theoretical orientation regarding the nature of "emotional disturbance." The literature refers to these theoretical orientations as conceptual models of "emotional disturbance" (Kauffman, 1993). Typically these conceptual models include: psychodynamic

models (Axline, 1947; Bettelheim, 1970), biogenic models (Feingold, 1970; Leibowitz, 1991), psychoeducational models (Long 1974; Maher & Zins, 1987), behavioral models (Kerr & Nelson; 1989), ecological models (Rhodes, 1967), sociological models (Rhodes & Head, 1974), and humanistic models (Rogers, 1983). These conceptual models serve to guide their practitioners' approach to EBD (e.g., etiology of EBD, the nature of emotional disturbance, assessment practices, and effective intervention strategies).

**Research Question 1.** Research indicates that students in need of special education services for EBD range from 3 to 6 percent of the school age population. Also, these students present unique challenges to those charged with their education. To address these unique challenges, effective and replicable methods and strategies for teaching students classified as EBD need to be identified. Preservice teacher preparation programs for EBD teachers tend to operate under a theoretical orientation regarding the nature of "emotional disturbance" which they may pass on to their graduates. An understanding of the theoretical orientations of the various preservice preparation programs may shed light on the state of the field of EBD.

Research Question 1 addresses the following issue: If teachers' theoretical orientations are influenced by the theoretical orientation of their preservice personal preparation programs, what orientations are teacher preparation programs using to train future personnel of EBD students?

**Issue 2. Where should students classified as EBD be educated?** Currently, a major debate in special education rages between proponents of what is referred to as the Least Restrictive Environment (LRE) and proponents of "full inclusion" of students with disabilities in regular education. Proponents of the LRE support the availability of a continuum of educational services for students with disabilities (including students classified as EBD). This continuum ranges, on the one hand, from a belief in the

full inclusion of all students with disabilities in regular education classrooms, to a belief in the most restrictive environments (e.g., self-contained classrooms or separate schools). Proponents of full inclusion support the education of students with disabilities in the regular education classroom, with age appropriate peers, and in the student's neighborhood school. This issue, LRE vs. "full inclusion," can be framed in a variety of ways including the viewing of full inclusion as: a philosophical issue; an issue of definition and legality; an historical issue; and a practical and an empirical issue. Each of these issues will briefly be discussed below.

Philosophically, the debate has been described in terms of differing educational paradigms. Bassett, et al. (1996), identify the divergent views of professionals in the debate as "those who view inclusion as an emerging educational paradigm with broad implications for the services provided to all students, and those who view it as yet another placement option that can be added to the continuum of services" (p. 366). If one adheres to the former, a radical restructuring of current educational philosophy and practice is necessary, and if the latter, inclusion becomes one of many alternative placement settings in the continuum.

Differences in defining inclusion also speak to the legal aspects of the debate. Organizations such as The Association for People with Severe Handicaps (TASH, 1991) and advocates for full inclusion (e.g., Stainback & Stainback, 1992) characterize inclusion as educating all students with disabilities, regardless of the nature or severity of the disability in regular education classes, with age appropriate peers, in their neighborhood schools. This view, if adopted, is in direct opposition to current law (e.g., PL 94-145 EHA, PL 101-436 IDEA) and the continuum of placement options concept. Present law provides for educating students with disabilities to the maximum extent possible in the least restrictive environment (LRE). Individual educational need, linked to the

requirements of the LRE, is the primary concern and hallmark of special education; student placement issues are secondary. To understand how circular the definitional and legal debate can become, consider the following: one might legally argue that the definition of inclusion is educating students with disabilities, to the maximum extent possible, in the LRE, and that the practice has been going on for years.

The historical evolution of the term inclusion is rife with complications. There is no clear lineage from the 1960s term "mainstreaming," where the thrust was to educate students with disabilities as much as possible in regular education classrooms, to the 1980s Regular Education Initiative/General Education Initiative (REI/GEI), to the 1990s movement toward full inclusion (Hallahan, Kauffman, & Lloyd, 1996). The progression of these educational reforms presupposes a "one size fits all" approach that denies the individual characteristics, cognitive and affective/social, that define special education populations, including those students classified as EBD. Historically, these students (EBD) have been excluded from the earlier incarnations of inclusion and the practice continues today.

If any consensus on the inclusion debate is found it is established without an empirical data base that can conclusively show the efficacy of full inclusion for all students with disabilities and specifically those students classified as EBD (McMillan, Gresham, & Forness, 1996). The research that does exist only adds fuel to the debate. Consider the contentious debate over ALEM, a fully integrated educational model (Wang, Reynolds, & Walberg, 1985), the critical response to ALEM (Fuchs & Fuchs, 1988a), the equally critical rejoinder (Wang & Walberg, 1988), followed by yet another critical response (Fuchs & Fuchs, 1988b). The debate over inclusion continues, ranging from disputes over empirical validation to philosophical orientation, with very little consensus, especially with regards to students classified as

EBD. In fact, these students typically have been viewed, and continue to be viewed, as the most difficult to place (Mastropieri and Scruggs, 1996).

**Research Question 2:** Research Question 2 asks professors, who specialize in working with students classified as EBD, to state their opinion concerning inclusion of these students.

## METHOD

**Subjects.** Subjects for this study were college and university professors throughout the United States who specialize and teach in the area of emotional/behavioral disorders and/or behavior management. Three-hundred and thirty surveys (Table 1) were e-mailed to professors throughout the United States who specialize and teach in the area of emotional/behavioral disorders and/or behavior management. Of the one-hundred and twenty survey respondents (36%), 67 were male (56%), 43 were female (36%), and 10 respondent's gender (8%) could not be determined by the data.

Table 1. E-Mail Survey

The Undergraduate Research Group at the Department of Special Education at The College of New Jersey is conducting a survey of faculty in Departments of Special Education at Institutions of Higher Education to examine:

- (1) Faculty members' theoretical orientation toward behavior management or managing inappropriate behavior in classrooms (e.g., humanistic, cognitive, cognitive-behavioral, applied behavior analysis, or any other approach not mentioned), and
- (2) Faculty members' attitude toward the inclusion of students classified as emotionally/behaviorally disturbed.

If you would, please briefly respond via e-mail to the following:

What is your theoretical approach to behavior management?

What behavior management courses do you teach?

What is your attitude toward the inclusion of students classified as emotionally/behaviorally disturbed?

Are there other faculty members in your department we should contact? If so, could you please share their e-mail address with us?

**Instrument.** A survey was constructed (Table 1) requesting that subjects report: (1) their theoretical approach to behavior management; (2) what courses they are presently teaching in behavior management; and (3) their attitude toward the inclusion of students classified as emotionally/behaviorally disordered.

**Procedures.** The majority of the subjects were contacted using electronic mail (e-mail).



Subjects who did not have access to e-mail were contacted by "snail-mail" or facsimile transaction (fax). All contacts were made during the spring and fall semesters of 1997.

Several methods were used to identify institutions of higher education (IHE) to locate potential subjects in relevant departments of education. The first search procedure was conducted using a list of colleges and universities registered with the Council for Exceptional Children (CEC) obtained from CEC's home page at <http://www.cec.sped.org>. This list identified the target institutions whose home pages were accessed through the website, "US Universities by State," at <http://www.utexas.edu/world/univ/state/>. A search of relevant departments provided names of faculty to be contacted for the study. If e-mail addresses were not available through the Internet, phone correspondence was used to obtain this information. The second search procedure was conducted using the Directory of Programs for Preparing Individuals for Careers in Special Education (Council for Exceptional Children, 1997). Each IHE listed as having a program dealing with emotional/behavioral disorders was contacted by phone and e-mail addresses were requested. A third search procedure was incorporated into the respondent survey whereby individuals were asked to share the e-mail addresses of other professors in their department who would be appropriate to contact. A computer database was used to record all pertinent information, including the subject's name, school, state, and e-mail address. The database also maintained a record of contact and response dates, as well as delivery status.

**Data Analysis.** Survey Question 1 asked respondents to identify their theoretical orientation toward behavior management or managing inappropriate behavior in classrooms. Five members of the research team individually reviewed and categorized Question 1 responses. The research team then met and collapsed their individual responses into eight categories: Applied Behavior Analysis (ABA); ABA and Cognitive-Behavioral; Cognitive

Behavioral; Social Learning Theory; Eclectic; Psychoeducational; Humanistic; and, Other. One-hundred percent consensus was reached on all eight categories.

Survey Question 2 asked respondents to indicate their attitude toward the inclusion of students classified EBD. Five members of the research team individually reviewed and categorized Question 2 responses. As with Question 1 responses, the research team met and collapsed their individual Question 2 responses into four categories representing professors' attitudes toward the inclusion of students classified as EBD: Unconditional positive attitude toward inclusion; Conditional attitude toward inclusion; Opposed to inclusion; and, Question is not applicable/no response. One-hundred percent consensus was reached on all four categories. A response was categorized as **unconditionally positive** if the respondent's attitude indicated unconditional support for the inclusion of students classified as EBD (e.g., "I strongly support inclusion of students with E/BD;" "I believe that students with EBD must be included."). A response was categorized as **conditional** if the respondent's attitude indicated support for the inclusion of students classified as EBD, provided certain conditions were identified and met. Conditions expressed by respondents included the need for appropriate supports, the maintenance of a continuum of services, a concern for the welfare of peers, a concern for the legality of including EBD students, the issue of the etiology or severity of the disorder, or expression of another condition (e.g., "Inclusion should be an individualized, data-based decision based on student IEP, guided by the principles of LRE, and made by a Multidisciplinary Team (MDT)," "I am in favor of the full continuum of services for all students...I believe that such decisions should be made as specified by IDEA by qualified MDT based on the needs of the individual..." "I am in favor of including those students in regular education classrooms who demonstrate the potential to succeed in those set-



tings and who will be provided the supports needed to succeed in those settings”). A response was categorized as **opposed to inclusion** if the respondent was not supportive of the inclusion of students classified as EBD (e.g., “Full inclusion of the SED child, regardless of his/her severity of behavior problem or condition will be absolutely NO because such an inclusionary practice does not benefit the student nor his/her peers”). A response was categorized as **no response/inclusion not an issue** if the individual did not respond to the question or expressed that the topic of inclusion is not an issue (e.g., “I am opposed to labeling...Without labels it’s difficult to talk about inclusion”).

## RESULTS

Four-hundred professors throughout the United States were identified and a total of 330 surveys were sent, 324 via e-mail, four by mail, and two via fax. One hundred twenty-nine surveys were returned yielding 120 (36%) useable responses, and nine (3%) non-useable responses. Two-hundred and one professors did not respond: 148 non-responses (45%) and 53 undeliverable responses (16%) due to unknown servers or users. Server refers to an institution’s electronic mail system whereas user refers to an individual’s address within the electronic mail system.

Survey responses were received from IHEs in 37 of the 50 United States (74%). Of the 316 IHE with programs in the United States offering degrees in emotional disturbance/behavioral disorders, 90 programs responded (28%). Table 2 indicates by state the number of survey responses received, the number of state IHEs responding, the number of EBD programs in each state, and the percent of state programs responding (e.g., for California, 10 responses were received, the 10 responses represented seven of the 13 EBD programs in the state of California, and 54% of the state EBD programs in California responded).

Table 2. States, Survey Responses by State, Number of EBD Programs in State, and Percent of Programs in States Responding to Survey.

State	No. of Survey Responses per State	No. of Programs in State Responding	% of State Programs Responding
Alabama	4	2	33
Alaska	1	0	0
Arizona	1	3	100
Arkansas	2	1	50
California	10	7	54
Colorado	8	5	>100
Connecticut	3	2	66
DC	0	0	0
Florida	4	4	31
Georgia	8	6	46
Hawaii	0	0	0
Idaho	3	1	>100
Illinois	3	1	5
Indiana	1	0	0
Iowa	1	2	25
Kansas	1	1	13
Kentucky	6	4	100
Louisiana	0	0	0
Maine	0	0	0
Maryland	1	1	50
Massachusetts	2	2	40
Michigan	4	3	23
Minnesota	1	1	14
Mississippi	0	0	0
Missouri	4	3	17
Montana	1	1	25
Nebraska	2	1	17
Nevada	1	1	50
New Hampshire	4	3	100
New Jersey	2	4	>100
New Mexico	0	1	33
New York	1	1	4
North Carolina	2	2	17
North Dakota	0	0	0
Ohio	4	3	25
Oklahoma	0	0	0
Oregon	3	3	100
Pennsylvania	9	8	73
Rhode Island	0	0	0
South Carolina	2	1	10
South Dakota	0	0	0
Tennessee	1	1	33
Texas	2	2	20
Utah	4	3	100
Vermont	0	0	0
Virginia	6	2	12
Washington	5	3	75
West Virginia	2	1	33
Wisconsin	0	0	0
Wyoming	0	0	0

All percent figures rounded to nearest whole number.

**Research Question 1: Theoretical Orientation/Conceptual Models.** Table 3 depicts respondents’ theoretical orientation toward behavior management. Forty respondents (33.3%) indicated an Applied Behavior Analysis (ABA) orientation, 16 respondents (13.3%) indicated a combination of ABA and Cognitive-Behavioral orientation, 16 respondents (13.3%) indicated a Cognitive-Behavioral orientation, three respondents (2.5%) indicated a Social Learning Theory orientation, 27 respondents (22.5%) indicated

an Eclectic orientation, three respondents (2.5%) indicated a Psychoeducational orientation, seven respondents (5.8%) indicated a Humanistic orientation, and eight respondents (6.6%) were placed in the "Other" category due to insufficient data.

Table 3. Theoretical Orientation, Counts, and Percents.

	Counts	Percents
Applied Behavior Analysis (ABA) <sup>1</sup>	40	33 <sup>3</sup>
ABA - Cognitive-Behavioral	16	13
Cognitive-Behavioral	16	13
Social Learning Theory	3	3
Eclectic	27	23
Psychoeducational	3	3
Humanistic	7	6
Other <sup>2</sup>	8	5
Totals	120	100

<sup>1</sup> ABA category = 35 ABA, 3 ABA-Ecological, 2 ABA-Developmental, 1-ABA Social Learning Theory, and 1 ABA - psychoeducational.

<sup>2</sup> Other category = 1 Developmental, 1 Ecological, 1 Cooperative Discipline, and 3 Could not be determined or did not respond.

<sup>3</sup> Percents rounded.

When conceptual model orientation was analyzed by gender (Table 4), 23.3% of the male respondents had an ABA orientation compared to 10% of female respondents, 10.8% of the male respondents chose ABA/Cognitive-Behavioral as compared to 2.5% of the female respondents, 5.8% of male respondents chose Cognitive-Behavioral as compared to 3.3% of female respondents, 1.7% of male respondents chose Social Learning Theory as compared to .8% of female respondents, 8.3% of male respondents chose Eclectic as compared to 10.8% of female respondents, 2.5% of male respondents chose Psychoeducational as compared to 0% of female respondents, 1.7% of male respondents chose Humanistic as compared to 3.3% of female respondents, 1.7% of male respondents were categorized as "other" as compared to 5.0% of female respondents.

Table 4. Theoretical Orientation by Gender, Counts, and Percents

Model	M	M%	F	F%	O	O%	Tot
Applied Behavior Analysis (ABA) <sup>1</sup>	30	25	12	10.0	0	0	42
ABA/Cognitive-Behavioral	13	10.8	3	2.5	0	0	16
Cognitive-Behavioral	7	5.8	4	3.3	5	4.2	16
Social Learning Theory	2	1.7	1	0.8	0	0	3
Eclectic	10	8.3	13	10.8	4	3.3	27
Psychoeducational	3	2.5	0	0	0	0	3
Humanistic	2	1.7	4	3.3	1	0.8	7
Other <sup>2</sup>	0	0	6	5.0	0	0	6
Total	67	55.8	43	35.8	10	8.3	120

<sup>1</sup> ABA category = 35 ABA, 3 ABA-Ecological, 2 ABA-Developmental,

<sup>1</sup> ABA-Social Learning Theory, and 1 ABA-psychoeducational

<sup>2</sup> Other category = 1 Developmental, 1 Ecological, 1 Cooperative Discipline, and 3 Could not be determined or did not respond.

**Research Question 2: Inclusion Data.**

Research Question 2 asked respondents to report their attitude toward the inclusion of students classified as emotionally/behaviorally disturbed. Responses were collapsed into the following categories: (1) Positive; (2) Conditional; (3) Opposed; and, (4) No Response/ Inclusion not an issue.

Twelve respondents (10%) indicated an unconditional positive attitude toward the inclusion of students classified as EBD, 101 respondents (84%) indicated a conditional stance, three respondents (2.5%) indicated they were opposed to inclusion of EBD students, and four respondents (3.3%) saw the issue of inclusion of EBD students as a "non-issue" or supplied no response to the question (see Table 5).

Table 5. Attitude Toward Inclusion, Counts, and Percents.

Category	Count	Percent
Positive attitude toward inclusion of EBD	12	10
Conditional attitude toward inclusion of EBD	101 <sup>1</sup>	84
Need for appropriate supports	52	
Maintain continuum of services	71	
Concern for welfare of peers	13	
Concern for legality of inclusion of EBD students	2	
Dependent on the etiology of disorder	2	
Dependent on the severity of disorder	2	
Other	3	
Opposed to the inclusion of EBD	3	3
No Response/Inclusion not an issue	4	3

<sup>1</sup> Responses exceed 101 due to individuals selecting more than one condition.

**DISCUSSION**

**Research Question 1: Theoretical Orientation/Conceptual Models.** Theories about how students develop and learn, how they behave, the curriculum materials to be used, and the instructional methods employed do not originate in a vacuum: they stem from various psychological orientations (Wolfgang & Glickman, 1986). Research Question 1 is based on the assumption that there is a direct relationship between how we are taught and how we will teach. Specifically, the assumption is that teachers of students classified as EBD will tend to adopt the theoretical or psychological orientations of the professors who trained them. Therefore, an understanding of how teachers of students classified as EBD are trained or taught (e. g., psychological or theoretical orientations they

are exposed to) may shed light on how students classified as EBD are actually being taught in today's public schools.

Wolfgang and Glickman (1986) present a model that organizes theoretical/psychological orientations of child development into three broad categories:

1. The child develops from an inner unfolding potential.
2. The child develops as a result of external conditions.
3. The child develops from the interaction of inner and outer forces (p. 15).

The first interpretation of child development, that a child develops from an inner unfolding of her/his potential, presupposes that the child has an inner drive that seeks expression in the real world and that the child is fully capable of such expression if given an appropriate facilitating environment. Clustered under this first position are theorists such as Axline (1947), Moustakas (1972), Gordon (1974), Harris (1969), and Raths, Harmin, and Simon (1966). In broad terms these theorists may be considered to fall under the humanistic paradigm of child development.

The second interpretation of child development, the child develops as a result of external conditions, discounts concepts such as "inner forces" and instead emphasizes the influence of the "outer" environment of people and objects and its influence on child development. This position sees individual development as a result of the quality and quantity of stimulation from the environment (Wolfgang & Glickman, 1986) and is best represented by B. F. Skinner and the behaviorists paradigm.

The third interpretation of child development, the child develops from the interaction of inner and outer forces, "presupposes that internal and external forces are constantly interacting and focuses on what the individual does to modify the external environment as well as what the external environment in return does to shape him or her" (Wolfgang & Glickman, 1986, p. 15).

Theorists representing this paradigm come from social and developmental psychology (e.g., Adler, 1972, Dreikurs & Cassel, 1974, Glasser, 1992) and assume a position midway between the humanistic and behavioral interpretations of human development.

In a further analysis of the data, professors' survey responses concerning theoretical orientation were collapsed from the initial eight categories down to three categories.

Specifically, Category 1 now included ABA (42 responses), ABA-Cognitive Behavioral (16 responses), Cognitive-Behavioral (16 responses), and Social Learning Theory (three responses). This new category was named "Learning Theory" because all four orientations are based, to a large degree, on the operant conditioning model. Category 2, Eclectic (27 responses), retained its initial name. Category 3, renamed Humanistic, now included Psychoeducational (three responses), Humanistic (seven responses), and Other (six responses). Under the new classifications, 77 respondents (64%) comprised the "Learning Theory" category, 27 respondents (23%) comprised the Eclectic category, and 16 respondents comprised the Humanistic category).

Apparently a majority of the IHEs offering degrees in emotional disturbance/behavior disorders are training prospective teachers under some form of the Applied Behavior Analysis model (64%).

Wolfgang and Glickman (1986) make the following distinction between a "technician" and a "professional." They define a technician as an individual trained to employ one exact approach or procedure to solve a problem.

A technician does not need to judge alternatives, results, or long-range goals... The technician need not speculate about consequences before acting; he or she simply needs to act... The teacher-technician, when confronted by a disruptive student, simply gives the same command or takes the same action that he or she has always given or implemented (Wolfgang & Glickman, p. 6).

On the other hand, a professional-teacher is one who: has a broad knowledge of the spectrum of theoretical orientations concerning emotional disturbance (e.g., interventions, methodologies and strategies); collects data on the problem at hand; generates some working hypotheses as to which approach, under the specific circumstances of environment and student, might be appropriate; implements a plan of action; evaluates the plan; and, refines or revises the plan as necessary (Wolfgang & Glickman, 1986). The concept of professional-teacher is analogous to the artist whose palette contains all the colors of the spectrum. In a specific painting she may choose to select only certain colors in order to create a desired mood, knowing exactly what colors and combinations of colors will work best to accomplish the task. However, over the course of her artistic career she will use the entire spectrum of colors to create many different works of art.

It is assumed that simply because a professor, responding to the survey question 1 on theoretical orientation regarding emotional disturbance, listing a specific theoretical orientation that this professor may or may not believe in, only teaches from this particular orientation. It is also assumed that further condensing categories (e.g., ABA, ABA-Cognitive Behavioral, Cognitive-Behavioral, and Social Learning Theory comprising the category Learning Theory) for the sake of a broader analysis runs the risk of distorting the data. However, these concerns notwithstanding, it is interesting to note that 64% of survey respondents reported their theoretical orientation to emotional disturbance as some form of Learning Theory. Also it may be legitimate to ask what implications this has for the future of teachers of students classified as EBD and for the students themselves.

Table 6 depicts the collapsed theoretical orientation categories by gender. Fifty-two male respondents comprised the **Learning Theory** category as compared to 20 female respondents; 10 male respondents comprised

the **Eclectic** category as compared to 13 female respondents; and, five male respondents comprised the **Humanistic** category as compared to 10 female respondents. To test the hypothesis that there is no difference in the theoretical orientation toward emotional disturbance between male and female respondents a chi-square analysis was done. Results of the chi-square analysis were significant at the  $p < .005$  level (Chi-Square = 11.6,  $df = 2$ ,  $p < .005$ ).

Table 6. Collapsed Theoretical Orientation by Gender, Counts, and Percents.

Theoretical Orientation/ Conceptual Model	Male	Female
Based on Learning Theory <sup>1</sup>	52	20
Eclectic	10	13
Humanistic <sup>2</sup>	5	10
Total	67	43

Although there appears to be a statistically significant difference between male and female professors in their theoretical orientation toward emotional disturbance, this result must be viewed with caution. First, the categories were collapsed to make a chi-square analysis possible. Second, the "Other" category (see Table 4) was omitted from the chi-square analysis because the numbers were too small. However, if this significance is valid, then why is there this difference between male and female professors in their theoretical orientation toward emotional disturbance? Do some theoretical orientations or models reflect more "male-like" characteristics? "Female-like?" Why did twice as many females (10) report a Humanistic orientation as opposed to males (5)? Does gender play a role in determining preferences for particular theoretical orientations toward emotional disturbance? Future research is needed to address this issue.

**Research Question 2: Opinions Toward Inclusion.** An overwhelming majority of survey respondents (84%) expressed a conditional attitude toward the inclusion of students classified as EBD. Apparently professors are philosophically in agreement with the concept of inclusion, but are cautious about the reality of including students

classified as EBD. Their two major concerns were: (1) the need to maintain a continuum of placement options and (2) the need for appropriate supports and training of practitioners. Again, if the assumption holds true that teachers presently graduating from EBD preparation programs will adopt the theoretical orientation and attitudes of those who trained them, then we can expect the LRE vs. "Full Inclusion" debate to continue into the twenty-first century.

The debate on inclusion may continue to be carried out at the highest levels of educational policy making, research, and pedagogy. However this debate may obscure the practical realities of those in the inclusion trenches, the classroom teacher. Inclusion, to be successful, must have, among many other variables, the enthusiastic support of school administrators and classroom teachers. At present, support of inclusion by teachers has been shown to be a function of (1) the degree of intensity of the inclusion effort and (2) the severity of the student's disability (Mastropieri & Scruggs, 1996). There appears to be an inverse relationship between the effort given to inclusion by a district or school combined with the severity of students' disabilities and the support level of teachers. As the effort given to inclusion and severity of disability increases, teacher support for inclusion decreases.

Interestingly, this inverse relationship can be seen in the attitudes of school administrators and college faculty. Research indicates that the further one travels from public school classrooms, the higher the level of advocacy for inclusive programs. Again there is an inverse relationship with classroom teachers, those shouldering the bulk of the effort at implementing inclusive practices being less supportive of inclusion, and those that shoulder the least of the day-to-day work of implementing inclusion being the most ardent advocates (see Garver-Pinhas & Schmelkin, 1989; Horne, 1983; Mastropieri & Scruggs, 1996). It would appear that support of inclusive practices is less a function

of one's moral and philosophical position, definition, or existence of an empirical data and more a function of one's proximity to teaching students with disabilities and bearing the brunt of the responsibility for implementing inclusive practices.

Given the following—students classified as EBD are considered the most difficult to include; students classified as EBD are less likely to be successfully included; professors specializing in the area of emotional disturbance are cautious about the inclusion of students classified as EBD; and, a majority of regular education and special education teachers are opposed to, or not prepared for, the inclusion of students classified as EBD—we are left with an equivocal picture of the future inclusive education of students classified as EBD. Obviously the field of emotional and behavioral disorders is in need of effective models, methods, and strategies to better serve students classified as EBD—particularly their inclusion. This research indicates that the field will continue to emphasize those theoretical orientations based on learning theory to best serve students classified as EBD.

**Limitations.** This research is subject to several limitations which include: sampling procedure, the survey instrument, the use of e-mail as a data gathering tool, and the condensing of data for statistical analysis. In light of these limitations, results should be viewed with caution.

The population of interest was professors specializing in the area of emotional and behavioral disorders throughout the United States. Four-hundred professors were identified as prospective respondents. However, respondents were not randomly selected. Surveys were sent on a convenience basis (e.g., those professors whose e-mail addresses could be obtained through the Internet or by phone). Not all professors, at present, have and/or use e-mail. Therefore, survey respondents were limited to professors who (1) specialize in the area of emotional disturbance and (2) have and use e-mail. These

respondents (N=330) may not be representative of all professors specializing in EBD. Although 37 of 50 states having IHE offering degrees in EBD responded (74%), only 120 usable surveys were received (36%) representing 90 IHE offering degrees in EBD (28%). This low response rate may limit the representativeness of the data.

Although the survey was simply constructed to allow for ease of response, no pilot of the survey was conducted. Questions were open-ended allowing professors a great deal of latitude in their responses. This open-ended response format required data reduction techniques. Even though consensus was reached on all data reduction categories, there is always a risk of some essential qualities of the data being lost in the reduction process. Also, gender data was further reduced in order to do a chi-square analysis.

Although the use of e-mail as a data collection tool may have many advantages, there also are liabilities. Of the 330 surveys sent, 53 (16%) were returned due to unknown servers or users. However promising, the use of e-mail as a research tool may still be a ways off.

In summary, a national survey of 330 professors specializing in emotional/behavioral disorders was conducted. Professors were asked to indicate their theoretical orientation or conceptual model of emotional disturbance and to indicate their attitude toward the inclusion of students classified as emotionally or behaviorally disordered (EBD). Results indicate a majority of the professors prescribe to a theoretical orientation of emotional disturbance that is based on the behaviorist paradigm and an overwhelming majority of professors, although philosophically in agreement with the inclusion of students classified as EBD, view their inclusion with caution and concern.

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## Abstracts of Student- Authored Papers Presented at Refereed Conferences

Presented in Chronological Order

Megan Meyer and Margaret G. Ruddy,  
*Department of Psychology,  
The College of New Jersey*

*Does knowing a child's sex prenatally influence  
parental responsiveness to the baby?*

Poster presented at the Annual Meetings of  
the Eastern Psychological Association,  
Washington, DC, April 1997.

Might prenatal knowledge of a child's sex  
influence early responsiveness to the baby?  
For seven situations in which a baby might  
cry, expectant mothers were asked how long  
they would wait before responding to the  
crying. They also rated the importance of the  
child's developing each of nine qualities.  
Parents who knew the child's sex tended to  
say that they would wait a shorter time  
before returning to a crying baby, and they  
rated development of obedience, good man-  
ners, self-control, and respect for parents as  
less important, compared with parents who  
remained ignorant of the child's sex.

Monique Parsley,  
*Department of Psychology,  
The College of New Jersey*

*Segregation: Does it affect college students in  
the 90s?*

Poster presented at the Annual Meetings of  
the Eastern Psychological Association,  
Washington, DC, April, 1997.

This study examined college students' views  
about voluntary segregation on a college  
campus. Forty-four students (16 Black, 16

White, 12 Other) completed a seven-page  
survey. For each of ten situations in which  
voluntary segregation might occur on cam-  
pus (e.g. dining, games), students were asked  
what they would do (using a seven-point  
scale, with a lower number indicating segre-  
gation). There were also "percentage" and  
"ideal" questions, comparing students' actual  
and preferred interaction with different-race  
peers. The results indicated a moderate  
degree of voluntary segregation.

Daniel Caruso and Albert F. Eble,  
*Biology Department, The College of New Jersey*  
*Cytology and Cytochemistry of the Excretory  
System of the Soft-Shell Clam, *Mya arenaria*.*

\*Paper presented at the New Jersey Academy  
of Sciences 42nd Annual Meeting,  
Monmouth University, West Long Branch,  
NJ, May 1997.

Clams were collected from Belmar, NJ and  
maintained in all-glass aquaria. Morphology  
of the heart, kidney, and pericardial gland  
was observed using stereomicroscopy. Organs  
were excised, fixed, embedded, and sectioned  
prior to histological and histochemical stain-  
ing. The heart is composed of a single ventri-  
cle with two separate atria and lies in the  
pericardial coelom. The kidney is located  
just ventral to the heart and lies in the reno-  
coel. The pericardial gland is distinguished  
by its brown color and is embedded in the  
mantle adjacent to the pericardial coelom.  
Ventricular muscle fibers are organized into  
large trabeculae and bound by collagenous



connective tissue. Atria exhibited much thinner muscular trabeculae and diminished connective tissue; the epicardium consisted of large podocytes. Muscle trabecular in both the ventricle and atria contained glycogen and neutral glycoproteins. The kidney is a compound, tubular gland; renal tubule cells are arranged as a simple, columnar epithelium containing spherical nuclei with uniform heterochromatin. The apical surface of renal tubule cells exhibited apocrine-type secretory activity; evidence of apoptosis was also present. The basement membrane of renal tubule cells is in direct contact with hemolymph sinuses. The pericardial gland is also a compound, tubular gland with numerous glandular acini which are bathed by hemolymph sinuses. Pericardial tubule cells are simple, cuboidal, granular, and are regarded as podocytes. Nuclei are ovoid with scattered heterochromatin and are located basally. A dorsal limb of the kidney extends into the pericardial coelom where it covers a portion of the aortic bulb.

\*This paper was the winner of the "Best Student Paper Award" at the 1997 Meeting of the New Jersey Academy of Sciences.

Holly Cowell and Albert F. Eble,  
*Biology Department, The College of New Jersey*  
*Fluorescence Microscopy of Mitochondria and Lysosomes in Hemocytes of the Hard Clam, Mercenaria mercenaria.*

Paper presented at the New Jersey Academy of Sciences 42nd Annual Meeting, Monmouth University, West Long Branch, NJ, May 1997.

Moore and Eble (1977) identified three types of hemocytes in the hard clam, *Mercenaria mercenaria*. Small granulocytes and large granulocytes contain four types of granules in the cytoplasm: filamentous, refractile, blunt, and dot granules (Moore and Eble, 1977). Agranulocytes are mainly devoid of granules. Hemocytes were treated with Rhodamine 123, a mitochondrial fluores-

cent probe, and Lyso Tracker Red, a lysosomal fluorescent probe, in order to determine the appearance and location of mitochondria and lysosomes in small and large granulocytes. Correlation between fluorescent images and phase-contrast images identified filamentous granules as mitochondria, and blunt granules as lysosomes.

Margaret G. Ruddy, Michelle J. O'Neill,  
and Michelle K. Rone,  
*Department of Psychology,*  
*The College of New Jersey*

*Babies with high visual shift rates: More active or more inattentive?*

Poster presented at the Annual Meetings of the American Psychological Society, Washington, DC, May 1997.

Six-month-olds saw nine pairs of slides, then played with nine toys. Babies with more frequent shifts of visual attention between slides, predictive of later attention deficits (Ruddy, 1996), manipulated the toys less actively (less pushing, pressing, or banging on the toys). Thus, shift rate seems to reflect inattentiveness, not hyperactivity.

Michael C. Johnson,  
*Communication Studies,*  
*The College of New Jersey*

*"Give Them What They Want: American Society and the Media Coverage of Timothy McVeigh and Richard Jewell."*

Paper presented at the 1997 Annual Meeting of the National Communication Association, November, Chicago, IL.

The bombing of the federal building in Oklahoma City and Centennial Park in Atlanta were two of the most widely covered news stories of the past decade. These two acts of terrorism, common in their targeting of innocent civilians, were unlike any other news stories in American history. Terrorism has been seen as an issue dealt with only in distant countries. The portrayal of the sus-

pects in both of these cases on television and in the newspaper would give great insight into the character of American media and American society. This study utilized close reading techniques to qualitatively evaluate the content of coverage of McVeigh and Jewell in the *New York Times* from the time that they were named as suspects until their arraignment (in the case of McVeigh) or release from suspicion (in the case of Jewell). Articles were examined for common themes and for information that was either included or conspicuous for its exclusion. These themes were evaluated and compared to conceptions widely held in American society. The examination of the articles yielded a number of interesting findings. In the case of McVeigh, there was a clear portrayal of the suspect as a "loner" who did not widely associate with others and an individual who seemed overzealous in his feelings regarding personal liberties. Jewell, like McVeigh, is portrayed in the articles as a "loner" and claimed that he openly sought recognition in the past. The profile that fit McVeigh, a profile supported by popular media and American society, was applied to Jewell despite his lack of involvement in the crime. The role of the media and the American public in creating and perpetrating these misconceptions if discussed in detail.

Marisa Parisi and Thomas Patrick,  
*School of Business, The College of New Jersey*  
(*Marisa Parisi is currently employed at Chubb & Son Insurance*)

*The relationship between Moody's Bond Rating and the Altman Z Score for firms in the transportation industry: A case study.*

Paper presented at the Northeast Business and Economics Association Meeting, Philadelphia, PA, September 1997.

This paper attempts to show the relationship, if any, between Moody's corporate bond ratings and the probability that a company will go bankrupt. The ultimate purpose of this study is to determine whether Moody's

rating system provides an accurate means of evaluating the quality of corporate bonds according to their degree of bankruptcy risk. The results of this study provide evidence that there is a definite correlation between Moody's A and C ratings and their respective Altman Z scores.

D. L. Lovett, P. D. Clifford, and D. W. Borst,  
*Biology Department, The College of New Jersey,*  
*and Illinois State University, Normal, Illinois*  
*Hypoosmotic Stress Causes Sustained Elevation of Methyl Farnesoate (MF) Levels in the Green Crab (Carcinus maenas).*

Paper presented at the Annual Meeting of the Society for Integrative and Comparative Biology, Boston, MA, January 1998. Abstract published in *American Zoologist* 37(5): 86A, 1997.

Hemolymph levels of MF in the green crab are increased by several types of physiological stress. In this study we examined the response of MF levels to changes in salinity. Crabs were acclimated to either full-strength (32 ppt, high salinity) or dilute (10 ppt, low salinity) seawater and then transferred to seawater with the same or a different salinity. Crabs acclimated to high salinity had low (basal) MF levels ( $2.5 \pm 0.8$  ng/ml). When these animals were transferred to low salinity, MF levels rose within 8 h, increased to high levels ( $32.7 \pm 7.7$  ng/ml) within 24 h, and remained at this level for the duration of exposure to low salinity. MF levels in control animals remained unchanged. When crabs acclimated to low salinity were transferred to high salinity, MF levels dropped from high levels to basal levels in less than 6 h, whereas MF levels of control animals remained elevated. When animals were transferred to various dilutions of seawater below 25 ppt, MF levels increased in a dose-related way as the salinity decreased. We also observed that MF levels were weakly correlated with gill  $\text{Na}^+ - \text{K}^+$ -ATPase activity. These observations suggest that MF may be involved in the modulation of blood osmo-

lality. Supported by an MBL summer fellowship (to DLL) and NSF grant IBN 9319206 (to DWB).

Margaret G. Ruddy and Viki Szemore

*Attention at 14 months: Prediction from child and parent play at six months.*

Poster presented at the Annual Meetings of the Eastern Psychological Association Meetings, Boston, MA, February, 1998.

To what extent is toddler attentiveness to toys predicted by distractibility at six months?

To what extent do parents modify toddlers' play style? In a longitudinal study, each six-month-old and a parent were observed in joint play with nine toys; at 14 months, children played independently (10 minutes) with toys in two baskets. Frequencies of both children's distractibility from toys and parents' toy demonstrations at six months made independent contributions to prediction of toy-shift frequency at 14 months.

*Multi-faceted investigations of the effect of experience on spatial ability.* Symposium presented at the Annual Meetings of the Eastern Psychological Association, Boston, MA, February, 1998.

MaryAnn Baenninger, Chair

Amy Silberbogen, MaryAnn Baenninger, and Nancy Breland. Translating real-life experience into high spatial performance: Block design and quilt design.

Lori Disbrow, Gabriella Stabile, and Lauren Flynn. Improving children's spatial ability using toys and spatial games.

Beth Ann Maddalon, Karen Langan, and Melissa Terlecki. Children's self-perceptions of competence on spatial tasks: Implications for performance.

MaryAnn Baenninger, Neil Albert, and Linda Zieman. Predicting spatial performance: A revised version of The Spatial Activities Questionnaire.

Spatial ability is the ability to visualize and mentally manipulate objects as they change orientation, or position, relative to other objects. It is essential for success in many highly technical or scientific careers, including engineering, organic chemistry, aeronautics, and mathematics. Women, on average, score less well on tests of spatial ability than do men. Some women, of course, excel in spatial ability, and some men perform quite poorly. However, studies have shown that poor spatial ability, or lack of confidence in spatial ability, serves as a serious gatekeeper, preventing women from choosing technical careers. This state of affairs has changed little over time in part because of the widespread belief that sex-related differences in spatial ability have biological origins, and the tacit acceptance that this talent cannot be changed or improved. In this symposium we will discuss a variety of research efforts that have explored the impact of training and experience on the spatial ability performance of participants ranging in age from 6 to 80.

Lee, F., Rex, S., Wen, M., VanDeren, C., Prasad, G., Arico, M., Burke, C., Clark, J., Fager, K., Taglietta, D., Fairchild, C., Rolf, R., Johnson, S., Hamilton, T., Rose, *W. Bristol-Myers Squibb, PRI, Oncology Drug Discovery, Princeton, NJ.* (*G. Prasad is a student at The College of New Jersey*). This abstract is reprinted with permission of F. Lee, Bristol-Myers Squibb

*Paclitaxel-resistant xenografts in nude mice grown directly from human primary tumor biopsies.*

Paper presented at the AACR Annual Meeting, New Orleans, LA, March 1998.

The predominant mechanism(s) by which human cancers develop resistance to TAXOL, a broad-spectrum anti-cancer agent, is not well understood. Modes of resistance developed in tumor cells by in vitro techniques may not be the prevalent mechanism in vivo. For this reason, tumor xenograft models were established by implanting

tumor biopsies obtained from TAXOL resistant patients directly into irradiated nude mice, without any intervening *in vitro* steps. Particular efforts were made to obtain biopsies from patients who received TAXOL as first-line therapy. Three models were established—two ovarian (Pat-7, Pat-23) and one breast (Pat-21) ca.—which retain the paclitaxel (Ptxl) resistance phenotype in nude mice. When treated with a maximally tolerated regimen of Ptxl (iv, q2dx5), all three models yielded tumor growth delay equivalent to less than 1 log of tumor cell kill. *In vitro*, Pat-7 is cross-resistant to multiple agents, including several MDR substrates. However, classical MDR reversal agents (verapamil and cyclosporin A) were only modestly successful in reversing Ptxl resistance (= 25%), in terms of both cytotoxicity and cellular accumulation of <sup>14</sup>C-Ptxl. Western and Northern analyses of *mdr-1* expression failed to reveal the 170 kD.Pgp protein or the corresponding RNA. Low level of *mdr-1* expression was detected by RT-PCR, however. In conclusion, multiple mechanisms exist in clinical TAXOL resistant tumors which can limit the cellular accumulation of Ptxl resulting in therapeutic drug resistance.

Christina Giatropoulos,<sup>1</sup> Melissa Costa<sup>2</sup>, Howard K. Reinert,<sup>1</sup> and Lauretta M. Bushar,<sup>2</sup>

*Biology Department, The College of New Jersey,<sup>1</sup> and Biology Department, Beaver College<sup>2</sup>*

*Genetic Variation in the Timber Rattlesnake, Crotalus horridus.*

Paper to be presented at the 54th Annual Northeast Fish and Wildlife Conference, Camp Hill, PA, May 1998.

The timber rattlesnake (*Crotalus horridus*) retains a large continuous (and therefore presumably “genetically healthy”) distribution across much of the south-central and southeastern United States. However, in the Northeast this species has experienced extensive habitat loss, population fragmentation,

and extirpation resulting in a highly discontinuous distribution. Information about the amount of genetic variation in these scattered populations is useful in the management of this species. We are using a type of DNA fingerprinting referred to as microsatellite analysis to assess genetic variability in the timber rattlesnake. PCR primers designed to amplify microsatellite loci are being used to screen timber rattlesnakes representing populations in New Jersey, Pennsylvania, and Virginia. Preliminary results will be presented, including several measures of genetic variability within each population (number and frequency of microsatellite alleles, average heterozygosity, and probability of identity) and genetic distances among these populations. The conservation and management implications of these findings will be discussed.

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*The Impact of Fire on Timber Rattlesnakes (Crotalus horridus) in the Pine Barrens of New Jersey.*

Paper to be presented at the 54th Annual Northeast Fish and Wildlife Conference, Camp Hill, PA, May 1998.

The timber rattlesnake (*Crotalus horridus*) is officially listed as an endangered species in New Jersey. In the Pine Barrens of southern New Jersey rattlesnake populations are small, isolated, and may be particularly sensitive to both natural and human-induced habitat alterations. In April 1995 an intense wildfire burned 19,830 acres, including 90 percent of the pinelands forest habitat used by one of these remaining rattlesnake populations. During the past four years, an average of 10 rattlesnakes has been monitored with radiotelemetry in an attempt to assess their response to the fire-induced habitat alterations and subsequent habitat changes. All monitored snakes that were overwinter-

ing in wetland habitats at the time of the fire emerged unharmed. Some hibernacula that were severely impacted by the fire were abandoned for adjacent, unburned sites. However, hibernacula that suffered less intense fire continued to be used for overwintering. The subsequent capture of an additional 36 adult snakes suggests that the fire had minimal direct impact upon the population. Activity range areas and movement patterns appear to have remained fairly stable over the three-year period, and several snakes have remained largely within the fire-impacted habitat during their active season movements. Rapid regeneration of understory vegetation growth has occurred in burned habitats and the population density of white-footed mice (*Peromyscus leucopus*), a major prey species, has remained similar to that of unburned habitats. These factors, combined with the occurrence of small areas of unburned habitat refugia have partially mitigated the impact of the fire on the rattlesnake population.

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*Play persistence and creativity at 18 months:  
Predictions from distractibility.*

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According to previous research, individual differences in sustained attention are somewhat predictable from the first half-year of life. The present longitudinal study again found that children's persistence in toy play at 18 months (with 16 toys available behind small doors) could be predicted from their lack of distractibility at six months. However, the percent of time spent creatively combining toys was greater for children who had been more distractible, as well as for children with higher language comprehension.

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