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EDITORS' INTRODUCTION

Since 2000, the *UMBC Review: Journal of Undergraduate Research* has been a unique outlet to showcase research from UMBC students working with UMBC faculty. Volume 16 of the *UMBC Review* continues this tradition, with ten fascinating articles from students working in various departments across campus. The *Review* has a rigorous selection process: papers are submitted and sent out for review between May and September of each year, and the best among these are selected to become a part of the next edition, to be released in April of the following year.

The *UMBC Review* provides an exclusive opportunity to UMBC students, for many of whom this is only the first foray of many into the publication process. We hope that publication in the *UMBC Review* will help these authors achieve their academic and professional goals, whatever these may be. We also hope that you, the reader, enjoy the great diversity of disciplines featured in this publication. The following articles are included in Volume 16:

Kendall Queen and his colleagues thoroughly analyze the behavior among cells of islets in the pancreas by simulating their secreted hormone interactions in various scenarios including physiological proportions of cells and spatial diffusion of hormones in a 3 × 3 × 3 islet.

Hollie Adejumo and her research team evaluate three different water treatment methods as part of efforts to improve water quality in Isongo, Kenya.

Sarah Klimek elucidates the ethical dilemmas surrounding Britain's Kindertransport program leading up to the Second World War.

Boris Tizenberg analyzes a conflict between the moral theories of philosophers Sharon Street and David Copp.

Alexis Rubin explores the relationships among hearing ability, social skills, and academic achievement in children.

Hannah Jones challenges the narrative surrounding Joseph Townsend, a figure who rose to prominence in Baltimore in the early years of American independence.

Ryan Kotowski presents a reanalysis of subject pronouns in the grammar of Modern Colloquial French.

Alexa White details the current habits and outcomes of waste disposal on the UMBC campus, and gives thorough insight on how to improve them.

Caitlyn Leiter-Mason takes a critical stance on the Question 6 debate in Maryland in which the protections of *Roe v. Wade* were codified into the state constitution.

Alana Lescure investigates the role of RpS9 — a ribosomal protein — in yeast cells, and demonstrates the consequences of its depletion.

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Without the work of the faculty advisers and mentors of our student authors, the *UMBC Review* could not uphold the standard of quality that we strive for in the research that we publish. These faculty advisers provided guidance to their students that allowed them to produce these fine research papers. In addition, these mentors lent their support to authors as well as editors throughout the publication process:

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Erle Ellis – *Department of Geography & Environmental Systems*
Marjoleine Kars – *Department of History*
Lasse Lindahl – *Department of Biological Sciences*
Stanley McCray – *Department of Modern Languages, Linguistics & Intercultural Communication*
Bradford Peercy – *Department of Mathematics & Statistics*
Jessica Pfeifer – *Department of Philosophy*
Daniel Ritschel – *Department of History*
Shuyan Sun – *Department of Psychology*

The reviewers who contributed their time and effort to review papers for the *UMBC Review* have our deepest gratitude. These reviewers, experts in their respective fields, were able to ensure us that the papers in this edition are relevant and novel in their disciplines. Unfortunately, in the interest of anonymity, we are not able to thank these reviewers by name.

We are also grateful to the proofreaders from all over the UMBC campus who lent us their perspectives during the editing process:

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Guenet Abraham – *Associate Professor, Department of Visual Arts*

The editors hope that Volume 16 of the *UMBC Review* is as enriching for the reader as it was for the editors to produce.

EDITORS

Cameron Rhode – *Junior, Biological Sciences*
Benjamin Woodworth – *Senior, Modern Languages, Linguistics & Intercultural Communication*

MODELING THE BUILDING BLOCKS OF THE PANCREATIC ISLET

CONNECTING α-, β-, *AND* δ-*CELLS*

KENDALL **QUEEN**

Co-Authors: Annie Dai[1], David Palensky[2], Alex Piatski[3], and Gina Vockeroth[4]

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The spring semester of my sophomore year was at its close and I was excited to conduct research here at UMBC. When I joined the Interdisciplinary Program in High Performance Computing, an eight-week summer research program offered by the UMBC Department of Mathematics and Statistics, I was both ecstatic and anxious. I really was not sure what to expect, as this was my first research experience. From the first day of classes, my knowledge base was expanded. I had very little experience with high-performance computing and I knew even less about the functions of the pancreas. What I did know was how to use the tools I needed to be successful in my research. I learned everything I needed to know for my project in just a few weeks. As a computer engineering major, I never thought I would work in biology again. Once I was introduced to the topic, I found that I liked to relate mathematical principles to biological concepts and processes. I now have a newfound appreciation and respect for biological processes and for the ability of science to cross fields of study to produce new knowledge.

1 INTRODUCTION

Diabetes is a metabolic disorder characterized by high blood glucose levels. Type I diabetes, a result of destroyed β-cells, prevents the body from producing insulin in order to effectively decrease blood glucose levels. Type II diabetes occurs when the body becomes resistant to insulin. The portion of the United States population that is affected by diabetes grew from 8.3 percent in 2010 to 9.3 percent in 2012, or from 25.8 million people to 29.1 million people.[1]

The cells responsible for the regulation of blood glucose are found in the islets of Langerhans, located in the pancreas. While these islets contain five types of cells, we focus on the three major types – α-, β-, and δ-cells. The β-cells experience voltage oscillations when glucose is introduced. This is due to the closing of energy-sensitive potassium channels, or K(ATP) channels, leading to the flow of calcium into the cell, which results in insulin release. The α-cells secrete glucagon, whose levels rise when blood glucose levels are low, and glucagon levels are regulated by insulin and somatostatin. The δ-cells secrete somatostatin, which inhibits α- and β-cells in order to help control insulin levels.

We are interested in modeling islets made up of these cells in order to further understand hormone or paracrine interactions among the cells. In order to accomplish this, we extend the Tri-Hormone Model, which simulates the interactions among the three cell types. This model simulates the interaction of a population of δ-cells with α- and β-cells by allowing the somatostatin to suppress insulin and glucagon through special potassium channels (GIRK channels). It also simulates the interaction of β-cells with α- and δ-cells by allowing insulin to inhibit glucagon secretion through K(ATP) channels. In this model, these interactions take place within a common space in the islet. This simulation concludes that paracrine interactions are able to suppress α-cells that secrete glucagon inappropriately when those cells have a limited number of parameters.[9]

Our model scales the Tri-Hormone Model into an $N \times N \times N$ cube with the capability of choosing the arrangement and quantities of the different cell types. We incorporate the well-known electrical β-cell coupling and model the chemical (paracrine) interactions between α- and δ-cells as diffusive. The α- and δ-cells do

not communicate electrically via gap junctions, so their secretion is treated as diffusion. We model secretory molecules, s, by

$$\frac{\partial s}{\partial t} - D\nabla^2 s = f(u,x) \tag{1.1}$$

where u can be different state variables of the cell.

For our computational model, we implement a system of 26, 23, and 21 ordinary differential equations for α-, β-, and δ-cells, respectively. To interpret how these cells interact, we plot the rates of change for variables such as voltage, calcium, and the hormone that is secreted by each cell.

We simulate islets while considering varying distributions and arrangements of α-, β-, and δ-cells. We look at four different cases, three of which display the interactions in a cubic model arranged in three planes of each type of cell. The fourth case is a rodent islet cell distribution, which accurately depicts the observed percentages of α-, β-, and δ-cells in a rodent islet. We compare the rodent islet to our three-plane distribution in order to observe the differences in secretion in space for different cell distributions.

2 BACKGROUND

The endocrine component of the pancreas is made up of groups of hormone-releasing cells called islets of Langerhans. These clusters are made up of individual α-, β-, and δ- cells. The α-cells secrete glucagon, a hormone that increases blood glucose levels. To lower glucose levels, β-cells release insulin. Finally, when glucose levels are high, δ-cells secrete somatostatin to regulate the α-cell and β-cell secretions.

A major difference between rodent and human islets is found in the percentages of α-, β-, and δ-cells. In rodent islets, β-cells comprise 60 to 80 percent of the total islet cell population, α-cells make up about 15 to 20 percent, and δ-cells account for less than 10 percent. In human islets, β-cells make up 48 to 59 percent of the total number of islet cells, α-cells compose about 33 to 46 percent, and δ-cells make up less than 20 percent.[7]

Another difference between rodent and human islets is the spatial distribution of α-, β-, and δ-cells. In rodents, the inner realm (the core) of an islet is made up of β-cells, and the circumference (the mantle) is composed of α- and δ-cells. In contrast, human islets have more disorganized cell population distributions in which most

β-cells are next to α- and δ-cells. An additional difference between rodent and human islets is the intercellular communication occurring in β-cell populations via electrical coupling. In rodents, the β-cells perform their electrical coupling as a syncytium. In human islets, however, electrical coupling occurs between clusters of β-cells in the same islet, but not between islets.[7] In Section 2.1, we describe a general model of the paracrine interactions among the three cell types. Section 2.2 provides the physiological and mathematical models behind each paracrine interaction in the Tri-Hormone Model. In Section 3, we outline the computational structure of the islet. Results follow in Section 4 with concluding remarks found in Section 5.

2.1 TRI-HORMONE MODEL CELL REPRESENTATION AND INTERACTION

The Tri-Hormone Model can be used to simulate paracrine interactions. Such a model consists of three representative cells: one α-, one β-, and one δ-cell. Each cell secretes into a closed space,

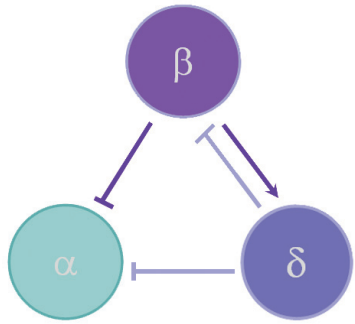

FIGURE 2.1. **TRI-HORMONE MODEL.** The α-, β-, and δ-cells interact. Arrows show activation, and T arrows show inactivation.

and all cells are influenced by this secretion. To further simplify the computation, scientists ignore diffusion and neglect all spatial components. As a result, at the time a molecule is secreted, all cells in the system feel it instantaneously. The following equation models insulin secretion:

$$\frac{dIns_{comp}}{dt} = \frac{ISR}{v_{comp}} - f_{comp,b} Ins_{comp} \tag{2.1}$$

The method of change of insulin in the compartment is the Insulin Secretion Rate (ISR) per unit volume minus insulin degradation with the rate $f_{comp,b}$. Similar equations hold for glucagon in the α-cell and somatostatin in the δ-cell. In the Tri-Hormone Model, there exist four main paracrine interactions: 1.) β-cell inhibiting α-cell (glucagon) secretion. 2.) β-cell stimulating δ-cell (somatostatin) secretion. 3.) δ-cell inhibiting β-cell (insulin) secretion. 4.) δ-cell inhibiting α-cell (glucagon) secretion, as shown in Figure 2.1.

2.2 PHYSIOLOGY BEHIND PARACRINE INTERACTIONS IN THE TRI-HORMONE MODEL

The Tri-Hormone Model is a direct representation of small-scale interactions among α-, β-, and δ-cells. The following sections explain how each type of cell works with and interacts with the other types to create the effect of a pancreatic islet.

2.2.1 The β-cell inhibition of α-cell secretion

Insulin (*Ins*) inhibits α-cell secretion by opening K(ATP) channels. This is modeled by the following equations:

$$Effect_a = \frac{0.006}{1 + \exp\left(\frac{-Ins + 100}{40}\right)} \tag{2.2}$$

$$g_{K(ATP)a} = \overline{g}_{K(ATP)a} * Effect_a + 0.04 \tag{2.3}$$

It is important to note that $Effect_a$ is the effective insulin α-cells receive. As insulin increases, $g_{K(ATP)}$ increases as well. An increase in $g_{K(ATP)}$ usually causes a decrease in glucagon secretion.[8]

2.2.2 The β-cell stimulation of δ-cell secretion

To create the stimulatory effect that relates β- and δ-cell secretions, an inward GABA Cl channel is used. This can be done because GABA is secreted alongside insulin, so the effect of GABA can be modeled based on the release of insulin by the β-cell.[2] The following equations are used to model this effect:

$$Eff\,Id = \frac{0.8}{1 + \exp(\frac{-Ins + 150}{50})} \tag{2.4}$$

$$IGABA = 0.1 Eff\,Id * Vd \tag{2.5}$$

where Vd is the δ-cell voltage.

2.2.3 The δ-cell inhibition of β-cells

The way δ-cells inhibit β-cells is through somatostatin (*Som*) activation of G-protein-coupled inwardly-rectifying potassium (GIRK) channels.[6] This is modeled as if it were a K channel.

$$Eff\,Is = \frac{1}{1 + \exp(\frac{-Som + 10}{10})} \tag{2.6}$$

$$IGIRKb = 10 Eff\,Is(Vb - (-80)) \tag{2.7}$$

where Vb is the voltage of the affected β-cell.

2.2.4 The δ-cell inhibition of α-cells

The inhibition of α-cells is a bit more interesting. In addition to GIRK channel inhibition of α-cells, somatostatin from δ-cells de-primes granules in order to inhibit α-cells.[5] This is modeled by the following equation, which correlates glucagon secretion with the rate of change in glucagon granules as somatostatin increases.

$$GSR_{factor} = \frac{5}{1 + \exp(-Som + 20)} \tag{2.8}$$

In other words, this process affects the glucagon secretion rate (GSR) in the glucagon version of equation 2.1.

3 METHODOLOGY

Our currently working code implements the Tri-Hormone Model of an islet. We translate that code into MATLAB code. We then scale the original model in order to implement a model of an islet with more than one α-, β-, and δ-cell each. Details concerning additional parameter values can be found in the technical report.[3]

3.1 EXTENDING THE TRI-HORMONE MODEL

The Tri-Hormone Model consists of an islet with one of each cell type that secretes instantaneously into a shared space. In order to extend this model from three cells to a more physiologically sized islet, we partition each type of cell in MATLAB so that each can be run through an ordinary differential equation (ODE) solver. For α-, β-, and δ-cells, we use functions of 24, 21, and 19 differential equations, respectively. In order to simulate the Tri-Hormone Model, we run each of these cell functions simultaneously. The variables of each cell are solved and stored in order, from α to β to δ, into a matrix that is $N \times M$, where N = the number of time steps and M = the sum of the cell variables.

To model various paracrine interactions, we add coupling parameters (in this case, in the form of currents) to our voltage equations. This allows us to make a dynamic system of cells that are affected by the secreted hormones, as well as by the individual cell voltages. We observe the total amount of secretion that each cell receives, then sum all the values of a secreted hormone, creating a scalar value used by our functions.

In order to implement our scaled model for more than one cell of each type, we vectorize our coupled islet function. Given a user input, the initial values for the differential functions are duplicated for each new cell implemented. Due to the compatibility of MATLAB with vector algebra, we easily exchange our initial function parameters with vector values. We consider three different distributions of a $3 \times 3 \times 3$ cell islet with three contiguous planes of α-, β-, and δ-cells.

The α, β, and δ functions are scaled by Na, Nb, and Nd, respectively, where Nx is the number of x-cells. The variables of each cell are then multiplied by the number of cells of that type. We can look at the paracrine effects on a much larger scale with different distributions of each cell type.

1. **Na = Nb = Nd = 1**
   This case is the Tri-Hormone Model explained earlier. It consists of a compartmentalized islet of one of each cell. We compare this version to the code provided by the NIH to ensure accuracy.

2. **Na = Nb = Nd = 9**
   This case observes the effect of the sum of somatostatin and insulin secretion on each cell in the islet at every time step.

3. **Na = Nb = Nd = 9**
   This case observes the Case 1 islet but accounts for the average amount of somatostatin secreted by dividing the secreted sum by the number of cells secreting that somatostatin. In other words, the summed somatostatin is divided by the number of δ-cells, and the summed insulin secretion is divided by the number of β-cells (in this case, nine).

4. **Na = 5, Nb = 20, Nd = 2**
   This case emulates the observed distribution of cells in a rodent islet. This case also keeps the division by the number of cells secreting, as in Case 3, to account for the changing number of β- and δ-cells.

3.2 CELL COUPLING

In order to simulate β-cell coupling via gap junctions, we implement a matrix vector product that models the change in voltage in each cell. We duplicate a linear index representation of each cell.[4] We give each cell a (i, j, k) entry with $i + (j - 1)N + (k - 1)N^2$ in an $N^3 \times N^3$ matrix.

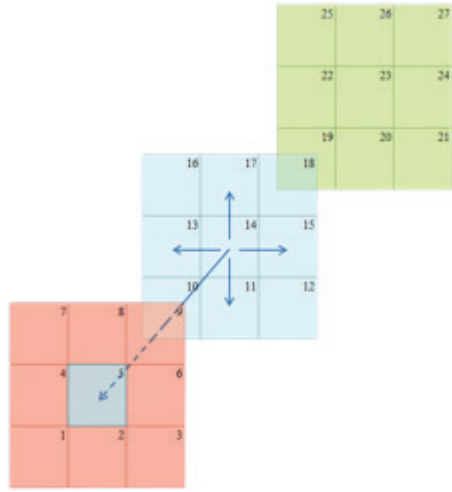

FIGURE 3.1. **EXAMPLE OF CELL COUPLING IN A PLANAR STATE.** Each colored plane corresponds to a different cell type.

For our 3 × 3 × 3 islet, our coupling function places the three-dimensional positions of our β-cells in a vector that is then transcribed into our coupling matrix. The (i, j) entry of the matrix represents the connection value for the ith and jth cell (either 0 or 1). For the ith cell in the matrix, our function sums the ith row, which represents the individual connections for one cell, and stores this value in the (i, i) position. We then take the product of our coupled matrix and our vector of β-cell voltages found at that time step via the ODE solver.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	-3	1		1						1																	
2	1	-4	1		1						1																
3		1	-3			1						1															
4	1			-4	1		1						1														
5		1		1	-5	1		1						1													
6			1		1	-4			1						1												
7				1			-3	1								1											
8					1		1	-4	1								1										
9						1		1	-3									1									
10	1									-4	1		1						1								
11		1								1	-5	1		1						1							
12			1								1	-4			1						1						
13				1						1			-5	1		1						1					
14					1						1		1	-6	1		1						1				
15						1						1		1	-5			1						1			
16							1						1			-4	1								1		
17								1						1		1	-5	1								1	
18									1						1		1	-4									1
19										1									-3	1		1					
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21												1								1	-3			1			
22													1						1			-4	1		1		
23														1						1		1	-5	1		1	
24															1						1		1	-4			1
25																1						1			-3	1	
26																	1						1		1	-4	1
27																		1						1		1	-3

FIGURE 3.2. **COUPLING MATRIX CONTAINING α- (PINK), β- (BLUE), AND δ- (GREEN) CELLS.**

Given that our matrix does not consist purely of β-cells, we adjust the coupling matrix to create a new linear index of only the positions of β-cells in our system, and call this *ListB*. We then index the original coupling matrix by omitting all rows and columns that do not have values in *ListB*. We do this because the coupling is not affected by any row or column that represents a connection to an α- or δ-cell, since the electrical coupling only occurs in adjacent β-cells. We define adjacency as one unit away in the *i*, *j*, or *k* direction. We then observe a square matrix that has dimensions of the size of *ListB* squared. Finally, we augment the diagonal values by assigning each value to the multiplicative inverse of the sum of all of the representative connections in each row, representing the coupling of the remaining β-cells.

$$C = \begin{bmatrix} -2 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & -3 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & -2 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & -3 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & -4 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & -3 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & -2 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & -3 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & -2 \end{bmatrix} \quad V_b = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \\ v_7 \\ v_8 \\ v_9 \end{bmatrix}$$

The matrix above is the coupling matrix for a 3:3:3 model, which has nine β-cells. Thus, it is 9 × 9. Our product represents a slight voltage change that is incorporated in a similar fashion to the other coupling functions — concatenation of a zero vector of placeholders with the vector of calculated β variables from the differential equations. This is calculated at every time step. To improve efficiency, the coupling matrix and its indexed version are calculated in the wrapper program before the main function and the ODE solver are called. This is done because once the number and position of β-cells are known, the coupling matrix stays constant; it is only the β voltage vector that changes at every time step.

3.3 SECRETION

Next we simulate the secretion and diffusion of insulin, glucagon, and somatostatin molecules. We decide to take advantage of our already discretized system, and treat the locations of the cells as points in space. We consider a standard diffusion reaction problem:

$$s_t = (D\nabla^2 s) + f(u, x, y, z) - ks, -\infty < x, y, z < \infty \tag{3.1}$$

Here, f is a function of variables u, such as voltage, and space where the cells are located. The parameter k is the degradation of the secreted molecules.

We use a simple finite central difference approximation of the second order, instead of taking a limit derivative. In the single dimensional case, $s_x = \frac{\partial s(x,t)}{\partial x}$. Thus we can approximate $s_x \approx \frac{s(x + \Delta x/2, t) - s(x - \Delta x/2, t)}{\Delta x}$. We use the same approximation for the second derivative, and get our diffusion equation.

$$s_{xx} \approx \frac{s(x + \Delta x, t) - 2s(x,t) + s(x - \Delta x, t)}{(\Delta x)^2} \tag{3.2}$$

We then extend this case to R^3 to get

$$\nabla^2 s = \frac{s(x + \Delta x, y, z, t) - 2s(x, y, z, t) + s(x - \Delta x, y, z, t)}{\Delta x^2} + \frac{s(x, y + \Delta y, z, t) - 2s(x, y, z, t) + s(x, y - \Delta y, z, t)}{\Delta y^2} + \frac{s(x, y, z + \Delta z, t) - 2s(x, y, z, t) + s(x, y, z - \Delta z, t)}{\Delta z^2}$$

This diffusion approximation is calculated by passing in the full coupling matrix that was developed by previous researchers[4], since we now care about the interaction between any two adjacent cells, rather than just β-cells. Thus we obtain a new discretized diffusion reaction equation:

$$\hat{s}_t = \frac{D}{(\Delta x)^2} C\hat{s} + \hat{f} - k\hat{s} \tag{3.3}$$

where we assume $\Delta x = \Delta y = \Delta z$. Here, C is the full coupling matrix. The $\hat{f}$ is the vector function of secretion into the system. For this example, we will use δ-cell somatostatin secretion. We have

$$\hat{f} = DeltaLoc * Effsfun \tag{3.4}$$

Effsfun is a function that calculates the amount of effective (non-decayed) somatostatin that leaves a δ-cell. It is then multiplied by *DeltaLoc*, which is a binary vector of the same length as the linear ordering of the system. *DeltaLoc* has 1s in the positions of δ-cells, and 0s in the positions of α- and β-cells. The multiplication of these two vectors results in a proper model of the initial somatostatin entering the system. We use an equivalent process for α-cell glucagon and β-cell insulin secretion.

3.4 PARACRINE EFFECTS ON HETEROGENEITY

In order to simulate the effects of paracrine coupling on the heterogeneity of α-cells, we assign two different $g_{K(ATP)}$ values ($26.5EffIa + 0.04$, $32EffIa + 0.04$) to the α-cells in our islet. This $g_{K(ATP)}$ value is the conductance for the K(ATP) channel in the α-cell, which varies depending on the amount of glucose in the blood. We simulate a high blood glucose level with our $g_{K(ATP)} = 26.5EffIa + 0.04$. We then run tests with and without the effects of β- and δ-cells felt on α-cells to see how paracrine coupling impacts the heterogeneity of α-cells.

4 RESULTS

We perform computational experiments on several islets with cell proportions (α : β : δ).

4.1 CASE 1: (1:1:1) TRI-HORMONE MODEL

In order to check the accuracy of our MATLAB code against the existing Tri-Hormone Model code, we first run simulations of a three-cell islet, which contains one of each cell type. This is modeled as a compartmental islet in which the secretion from each cell is felt instantaneously and without regard to space inside the islet. Below in Figure 4.1, we plot the voltages for each cell type and compare them with the voltages from the previous code of the Tri-Hormone Model. These voltages, in mV, correspond with each cell's secretion,

in μM, and we find similar oscillation patterns and timings for each. For a 10-minute simulation we observe that our α-cell voltage begins spiking around the two- and six-minute marks with maximum and minimum amplitudes around 10 and -50 mV, which are comparable to the values obtained from the NIH's code. For the β-cell voltage in MATLAB, we notice oscillation spikes around the two- and six-minute marks, which correspond to the voltage spikes in the Tri-Hormone Model code. The β-cell values for the oscillations also correspond as we see the maximum and minimum at 10 and -40 mV. We also observe that the voltages for the δ-cell in MATLAB experience oscillation spikes from two to five minutes with maximum and minimum amplitudes at about 0 and -50 mV. These cell voltages confirm that we are able to successfully recreate the Tri-Hormone Model in MATLAB.

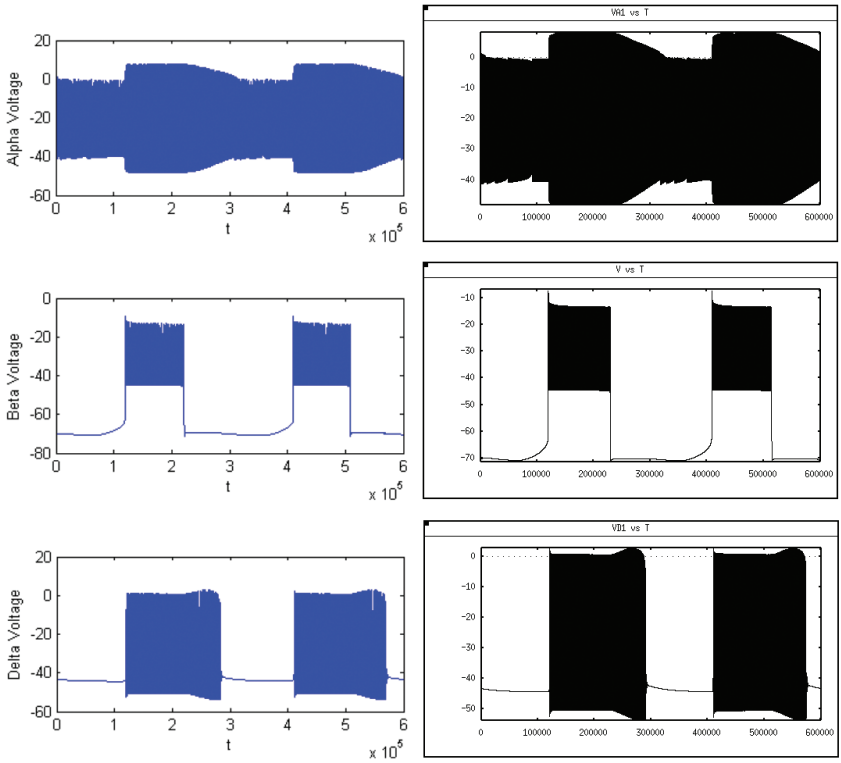


FIGURE 4.1. **MATLAB CODE (LEFT COLUMN) COMPARISON WITH PREVIOUS CODE (RIGHT COLUMN).**

We show α-, β-, and δ-cell voltages in column 1; glucagon, insulin, and somatostatin secretion in column 2; and α-, β-, and δ-cell calcium levels in column 3 of Figure 4.2.

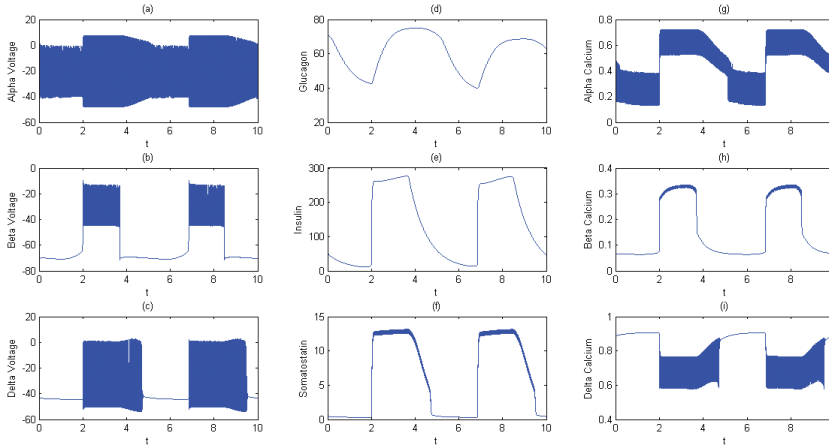


FIGURE 4.2. **TRI-HORMONE MODEL (1:1:1) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells.

4.2 CASE 2: (9:9:9) MODEL WITH SUMMED SECRETION

In obtaining Figure 4.3, we run simulations on a 3 × 3 × 3 cubic islet with three sequential planes, each containing nine cells of a different cell type. For this case, we apply the sum of the somatostatin to each α- and β-cell, as well as the sum of the insulin on each α- and δ-cell. This is done to see the change in voltage when each cell is overwhelmed by the amount of hormone it receives. For a 10-minute simulation, we see that the voltage for the α-cell experiences large bursts for extended periods of four minutes (between the two- and six-minute marks) instead of two-minute bursts as in the Tri-Hormone Model. Glucagon secretion also behaves differently in that it peaks at 77.5 μM around the two-minute mark and begins to decrease steadily until after 10 minutes. In comparison, the Tri-Hormone simulations show glucagon secretion oscillations that range from 40 to 75 μM. We also observe a diminishing in the period for β-cell oscillation. The voltage oscillations exhibited by the β-cells spike for less than two minutes, which is in contrast to our Tri-Hormone Model, which displays oscillation spikes for two minutes. The δ-cell in this summed simulation is in

stark contrast to the δ-cell of the Tri-Hormone Model in that its voltage oscillates for the entire 10 minutes instead of experiencing non-oscillating periods. The δ-cell also behaves differently in regard to somatostatin secretion. Somatostatin seems to secrete at regular intervals of five minutes as opposed to in the Tri-Hormone Model, which has periods of 2.5 minutes. The values to which cell somatostatin secretion oscillates in this simulation range from 5 to 12.5 μM in comparison to 0 to 12.5 μM in the Tri-Hormone Model. Somatostatin is being released at a higher rate throughout this simulation.

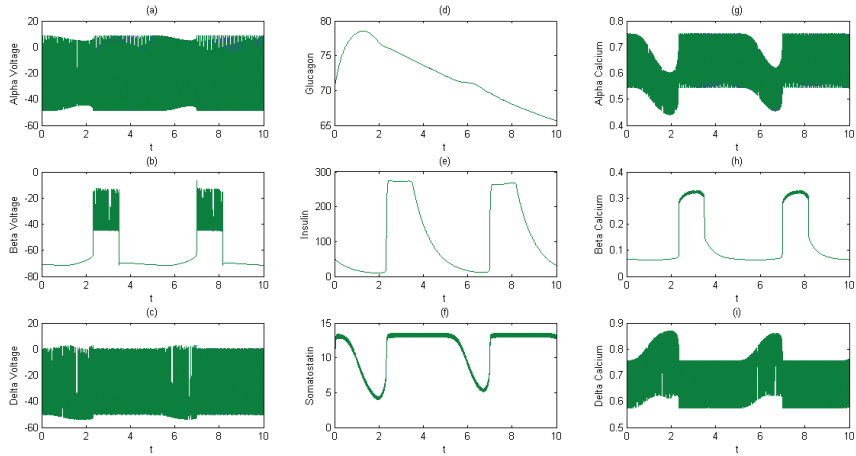


FIGURE 4.3. **CASE 2 (9:9:9) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells. High levels of somatostatin maintain high-amplitude α-cell voltage oscillations with a corresponding loss in glucagon oscillations.

4.3 CASE 3: (9:9:9) MODEL WITH NORMALIZED SECRETION

In obtaining Figure 4.4, we run simulations on the same islet as in Case 2, but we vary the secretion values over the two cases. This case sums the amount of insulin detected by the α- and δ-cells and divides it by the number of β-cells — in this case, nine. We also sum the amount of secreted somatostatin that is detected by α- and β-cells and divide the sum by the number of δ-cells. This is done so that each cell detects the average amount of secretion. When we average the secretions, the behavior of the α-, β-, and δ-cells resembles the behavior seen in the Tri-Hormone Model. The voltage for the α-cell shows maximum oscillations from two to four and from seven to

nine minutes from 10 to -50 mV, just as in the Tri-Hormone Model. The β-cell voltage also resembles the Tri-Hormone Model behavior by showing oscillation spikes around the periods between the two- to four- and seven- to nine-minute marks, with oscillations between 10 and -40 mV. The voltage for the δ-cell also exhibits maximum oscillations between the two- and five-minute marks and between the seven- and nine-minute marks, having oscillations between 0 and -50 mV. The behavior of each of these cells imitates the behavior shown in the Tri-Hormone Model.

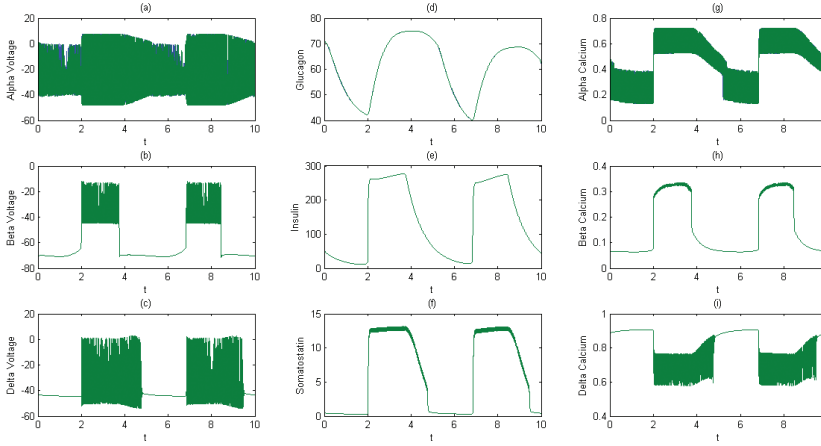


FIGURE 4.4. **CASE 3 (9:9:9) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells. Replacing total somatostatin with average levels returns the traces to those of Case 1 (1:1:1).

4.4 CASE 4: (5:20:2) MOUSE ISLET WITH NORMALIZED SECRETION

Figure 4.5 is obtained by simulating a mouse islet cellular distribution for a 3 × 3 × 3 cubic islet. Just as in Case 3, the amount of secretion is divided by nine in order to examine the effects that different cell distributions have on cell behavior. In this simulation, we notice a longer period of maximum oscillation for the voltage of α-cells compared to our averaged model. The range of oscillation is comparable, but the period spans for three minutes (two- to five-minute mark) instead of two minutes (two- to four-minute mark). Glucagon behavior also differs slightly from that of the averaged model with values ranging from 50 to 75 μM instead of 40 to 75 μM. The β-cell

behavior is consistent with the averaged model. The voltages for the β-cell exhibit bursts from two to four minutes and from seven to nine minutes, just as in the averaged model. Compared with our averaged model, δ-cell behavior also changes. The δ-cell voltage exhibits longer bursts of about four minutes (from two minutes to just under six minutes) instead of about three minutes. There is also an initial burst in voltage at time 0, which we do not see in any other case. The somatostatin secretion also experiences extended maximum bursts. We see somatostatin spike at two minutes from 0 to 12.5 μM for three minutes instead of for two minutes as with our averaged model.

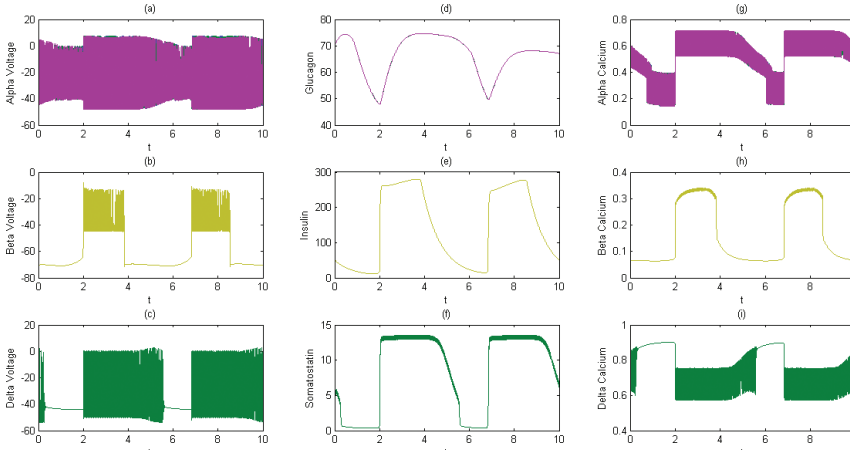


FIGURE 4.5. **CASE 4 (5:20:2) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells. The change in cell type distribution increases the time in the active phase of the burst period.

4.5 SPATIAL CASE 3

Upon the implementation of spatial coupling, we run the same cell distributions as in the compartmentalized Cases 3 and 4. Figure 4.6 shows the data for Case 3. The amplitudes of the various values tend to be smaller than those in the compartmentalized models. This is because we are no longer passing in the full hormone secretion values to each cell at each point. The secreted hormones are now dependent on space and time, and with an added delay constant, they result in smaller values at each discretized point.

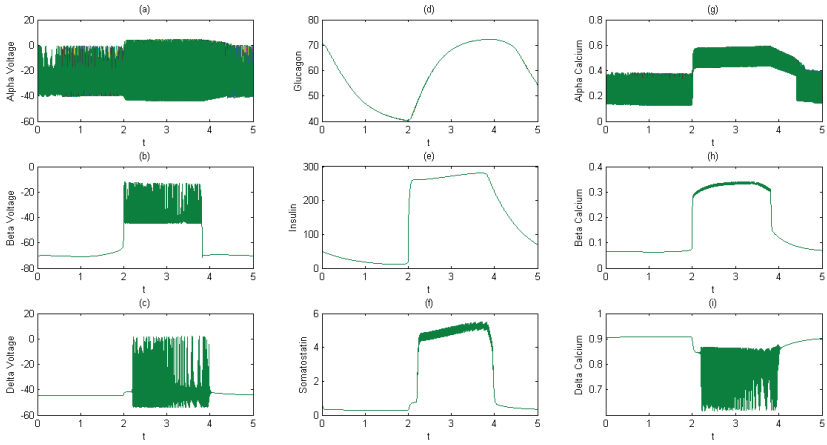


FIGURE 4.6. **SPATIAL CASE 3 (9:9:9) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells. There is a slight decrease in amplitude in the high-amplitude behavior, usually through 4.5 minutes. Traces here are only five minutes.

We are also able to create a visual representation (Figure 4.7) of the flow of the secreted hormone, insulin, through the discretized islet.

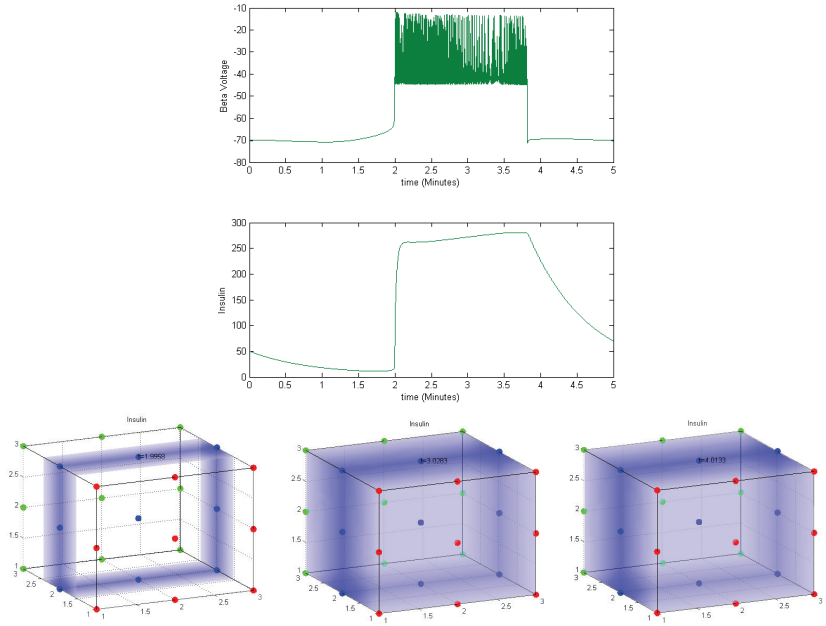


FIGURE 4.7. **ISLET STRUCTURE AND INSULIN SECRETION IN SPATIAL CASE 3 (9:9:9).** Density of blue relates to concentration of insulin. We see insulin distribution at t = 1.9950 minutes, 3.0283 minutes, and 4.0133 minutes, corresponding to the voltage and insulin traces above.

At the exact time when the β-cell voltage spikes, the amount of insulin greatly increases, as is confirmed by the 3D model at that point in time.

4.6 SPATIAL CASE 4

Figure 4.8 shows a similar process for the spatial analogue of the compartmentalized Case 4. There are some noteworthy observations here as well. The α-cell voltage greatly increases after the first β-cell voltage spike. Until that point, the voltage oscillations have much smaller amplitudes. The δ-cell voltage spike also occurs after the first β-cell voltage spike. Another key thing to note is the spectrum of color in our graph. We graph each cell with a different color to see if the cells are behaving differently.

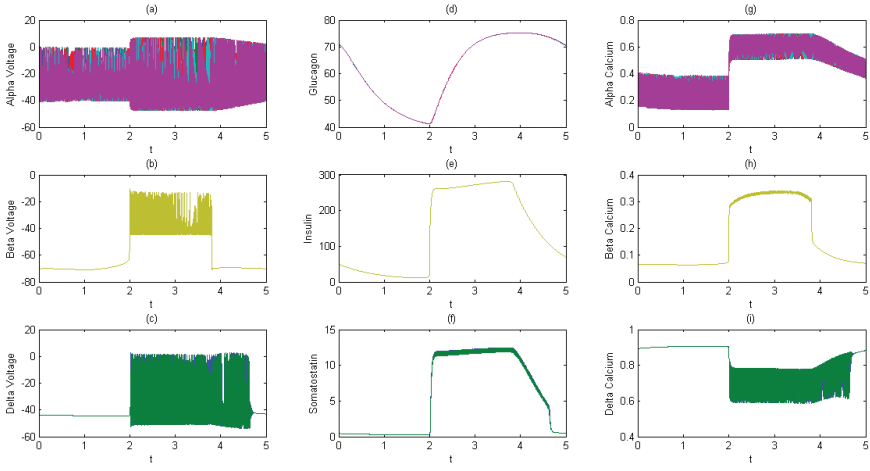


FIGURE 4.8. **SPATIAL CASE 4 (5:20:2) RESULTS.** Columns show voltage (mV), hormone secretion (μM), and cytosolic calcium (μM) for each row of α-, β-, and δ-cells.

In the compartmentalized model, we see very little color variation, as expected. Since all cells receive the same hormonal inputs, they all act the same. However, now that the cells are in different points in space, they receive different amounts of insulin and somatostatin, resulting in multiple cells acting heterogeneously.

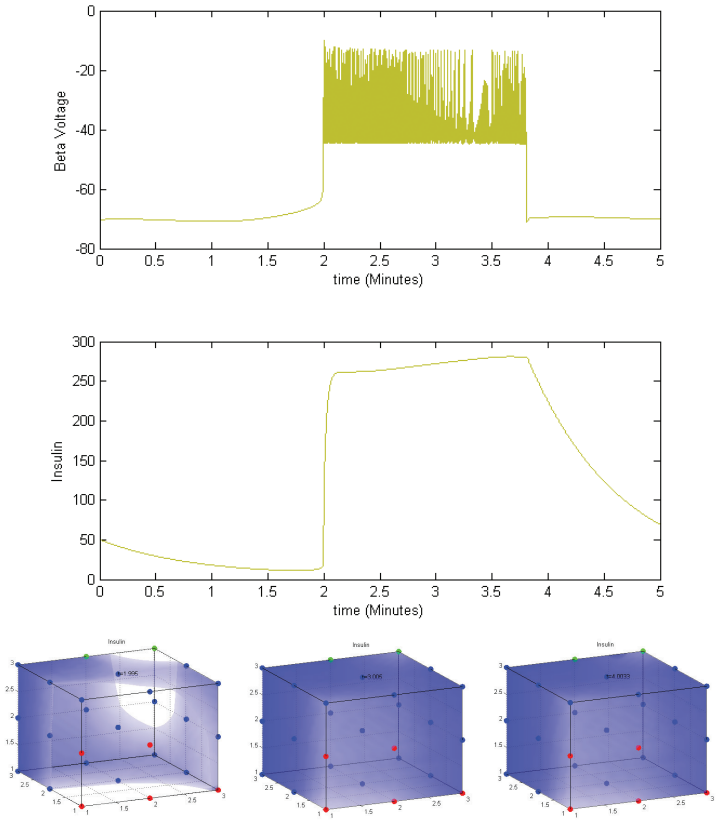


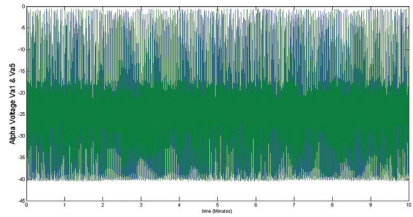
FIGURE 4.9. **ISLET STRUCTURE AND INSULIN SECRETION IN SPATIAL CASE 4 (5:20:2).** Density of blue relates to concentration of insulin. We see insulin distribution at t = 1.995 minutes, 3.005 minutes, and 4.033 minutes, corresponding to the voltage and insulin traces above.

In doing a similar visual simulation of insulin secretion, shown in Figure 4.9, we find that the insulin spreads much more rapidly into the cell. This is a result of the cell distribution containing a majority of β-cells.

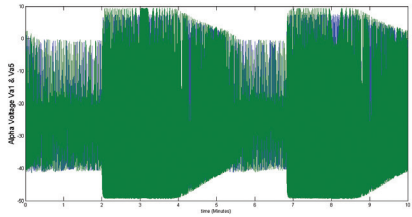
4.7 PARACRINE INTERACTIONS AND α-CELL HETEROGENEITY

We are able to simulate heterogeneity in α-cells with and without paracrine coupling. This is done in order to see if paracrine coupling can help normalize this α-cell heterogeneity. Each of these two simulations uses a 3 × 3 × 3 cubic islet. For the averaged 9:9:9 cell distribution islet, we assign $g_{K(ATP)} = 26.5 EffIa + 0.04$ to four α-cells

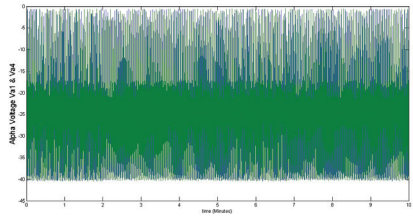
and $g_{K(ATP)} = 32EffIa + 0.04$ to five α-cells. The non-coupled case shows differences in oscillation frequency among the heterogeneous cells. This is shown by the lack of overlap in the two voltage plots. However, when we account for the paracrine effects on the α-cells, they start to exhibit more homogeneous behavior. This can be seen in the increase in overlap of the cell voltages. We then run the same simulation with the mouse islet distribution. We assign $g_{K(ATP)} = 26.5EffIa + 0.04$ to three α-cells and $g_{K(ATP)} = 32EffIa + 0.04$ to two α-cells. The voltage oscillations in the non-coupled islet also exhibit a lack of voltage overlap among the cells. However, when the α-cells are coupled with β- and δ-cells, there is an increase in overlap, which means the α-cells begin to behave more similarly to one another. One difference between this mouse islet and the 9:9:9 cases is that the mouse islet exhibits a longer period of maximum voltage oscillation.



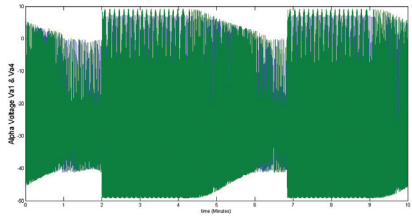
(A) HETEROGENEOUS 9:9:9 ISLET WITH NO COUPLING



(B) HETEROGENEOUS 9:9:9 ISLET WITH COUPLING



(C) HETEROGENEOUS MOUSE ISLET WITH NO COUPLING



(D) HETEROGENEOUS MOUSE ISLET WITH COUPLING

FIGURE 4.10. **HETEROGENEOUS ISLETS WITH AND WITHOUT CELL COUPLING.**

5 CONCLUSION

In producing our computational model of a pancreatic islet, we have gained a better understanding of how islet size and cell distribution can affect cell behavior. We were able to properly scale the Tri-Hormone Model to a 3 × 3 × 3 cubic islet. We also successfully implemented a model in which the user is able to determine cell arrangement. This was done in order to simulate different cell proportions, specifically a mouse islet distribution, in which we were able to observe different cell behaviors than we did in the Tri-Hormone Model. Spatial aspects of the islet were also taken into consideration by modeling secretion with secretion equations. We were also able to run simulations testing the effects of paracrine coupling on α-cell heterogeneity.

When we scaled the Tri-Hormone Model from a three-cell model to a 27-cell model, we were able to replicate cell behavior. After we averaged the amount of secretion detected by each cell, the voltages and secretion for each cell emulated that which was found in the Tri-Hormone Model. We then compared this result with a mouse islet cell distribution. When more β-cells were incorporated into an islet as in the mouse islet, we saw a change in behavior in the α- and δ-cells. We saw an increase in the voltage oscillation period for these cells, which could be due to the increase in insulin in the islet.

We also noticed that paracrine effects had a taming quality in regard to α-cell heterogeneity. When we did not account for paracrine coupling and assigned different $g_{K(ATP)}$ values to our α-cells, we observed different behaviors among cells. However, when we accounted for the effects that β- and δ-cells had on α-cells, the α-cells began to act more homogeneously.

Moving forward in this project, it would be interesting to simulate larger islets. This would be done in order to test whether scaling an islet affects cell behavior. Creating larger islets would also allow the user to simulate more complex and realistic cell arrangements.

It would also be interesting to run simulations in which the distance between cells is not one unit in the (i,j,k) direction. This could be done in order to observe how certain cells behave when surrounded by a specific type of cell (for example, how an α-cell that is surrounded by β-cells behaves compared to an α-cell whose neighbors vary).

ACKNOWLEDGMENTS

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AUTHOR BIO

Kendall Queen is a Meyerhoff Scholar at UMBC who is majoring in computer engineering. His primary interests lie in robotic sciences; however, after spending his summer at UMBC working on a research project involving biological application of mathematics, he is considering furthering his education in biology to pursue biological engineering. He would like to thank his faculty mentor, Dr. Bradford Peercy, and summer program coordinator, Dr. Matthias Gobbert, for helping to guide his team to achieve progress and success in his team's research project. He also wants to recognize Dr. Arthur Sherman and Dr. Margaret Watts of the National Institutes of Health (NIH) for providing the project and hosting his team visit to the NIH. He would also like to recognize his team members — Annie Dai, David Palensky, Alex Piatski, Gina Vockeroth, and graduate assistant Teresa Lebair — for the tremendous time, effort, and energy they all put into making this research project a success.

EVALUATING THE ABILITY OF LOW-TECH PROCESSES TO REMOVE BACTERIAL CONTAMINANTS FROM DRINKING WATER IN KENYA

HOLLIE **ADEJUMO**

Co-Authors: Madison Bondoc and Dalton Hughes

Approximately 760 million people lack access to clean drinking water; a disproportionate fraction of those people are located in Sub-Saharan Africa. High chemical and bacterial contaminant levels in drinking water may cause a myriad of health complications. The small community of Isongo, Kenya lacks clean drinking water for its 500 residents. The residents currently retrieve water from an unprotected spring located approximately 20 minutes away from some homes. In January 2013, the UMBC chapter of Engineers Without Borders (EWB-UMBC) traveled to Isongo to assess the current water quality and interview community members who use this water source. Results from the water quality tests revealed high levels of indicator organisms such as *Escherichia coli* and other fecal coliforms. Interviews indicated that many children suffer from dysentery and other waterborne diseases. Residents also expressed an interest in receiving information on best practices for sanitation and hygiene. In this report, we compare the abilities of three different methods to remove bacteriological contaminants from water supplies. The findings of this study will result in identification of a treatment system that can improve water quality and the overall health of the Isongo population.

INTRODUCTION

Engineers Without Borders (EWB) is an international organization that designs and implements sustainable projects in communities around the world. The University of Maryland, Baltimore County (UMBC) chapter of EWB was established in 2009 to bring students together to apply their theoretical knowledge to solve real-world problems. This study shares the motivations of the EWB-UMBC chapter and aims to bring clean water to Isongo, Kenya.

Isongo is a small farming community in western Kenya consisting of approximately 500 residents. The village expressed a need for clean water to EWB-UMBC; this need laid the foundation of EWB-UMBC's ongoing partnership with the community for the Kenya Clean Water Project. An EWB-UMBC assessment team traveled to Isongo in January 2013; spoke with residents about the intersection of water, sanitation, and hygiene; and conducted chemical and bacteriological assays for indicator organisms. These organisms indicate the potential presence of pathogens. Total coliform tests can indicate that bacterial contaminants exist in the water source, but these tests do not indicate whether the bacteria cause illness. The presence of *Escherichia coli*, a fecal coliform in the family Enterobacteriaceae, constitutes a higher risk of pathogen transmission. The results of the assays are summarized in Table 1.

TABLE 1. **CHEMICAL AND BIOLOGICAL ASSAY DATA COLLECTED ON-SITE IN ISONGO, KENYA.**

PARAMETER	BOREHOLE AT GUEST HOUSE (REFERENCE)	ISONGO DRINKING WATER	ISONGO WASH WATER
Total chlorine (mg/L)	< 0.5	< 0.5	< 0.5
Total coliforms (count/mL)	< 1	27	41
Escherichia coli (count/mL)	< 1	27	45
Enterobacteria (count/mL)	< 1	17	29

As Table 1 shows, the drinking water supply in Isongo is contaminated with high levels of indicator organisms, including *E. coli*, enterobacteria, and total coliforms. The presence of these organisms indicates that human pathogens, which cause many waterborne diseases, may be present in the water supply. Note that the bacteriological levels in the wash water were even higher than those in the drinking water supply. The reference source, which was deep groundwater, did not contain any bacteriological contaminants.

The objective of the project was to evaluate the abilities of three water treatment processes to remove bacteriological contaminants from a surrogate water supply, namely the Albin O. Kuhn Library Pond on the UMBC campus. The following treatment methods were investigated: the PUR™ water purification kit, solar disinfection (SODIS), and biosand filtration. Each method was used to treat water collected from the Library Pond. The applicability of these processes in Isongo is also discussed.

EXPERIMENTAL MATERIALS AND METHODS

Surface water samples were collected at the Albin O. Kuhn Library Pond. To quantify the abilities of the three water treatment technologies to remove bacteria from the Library Pond water, bacterial counts were measured using 3M Petrifilm test kits, shown in Figure 1. Inoculation was performed by transferring 1 mL of the sample onto the growth region of each Petrifilm plate. A plastic spreader was then used to evenly distribute the water sample across the growth region. The plates were incubated at 37°C, and bacterial colonies were counted after 24 hours.

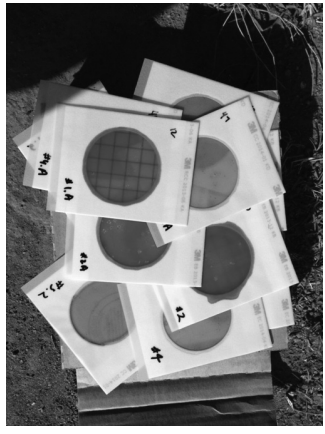

FIGURE 1. **PHOTO OF 3M PETRIFILM TEST KITS.** Colonies of total coliforms, *E. coli*, and enterobacteria were counted on the 3M Petrifilm plates.

PUR PURIFIER OF WATER

Developed in 1990 by Recovery Engineering, Inc., the PUR process is mostly used in household humanitarian applications to reduce the concentration of bacteria, viruses, protozoa, metals, and chemicals from water. Each PUR packet, composed of iron(III) sulfate and calcium hypochlorite, was added to five liters of untreated pond water. After five minutes of stirring, the solution was allowed to settle for five minutes. During this period, three main processes helped to separate suspended solids from water: coagulation, flocculation, and sedimentation. In coagulation, iron sulfate stabilizes the surface charge of dissolved solids and calcium hypochlorite disinfects the water by inactivating microorganisms. As a result, the suspended particles are capable of aggregating, and eventually form a floc. As the water is stirred, more particle collisions occur and larger flocs form. In sedimentation, the majority of the suspended solids, now in large flocs, settle to the bottom of the container, allowing for easy cloth-based filtration. The bacteriological results stemming from PUR treatment of Library Pond water are shown in Figure 2.

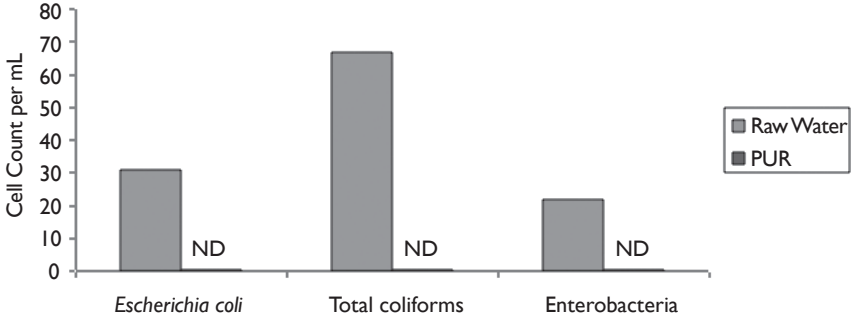

FIGURE 2. **RESULTS FROM PUR TREATMENT OF LIBRARY POND WATER.** After treatment, bacterial counts were not detected (ND). These results demonstrated that the PUR process was successful in removing the bacterial contaminants.

SOLAR DISINFECTION (SODIS)

The second water treatment that was explored was solar disinfection, or SODIS. These experiments were conducted in clear two-liter soda bottles that were filled with untreated water. The bottles were laid flat on their sides (*i.e.*, parallel to the floor) on the roof of the UMBC Engineering Building for six hours under direct sunlight.

During this six-hour exposure time, cells in the bottles absorb ultraviolet (UV) light, which dimerizes the cytosine and thymine bases in DNA. This dimerization prevents DNA replication from occurring. Inhibiting DNA replication prevents bacterial growth in the bottles. Clearly, this treatment process is most effective on clear, sunny days. Weather conditions involving cloud cover often necessitate SODIS treatment for more than one day. Bacteriological results from SODIS trials are shown in Figure 3.

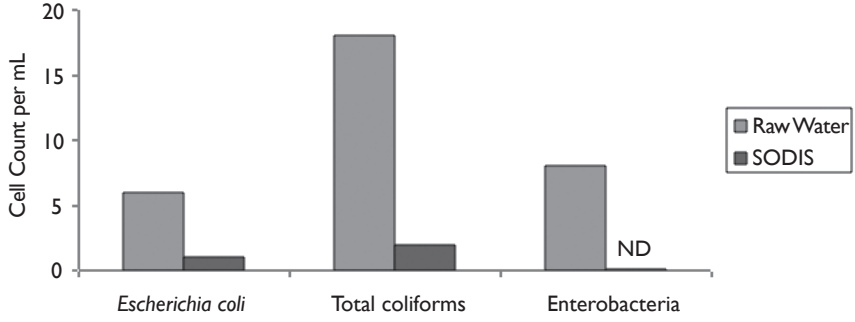

FIGURE 3. **BACTERIOLOGICAL RESULTS FOR SODIS TREATMENT OF LIBRARY POND WATER.** No enterobacteria were detected (ND) and more than 90% of the *E. coli* and total coliforms were eliminated.

BIOSAND FILTRATION

The biosand filter was constructed from a 20-liter bucket, PVC pipe, 0.25-inch gravel, and fine sand. This laboratory-scale biosand filter included a diffuser plate to reduce the kinetic energy of influent water and to provide an even distribution of water across the cross-sectional area. The research team acknowledges the assistance of Mr. Victor Fulda, CBEE Engineering Technician, in constructing the biosand filter. During operation, small particles, including bacterial cells, are captured in the sand layer. The gravel at the bottom of the filter allows for efficient collection of water and transmission to the spigot. A diagram of the constructed biosand filter is shown in Figure 4.

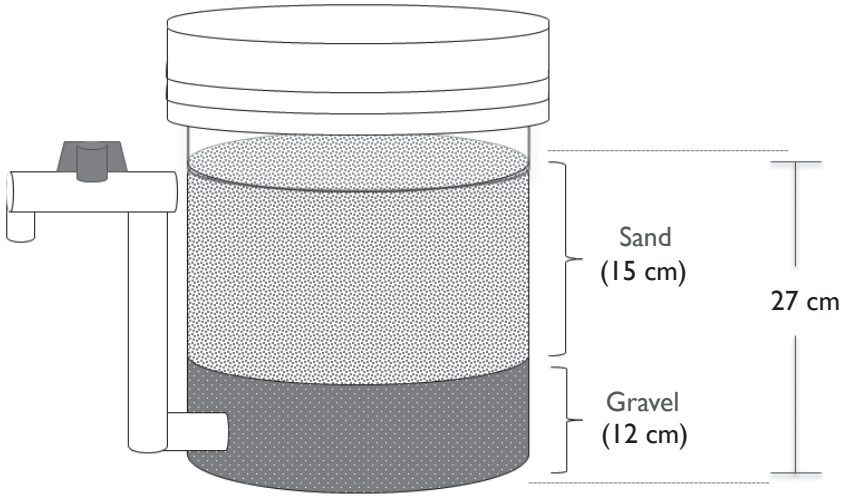

FIGURE 4. **DIAGRAM OF THE BIOSAND FILTER.** Water flows through the sand layer and then is discharged from the PVC spigot.

During operation, water is introduced at the top of the filter and flows through the sand layer. After traveling through the gravel layer, the water flows through the PVC pipe and out of the spigot. The pressure gradient between the water and atmosphere provides enough hydraulic head for the water to flow at a constant rate of 40 cm^3/min. Over time, a biologically active layer called the *schmutzdecke* forms at the top of the sand surface. This layer is composed of impurities, organic matter, and particles that are trapped at the surface. The *schmutzdecke* aids in the water purification process but can also increase head loss across the filter, which leads to reduced flow rates.

The collection method involved the use of a five-gallon bucket to obtain water from the edge of the Library Pond – simulating the typical collection method in Kenya. The water collected from the pond initially had high counts of *E. coli*, total coliforms, and enterobacteria. Prior to data collection, the biosand filter was rinsed with the water sample to remove traces of other water sources. After treatment using the laboratory-scale biosand filter, bacteriological counts decreased significantly. Figure 5 shows that *E. coli* and other enterobacteria were not detected in the water after treatment and only trace levels of coliforms were detected.

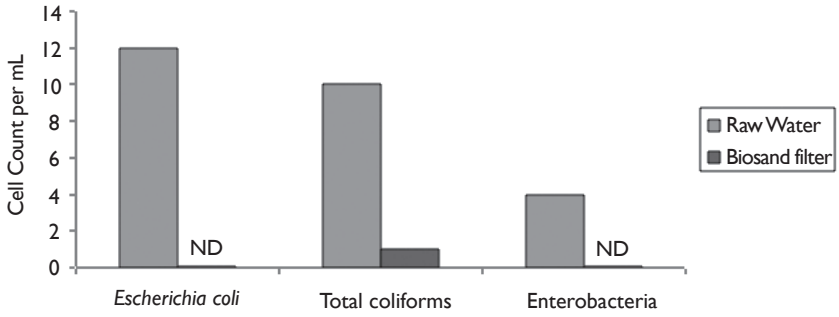

FIGURE 5. **BACTERIOLOGICAL RESULTS FROM BIOSAND FILTER TREATMENT OF LIBRARY POND WATER.** No *E. coli* or enterobacteria were detected (ND) and >90% of the coliforms were eliminated.

REMOVAL EFFICIENCY

The removal efficiency of the bacterial populations in each of the three treatment processes can be calculated with the equation below, where η represents the removal efficiency, c_{in} is the bacterial cell count before treatment, and c_{out} is the bacterial cell count after treatment.

$$\eta(\%) = \left(1 - \frac{c_{out}}{c_{in}}\right) * 100\%$$

The results indicate that the PUR treatment removed nearly 100% of total coliforms, *E. coli*, and enterobacteria. The SODIS method removed 100% of enterobacteria and most, but not all, of the total coliforms and *E. coli*. Biosand filtration also demonstrated a high removal of coliforms, and nearly 100% removal of the *E. coli* and enterobacteria. The calculated removal efficiencies for all processes and contaminants are shown in Table 2. In summary, these results indicate that the three water treatment options were all successful in removing bacteriological contaminants from water.

TABLE 2. **REMOVAL EFFICIENCIES OF EACH WATER TREATMENT OPTION.**

PARAMETER	PUR	SODIS	BIOSAND FILTRATION
Total coliforms	~100%	94%	90%
Escherichia coli	~100%	83%	~100%
Enterobacteria	~100%	~100%	~100%

DISCUSSION

The three water treatment methods investigated have several advantages and disadvantages that affect their ability to be deployed in Isongo. One advantage of the PUR process is the excellent treatment efficiency; PUR removed 100% of the bacteriological contaminants. In addition to the high removal efficiency, PUR can also remove select chemical contaminants from water, although chemical contaminants were not specifically monitored in this study. However, PUR is expensive; households need to buy a packet for each 20-liter jerry can of water. The PUR solution is implemented at the household level and so there may be some members of the community that would not use PUR and would continue to consume contaminated drinking water. For this reason, the researchers do not think that PUR represents an adequate solution for the water quality problems in Isongo.

The SODIS method is extremely inexpensive, particularly because plastic bottles are widely available in Isongo. Because this treatment process only requires two-liter plastic bottles, no complicated or expensive construction is necessary. The major disadvantage of this process is that a long period of time is required to obtain a relatively low volume of water. Similar to PUR, SODIS is a household solution. Ensuring that all households follow the correct treatment procedures is a challenging task, and failure to do so may lead to improper treatment. In this case, the water may retain pathogens and represent a public health concern.

The biosand filter approach involves construction, but the required materials are fairly available and inexpensive. In addition, biosand filters require minimal maintenance and can be constructed using concrete for increased durability. Unlike PUR and SODIS, biosand filters can be adapted for larger-scale systems and can be used as a community solution to water quality issues. Several filters

can be constructed in order to meet the water requirements. One major advantage of the biosand filter is that the solution is sustainable – the community members can easily become involved with the construction and management of the product. Biosand filters are an affordable option for water treatment, with the cost of filters ranging from $12 to $30 per treatment system, depending on the availability of construction materials. Disadvantages of this treatment option include a low effluent flow rate and a low removal efficiency of chemical contaminants. In addition to these disadvantages, the biosand filter approach may require a few weeks for the *schmutzdecke* to develop completely. As a result of the time required to construct the biosand filter and for the bioactive layer to form, the biosand filter does not provide an immediate solution to the water quality problems in Isongo.

FUTURE WORK

Now that the three chosen processes have been investigated individually, the research team would like to pursue treatment studies focused on assessing the effectiveness of SODIS, biosand filtration, and PUR treatment performed in series. Such a scenario will build upon the advantages of each process, while addressing some of the critical weaknesses of individual methods. For example, the high removal efficiencies found for each process may provide a synergy that removes nearly all traces of bacteriological contaminants. It would also be beneficial to investigate other methods of bacterial detection. 3M Petrifilms, while widely used in the food industry, have a detection limit of 100 counts per 100 mL. Other methods such as the Colilert Method by IDEXX Laboratories have a reported detection limit of 10 counts per 100 mL, providing a more sensitive method for bacterial detection.

The EWB-UMBC team is planning to drill a borehole and install a hand pump for the Isongo community. Approval of the team's plans was received in May 2014. While this well should reduce the need for subsequent treatment (recall from Table 1 that groundwater had low levels of bacteriological contaminants), the team is still interested in discovering and implementing more effective solutions.

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THE TRAGEDY OF RELUCTANT COMPASSION

JEWISH CHILD REFUGEES AND BRITAIN'S KINDERTRANSPORT PROGRAM BEFORE THE SECOND WORLD WAR

SARAH **KLIMEK**

At first glance, Britain's Kindertransport program struck me as a uniquely successful humanitarian effort amid the relentless horrors of the Holocaust. In the final months before the Second World War, the British government offered temporary refuge to 10,000 Jewish children living under the growing menace of Nazi anti-Semitism. What could be more admirable? I came across the Kindertransport while doing some background research for my history capstone course with Dr. Ritschel on the British home front during the Second World War. For a program that was invariably depicted as a heroic rescue mission, I was surprised that I had never heard of it before and decided to focus my research on its creation and implementation. As my research progressed, however, I realized that the benign façade of the Kindertransport hid a much more troubling story. Far from a shining example of one country's magnanimous efforts in the face of chilling oppression, the tale behind Britain's Kindertransport reveals the profound ethical dilemmas created by a highly calculated act of reluctant humanitarianism. Tragically, the ones who ultimately paid the price were the very children, now collectively known as the "Kinder," whom Britain intended to save. I was hooked by the story of the Kindertransport and hope readers will find it equally moving.

INTRODUCTION

Great Britain's Kindertransport program is widely regarded as one of the most important humanitarian efforts to save European Jews before the Second World War. This rescue mission, which was initiated shortly after the Kristallnacht pogrom in November 1938 and continued until the outbreak of war in September 1939, transported thousands of mostly Jewish children from Nazi territories to Britain. Upon their arrival, the children were placed in family homes and hostels throughout Britain, where they spent the war in relative comfort and safety. Compared to the actions of other European countries and the United States, British actions on behalf of child refugees were extremely generous.[1] By July 1939, European countries such as France and Sweden had taken in no more than several hundred Jewish children from Germany, while the U.S. had rejected facilitating the entry of German child refugees entirely.[2] In Britain, by contrast, the Movement for the Care of Children from Germany, the British umbrella organization that coordinated the Kindertransport effort, would rescue nearly ten thousand children in the nine months of its operation before September 1939.[3] Since there is little doubt that the Kindertransport saved the lives of children who would have perished in the Holocaust, the program has been rightly applauded as a singularly remarkable act of British kindness and generosity.

Despite the undeniable accomplishments of this humanitarian effort, this study of the memoirs written by the children of the Kindertransport offers a substantially more qualified view of the program and its legacy. Recollections by the children, now collectively known as the "Kinder," not only provide first-hand accounts of the children's experiences and survival during the war, but also highlight the traumatic consequences that they endured as a result of their survival. While the children all conveyed their sincere gratitude to those who saved their lives, they also reflected on the disappointments, hardships, and tragedies that they encountered along the way. Their memoirs and recollections reveal that, for the overwhelming majority of the Kindertransport children, the primary source of the trauma they faced in the aftermath of their rescue resulted from the separation from their families.[4]

The children's separation was unfortunately a defining element of the Kindertransport. The program only allowed for the

admission of unaccompanied children up to the age of seventeen, meaning that, in the vast majority of cases, the children's families were forced to stay behind in Central Europe when their young sons and daughters left for England.[5] While at the time this separation was assumed to be temporary, the severity of the menace facing Jews in Germany that had prompted this program also hinted that the separation would become far more permanent, an implication that we now know was grimly accurate. Tragically, historians have estimated that, of the ten thousand children rescued on the Kindertransport, ninety percent of them lost their parents, and in most cases their entire families, in the Holocaust.[6]

The condition that only children up to the age of seventeen were eligible for the transports was rooted in pre-war British immigration policy. This policy was driven in part by a variety of internal and external pressures, but also by the government's own highly ambivalent views on Jewish immigration. After Hitler rose to power in 1933, Britain was faced with a steadily growing number of Jewish applicants looking desperately for a safe haven from Nazi anti-Semitism. The British government responded by steadfastly refusing to make any special accommodations on behalf of Jewish refugees. Despite the deteriorating conditions in Germany and concerted efforts of domestic refugee organizations in Britain to elicit a more welcoming response, the Chamberlain government continually resisted all appeals to allow a greater number of Jewish refugees into the country. It was only after Kristallnacht, the anti-Jewish pogrom in 1938 that generated intense public pressure for some action in response, that the British government agreed to the implementation of the Kindertransport.

We now know that the Kindertransport had tragic implications for the children who were rescued. The children's lives were saved, but they also found themselves alone and isolated in a foreign country that would not accept the rest of their families. After the end of the war, the children were left to discover that nearly all of those they had left behind had perished. Of course, British government officials cannot be blamed for the fate of the children's families. Their about-face and the concerted efforts of the refugee organizations involved in the Kindertransport clearly saved thousands of Jewish children's lives, and the fact that such a mammoth task was accomplished within nine months is both remarkable and admirable. Yet the limited scope of the Kindertransport and its deliberate exclusion of adults from its purview ensured that this comparative

humanitarian triumph would also add to the immense tragedy of the Holocaust.

The Kinder's reflections on their initial separation and their traumatic discoveries of the loss of their families after the war highlight the ambivalent consequences of this reluctant rescue mission. It is clear that, if given the choice anew, few of the children would have chosen to stay and die in Germany. Nevertheless the very program that provided for their rescue also created the traumas of separation and loss that substantially harmed the children's psychological and emotional well-being. As such, the Kindertransport narrative demonstrates the ethical dilemmas that such reluctant humanitarian actions engender, while the children's stories collectively reflect the unfortunate but perhaps inevitable consequences of Britain's reluctance to implement substantial refugee assistance measures. Through their memoirs and reflections, the Kinder create a unique narrative that highlights both the successes and tragic failures of the Kindertransport program.

This research paper offers an analysis of the Kindertransport program, particularly the factors that shaped the development of Britain's immigration policy in the 1930s, the creation of the Kindertransport as a product of this policy, and the impact of the program on the children's lives. This analysis will first examine the contemporary debates surrounding Britain's immigration policy in the 1930s and the factors that eventually persuaded the Chamberlain government to agree to the implementation of the Kindertransport. An examination of the children's experiences will then emphasize some of the common themes presented in the Kinder's memoirs, particularly their struggles with separation, isolation, and survivor's guilt. In doing so, my research will seek to reveal the psychological and ethical problems that stem from the Kindertransport and the hesitant refugee policy that shaped it. The intent of my analysis is to highlight the moral ambiguity behind official British attitudes towards Jewish refugees, and the ways in which this shaped immigration policy before the war and the subsequent lives of the children who were saved through the Kindertransport.

BRITISH IMMIGRATION POLICY IN THE 1930S

Britain's response to Jewish refugees in the years leading up to the Second World War needs to be considered in the context of the circumstances that led to refugees' attempts to flee from Germany

and central Europe in the 1930s. After Hitler's appointment as Chancellor of Germany in 1933, the new German government began to mix official discrimination and state-sponsored violence with anti-Semitic policies that gradually stripped Jews of their economic, political, and social rights.[7] The most infamous piece of Nazi legislation, the 1935 Nuremberg Laws, established criteria based on family background to define those considered Jewish and deprived them of their full citizenship status and their right to marry or employ anyone "of German or related blood."[8] After Germany's annexation of Austria in March 1938, the Nazi government initiated a chilling policy of forced emigration, in which Jews were stripped of their remaining economic assets and required to secure an emigration visa within two weeks or risk being deported to a concentration camp.[9] While Jewish emigration rates had fluctuated in the preceding years in accordance with peaks and lulls in anti-Semitic violence, they now increased rapidly as the harsh and dangerous realities of life in Germany became more apparent.[10]

Official British policy towards Jewish immigration during this period combined clear recognition of the situation facing Jews in Germany with an unwillingness to do much about it. From 1933 to the spring of 1938, the British government admitted refugees only on a temporary basis, until they re-emigrated to destinations abroad, while charitable organizations like the Jewish Refugees Committee underwrote their financial maintenance during their stay.[11] Although Anglo-Jewish leaders pushed for the government to offer temporary asylum to all German refugees, government officials insisted that there could be no automatic "right of asylum," and therefore the government would only grant asylum on an individual basis and at its own discretion.[12] The government maintained this policy until the German annexation of Austria in 1938, which brought a new wave of Austrian Jewish refugees that put unbearable strains on the financial support provided by the Anglo-Jewish community.[13] In response, the government tightened restrictions by reinstituting a visa system for all German and Austrian immigrants, which moved the flood of refugees from British ports to consulate offices in their home countries and slowed the process by which the refugees could gain entry to Britain.[14] Visas were generally denied to anyone suspected of being a refugee unless he or she could prove a means of financial support and plans for re-emigration.[15] Since the German government had confiscated private Jewish assets, this presented an insurmountable hurdle for most applicants. As Jewish

refugees became increasingly desperate, the government responded only with further restrictions.

In explaining their position, officials highlighted the high economic costs of providing for a mass influx of refugees, concerns about fueling domestic anti-Semitic sentiments, and the need to maintain good diplomatic relations with Germany as reasons for their indifferent response to the desperate plight of Jewish refugees. Britain was indeed in the midst of an economic depression and had been struggling with high unemployment rates.[16] In addition, both the Home Secretary Samuel Hoare and representatives of the Jewish community in Britain raised concerns about the presence of anti-Semitism in Britain.[17] In the late 1880s, the arrival of Jewish immigrants from Eastern Europe led to a resurgence in domestic anti-Semitism and later played an important role in the development of some of Britain's first immigration restrictions.[18] Anti-Semitic hostility resurfaced once again with a new wave of Jewish refugees to Britain during the 1930s, driven in part by complaints that the immigrants would compete with British citizens for increasingly scarce job opportunities.[19] Anti-Jewish propaganda and demonstrations by British fascist organizations further raised anxieties about the potential implications of a more open refugee policy.[20] A certain degree of anti-Semitic prejudice was also evident among members of the government itself. Even though he disapproved of the violent measures employed by the Nazis, Prime Minister Neville Chamberlain admitted that he could understand the German dislike of their Jewish population.[21] Clearly, the British government's reluctance to help Jewish refugees escape Nazi anti-Semitism was shaped by both economic anxieties and anti-Semitic prejudice.[22]

The British government was also concerned about the effects that its refugee policy would have on its relationship with Germany.[23] Britain was anxious to limit interference in Germany's internal affairs, fearing that any criticisms or substantial action in response to the country's treatments of its minorities would antagonize and isolate the Nazi regime.[24] After the destruction brought on by the First World War, Britain had neither the economic means nor the public support to deal with another military conflict, and was therefore keen to avoid that outcome.[25] As a result, although members of the government may have disapproved of German actions towards its Jewish population, they were determined to limit official criticisms to avoid provoking any hostilities.[26] The British

government's desire to maintain peaceful relations with Germany trumped any objections they may have held regarding Nazi anti-Semitic policies.

QUESTION OF JEWISH REFUGEES IN THE WAKE OF KRISTALLNACHT

While the British government consistently avoided dealing with the problem of Jewish refugees, the Kristallnacht pogrom in 1938 forced the issue. On the night of November 9, Nazi storm troopers and party members viciously attacked Jewish communities across Germany, breaking shop windows and burning homes and synagogues.[27] Close to one hundred Jews were killed and approximately 30,000 Jewish men were rounded up and taken to concentration camps.[28] In addition, Germany immediately passed a new series of laws that effectively prohibited Jews from participating in the German economy and public sphere.[29] These events genuinely appalled the British public and offered stark evidence of the violent treatment the Jewish population faced under Nazi rule. Chamberlain wrote to his sister a few days later, "I am horrified by the German behaviour to the Jews."[30] Similar outcries reverberated throughout the British public and Parliament.[31] Geoffrey Mander, a Liberal Member of Parliament (MP), described the events in Germany as "nothing but a reversion to paganism" and acknowledged a "feeling of universal disgust at the horrible brutality of what is going on."[32]

Kristallnacht clearly illustrated the Jewish plight in Germany, but it also increased public scrutiny of what the British government was doing to help Jews trying to escape such persecution. Government officials quickly recognized the pressure to take some action in response. At a Cabinet meeting on November 16, just a few days after Kristallnacht, Lord Halifax opened up a discussion of "the Jewish Problem" by reviewing some of the criticism that the government had received, both at home and in the United States, for not doing enough to address the growing issues of German anti-Semitism and the exodus it had spurred among Europe's Jewish population.[33] The Foreign Secretary was particularly concerned with the effects that Britain's reluctant refugee policy had on its relationship with the United States, and suggested that the government needed to respond in some measure to the events of Kristallnacht, not only for the sake of those trying to flee Nazi persecution but for the sake of the government's reputation as well.[34]

Despite the mounting pressure, there was no consensus on how or to what extent Britain should respond to the crisis. During a debate on racial, political, and religious minorities in the House of Commons on November 21, some opposition MPs, such as the Labour party's Philip Noel-Baker, argued that the British government should protest the pogrom and warn Germany that cordial relations could not exist if such anti-Semitic measures continued.[35] Noel-Baker presented a lengthy description of Kristallnacht, illustrating in detail the violence and humiliation that the Jewish population suffered during the pogrom.[36] He described one instance in Nuremberg in which "the inmates of the Jewish hospital were forced to line up on parade," while a Jewish boarding school in Caputh "was invaded and utterly demolished at 2 a.m. The young children were driven, without adult guidance or protection, into the night."[37] However, while Noel-Baker gave an impassioned argument for the need to implement stronger refugee assistance measures, Conservative MPs warned fellow House members that they must refuse to let their response become "stimulated by sentiment," and insisted instead that they address the issue "on severely practical grounds."[38] Though they all eloquently expressed their own condemnation of the pogrom, their views on how Britain should respond from a policy standpoint were much more mixed.

One point of agreement among members of the government and their supporters in the House was that other countries would be far better equipped to deal with the crisis and ought to be the ones to offer resettlement opportunities for Jewish refugees. Archibald Southby, a Conservative MP, claimed that "it is outside this country" where a solution to the problem of finding asylum for refugees could be found.[39] While members of the Cabinet likewise hoped to induce other countries to take more substantive action, they also discussed the possibility of opening up land for refugee settlement in British colonies.[40] Among the most frequently discussed options were British Guiana and Kenya, but some officials raised concerns over how well equipped these developing colonies would be to absorb large numbers of new settlers.[41] As the Secretary of the State for the Colonies pointed out, large areas of forests in British Guiana would have to be cleared and uncharted areas surveyed before refugees could arrive.[42] Although the government reviewed these colonial options, few definite plans were made beyond the promise to further examine the possibility of settlement.[43]

With regard to the entrance of Jewish refugees into mainland Britain, the same political and economic concerns that had impeded previous attempts to address the issue resurfaced once again. The issue of Anglo-German relations in particular continued to play a major role in Britain's response to Nazi anti-Semitism and the ever-growing influx of Jewish refugees. In his speech to the House of Commons on November 21, Hoare expressed his firm opposition to calls that Britain confront Germany on its anti-Semitic policies, stating that he was against "all attempts to intervene in the domestic affairs of other countries," and committed to maintaining friendly relations with Germany.[44] Hoare also went on to reiterate the potential economic consequences of accepting more refugees. Pointing to Britain's already high rate of unemployment, Hoare argued that the arrival of more refugees would not only aggravate these existing economic problems, but also further encourage the growth of anti-Jewish and anti-immigrant movements.[45] In light of these continuing barriers, Hoare warned, "I have to be careful to avoid anything in the nature of mass immigration."[46] In short, despite mounting public pressure in the wake of Kristallnacht, the government appeared unwilling to consider any substantial changes to its contemporary immigration procedures or its policies towards Jewish refugees.

THE KINDERTRANSPORT SCHEME

Fortunately, the Anglo-Jewish community offered alternative measures to address the question of Jewish refugees in Britain. On November 15, a delegation of Jewish representatives that included Zionist leader Chaim Weizmann and Lionel de Rothschild, a member of the prominent banking family, met with Chamberlain to discuss possible measures to assist Jews trying to escape Nazi Germany.[47] Among other suggestions, the committee recommended that Britian could accept the transfer of unaccompanied children from Germany and neighboring states.[48] This "Kindertransport" program signified the desperation of the Anglo-Jewish community as they sought to help Jews fleeing Nazi persecution. The brutal events of Kristallnacht forced Anglo-Jewish leaders to search for any measures they could take to provide more substantial assistance to Jewish refugees and pressure the government to adopt a more positive response.[49] The Kindertransport proposal presented the government with an alternative group

of refugees whose arrival did not pose the same economic and political challenges as that of adult immigrants, and therefore could not be rejected as easily. In this context, the Kindertransport represented a final desperate tactic adopted by Jewish leaders in Britain.

Britain had accepted groups of unaccompanied child refugees in previous international crises as a way to assist communities fleeing war or persecution. During the Spanish Civil War, the government sanctioned the transfer into Britain of four thousand Basque children whose maintenance was undertaken by the National Joint Committee for Spanish Relief.[50] The Inter-Aid Committee for Children from Germany had been established in 1936 to coordinate smaller-scale efforts to bring Jewish children to Britain for the purposes of education.[51] Since the Inter-Aid Committee's work was well underway by 1938, the Kindertransport represented a viable proposal that the Jewish community could offer to the government, since it could be construed as merely an expansion of an existing program. In fact, the Movement for the Care of Children from Germany, which was created to oversee the Kindertransport, was a merger of the Inter-Aid Committee and other refugee organizations willing to help in the effort.[52] Moreover, Anglo-Jewish leaders assured the government that the children's transport and maintenance would be guaranteed "either by their funds or by generous individuals," and that the Home Office would only have to issue the necessary visas to facilitate the children's admission into the country.[53]

The proposal for large-scale admissions of Jewish children, which was brought up at the Cabinet meeting on November 16, received favorable consideration from Hoare and was raised again at the House of Commons debate on November 21.[54] Although the Home Secretary had made it clear that he did not think Britain could do much to expand adult immigration, he was compelled to admit that Britain could allow children into the country "without any harm to our own population."[55] Interestingly, though he had previously shown little concern for the fates of adult refugees, Hoare suddenly expressed concern for the heart-wrenching decision that would face the children's parents: "I could not help thinking what a terrible dilemma it was to the Jewish parents in Germany to have to choose between sending their children to a foreign country, into the unknown, and continuing to live in the terrible conditions to which they are now reduced in Germany."[56] His concern, however, was only momentary. Hoare was comforted by the thought that the

parents would prefer to part with their children rather than keep them in danger in Germany, and therefore praised the government's efforts to ease the suffering of the European Jewish population.[57]

The British government's reasons for accepting the Kindertransport program stemmed largely from an ethically questionable combination of its reluctance to make any substantial policy accommodations for Jewish refugees and a desire to protect its own reputation. Kristallnacht had provided an appalling display of the growing brutality of Nazi anti-Semitism, and the House of Commons debate in November revealed that its members held no illusions about the very serious dangers that confronted the Jewish population in Central Europe. Although the pressure to act increased after Kristallnacht, the government was still reluctant to change its position on Jewish immigration. The Kindertransport proposal offered British officials a decidedly convenient compromise. By accepting only child refugees, the government could offer a positive response to the crisis while avoiding any of the problems it had previously cited as explanations for its restricted approach to adult immigration. Daniel Lipson, a Conservative MP, succinctly pointed out that any children who were brought over "will not be competing in the labour market," so the government would presumably not have to worry about any immediate economic repercussions.[58] In addition, given the government's fears about increasing anti-Semitism in Britain, the Kindertransport provided a politically safer solution. As one of the coordinators of the Kindertransport, Nicholas Winton, noted dryly, "children and animals are the two easiest things for which to get sympathy and raise money."[59] The Kindertransport presented government officials with an attractive humanitarian program that protected the government from charges of indifference without requiring it to reconsider its stance on adult immigration.

THE KINDERTRANSPORT BEGINS

With the approval of the government now secured, the task of organizing the Kindertransport shifted to the Movement for the Care of Children from Germany and a host of other contributing refugee organizations.[60] Applications were submitted by Jewish communities in Germany and central Europe, with special attention given to those whose parents had been deported or interned and boys who had been placed in concentration camps.[61] The children who were chosen for the transports were seventeen years of age or

younger, with some as young as two and a half.[62] Once a group of children had been notified and were assembled for their departure, they usually traveled by train across the German-Dutch border to the Hook of Holland, where they boarded ferries destined for Harwich, England.[63] Upon their arrival, the children who already had sponsors who committed to provide for them went off to Liverpool Street Station in London, where they met up with their foster families.[64] Children were placed in both Jewish and non-Jewish foster homes throughout the country, most often with lower middle class families.[65] Children who were not guaranteed by a sponsor were sent to temporary reception centers at vacant summer camps, most notably at Dovercourt Bay, while the Movement looked into offers from potential foster families.[66] The children who remained without sponsors when the centers closed were resettled more permanently in hostels.[67] From December 1938 until the outbreak of war in September 1939, the Kindertransports successfully brought over 9,354 children from Germany and Austria and 669 children from former Czechoslovakia.[68] Given the limitations imposed by the program's criteria and the urgency with which the organizations needed to act, the number of children transported in just nine months was truly remarkable.

THE CHILDREN OF THE KINDERTRANSPORT

The reluctant humanitarianism that defined the creation of the Kindertransport would subsequently have enormous consequences on the experiences of the children who were separated from their families and brought to England. The parents, of course, endured the first trauma. Though a tragically small percentage of the parents survived the war, accounts from the few who did highlight the heart-wrenching dilemma created by the opportunity to send their children away. One mother, Charlotte Levy, described the circumstances in which she decided to send her son to Britain: "The degree of despair to which you can be driven is best revealed by this reversal of one's normal feelings and principles. To feel happiness about what? About being able to send one's little boy of nine away to a foreign country whose language he does not speak, to people one does not know oneself, not sure if one will ever see him again?"[69] However, having been denied visas from four different countries and struggling to take care of a dying husband recently returned from prison, the chance to send her son away became "a light in the

darkness."[70] While Charlotte Levy and so many others ultimately preferred to part with their children to ensure their safety, their willingness to relinquish their children was clearly an indication of the sheer desperation of their situation in Germany.

The memoirs of the Kinder provide an invaluable glimpse into the experiences of those who were saved by the transports. Three collections of memoirs provided the primary source testimony that will allow us to analyze the Kinder's experiences. *We Came as Children*, published in 1966, presents excerpts of anonymous entries from Kinder that cover such topics as separation, adjusting to a new life in England, and discovering the fates of their families. *I Came Alone: The Stories of the Kindertransport* was published much later, in 1990, and features written accounts of the Kinder's experiences that range from a few brief paragraphs to several pages. *Into the Arms of Strangers: Stories of the Kindertransport*, published in 2000, chronicles the experiences of thirteen Kinder, beginning with their initial separations from their families and continuing years after the war's end.

In these memoirs, we meet children like Eva Hayman, who was fifteen years old when she arrived in Britain from Čelákovice, Czechoslovakia, with her ten-year-old sister.[71] As they began their journey to England, devastated by the separation from their family, Eva promised Vera that she would look after her, writing, "I said to my sister, 'Don't be afraid, you will always have me.'"[72] However, at Liverpool Street Station, Eva and Vera were immediately separated from each other, as Vera went to stay with a family in Lancashire while Eva went to a boarding school in Bournemouth.[73] Once she finished schooling, Eva spent the rest of the war working in a wartime hospital.[74] After the war ended, Eva received the devastating news that both her parents had died.[75] She eventually relocated to New Zealand, where she currently lives, while Vera remained in England.[76]

Kurt Landes was only eleven when he left Vienna with his older sister.[77] When they arrived in Britain, both Kurt and his sister stayed briefly at Dovercourt and "Harritch" summer camps before they, like Eva and her sister, were separated.[78] Kurt spent the war years with a childless couple in Birmingham, afterwards staying in hostels before pursuing further schooling.[79] Kurt also lost both his parents and nearly his entire family in the Holocaust. [80] Now settled in Jerusalem with a family of his own, Kurt reflected, "I sometimes wonder how I would have faced up to the challenge of deciding whether to send my children off to a foreign land."[81]

The stories that make up the Kindertransport narrative are, of course, as diverse as the children themselves. Differences in age, where and with whom the children stayed during the war, and where they ended up afterwards give each account its individual character. Amid these differences, there are several common themes that highlight the distinct nature of the Kindertransport experience. The most striking similarities among the Kinder's memoirs are their collective emphasis on the traumas of loneliness, isolation, and guilt, both immediate and long-term, which stemmed from the separation from their families. The length of time between their experiences as children and the creation of these memoir collections allowed the Kinder to take a broader view of their very personal experiences. With a deeper understanding of the political context of prewar and wartime Europe, and now as parents themselves, the Kinder's reflections frequently express both a sense of gratitude for the precious chance at survival they received and recognition of how difficult the decision to separate must have been for their families. While their reflections take on this nuanced view, the traumatic nature of their experiences remains clear throughout their accounts. As expressed through the stories of Eva Hayman, Kurt Landes, and many others, their lives reveal the tragic consequences of this reluctant humanitarian program and the qualified nature of the program's success.

THE MOMENT OF PARTING

The children's initial separation from their families marked their initiation into the Kindertransport experience. Many of the children were understandably frightened and upset over the prospect of suddenly leaving their families. Eva Hayman explained, "To me, it was all unreal. I didn't believe that this was happening to us. I just wanted to go back in time."[82] Similarly, one child who was eleven at the time remembered "crying bitterly and saying: 'Please, Mummy, please don't send me away.'"[83] For the children who were more aware of the anti-Semitism they faced in their home countries, this reluctance to leave was coupled with a conflicting sense of relief at the chance to get away from life in Nazi Germany. As one child recalled, "I hated leaving home, the decision was fairly suddenly sprung on me, but even at the age of ten I realised that I was coming to a place where I would no longer have to be frightened."[84] The chance to leave offered them a precious chance of safety, but came at the cost of leaving their homes and families.

Other children barely realized the meaning of their separation. Kurt Landes' sister also cried profusely when it was time to say goodbye, but Kurt remembered that he barely registered the significance of the event, writing, "I had been away before from home, to summer camps, the Alps and even Yugoslavia, and took this to be just another good-bye."[85] Kurt's reaction to his departure was typical of a significantly large number of children who went on the transports. Not only were they relatively unconcerned about leaving their families, they often were excited about the prospects of their impending journey. As another child recalled, "I seem to remember more vividly the pleasure of the great adventure ahead — going across the sea to England. Somehow I appear to have missed any feeling of wrench, or more probably my parents — who were very sensible — managed not to show any sign of sorrow at the parting."[86] Many of the Kinder remembered their parents' similar attempts to reassure them. As one Kind wrote, "My parents made light of the parting, saying that they would follow soon."[87] Comforted by their parents' reassurances that they would eventually be reunited, the children said goodbye to their families and embarked on their journey to a new life and uncertain future in Britain.

ISOLATION AND CULTURE SHOCK DURING THE WAR YEARS

Once the children arrived in Britain, the realities of their new situation began to sink in. For many, the impact was overwhelming.[88] Herbert Holden, who had been thoroughly excited about the trip, described his markedly changed feelings after he arrived, writing, "Our first day in Birmingham was hell. It suddenly hit me that we were in a foreign country without knowing the language, with no relatives or friends."[89] Over the next six years, the children faced the daunting task of adjusting to their new lives in a completely foreign country, and since even siblings were frequently separated, most had to do so all on their own. The emotional traumas they encountered as a result reflected not only the inherent challenges of emigrating to a foreign country, but also the fact that, due to the circumstances of their rescue, the children had to deal with these challenges without the support or comfort of their families.

When the children first confronted the prospect of adjusting to a life in an alien country, they were often overcome with an acute sense of homesickness. While writing in her diary after moving in

with her new foster family, twelve-year-old Inge declared, "When I am dead they will have to put on my grave that here lies a child who died of homesickness."[90] Likewise, accounts from Bunce Court in Kent, which took in around one hundred children from the transports, described the children as "very disturbed and very restless and very unhappy, because they had lost their homes and their parents."[91] Such severe homesickness was especially common among the children when they first arrived in Britain, when the memory of their families and the separation was still recent.

As the children settled down with foster families or in hostels for the duration of the war, this initial homesickness developed into a profound sense of loneliness and isolation that often haunted the children throughout the war years. During this period, the children's living situations played a key role in determining the severity of their loneliness and the extent to which it persisted throughout the war. More often than not, there were elements in the hostels or foster homes that merely aggravated their sense of abandonment. Eva Hayman, who had already endured the successive separations from her family and then her sister, remembered that being "the only stranger" at her school in Britain left her feeling completely alone, writing, "I wrote of that time in my diary: 'I never dreamed that one could be so lonely.'"[92] Likewise, fourteen-year-old Lorraine Allard remembered, "There was a terrible void and a terrible loneliness for love and for warmth."[93] Some children were even isolated within the foster families that took them in and made to feel unwelcome. One Kind explained, "I was given margarine when the rest of the family ate butter, on only one slice of bread was I allowed to put jam — the very jam for which I had collected the brambles. When visitors came I was banished to the kitchen where I also had my meals."[94]

Of course, there were also factors that could help combat the children's sense of abandonment. One of the older children who went to work at a children's hospital in Surrey remembered that she felt "utterly abandoned and lost," when she first arrived, but at the hospital "there were five more refugee girls and we were all very glad of each other's company."[95] Yet even children who were among other refugees or in caring homes did not always escape a feeling of loneliness. One child, who initially stayed in a group home, described the challenges of trying to settle down and establish roots even in a hostel setting, recalling "I did not make any friends, with all the moving, reshuffling and strangeness it would have been difficult I suppose, and one felt always alone."[96] While the children's

separation from their parents was difficult enough, their isolation from other refugees, the instability of their living situations, and the damaging effects of unloving foster families became additional traumas that contributed heavily to their difficulties.

As the children confronted the emotional effects of being separated from their families and alone in Britain, their isolation was exacerbated by an overwhelming and bewildering sense of culture shock. While this was inevitable to a certain degree, there were elements of British culture, such as the notoriously reserved British manners, that proved particularly difficult for the children to adjust to, especially given the nature of their arrival. Nine-year-old Inge Sadan explained that "Europeans and Jews all together are very warm," but recalled that when she arrived in England, "everybody seemed very reserved. There were no hugs and no kisses. Everything was cold."[97] Another child remembered that his foster mother was "somewhat aloof," explaining, "It was her manner. She was loving, but she didn't hug and kiss me, whereas my mother was the exact opposite."[98] Though a seemingly harmless trait of British culture, this absence of warmth came at a time when the children may have needed it the most, since they were dependent on those who took them in to provide the familial comfort and affection they had lost. Consequently, even children who were welcomed into an otherwise loving family were affected by this lack of outward affection. One Kind reflected, "They were in fact a truly charming and genuine family. It was not their fault that I found their life a little restrictive, a little lonely and lacking in any expression of affection."[99] Despite the best intentions of the families, this culture of reserve often reinforced the fact that the children were in an unfamiliar home and further highlighted the absence of their own families.

The language barrier, which presented another formidable challenge, took on a special significance for the children. Many tried to learn English as fast as possible simply out of necessity. As one child explained, "I knew absolutely no one who could understand German and I became desperate to make myself understood."[100] While learning English was an inevitable adjustment that the children had to make, their native languages represented their last remaining connection to their homes, and some of the children were reluctant to learn a new one. One child tried to avoid learning English for several years, explaining, "the German language was all that was left to me of my childhood and I did not want to give it up."[101] Unfortunately, many of the Kinder did in fact lose the ability to speak in their native language,

sometimes permanently. Kurt Fuchel, who had learned English within six weeks of arriving in Britain, regrettably noted that he rapidly lost his German as a result and had "never been able to re-learn it."[102] The loss of their native languages, which resulted from the Kinder's total immersion into English culture and complete alienation from their homes, represented a real and a symbolic loss for the children, since native language was one of the last remnants of their home lives that the children retained.

Throughout the war years, the consequences of Britain's constrained refugee policy were already taking shape. While the Kindertransport ensured that the children would spend the war living in relative safety, the transition clearly had tangible effects on their emotional and mental wellbeing.[103] The successive separations that they endured — from their families, any siblings who travelled with them, and their cultural background — essentially cut the children off from their own childhoods during the war years. In the midst of these circumstances, the children confronted challenges well beyond what could ever normally have been expected of them.

DISCOVERING THE FATES OF THEIR FAMILIES

While British officials received numerous reports early on in the war detailing Nazi atrocities against European Jews, their reluctance to fully accept and propagate this information meant that the British public remained largely unaware of the Holocaust until after the war.[104] As a result, the Kinder's hopes of reuniting with their families still seemed to be a real possibility following the initial news of the Allied victory in Europe. Although they could neither communicate with nor learn of the fates of their families during the war, the children waited both expectantly and fearfully for news throughout their time in Britain. Michael Hellman described the war years as "a time of increasing anxiety about the fate of those we left behind."[105] Despite their anxieties, children like Lorraine Allard clung to the hope of seeing their families and were heartened by the fact that the war was finally over. On V-E Day, which marked the end of the war in Europe, Lorraine remembered, "It was just wonderful, wonderful. We all danced in Piccadilly Circus. And for me, I just thought, well this is it, I'm going to see my parents next week."[106]

While the end of the war gave the children hope that they would finally reunite with their families, this proved to be a devastating disappointment for most. The few children whose parents

did survive often heard directly from their families. However, since by the end of the war, six million Jews had been murdered through Hitler's Final Solution, the children's chances of seeing their parents were tragically small.[107] For the children who eventually received the devastating news that their families had perished, their searches often took several months, if not years, and sometimes were never fully resolved. Lorraine learned of the deaths of both of her parents a few months after the war ended through the coldly impersonal Red Cross notices and published lists of those who died in concentration camps.[108] Others tried to locate their families by returning to their hometowns. Hedy Epstein decided to go back to her hometown in Kippenheim in 1947 to find out what happened to her parents.[109] She did not learn that they had been sent to Auschwitz until 1956.[110] In some cases, the children never fully learned what happened to their loved ones. One child remembered, "The death of my parents was only confirmed by the lack of information to the contrary."[111] After years of fearing for their parents' safety and waiting for any news on their behalf, these children were left in gnawing uncertainty over the final fates of their families and were denied any sense of closure.

The children's discovery of — or failure to discover — their parents' fates marked the beginning of a second phase of the Kindertransport experience. The children whose parents did not survive had to come to terms with the shattering realization that a reunion with their families would never take place. Even those whose parents did survive now faced the daunting task of trying to re-establish a relationship after spending six difficult years, if not more, apart from their families, most of whom had endured Nazi death camps or spent years in hiding. Kurt Fuchel, who had forgotten his German once he learned English, was barely able to communicate with his parents when they first met after the war, an experience that was all too common among the children who reunited with family members.[112] Having spent so many years apart, Kurt recalled that he and his parents initially had trouble rebuilding their relationship, explaining, "My parents let go of a seven-year-old and got back a sixteen-year-old. My mother, especially, wanted to carry on where she'd left off. But a sixteen-year-old doesn't like to be treated like a seven-year-old."[113]

Despite these uncomfortable first reunions, some of the children were eventually able to revive their old relationships. As Inge Sadan explained, "Although it was very difficult in the beginning, we did manage it. After about a year I felt part of the family again."[114]

For others, however, the prolonged separation left permanent scars on their familial ties.[115] One of the Kinder, whose mother decided to remain in Germany after the war, stated, "We visit each other occasionally but the years we were separated have proved too great a gulf to be bridged."[116] Although their family members had physically survived the war, these Kinder still ended up losing the familial relationships they once had.

SURVIVOR'S GUILT

For many Kinder, the hardest challenge would perhaps be to live with the knowledge that they had survived while their families had perished in the Holocaust. Survivor's guilt burdens the living victims of all atrocities, and the children of the Kindertransport were no exception.[117] Reflecting on her experiences, Eva Hayman wrote, "My experience of coming to England made me grateful for life, but also guilty for being alive. Here I was alive, and my parents were dead. I didn't suffer, and they had suffered. It didn't seem fair that I should be here."[118] In the poem "Cast Out," another Kind captured this haunting guilt with the unnerving statement, "Sometimes I think it would have been / easier for me to die / together with my parents than / to have been surrendered by / them to survive alone."[119]

To assuage such devastating feelings of guilt, the children often spent their future lives trying to justify their existence, to prove to themselves that they deserved the rescue they had received. After being constantly reminded that other children could have been rescued in her place, one Kind explained, "Since then I have always been obsessed with the thought that I must justify my survival."[120] Reflecting upon his rescue, Fred Durst explained, "I have been grateful ever since, and spend considerable time on social matters to try and repay my debt to society."[121] The agonizing guilt that so many of the Kinder felt for surviving while their families perished remained a heavy psychological burden and often haunted the children for the rest of their lives.

The Kinder's lives in the years after World War Two finally revealed the true implications of the Kindertransport policy. Several decades after the children's rescue and their initial arrival in Britain, the effects of their separation and its post-war emotional and psychological consequences still remained. As Erika Shotland remarked, "After fifty years in England, being happily married, bringing up lovely daughters and now being a grandmother myself, a feeling

of loss still persists."[122] The Kindertransport was no longer just a temporary rescue measure, after which the children could return to the lives they once had. Instead, the emotional and psychological consequences of their survival remained long after the war's end.

CONCLUSION

The experiences and reflections that the Kinder recorded in their memoirs provide a testament to the ethically complicated nature of this humanitarian program. In their memoirs, the Kinder made sure to express their heartfelt gratitude to Britain for saving their lives through the Kindertransport. As one Kind summed up, "'Britain, without you we would not be here today, thanks.'"[123] The Kinder's reflections were introspective, focused primarily on capturing their own experiences and rarely attempting to cast blame on others for their sufferings.[124] Nevertheless, the Kinder's accounts revealed the full range of the lasting emotional and psychological traumas created by the nature of their rescue. These traumas that the Kinder suffered, together with the ethically dubious political motivations that defined the program, inevitably cast a pall over this humanitarian mission. Robert Sugar, who was eight years old when he arrived in Britain, succinctly summarized the complexities of the Kinder's experiences: "People wonder how anyone whose life was saved could qualify how he was saved. He should just be happy to be saved and take anything. But real life isn't like that."[125]

Not surprisingly, the children's separation from and loss of their families underlay the reflections that they presented in their memoirs. The resulting ambiguity is evident in the memoirs of the Kinder, as they combined their frequent expressions of thanks with their equally frequent reflections on the hardships and tragedy they encountered along the way. In some cases, the pains of separation and loss were even evident in the Kinder's expressions of gratitude. Bertha Leverton, who described the Kindertransport as "an act of mercy, not equalled anywhere else in the world," acknowledged her struggles to feel grateful when she first arrived in Britain, describing herself as "feeling guilty for not feeling as grateful as I should have been, and not liking very much where I found myself."[126] Similarly, as one Kind explained, "I shall always be grateful *now* for what was done for us then, although I wish it had not been rammed down my throat so much as a child . . . Now I understand better and I could have given my love and gratitude even in those early days if love

had been given to me more freely."[127] While the Kinder's gratitude for their survival was undoubtedly heartfelt and sincere, they also remembered the extremely difficult experiences that they endured along the way. Their reflections and memoirs attest to the unique and complex nature of their experiences as children of the Kindertransport and to the conflicting effects of survival and suffering.

The story of the Kindertransport is as much about shortcomings of official British policy as it is about the psychological pains of survival. At its core, the Kindertransport was a humanitarian program, proposed by the Anglo-Jewish community as a final desperate effort in the midst of the extremely dire circumstances facing Jews in Germany. Yet from the perspective of the British government, which had responded very reluctantly to calls for assistance to victims of Nazi anti-Semitism, the Kindertransport provided an easy course of action that allowed it to make the magnanimous gesture of rescuing Jewish children without having to deal with the difficulties of accommodating the rest of their families. The great tragedy of the Second World War lies in the fate that awaited the Jews left behind in Europe, yet we cannot minimize the suffering endured by the Kinder as a result of the calculated compassion that shaped their rescue. Rabbi John Rayner, who came as a child on one of the last transports organized before the war, best summed up the political context in which the Kindertransport was implemented: "There was insensitivity, too, and many criticisms have been justly levelled against British policy during the Nazi years, which could no doubt have saved many more refugees if the will had been there."[128] The history of the Kindertransport provides a critical warning about the moral ambiguities present in all such humanitarian schemes, reminding us of the need to view our own acts of qualified compassion, such as the recent and strikingly similar "Dream Act," with a critical and wary eye. As the Kinder's memoirs so vividly demonstrate, the consequences of failing to do so have the potential to be profoundly and irreversibly harmful.

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114. Ibid, 231.
115. Norton, "The *Kindertransport*: History and Memory," 86.
116. Gershon, *We Came as Children*, 116.
117. See William G. Niederland, "Clinical Observations on the 'Survivor Syndrome,'" *International Journal of Psycho-analysis* 49, no. 2-3 (1968): 313-5; William G. Niederland, "Psychiatric Disorders Among Persecution Victims," *Journal of Nervous and Mental Disease* 139, no. 5 (1964): 458-74.
118. Harris and Oppenheimer, *Into the Arms of Strangers*, 248.
119. Gershon, *We Came as Children*, 174.
120. Ibid, 31.
121. Leverton and Lowensohn, *I Came Alone*, 75-6.
122. Ibid, 314.
123. Ibid, 33.
124. Norton, "The *Kindertransport*: History and Memory," 90-1.
125. Harris and Oppenheimer, *Into the Arms of Strangers*, 136.
126. Leverton and Lowensohn, *I Came Alone*, 8; Harris and Oppenheimer, *Into the Arms of Strangers*, 148.
127. Gershon, *We Came as Children*, 151.
128. Leverton and Lowensohn, *I Came Alone*, 247-8.

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DARWINISM AND MORAL REALISM

BORIS **TIZENBERG**

I came to study my research topic after taking an upper-level philosophy of science elective that focused on natural selection. After discussing my final paper with Dr. Pfeifer, the professor for the course, she suggested I use the paper as a basis for a research project. This paper continues a debate between two philosophers, Sharon Street and David Copp. It is an investigation into the problem that natural selection causes for moral realism — that there are objective moral truths independent of our moral attitudes — as presented by Sharon Street. David Copp believes he has come up with a way for true and objective moral rules to be possible, even if Darwinian forces caused us to evolve to make certain moral judgments. He presents a possible solution to the problem, which I reject, but suggest that he is correct in asserting that a solution is possible.

In this paper I analyze David Copp's argument regarding natural selection and moral realism. Copp's argument is a response to a significant problem for moral realism raised by Sharon Street, which she calls the Darwinian dilemma. The first section begins by describing Street's adaptive link account. The second section describes the Darwinian dilemma that Street uses to justify why the existence of Darwinian forces in ethics undercuts moral realism. The third section addresses how Copp believes realists can use both the adaptive link account and an amended version of the tracking horn of the dilemma to come up with what he calls the quasi-tracking account. I will also explain why Copp believes that moral realism is still possible even if the adaptive link account and the Darwinian dilemma are both true. This will require using his society-centered moral theory to explain why our moral beliefs tend to semi-track the moral truth. Finally, the fourth section argues that Copp's belief that the Darwinian dilemma does not necessitate the rejection of moral realism has a valid ground, but his society-centered moral theory does not accomplish its task of justifying the quasi-tracking account. Instead, the account is capable of avoiding the Darwinian dilemma altogether for a very different reason than Copp suggests.

THE ADAPTIVE LINK ACCOUNT

This argument requires multiple assumptions. First, the Darwinian hypothesis has to be held true. The Darwinian hypothesis is the view that evolutionary forces have influenced human moral psychology to the degree that even its very nature, including the content of our moral beliefs, can be at least partially explained by evolutionary theory. There are various proposals for the specific way evolutionary pressures shaped our moral psychology. One such proposal is the adaptive link account.

To describe the adaptive link account I will cite both Sharon Street and Philip Kitcher. The idea is that certain kinds of evaluative responses promoted reproductive success among our distant ancestors by creating adaptive links between our ancestors' circumstances and their responses to those circumstances by helping to induce those emotions, beliefs, and actions that were reproductively advantageous (Street 127). Street notes that our distant ancestors likely did not have the cognitive capacity to form moral beliefs, so it is more likely that Darwinian forces indirectly influenced our moral beliefs

by directly influencing primitive pre-conceptual states of those distant ancestors (Street 118-120).

The adaptive link account can be broken down into four stages. First, Darwinian forces selected for basic psychological capacities and dispositions in our distant ancestors. The presence of these capacities and dispositions led to the development of dispositions that tended to form certain evaluative attitudes. Certain kinds of behaviors would have been adaptive for ancestors, and in this stage humans developed dispositions that led them to form evaluative attitudes that resulted in such adaptive behaviors (Street 129). In the second stage, selection for capacities and dispositions affected the cognitive abilities of less distant ancestors (Street 127). More specifically, it influenced the content of the evaluative judgments they came to be disposed to make. This stage allows for an explanation to be made as to why humans evolved a tendency to make judgments that favored behavior that was adaptive for distant ancestors. For example, this stage can be used to explain why humans evolved to look favorably upon helpful behavior and are encouraged to reward this type of behavior with help in return (Street 127). The third stage involves the appearance of a non-reflective tendency to form certain basic moral beliefs (Street 127). The fourth stage was proposed by Kitcher and is outside of Street's original proposal. Kitcher believes that the evolutionary function of having a capacity for normative governance was to promote social cohesion. Selective pressures would favor those behaviors that promoted social cohesion and oppose those that favored selfish and antisocial behavior (Kitcher 176). Copp assumes that all four stages of the adaptive link account are true. Street argues that this account describes the effects of evolution of moral psychology well without postulating the existence of moral truths that are independent of our moral attitudes, thus avoiding the problems that realists face with the Darwinian dilemma (Street 109, 113, 121).

THE DARWINIAN DILEMMA

The Darwinian dilemma appears to lead to the conclusion that, given the Darwinian hypothesis and given moral realism, natural selection seems unlikely to produce moral truths. Moral realism is the philosophical view that dictates the existence of knowable moral truths that are independent of our moral attitudes (Street 110-111). Street's view, in contrast to moral realism, is a form of

constructivism, according to which moral truth is constructed from our moral attitudes. In a constructivist view, the source of our moral attitudes does not matter. Whatever our attitudes happen to be, moral truth is constructed from them. In contrast, according to moral realism, which moral claims are true is not a function of what moral truths we happen to hold. Therefore, depending on one's view of moral epistemology, it is possible for our moral attitudes to mislead us about moral truth. For example, if we justify moral claims by applying coherency considerations to our moral attitudes, and if we start off with moral attitudes that are radically incorrect, then coherency considerations will not yield moral truth. Therefore, according to Street, if the Darwinian hypothesis is true, realists face a dilemma, which she calls the Darwinian dilemma.

The dilemma is presented as a choice between two options: realists must either affirm or deny the tracking thesis. The tracking thesis is the hypothesis that natural selection affected our moral psychology in such a way that our moral beliefs tend to track the moral facts (Copp 191). Denying the tracking thesis means to deny that natural selection affected our moral psychology in a way that tracked moral truths. Street argues that this leads to viewing Darwinian forces as pushing our evaluative judgments away from moral truths. She reasons that a moral realist who denies the tracking thesis must accept, if our moral beliefs are true, that it is only due to chance. Depending on chance to bring about moral truth seems too skeptical a result for the realist. To avoid this skeptical conclusion, it appears that realists who accept the Darwinian hypothesis must accept the tracking thesis (Street 121-122).

Street argues that realists who accept the tracking thesis must explain why it holds. In order to do so they must accept the tracking account (Street 135). The tracking account is the hypothesis that Darwinian forces caused our moral beliefs to be in line with moral facts because the capacity to detect moral truths promoted reproductive success (Street 125-126). She notes that the tracking account is unacceptable because it is contradictory to the adaptive link account, which is empirically more plausible. The two theories contradict each other because they provide different explanations for the current state of our moral beliefs. The adaptive link account claims that the moral beliefs that were reproductively advantageous to our ancestors were those that created "adaptive links" between our ancestors' environment and their response to it, while the tracking

account claims that those moral beliefs that best approximated the truth were the most advantageous. The adaptive link account provides an explanation that is more in line with Darwinism: certain beliefs, thoughts, and actions led to more advantageous responses to the environment and were selected for. The tracking thesis claims that characteristics that were closer to the truth were advantageous, and provides a weaker explanation from a Darwinian perspective (Street 128-135).

COPP'S REPLY

Copp argues, in response, that the tracking account can be rejected without denying the tracking thesis. Instead, one can accept the quasi-tracking account, the hypothesis that Darwinian forces caused our moral beliefs to quasi-track the moral facts because the capacity to detect moral truths promoted reproductive success among our ancestors. To quasi-track means that our moral beliefs will be close enough to the truth that rational reflection can lead to the truth. Copp argues that our moral beliefs tend to quasi-track moral facts because the capacity to detect moral truths was part of a system of evaluative responses that was adaptive for our ancestors. This system of evaluative responses was adaptive because it motivated behavior that enhanced reproductive success. The indirect influence of Darwinian forces on the content of our moral beliefs (as in accordance with the adaptive link hypothesis), when considered with all other influences, was such that rational reflection could correct for any distorting influences on their content and yield moral knowledge. Rational reflection would begin with moral beliefs that approximated truth and, through the use of our cognitive capacities, would attempt to establish a reflective equilibrium that would lead to moral truth. The use of a reflective equilibrium involves processes that create coherence among all beliefs. This account seems to escape the Darwinian dilemma by allowing for Darwinian influences on our moral beliefs while being consistent with moral realism (Copp 193-196).

To avoid the skeptical conclusion presented by denying the tracking thesis, one can take either the aggressive strategy or the defensive strategy. The aggressive strategy aims to show that Darwinian forces do tend to quasi-track moral facts, while the defensive strategy aims to show that the skeptical argument is unpersuasive. Copp chooses the aggressive strategy because it seems to provide a more forceful argument (197-198).

Copp admits that in pursuing the aggressive strategy, it would be insufficient to argue that the basic moral beliefs primed by natural selection seem intuitively approximately true. If the adaptive link account holds true, it is likely that the moral propositions that it predicts for us to hold will at least seem close to moral truth. The important thing is to explain why, if the adaptive link account is held to be true, the ability to quasi-track moral truth would have been part of a system of responses that was adaptive. The explanation needs to support the idea that, even if natural selection had led our moral psychology to be different from what it is, which would have led to different moral beliefs as a result, it is likely that our moral beliefs would still approximate the truth. If the explanation fails to show why our moral beliefs have to at the least approximate the truth, the approximate truth of our moral beliefs will appear to be a fortunate accident (Copp 197).

Copp believes that realists must propose a theory of truth conditions of moral judgments. This theory of moral truth can then be used to explain why beliefs influenced by Darwinian forces are in accord with the adaptive link account. In his attempt to provide such a theory, Copp proposes the society-centered moral theory. He reasons that we not only live in societies, but also seem to need to live in societies. This need may be problematic since people have conflicting interests. To help limit conflict, societies need to motivate us to live together peacefully, cooperatively, and productively. To help establish such living conditions, a society needs to be governed by shared norms — in other words, a social moral code. It appears that morality has the function of enabling a society to meet its ends. When the rules of the code are internalized by its members, people are motivated to be peaceful, cooperative, and productive (Copp 198).

This theory states that a basic moral proposition is true only if the moral code that would best serve to enable society to meet its needs included a relevantly corresponding norm. The theory is composed of two parts. The first is a standard-based account of the truth conditions of normative propositions. This account entails that there must be moral standards, not moral propositions. A moral proposition is "torture is wrong," while a moral standard is "no one is to be tortured." The second part is that the society-centered account of truth grounds the status of moral standards. This part requires that the moral standards entailed by the first part have authority in the society (Copp 199).

A society with a social moral code would generally experience fewer internal conflicts and less harmful conflicts than a society without such a code. There would be more cooperation, and its members would be more productive in pursuing their needs. Some moral codes would facilitate cooperation and productivity better than others, and according to society-centered theory, the code that would best serve the basic needs of a society is the code that is morally authoritative with respect to that society (Copp 199-200).

To answer the Darwinian dilemma, the society-centered theory needs to be connected with the adaptive link account's explanation of the development of our moral psychology. The adaptive link account does not depend on the truth of the moral judgments which it predicts that Darwinian forces selected for in us, yet it is compatible with their truth or approximate truth. The society-centered theory implies that our moral judgments would likely be approximately true. It does this by attempting to justify the quasi-tracking account (Copp 201). In the fourth stage of the adaptive link account, Kitcher claims that selective pressures would favor those behaviors that promoted social cohesion and oppose those that favored selfish and antisocial behavior (Kitcher 176). According to Copp's society-centered theory, a basic moral proposition is true only if the moral code that would best serve the function of enabling society to meet its needs included a corresponding norm. According to Copp, if the adaptive-link account is true, evolution ought to select those behavioral norms that lead to social cohesion, and it is reasonable to believe that moral codes that lead to social cohesion will also be moral codes that would best serve the function of enabling society to meet its needs. The society-centered theory appears to provide an account of moral truth that justifies the quasi-tracking account and is compatible with the adaptive link account.

The quasi-tracking account does have some grounds. If there are moral truths, there is not enough reason to suggest that neither the basic principles that come about during the third part of the adaptive link account nor the cultural norms that come about during the fourth part would not resemble moral truths. Evolution does not necessitate that our moral beliefs be moral truths, yet it does not deny that they can approximate moral truth. However, Copp's solution is not adequate. Nevertheless, it is possible to escape the Darwinian dilemma given his account of moral truth, but for a different reason than he presents.

ESCAPING THE DILEMMA

I argue that Copp is correct in proposing that if our beliefs evolved to quasi-track the truth, rational reflection would guide them to moral truths. Humans have the capability to think rationally. If natural selection, through the adaptive link account, has led us to come close to moral truths, it is plausible that, through reflection, we would be able to ascertain these truths. For example, the concept of women's rights has a moral platform. In Western societies, it was held that a woman was the property of her father until she was married, allowing the ownership to be passed down to her husband. Over time, considerations of our moral attitudes led to the idea that women should not be considered property. Accepting the moral standard that every human being must be respected (assuming they have not done anything to lose that respect) and must be allowed certain rights, women should also be free to enjoy both. The advances in women's rights were relatively swift, and although it is possible to say that selection played a direct role in the establishment of this particular moral belief, selection usually takes many, many generations. It is more likely that rational reflection on our evaluative attitudes of the treatment of women had a more significant impact on this moral revelation. This change is moral progress. Hence, if it is the case that the society-centered view entails that our moral beliefs quasi-track the moral truth, it is reasonable to believe that through rational reflection we can come to have knowledge of moral truths.

The society-centered theory, however, is insufficient in justifying why our moral beliefs would tend to quasi-track the truth. There are other evolutionary forces that are non-selective, such as drift and migration, which might have influenced our current moral beliefs. The non-selective, or random, nature of these forces, prevents the society-centered theory from explaining why our moral beliefs would have to, at the least, quasi-track the truth. In other words, there is no good reason for our moral beliefs to quasi-track what is good for our society. If our moral beliefs do not quasi-track what is good for our society, then the society-centered theory is incapable of justifying the truth of our moral beliefs through the quasi-tracking account.

Copp could attempt to resolve this issue by providing an explanation as to why only selective evolutionary forces could have significantly affected our moral beliefs. However, there is an even deeper problem. Selection can only act on what is present in past populations. In other words, selection does not yield the best of all

possibilities, since all possibilities might not be present in past populations. However, according to Copp's theory of moral truth, a basic moral proposition is true only if the moral code that would best serve the function of enabling society to meet its needs included a relevantly corresponding norm. Even if selection and only selection is operating on a population, Copp cannot establish that our moral beliefs quasi-track moral truth, since moral truth requires that the moral code is the one that best serves societal needs. The society-centered theory does not guarantee that a norm that would best serve the function of enabling society to meet its needs would be present in a population, and therefore available for selection. Copp seems to be falling victim to the pitfalls of the adaptationist program outlined by Gould and Lewontin (1979).

However, Copp can escape the Darwinian dilemma in another way. The society-centered theory defines moral truth in terms of what is beneficial to society. According to Copp's society-centered account, a moral proposition is true only if it can either be a part of, or implied by, a moral code which best enables a society to serve its needs (Copp 200). If Copp's account of moral truth is correct, there is no need to defend the quasi-tracking account at all.

If moral truth is as Copp outlines, then it does not matter what our moral beliefs are or where they came from. In other words, it does not make a bit of difference whether the moral beliefs framed by our evolutionary past quasi-track the truth. Even if evolution produced radically incorrect moral beliefs, other disciplines — such as political or social science — could produce the correct ones. We need not use the beliefs produced by evolution to ground moral knowledge at all. Instead we can simply empirically study what moral codes will best allow society to meet its needs.

The reason the Darwinian dilemma arises in the first place is related to a particular view of moral knowledge — that we gain moral knowledge by starting with our moral beliefs and using rational reflection to correct these (perhaps by correcting inconsistencies in our moral beliefs or by using some method of reflective equilibrium on these beliefs). The problem is that if these beliefs are not close to the truth, then there is little reason to think that rational reflection will yield moral knowledge. Therefore, if evolution has produced moral beliefs that are distant from the truth, the moral realist cannot account for how we might come to have moral knowledge. However, if Copp's account of moral truth is correct, we can rely on the social sciences to determine which moral codes best serve society's

needs. (It is important to note that Copp does not believe that his meta-ethical theory of moral truth is derived from moral beliefs in this way. Meta-ethical beliefs are not epistemically grounded in the same way as object level moral beliefs.)

Thus, there is no need to defend the quasi-tracking account since the Darwinian dilemma no longer poses a threat to moral realism. As mentioned earlier, the dilemma requires realists to either justify what about the capacity to detect moral truths would be reproductively advantageous, or deny that natural selection affected our moral psychology in a way that tracked the moral truth. However, even if the moral codes that were reproductively advantageous were far from the truth, political and social sciences could determine the correct ones. Studying what moral codes will allow society to meet its needs most effectively can be pursued independently of current moral beliefs. In the same manner, even if natural selection did not affect our moral psychology in a way that tracked the truth, political and social sciences would be unimpeded in their pursuit. Copp's account of moral truth through the society-centered theory circumvents the Darwinian dilemma, even if the quasi-tracking hypothesis turns out to be false.

Copp could respond by suggesting that even if the society-centered theory may make Darwinian selection of moral judgments unnecessary once disciplines that are capable of determining what is beneficial arise, it does not exclude selection as a possible driving force in discovery. Access to moral truth may be a combination of this type of selection and knowledge gained from other disciplines. Therefore, the society-centered theory does not prevent Darwinistic selection of moral judgments from leading to the moral truth. However, the theory still does not justify the claim that Darwinism does not undermine moral realism. If his account of moral truth is correct, the Darwinian dilemma does not undercut moral realism, even if our moral beliefs do not quasi-track the moral truth.

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EFFECTS OF SOCIAL SKILLS ON HEARING-IMPAIRED CHILDREN'S ACADEMIC ACHIEVEMENT

A MEDIATION ANALYSIS

ALEXIS **RUBIN**

The research presented explores the relationship between social skills and academic achievement among hearing-impaired children. My desire when I began my research was to explore an area of functioning for children with disabilities. Within the Quantitative Mathematics lab at UMBC led by Dr. Shuyan Sun, I gathered data from the ECLS-K, a longitudinal study following children from kindergarten to the eighth grade. The ECLS-K included a relatively large subpopulation of hearing-disabled children and so I chose to investigate that disability. The following paper is the culmination of my own research on the real-world implications of hearing impairment in children.

ABSTRACT

Previous research suggests that hearing-impaired children without adequate social skills perform at lower levels academically than normally hearing children. However, there is no study that explicitly examines whether hearing impairment negatively affects academic achievement through social skills — in other words, whether social skills mediate the relation between hearing impairment and academic achievement. By using data from the Early Childhood Longitudinal Study Kindergarten Cohort, this study found that hearing-impaired children had lower social competency and academic achievement than normally hearing children, and that a specific subset of social skills mediated the relation between hearing impairment and academic achievement. Teacher-reported approaches to learning were found to be a significant mediator. The findings have important implications for both research and practice.

A major educational concern today is how to effectively educate children with disabilities so that they may reach their fullest potential. The 2010 U.S. Census approximates that there are 212,000 children under the age of five with some form of hearing disability. Previous studies have shown that hearing impairment has a lifelong negative impact on individuals' development. For instance, Järvelin, Mäki-Torkko, Sorri, and Rantakallio (1997) compared hearing-impaired individuals and their normally hearing peers (N=11,780) at the age of 25. They found that individuals with serious impairments performed at lower levels than their peers during elementary education and that such individuals were also far less likely to be accepted into higher education settings (a 64 percent acceptance rate was observed in comparison to an 88 percent acceptance rate of individuals without similar impairments). In addition, at the time of the study, 14 percent of impaired individuals were unemployed, while unimpaired individuals had an unemployment rate of only seven percent. In order to effectively prepare hearing-impaired children for successful academic careers and future employment, efforts must be made to determine characteristics that aid academic success in hearing-impaired children so that proper educational interventions may take place.

Previous research has highlighted the positive effects of social skills on children's academic achievement. For instance, Buckner, Mezzacappa, and Beardslee (2009) found that children with high self-regulation performed better academically than those with low self-regulation, and that academic performance may increase if self-regulation were to be promoted in the classroom. Likewise, Duncan et al. (2007) found that children with longer and more focused attention spans had high levels of later achievement. In a study by Romano, Babchishin, Pagini, and Kohen (2010), maternal reports of their kindergarten children's desirable social skills significantly predicted reading and math competency in the third grade. Malecki and Elliot (2002) also found that children's positive social skills (including cooperation, assertiveness, and self-control) correlated positively with academic achievement, whereas problem behaviors correlated negatively with academic achievement. However, these studies, like much prior research, were mainly conducted on normally hearing children, so it is not yet clear whether the same is true for hearing-impaired children. Existing evidence on the relation between social skills and academic achievement in hearing-impaired children is scarce. Luckner and Muir (2001) interviewed special education teachers, general education teachers, and parents of 20 high-achieving, profoundly hearing-impaired children. It was found that the most important teacher-reported and parent-reported attributes for academic success in these children were determination to learn, organizational skills, and ability to form meaningful social relationships. Luckner and Muir suggested that a combination of such skills may facilitate academic development in other hearing-impaired children, even those whose hearing impairment is not as severe.

Interpersonal and communication skills may also contribute to hearing-impaired children's learning outcomes. Long, Stinson, and Braeges (1991) found that hearing-disabled children who have difficulty communicating with their peers and teachers may become discouraged in the classroom, possibly leading to inattentiveness and disinclination towards learning. As shown by Anita, Jones, Luckner, Kreimeyer, and Reed (2011), difficulties in communication may hinder the development of appropriate social skills that, as previously described, are of high importance in academic settings. Stinson, Whitmire, and Kluwin (1996) further found that hearing-impaired children who reported feeling more comfortable around hearing-impaired peers and having less positive interactions with non-impaired peers were more likely to feel separation and

discouragement, which could hinder their academic achievement. These findings form the basis of the current study, which examines whether hearing impairment negatively affects academic outcomes indirectly by affecting children's interpersonal and communication skills.

Though the effects of the presence or lack of social skills on academic achievement for normally hearing children are relatively well understood, research specially conducted for hearing-impaired children is rare. Moreover, the mechanism by which hearing impairment negatively affects children is not clear. Prior research discussed earlier suggests that hearing impairment may affect children's academic achievement through social skills. In other words, social skills could mediate the relation between hearing impairment and academic achievement. Unfortunately, the mediation hypothesis has not been explicitly examined in the literature. To address such gaps and extend previous research, this study examined the following:

> Differences in academic performance between hearing-impaired and normally hearing children
>
> Differences in levels of social skills between hearing-impaired and normally hearing children
>
> The impact of hearing impairment on children's academic development as mediated by social skills

METHOD

PARTICIPANTS

Data were drawn from the public-use data set of the Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K; U.S. Department of Education, National Center for Education Statistics, 2006). The ECLS-K focuses on children's early school experiences, beginning with kindergarten and following the same children through middle school. It collects a large amount of data from a nationally representative sample of children, their families, and their schools; in doing so, it allows researchers to study how a wide range of family, school, community, and individual factors are associated with children's development and school performance. Two groups of children (N=747) were included in the current analysis.

The normal hearing group included 582 children who were reported to have normal hearing and who did not receive any special-needs services at school. The hearing difficulty group included 165 children who were reported to have difficulty hearing normal conversation. Demographics of the sample used for analysis are presented in Table 1.

TABLE 1. **DEMOGRAPHICS OF THE SAMPLE USED FOR ANALYSIS.**

		N	%
Hearing Status	Normal Hearing	582	77.91
	Hearing Difficulty	165	22.09
Sex	Male	474	63.45
	Female	273	36.55
Race/Ethnicity	White	368	49.26
	Black	140	18.74
	Hispanic	126	16.87
	Asian	54	7.23
	Other	59	7.90
Mother's Education	Some High School or Less	152	21.02
	High School Diploma	218	30.15
	Some College	218	30.15
	College Degree	94	13.00
	Above College Degree	41	5.67

MEASURES

Academic Achievement. Children's academic achievement was indicated by their assessment scores in reading, mathematics, and general knowledge. The reading assessment included questions designed to measure basic reading skills, vocabulary, and comprehension. The mathematics assessment was designed to measure conceptual and procedural knowledge of mathematics as well as problem-solving ability. The general knowledge assessment consisted of items that, in a single scale, measure knowledge of both the natural sciences and social studies. IRT scale scores from those assessments were used in this study. Reliability estimates for this data set were .97 for reading, .94 for mathematics, and .89 for general knowledge, as demonstrated by Tourangeau, Nord, Lê, Pollack, and Atkins-Burnett (2006).

Social Skills. Children's social skills were measured by both teacher reports and parent reports on a Social Rating Scale (SRS). The SRS was adapted with permission from Elementary Scale A ("How Often?") (Gresham and Elliott, 1990). Teachers and parents were asked to tell how often a student exhibited certain social skills and behaviors (1 — never, 2 — sometimes, 3 — often, or 4 — very often). Five subscales were formed from the teacher SRS: Approaches to Learning, Self-Control, Interpersonal Skills, Internalizing Problem Behavior, and Externalizing Problem Behavior. The parent SRS was geared to the home environment and had five subscales: Approaches to Learning, Self-Control, Social Interaction, Sad/Lonely, and Impulsive/Overactive. Reliability estimates of subscale scores varied from .63 to .89 (Tourangeau, Nord, Lê, Pollack, & Atkins-Burnett, 2006).

Mediators. The five teacher-reported subscales were designed to parallel the five parent-reported subscales. Each subscale contained similar questions modified to gain an understanding of either educational settings or home environments. The Approaches to Learning subscales included questions pertaining to children's organizational skills, flexibility, attentiveness, ability to persist on a task, ability to learn independently, and eagerness to learn. The Self-Control subscales contained questions that tapped into children's abilities to regulate their tempers, accept peer suggestions for group activities, respond well to peer pressure, and respect the belongings of others. The teacher-reported Interpersonal Skills subscale and the parent-reported Social Interaction subscale were designed to be parallel and requested information on children's relationships with differing individuals, how children comforted or aided other children, children's abilities to form and maintain friendships, children's abilities to express their feelings, and how sensitive children were to the feelings of others. The teacher-reported Internalizing Problem Behavior subscale and the parent-reported Sad/Lonely subscale were designed to be parallel and consisted of questions about the presence of anxiety, loneliness, low self-esteem, and sadness in a child. Lastly, the teacher-reported Externalizing Problem Behavior subscale and the parent-reported Impulsive/Overactive subscale were designed to be parallel and questioned how often children got angry, argued, acted impulsively, fought, and disturbed activities. The definitions of the mediators are adapted from Tourangeau, Nord, Lê, Pollack, and Atkins-Burnett (2006).

Covariates. Three covariates were included in data analysis: child sex (male, female), child race/ethnicity (White, Black, Hispanic, Asian, and Other), and socioeconomic status or SES (measured on a continuous scale from -3 to 3). These covariates were selected because they were found to correlate frequently with academic achievement in the literature.

PROCEDURE

To assess group differences in academic achievement and social skills between normally hearing children and hearing-impaired children, an independent-measures *t* test was used. To perform mediation analysis, a parallel mediator model (shown in the figure) was analyzed using the PROCESS, a set of SPSS macros written by Hayes (2012). Five subscale scores from teacher SRS reports and five from parent SRS reports were included as parallel mediators.

FIGURE. **THE PROPOSED MEDIATION MODEL WITH SRS SUBSCALES AS MEDIATORS.** Sex, race/ethnicity, and socioeconomic status were included as covariates. Separate analyses were conducted for reading, mathematics, and general knowledge. Only the boldfaced "Teacher-Reported Approaches to Learning" subscale was found to be a significant mediator between hearing impairment and academic achievement.

This mediation model estimates two distinct types of effect: direct effect and indirect effect. Here, the direct effect is the effect of hearing impairment on academic achievement, after controlling for the effects of demographics and children's social skills. The indirect effect is the extent to which hearing impairment affects children's social skills, which in turn may affect their academic achievement. An indirect effect was estimated for each mediator. A negative estimate of direct or indirect effect suggests that hearing impairment has a negative effect on academic achievement. A direct effect is statistically significant if the p value is less than 0.05 or if the 95% confidence interval (CI) does not cover zero. An indirect effect is statistically significant if zero is not included in its bootstrap confidence interval. Separate analyses were conducted for reading, mathematics, and general knowledge.

RESULTS

GROUP DIFFERENCES

Means and standard deviations of continuous variables are reported in Table 2. An independent-measures *t* test was used to compare children with hearing difficulty to normally hearing children in academic achievement and social skills. Children with hearing difficulty performed worse than normally hearing children in reading ($t = 3.85, df = 689, p < 0.001$), mathematics ($t = 4.85, df = 709, p < 0.001$), and general knowledge ($t = 6.33$, $df = 686$, $p < 0.001$). Compared with normally hearing children, children with hearing difficulty also had lower parent-reported scores on the Approaches to Learning subscale ($t = 2.83$, $df = 744$, $p = 0.005$), higher parent-reported scores on the Sad/Lonely subscale ($t = -3.72$, $df = 742$, $p < 0.001$), and higher parent-reported scores on the Impulsive/Overactive subscale ($t = -3.37$, $df = 737$, $p = 0.001$). As for teacher-reported SRS scores, children with hearing difficulty scored lower on the Approaches to Learning subscale ($t = 3.08$, $df = 642$, $p = 0.002$), lower on the Interpersonal Skills subscale ($t = 2.05$, $df = 636$, $p = 0.04$), and higher on the Internalizing Problem Behavior subscale ($t = -2.09$, $df = 634$, $p = 0.04$).

TABLE 2. **DESCRIPTIVE STATISTICS FOR NORMAL HEARING GROUP AND HEARING DIFFICULTY GROUP.**

	NORMAL HEARING		HEARING DIFFICULTY	
	M	**SD**	**M**	**SD**
Socioeconomic Status	0.00	0.75	-0.07	0.64
Reading IRT Scale Score	65.39	20.92	57.97	18.44
Mathematics IRT Scale Score	54.12	18.79	45.81	16.71
General Knowledge IRT Scale Score	30.98	8.64	25.81	8.54
Parent-Reported Approaches to Learning	2.90	0.54	2.77	0.58
Parent-Reported Self-Control	2.79	0.59	2.70	0.58
Parent-Reported Social Interaction	3.18	0.62	3.10	0.69
Parent-Reported Sad/Lonely	1.68	0.49	1.84	0.52
Parent-Reported Impulsive/Overactive	2.10	0.80	2.34	0.78
Teacher-Reported Approaches to Learning	2.77	0.75	2.55	0.72
Teacher-Reported Self-Control	3.07	0.64	2.95	0.67
Teacher-Reported Interpersonal Skills	2.95	0.65	2.81	0.72
Teacher-Reported Externalizing Problem Behavior	1.76	0.69	1.86	0.75
Teacher-Reported Internalizing Problem Behavior	1.69	0.54	1.80	0.62

MEDIATION ANALYSES

For reading scores (Table 3), the teacher-reported Approaches to Learning subscale was the only significant mediator in the model (indirect effect: -2.27, 95% bootstrap CI: -4.44 to -0.46). In other words, hearing difficulty is negatively related to the demonstration of successful approaches to learning, which in turn affects children's reading. After controlling for social skills and covariates, it was shown that the two groups of children did not differ in their reading scores (t = -1.46, df = 496, p =0.14). This signifies that hearing impairment did not have a significant direct effect on reading scores (direct effect: -2.85, 95% CI: -6.68 to 0.98). These results suggest that hearing impairment only negatively affects reading achievement through teacher-reported approaches to learning. The mediation model explained 34 percent of the variability in reading scores.

TABLE 3. **A SUMMARY OF DIRECT EFFECT AND INDIRECT EFFECTS OF HEARING IMPAIRMENT ON READING SCORES.**

DIRECT EFFECT OF HEARING IMPAIRMENT ON READING SCORES				
			95% CI	
	EFFECT	**SE**	**LOWER BOUND**	**UPPER BOUND**
Direct Effect	-2.85	1.95	-6.68	0.98
INDIRECT EFFECTS OF HEARING IMPAIRMENT ON READING SCORES THROUGH MEDIATORS				
			95% Bootstrap CI	
MEDIATOR	**EFFECT**	**SE**	**LOWER BOUND**	**UPPER BOUND**
Parent-Reported Approaches to Learning	-0.53	0.34	-1.38	0.00
Parent-Reported Self-Control	-0.23	0.26	-0.98	0.09
Parent-Reported Social Interaction	-0.07	0.16	-0.64	0.10
Parent-Reported Sad/Lonely	-0.27	0.31	-1.01	0.24
Parent-Reported Impulsive/Overactive	-0.12	0.26	-0.78	0.32

INDIRECT EFFECT OF HEARING IMPAIRMENT ON READING SCORES THROUGH MEDIATORS				
			95% Bootstrap CI	
MEDIATOR	EFFECT	SE	LOWER BOUND	UPPER BOUND
Teacher-Reported Approaches to Learning*	-2.27	1.01	-4.44	-0.46
Teacher-Reported Self-Control	0.20	0.28	-0.12	1.21
Teacher-Reported Interpersonal Skills	0.28	0.42	-0.43	1.35
Teacher-Reported Externalizing Problem Behavior	-0.07	0.18	-0.77	0.12
Teacher-Reported Internalizing Problem Behavior	-0.16	0.21	-0.91	0.08

*The only significant effect is the indirect effect of hearing impairment on reading scores through teacher-reported approaches to learning (its 95% bootstrap CI does not cover zero).

For mathematics scores (Table 4), the indirect effect of teacher-reported approaches to learning was significant (indirect effect: -2.34, 95% bootstrap CI: -4.52 to -0.54). Other mediators were not statistically significant. Even after controlling for social skills and covariates, it was shown that children with hearing difficulty still had lower mathematics scores than normally hearing children (t = -2.42, df = 505, p =0.02). In other words, the direct effect of hearing impairment on mathematics scores was statistically significant (direct effect: -4.19, 95% CI: -7.58 to -0.79). In summary, the data suggest that hearing difficulty directly affects children's mathematics achievement in addition to indirectly affecting children's mathematics achievement through teacher-reported approaches to learning. The mediation model explained 36 percent of the variability in mathematics scores.

TABLE 4. **A SUMMARY OF DIRECT EFFECT AND INDIRECT EFFECTS OF HEARING IMPAIRMENT ON MATHEMATICS SCORES.**

DIRECT EFFECT OF HEARING IMPAIRMENT ON MATHEMATICS SCORES				
			95% CI	
	EFFECT	SE	LOWER BOUND	UPPER BOUND
Direct Effect*	-4.19	1.73	-7.58	-0.79
INDIRECT EFFECTS OF HEARING IMPAIRMENT ON MATHEMATICS SCORES THROUGH MEDIATORS				
			95% Bootstrap CI	
MEDIATOR	EFFECT	SE	LOWER BOUND	UPPER BOUND
Parent-Reported Approaches to Learning	-0.12	0.18	-0.68	0.10
Parent-Reported Self-Control	-0.09	0.16	-0.69	0.06
Parent-Reported Social Interaction	0.06	0.13	-0.08	0.54
Parent-Reported Sad/Lonely	0.09	0.25	-0.36	0.68
Parent-Reported Impulsive/Overactive	-0.18	0.23	-0.82	0.16
Teacher-Reported Approaches to Learning*	-2.34	1.00	-4.52	-0.54
Teacher-Reported Self-Control	0.34	0.32	-0.06	1.32
Teacher-Reported Interpersonal Skills	0.17	0.28	-0.15	1.06
Teacher-Reported Externalizing Problem Behavior	-0.03	0.14	-0.53	0.14
Teacher-Reported Internalizing Problem Behavior	-0.01	0.14	-0.37	0.25

*The two significant effects are the direct effect and the indirect effect of hearing impairment on mathematics scores through teacher-reported approaches to learning (neither CI covers zero).

Similar patterns were found for general knowledge (Table 5). Teacher-reported approaches to learning were the only significant mediator in the model (indirect effect: -0.59, 95% bootstrap CI: -1.25 to -0.12). Even after controlling for social skills and covariates, it was shown that children with hearing difficulty still had lower general knowledge scores than normally hearing children (t = -5.04, df = 504, p <0.001). Stated differently, the direct effect of hearing impairment on general knowledge was statistically significant (direct effect: -4.09, 95% CI: -5.68 to -2.49). In summary, hearing difficulty has a significant direct negative effect on general knowledge in addition to a significant indirect negative effect on general knowledge through teacher-reported approaches to learning. The mediation model explained 34 percent of the variability in general knowledge scores.

TABLE 5. **A SUMMARY OF DIRECT EFFECT AND INDIRECT EFFECTS OF HEARING IMPAIRMENT ON GENERAL KNOWLEDGE SCORES.**

DIRECT EFFECT OF HEARING IMPAIRMENT ON GENERAL KNOWLEDGE SCORES				
			95% CI	
	EFFECT	**SE**	**LOWER BOUND**	**UPPER BOUND**
Direct Effect*	-4.09	0.81	-5.68	-2.49
INDIRECT EFFECTS OF HEARING IMPAIRMENT ON GENERAL KNOWLEDGE SCORES THROUGH MEDIATORS				
			95% Bootstrap CI	
MEDIATOR	**EFFECT**	**SE**	**LOWER BOUND**	**UPPER BOUND**
Parent-Reported Approaches to Learning	-0.09	0.09	-0.39	0.02
Parent-Reported Self-Control	-0.04	0.08	-0.32	0.04
Parent-Reported Social Interaction	0.03	0.06	-0.04	0.26
Parent-Reported Sad/Lonely	-0.02	0.13	-0.30	0.23
Parent-Reported Impulsive/ Overactive	-0.05	0.11	-0.33	0.12

INDIRECT EFFECTS OF HEARING IMPAIRMENT ON GENERAL KNOWLEDGE SCORES THROUGH MEDIATORS				
			95% Bootstrap CI	
MEDIATOR	EFFECT	SE	LOWER BOUND	UPPER BOUND
Teacher-Reported Approaches to Learning*	-0.59	0.28	-1.25	-0.12
Teacher-Reported Self-Control	0.02	0.10	-0.10	0.38
Teacher-Reported Interpersonal Skills	0.00	0.07	-0.20	0.11
Teacher-Reported Externalizing Problem Behavior	0.03	0.09	-0.06	0.34
Teacher-Reported Internalizing Problem Behavior	0.03	0.08	-0.09	0.27

*The two significant effects are the direct effect and the indirect effect of hearing impairment on general knowledge scores through teacher-reported approaches to learning (neither CI covers zero).

DISCUSSION

The present study made a significant contribution to the area of discussion by identifying a mechanism by which hearing impairment negatively affects children's academic performance. Using the ECLS-K data, it was found that hearing-impaired children had poorer social skills and performed worse academically than normally hearing children. More importantly, the specific social skills that were included under teacher-reported approaches to learning (including organizational skills, task persistence, and eagerness to learn) were found to mediate the relation between hearing impairment and academic achievement. In other words, hearing-impaired children tended to be less organized, less attentive, and less independent learners than normally hearing children, which indirectly hindered their academic achievement. This mediation effect was found to be present in reading, mathematics, and general knowledge.

Findings from the present study have important implications for research and practice. There is an urgent need for more research on the mechanisms by which hearing impairment and other types

of disabilities affect children's school performance. This study successfully identified teacher-reported approaches to learning as one mediator of academic achievement. It is necessary to explore other potential mediators such as classroom characteristics and the use of special education services as well as children's personalities and home environments. Identification of significant mediators may facilitate the development of effective interventions to improve children's learning outcomes. There exist a multitude of interventions designed to boost children's academic achievement, including but not limited to in-school training groups on social skills, increases in one-on-one instruction time, and promotion of a more encouraging learning atmosphere at home. Further investigation into every possible type of intervention is necessary.

It is important to note that the ECLS-K data used in this study are not experimental data and consequently cannot be used to make causal inferences. Although this study only used data collected in the spring of first grade, the longitudinal nature of the ECLS-K study allows research on the long-term effects of hearing impairment and social competency on academic achievement. The next research step is to extend this study to a longitudinal investigation.

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PHILANTHROPY AND REPUTATION IN THE LIVES OF JOSEPH TOWNSEND AND BALTIMORE'S "PUBLIC SPIRITED CITIZENS"

HANNAH **JONES**

I was extremely fortunate to have been asked, in July 2012, to do an independent research project for Baltimore Equitable Insurance, the company which Joseph Townsend founded in 1794. Together, UMBC graduate student Meghan Colabella and I set about gathering biographical information about the lives of the company's founders, directors, and policyholders, for use in their newsletters and other published materials. This position developed into an independent study under Dr. Marjoleine Kars from fall 2012 through August 2013. However, the subject seemed to call for deeper study in order to understand the complexities behind the staggering amount of public service these men had undertaken. Skeptical of the unadulterated altruism of these massive public figures and intrigued in particular by the scandal Townsend had experienced during the yellow fever epidemics, I resolved to supplement my primary source research from my earlier projects with secondary scholarly research to uncover the more nuanced motivations that led these men to become philanthropists. I applied for and received an Undergraduate Research Award in spring 2013.

"Take care not to perform righteous deeds in order that people may see them...When you give alms, do not blow a trumpet before you...to win the praise of others..."

Matthew 6: 1-2.

INTRODUCTION

During the winter of 1800-1801, Baltimore's *Federal Gazette* published a series of letters that nearly spelled disaster for one of the city's most influential leaders. Beginning in November, local physician Dr. James Smith, under the pseudonym "Humanitas," denounced prominent businessmen Joseph Townsend and Adam Fonerdan for having abused their power as members of the city's Board of Health during the recent yellow fever epidemic. Although the Mayor and City Council had lately lauded the men's "extraordinary exertions" in dealing with the public health threat, Smith was less willing to accept their altruism; seeking to "arouse [the public] from [its] delusive inactivity, or rather criminal stupidity," Smith accused Townsend and Fonerdan of failing to fulfill their duties to the poor and of accepting illicit payment for their charitable services.[1] Instead of "daily visiting the poor and afflicted," as the public and the city's administration believed, Smith provocatively claimed that "they kept themselves at home, and out of danger... When it was supposed that they were diligent and unwearied in their disinterested labors... most of their philanthropy centered on their own persons." Their assistance was limited to "sign[ing] orders of admission into the hospital," yet they received generous praise from the Mayor and City Council, as well as salaries and private donations.[2] Smith boldly called for a reorganization of the Board of Health, believing it to be run by "men inadequate to the task." Much as a constitution could not be written by physicians nor a bank run by mechanics, Smith explained, so too proper health laws could not be formulated by politicians; this work was best left to "men of science and humanity," as the editor of the *Baltimore American* concurred.[3]

Though Smith's demands evidently failed to produce notable change in the city's public health administration, they opened the door to a scandal that nearly cost Townsend his place at the pinnacle of Baltimore society. Likely emboldened by Smith's denunciations,

subsequent letters published in the *Federal Gazette* decried Townsend's actions in the case of a young orphan girl named Polly Elliot, to whom he had refused admission to the hospital. While it was this more human-interest story that engendered public outcry and resulted in negative repercussions for Townsend (who was not reappointed to the Board the following year and even lost his long-held position with the Baltimore Equitable Society), the two sets of accusations were indicative of a common phenomenon — one taking place not merely in Baltimore but throughout the country.[4] Smith's call for change in the city's administrative system — a change that would place expertise instead of reputation as the criteria for holding public office — contradicted the existing system, in which wealthy merchant elites merited social and political power merely by their enterprising nature and philanthropic reputations. The subsequent scrutiny of Townsend's altruism in the Polly Elliot case shows the growing public doubt of the merchant elite's right to rule, a right that had been in place since the Revolution.

THE RISE OF THE "PUBLIC SPIRITED CITIZENS"

The system that had allowed Townsend, a total parvenu in Baltimore society, to rise to the heights of power without much expertise, originated in the radical economic changes that took place in Maryland in the 1760s, and the following political upheaval in the wake of the Revolution. These two factors created what historian Charles G. Steffen has called a culture of "openness, fluidity, and impermanence," which both gave greater opportunities to ambitious newcomers and simultaneously made reputation enormously important among the city elite.[5] While affording some men unparalleled opportunity to accede to the throne of elite power without previous familial or financial connections, this openness simultaneously created anxiety about elites' merit and required the new elites to cultivate public trust through an exercise of philanthropic virtue.

When Townsend, a penniless but ambitious school teacher and Quaker, left his home in Chester County, Pennsylvania, after the devastation of the Revolutionary War, he was not alone in choosing Baltimore as his destination.[6] Prospects were particularly "rosy" in the city, which had been transformed by the wheat trade from a forgotten village on the banks of the Chesapeake Bay to the state's primary commercial center.[7] Since its founding in 1729, the town of Baltimore had been used as a port, but it was not until wheat

ousted tobacco as the state's primary commodity in the 1760s that the merchants operating out of the town began living within its borders instead of on surrounding plantations.[8] Unlike tobacco, which required large plantations to cultivate and was often handled by British commercial agents, wheat could be grown by smaller farmers in western Maryland and southern Pennsylvania and was distributed to a wider variety of buyers — this became especially true after the Revolution, when Britain no longer held a monopoly on American goods. The unpredictability of both production and purchase rates necessitated the establishment of warehouses to purchase, store, and sell the goods, while the divide between agriculture and commerce (plantation owners were no longer selling their own goods) allowed for the creation of a new class of local resident merchants, who did not need to own a plantation to engage in trade.[9]

As Baltimore's mercantile landscape became more complex and mature in the wake of these economic changes, the Revolution opened up new political possibilities for the merchant elite, in Baltimore as in the country at large. By the turn of the century Baltimore had surpassed Annapolis and every other Maryland city "in size and economic importance," but was still being governed by administrative structures created for the "tentative commercial settlement" it had been in 1729.[10] The explosion of the city's size and prominence put additional demands on its administration at exactly the time when the purge of elite royalists and a flourishing of new ideas about democracy and republicanism undermined the established socio-political hierarchy.[11] In this situation, young enterprising men like Joseph Townsend found opportunities, throughout the country as well as in Baltimore, to fill a power vacuum. Though unknowns in the city, these young men climbed to positions of municipal power by way of relatively minor appointments. This increased social mobility created what Steffen described, paradoxically, as an "open plutocracy": a society dominated by an elite that required wealth of its members but admitted any wealthy and civically-active white man, regardless of his family background. Just as they had used new opportunities to make fortunes without a birthright, these newcomers also had the chance to gain municipal power without previous social influence, which led the new merchant elite to become also the social and political powerhouses of the city.

Until the incorporation of the town in 1797 (at which time the City Council was created and first Mayor elected), the citizens of Baltimore, ever wary of "tyranny" following the Revolution, utilized

the "commission model" of municipal organization, which endowed nearly autonomous boards and committees with considerable power to handle local problems.[12] The first of these was the Mechanical Fire Company, originally organized in 1763 to cope with prevalent urban fires, which served, in the absence of alternative authorities, "as a de facto quasi-government for the next dozen years."[13] The centrality of the fire and fire insurance companies endured for several decades, and it was the Baltimore Equitable Society, a fire insurance company that still operates in the city today, that really established Townsend's high standing in the city.[14]

The path to civic prominence, opened by economic changes and political upheaval, is also evident in Townsend's case in the Board of Special Commissioners, an institution formed by the Maryland Assembly in 1782, the year before Townsend's arrival in the city. Created to address the dismal condition of the city's streets, this seven-man Board was given power "to superintend the leveling, pitching, paving and repairing the streets, and the building and repairing the bridges," but like the Mechanical Fire Company, it quickly gained power to become "a very potent body in the town's life."[15] Less than five months after its incorporation, the state legislature expanded the Commissioners' powers enormously, empowering them to enact fire prevention measures, sink wells and erect pumps, construct sewers, condemn property, and even regulate the dimensions of loaves of bread, in addition to being authorized to borrow and spend thousands of pounds to build up the city's infrastructure.[16] Townsend was elected to the Board in 1792 and remained there until its dissolution at the time of the city's incorporation in 1797, sharing in this immense influence.[17] He simultaneously became involved in efforts to improve the city's schools, liberate slaves through complicated legal proceedings, and eventually in various efforts to preserve the city's public health, as explained below.

These appointments, which earned Townsend a place in the "open plutocracy," brought with them vast and varied powers to control and influence the city and its people — powers for which Townsend had had no previous experience. As the son of a Pennsylvania farmer who had become a successful urban businessman and merchant, Townsend would have known very little about civil engineering, education, law, or medicine. Yet, in the cities of post-Revolution America, enterprise, initiative, and ubiquitous involvement sufficed in lieu of expertise, so he and men like him quickly became the cornerstones of urban administration.

There remained, however, an anxiety about the merit of these men to inherit the mantle of the elite. To compensate for their lack of familial prominence or occupational expertise, the new merchant elite came to rely on reputation to "[inspire] trust and [facilitate] access to resources" through continued appointment.[18] Public philanthropy formed the basis of this reputation, which assured the public of their virtue and ensured their continued appointment to positions of municipal power.[19]

REPUTATION AND PHILANTHROPY AT WORK IN THE CITY

The system of reputation that kept merchant elites in power despite their lack of expertise depended on the relationship between the concrete powers of civic appointment and the reputational power of public charity. Often the one could lead to the other, as elites were drawn into philanthropic projects through their work in municipal organizations. This was certainly the case for Townsend as his work on the Board of Special Commissioners led to his role in the creation of a Potter's Field; it also helped him create the web of elite contacts that would later save him when his reputation was threatened. The connection between civic appointment and reputation is also reflected in the institutions themselves, many of which were organized in such a way as to emphasize elite virtue and magnanimity. In many ways, then, historian Seth Rockman was correct in observing that "civic leadership, philanthropy, and...self-interest" intertwined in the lives of elites such as Townsend in ways that preserved their power and prominence.[20] Civic power fed reputation and vice versa, in a system that ensured the continued influence of a class of men who acceded to the role of elites without the benefits of either the familial prestige of the earlier planter aristocracy nor the technical expertise of true professionals. While this system remained effective during the period of transition between the Revolution and the turn of the nineteenth century, by the time Smith published his letter in the *Federal Gazette* this era of uncertainty and rapid expansion was coming to an end, and with it the system of reputation that held Townsend at the top of Baltimore society.

At the peak of its potency, the system of reputation by which Townsend had ascended to power could be found in the many intersections between municipal government and philanthropy in his daily endeavors. Perhaps the most obvious example is his

work with the Special Commissioners and his participation in the creation of a Potter's Field, a public burial ground for the poor or unidentified deceased. As a Commissioner, Townsend had been made aware of the prevalent problem of makeshift and haphazard burials: he and his associates published a notice in December 1792 deploring the unauthorized but common practice of burying the poor deceased under city streets, where the bodies were often discovered while the roads were being repaired.[21] Townsend then became one of the primary exponents of the effort to create the Potter's Field, being elected to every committee overseeing the project, and chosen to superintend the burial ground once it had been established. While it allowed him to nurture his reputation as a benefactor of the poor in the hearts and minds of Baltimore's citizens, the undertaking also allowed him to strengthen his bonds with the rest of the Baltimore elite. Over half of those appointed to oversee the project were already acquainted with Townsend through either business or philanthropy.[22] Such associational overlap was not unusual; as Dennis Rankin Clark described, "[t]he roster of every group, whether a fire company, a militia group or simply an ad hoc ward group organizing to solicit subscriptions for the poor, reveals the same pattern: top executive posts manned by the same few individuals, usually members of the elite."[23] Association with these "few individuals" became another source of public trust, and the path of entry into the "open plutocracy" depended on it. Newcomers joined organizations and undertakings in order to cultivate a relationship with this circle of greats, and thus gain acceptance as one of their number.[24]

As a crucial component of the elite power structure, this associational overlap did not go unnoticed by the people of Baltimore. A stockholder of the Baltimore Fire Insurance Company pointed it out in a letter to the *North American and Mercantile Daily Advertiser*, protesting that many of the candidates being considered for the company's Board of Directors already held "a profusion of offices," "more... than they can possibly do justice to" (he mentioned Townsend and Fonerden specifically, who were pursuing the positions of Secretary and President despite the fact that they were already officers of the Baltimore Equitable Society). This stockholder questioned whether men who collected so many appointments would be more likely to serve their own interests instead of those of the company or the city. To refute this line of thought, elites serving in positions of civic power defended the practice of associational overlap by presenting

the elites' concern for reputation as a "monitoring mechanism that force[d] self-interested persons to be honest."[25] In the same year that the Baltimore Fire Insurance Company was founded, another company, the Union Manufacturing Company, assured its members of the efficacy of this monitoring mechanism. The committee appointed to write the company's constitution put to rest any worries about entrusting the company to a small number of men, saying that "both the hope of acquiring reputation and the fear of punishment" would ensure the altruistic governance of the institution.[26] Far from being a source of anxiety, the Board members painted the concentration of power in the hands of the few as beneficial under the regulation of the system of reputation. This mentality was not native to the city of Baltimore, but existed in the country at large, driving the country's new elite classes to pursue reputation as "the ultimate check" in the new government. Hamilton himself, in the Federalist Papers, shared the sentiment put forth by the members of the Union Manufacturing Company committee — that "only personal responsibility before the eyes of the public — the threat of dishonor before an ever-vigilant audience — could restrain self-serving, ambitious politicians."[27]

While the associational overlap among elites helped anchor them in positions of social and municipal power, often the organizational structure of the institutions they served also performed the same function. Many of Baltimore's earliest municipal organizations used their charitable function to simultaneously promote the rhetoric of elite charity and reinforce the reputations of their elite officeholders. One of the most obvious examples of this was the Baltimore Almshouse, created in 1773 by the Maryland Assembly, which made its charitable services the direct result of elite action by giving its trustees the power to decide who could be granted admission. Asserting that the opinions of "intelligent men" were "the best known protection against abuses of charity," this organization ensured that any charity it offered would be distributed at the hands of the elites, who had superior moral judgment and could now lay claim to the thanks of the city's poor.[28] Other institutions did likewise, including the Savings Bank of Baltimore (the third oldest savings bank in the country, founded in 1818), which left it to its trustees to distinguish the "industrious and thrifty poor" who could deposit in its vaults, or the Baltimore General Dispensary (founded in 1801), which required that a applicant have the recommendation of a contributor to receive free medical assistance.[29]

Thus, many charitable institutions, while effectively serving the poor, also served to strengthen the image of elite magnanimity and superior moral judgment.[30]

THE YELLOW FEVER EPIDEMIC AND THE BALTIMORE BOARD OF HEALTH

Townsend made use of many avenues of involvement during his first years in the city to build his reputation for civic virtue: in addition to his work with the Special Commissioners he participated in the local meetinghouse of the Society of Friends (more commonly known as Quakers), founded the state's first Abolition Society, and ran the Baltimore Equitable Society, a fire insurance company, from its creation in 1794 until his death in 1841.[31] Like many of his fellow elites, who enjoyed neither familial prominence nor previous experience, the reputation that sprang from this involvement was the key to his continued success, making him both a staple financial powerhouse of the city and a philanthropic icon. He had built up trust with the people of Baltimore, both through his own actions and by the endorsement of his fellow elites. In light of this trajectory, his appointment to the city's Board of Health in 1793 could have been just another step in his climb up the social ladder; as a Board member, he was entrusted with new responsibilities that would paint him as a guardian of the city's good health and a savior of the people during a time of crisis. However, this image was complicated by the accusations published in the *Federal Gazette*. Today, these accusations signify that the system of reputation was growing more and more tenuous during this period.

Given his history of civic involvement and public service, Townsend was a clear choice in 1793 to be appointed by the City Council to the Baltimore Board of Health, "a group of local gentlemen" appointed to protect the public health against the threat of yellow fever.[32] Townsend was elected to the Board each year between 1793 and 1800 (excluding 1796, when it was not reformed), to combat the yearly visitation of the fever, which wreaked havoc on the city's population in late summer and early fall. During the 1794 epidemic, one in six residents of Fells Point (the area most susceptible to the disease due to the prevalence of disease-carrying mosquitoes near water) contracted the virus; in 1797, the numbers rose to one in four, and by the turn of the century about half of those who fell ill with yellow fever would die of it.[33] The fever of 1800 killed

nearly 1,200 citizens between August and October — almost five percent of the city's population, or the equivalent of over 31,000 today.[34] Under these conditions, the wealthy citizens of Baltimore fled the city for the surrounding countryside. As a result, businesses shut down, local government ground to a halt, and the poor, who had no way of leaving the city and nowhere to go, were left without access to basic necessities such as food and medical care.[35]

In such a time of crisis, almost all governmental authority defaulted to the Board of Health, channeling additional power to two solitary Board members remaining in the city: Townsend and his close friend Adam Fonerdan. As one of only two Board members to remain, Townsend enacted and carried out city-wide public health measures almost single-handedly. He enforced the city's quarantine (which was imposed, with greater or lesser stringency, until the turn of the century), enacted citywide cleaning projects, arranged burials, managed both the city hospital and the quarantine hospital at Hawkin's Point, inspected ships for possible infection, and collected general information about the city's health.[36] In addition to spearheading the city's public health administration, Townsend assisted in relief efforts, notably the erection of a refugee camp for the inhabitants of Fells Point, the area most susceptible to and most devastated by the fever.[37]

DENUNCIATION AND SCANDAL

Before the publication of James Smith's denunciations on November 12, 1800, Townsend's actions during the yellow fever epidemics seemed to be the crowning achievement of his activism. He had accumulated considerable municipal power during the crisis, and exercised it with sufficient magnanimity to warrant the lavish praise of the Mayor and City Council, who published a report after the epidemic lauding his actions:

> The Board of Health have had an arduous task through this afflictive scene; and to them the city of Baltimore is greatly indebted for their extraordinary exertions, especially to Mr. Adam Fonerden, and Mr. Joseph Townsend, who at the hazard of their lives remained at their post, and attended to make provision for the sick and the indigent, when deserted by most of their neighbors.[38]

It was the system of reputation at its finest: concrete power opening opportunities for philanthropic engagement which assured the public of Townsend's virtue and would have merited him continued appointment in the future. Yet this system, so vital to the survival of the city and country in the aftermath of the Revolution, was on the wane. Though it had functioned for Townsend during the crisis of the epidemic, the fact that a little-known physician such as Smith could so openly criticize him in 1801 shows that the automatic deference once shown to the philanthropic merchant elite was no longer as potent as it had once been.

The first defamatory letters that Smith published in the *Federal Gazette* on November 23 and December 25, 1800, challenged Townsend's sterling reputation by accusing him of neglecting his duties and accepting pay for what was supposed to be an act of civic service. These attacks continued on January 20, 1801 with the publication of the Polly Elliot story, which painted Townsend not merely as neglectful but as actively despicable. The girl, aged between ten and fourteen, had been living in the home of one Henry Purcell when she fell ill with the fever and was abandoned when the family fled the city. She was later discovered by grocer James Young and stonecutter William McCormick, who sought to have her admitted to the hospital but were refused by Joseph Townsend, who demanded a physician's certificate confirming that she had the fever. After spending "several hours" searching for a doctor to provide the requisite certification (there were supposedly only four practicing physicians left in the city), McCormick returned to Townsend, who granted her admission but refused to arrange for her transportation, supposedly casting the child out of his home. McCormick was therefore obliged to walk with Polly to the hospital, where she died four days later.[39]

Although the requirement of a physician's signature was entirely reasonable given the limited space available in the hospital (similar measures were enforced in Philadelphia during its 1793 epidemic),[40] these accusations proved highly combustible, sparking so much public discourse that the editors of the *Federal Gazette* eventually refused to publish anything more on the matter.[41] This passionate outcry was due to the nature of the accusations, which had challenged Townsend's reputation, and with it the foundation of his power in the city. Many historians, such as Toby Ditz and Joanne Freeman, have studied and discussed the importance of reputation for the early American elite, which became (according to Ditz)

like a theatrical performance in which a saintly persona masked a private reality, or (according to Freeman) a code of honor that regulated elite public behavior.[42] To be caught acting in a way that did not fit his reputation for saintly kindness was a disaster, as a merchant could be "immediately and unavoidably blasted and undone" by only "a small piece of gossip, a sniff of scandal."[43] The power of the businessman-philanthropist had for years been supported almost exclusively by public trust, but as blind faith in their altruism began to fade (as exemplified by Smith's accusations and the Polly Elliot scandal) in the face of a burgeoning professionalism in the public sphere, widespread skepticism of their merit began to emerge.

Challenging Townsend's rule by reputation was a new system of government promoted by Dr. Smith, a prominent physician and immunologist who would go on to gain fame by bringing European vaccination practices to America.[44] Dr. Smith lived in Fell's Point and had both treated fever victims and welcomed them into his home. He had even served as temporary physician of the city hospital throughout the 1797 epidemic during the illness of its ordinary physician, Dr. Joseph Way.[45] Smith was less willing than the Mayor and City Council to accept the benevolence of Townsend's administration, believing that medical specialists, and not the city's golden boys, should be in control of the public health.[46] Smith argued for the primacy of expertise over reputation and prominence: in one letter he complained that, much as a constitution could not be written by physicians nor a bank run by mechanics, so proper health laws could not be formulated by politicians.[47] This sentiment challenged the right to rule of the "public spirited citizens" who had inserted themselves into every facet of the city's administration since the Revolution. In retrospect, this challenge speaks to a coming change which would eventually usher in an age of professionalism in place of the "open plutocracy" that had flourished during the post-Revolution period of social and economic reorganization.[48]

For decades, men like Townsend had formed the backbone of urban development in American cities such as Baltimore, citing public trust built on philanthropic virtue as their sole credential. By the turn of the nineteenth century, however, things had begun to change. The city of Baltimore, incorporated in 1797, was developing more permanent forms of governance in place of ad hoc committees, and these new forms demanded more particular expertise than a generally-acknowledged "public spirit" and a reputation for philanthropy. Smith's letters marked the beginnings of

public skepticism of this older system of reputation, and the backlash against Townsend's once-indelible public virtue indicates that the general populace, too, was becoming suspicious of his merit. However, it would take much longer for the system of reputation to fade, and in 1801 it was still powerful enough to save Townsend from the Polly Elliot scandal and preserve his shining legacy even for distant posterity.

RESPONSE TO THE ACCUSATIONS: TOWNSEND'S DEFENSE

In his first letters, Smith had acknowledged the dangers of criticizing a man like Townsend, who had such an impressive reputation and with such powerful supporters, "some of whom are high in office."[49] For these men — fellow elites who also relied on the power of reputation for social influence and municipal authority — Smith's accusations were supremely dangerous; if philanthropic virtue was no longer sufficient for civic appointment, they would lose their only claim to power. Thus it is not surprising that Townsend's elite supporters were eager to defend him against Smith and his fellow detractors. "Unawed" by the high positions of his adversaries, Smith persisted with his criticisms, but throughout the weeks-long battle of words in the *Federal Gazette*, it was the respectability and reputation of Townsend's elite friends that held long-term sway over public opinion.[50]

Swiftly following the publication of the Polly Elliot missive, a series of letters defending Townsend appeared in the *Gazette*, written "by an impressive array of individuals" who used the force of their own reputations to turn the matter of Townsend's conduct into a question of one man's word against another.[51] The first to respond was John Hillen, an influential member of the City Council as well as a former Special Commissioner, Baltimore Equitable director, and one of Townsend's closest personal friends.[52] In his letter, Hillen stressed Smith's relative obscurity, painting him as a neophyte who was "over solicitous" in making his "first appearance in public." His lack of prominence, Hillen implied, indicated that he was not to be trusted, whereas Hillen, a respected city leader, swore to have been a witness to the events described and upheld his friend's good conduct.[53] In the same way, Townsend's next defenders, prominent citizen William Jenkins and the attending physician to the hospital, Collin Mackinzie, added the weight of their words by agreeing with

Hillen's testimony.[54] Next was Jesse Hollingsworth, a merchant and a prominent member of the elite who sat on the City Council as well as on the Board of Directors of the Baltimore Equitable Society. He, too, claimed to have been an eyewitness to Townsend's actions, not in this specific instance, but generally, throughout the duration of the epidemics. He claimed to have visited Townsend's home nearly every day and seen him (contrary to Smith's accusations) "surrounded with the distressed, giving relief to the poor, assistance to the sick, sending provisions to the barracks, giving admittance to the hospital, and providing for between twenty and thirty children." He called attention to all the things that Townsend had accomplished for the city, contrasting it with how little Smith had done in the public sphere. All of Townsend's previous deeds surely outweighed any single misdeed, he argued, even if the words of all these "reputable" men were not enough to refute Smith's claims.[55] This implied equivalence of public involvement with moral rectitude was a cornerstone of the system of reputation; it formed the basis of Townsend's continued appointment and had now become the cornerstone of his defense.[56]

This closing of ranks by the elite philanthropists was not entirely effective in deflecting Smith's detractions, as both he and Townsend emerged from the skirmish with tarnished reputations. Smith admitted in February 1801 that he had lost both friends and patrons as a result of his criticisms, and Townsend, for his part, lost his positions both on the Board permanently, and with Baltimore Equitable for the year following the scandal.[57] Nevertheless, both eventually recovered and went on to achieve continued prominence, showing, in Townsend's case, that the system of reputation, while perhaps waning, would not be so easily uprooted. That Townsend continued to wield great power in Baltimore until his death in 1841 testifies to the enduring power of reputation, which continues to hold sway over public memory even to the present day.[58]

THE "PUBLIC-SPIRITED CITIZENS" IN HISTORICAL SCHOLARSHIP

Until recently, most scholarship on Baltimore elites has conformed to the tale told by the majority of their contemporaries; chronicles and city histories call them "public-spirited citizens" and "fathers of the city" who could almost do no wrong.[59] This traditional view is difficult to avoid, and even recent historians have emphasized the enormity

of these men's contributions to the city's development. Sherry Olson, for example, wrote in 1997 that "All [of] the [city's] innovations...are traceable to a single network of gifted and articulate men whose ideas sprang up like mushrooms all over town."[60] However, scholarship over the past few decades has slowly begun to turn the tide of this laudatory epithet and seek a deeper understanding of both the unique positions these men occupied and the complicated motivations behind their philanthropic and municipal generosity. Historians Charles G. Steffen and Thomas M. Doerflinger, for example, have stressed the fluidity of early Baltimore's social hierarchy, and described the philanthropic merchant elite as an amalgamation of enterprising newcomers rather than an established monolithic elite class.[61] Works by historians Jerome Garitee, Toby Ditz, and Sheryllynne Haggerty contributed to this endeavor by outlining the importance of reputation in addition to and in collusion with profit in the lives of merchants and businessmen from this period.[62] Finally, Seth Rockman made the connection between charity and profit explicit, paving the way for more questions to be asked with regard to the utility and necessity of philanthropic work in the lives of the Baltimore elite. Rockman proposed that the ideal of charitable service was seen not only as a Christian duty, but also as a way of insuring oneself against the potential wrath of the angry poor: "The intertwining of civic leadership, philanthropy, and elite self-interest," he argued, "becomes evident in the prominence of those men leading poor relief efforts," who were the same men involved in the religious, political, and mercantile life of the city.[63] Increasingly, historians have recognized that the "public spirited citizens" who dominated early American urban culture relied on a system of reputation to maintain their power by promoting an impossibly virtuous public image. Townsend's life offers a powerful example of this system at work, while Smith's criticisms and the events of the Polly Elliot scandal indicate that it was beginning to fade at the turn of the century to give way to professionalism as we know it today.

CONCLUSION

The system of deference and reputation that held men like Joseph Townsend, and his fellow elite philanthropists, at the top of American urban culture during the second half of the eighteenth century seems feeble, as it relied completely on the successful promotion of a charitable and virtuous public persona. Against this long-standing system, inaugurated in the disorganization following the Revolution,

stood men like Dr. James Smith, who challenged the right of the merchant elite to rule based on reputation alone, and insisted that expertise should be the prerequisite to public power. This assertion, though reasonable to the modern mind, ultimately failed in the case of Joseph Townsend due to the reputational power of his elite friends. The system of government by a prestigious elite — for whom endeavors such as the Board of Health were more philanthropic than professional — proved durable and resilient enough to last through the dawn of the new century. At his death in 1841, Townsend's son Richard asserted that "no one who ever died in Baltimore, was perhaps more universally known, in the city" than his father — a statement supported by the lavish obituaries published even as far away as New Orleans, which proclaimed his "public spirit and practical benevolence."[64] The continuation of these laudatory epithets even into present-day scholarship shows that the system of reputation has not been completely dissolved in public memory. The example of Joseph Townsend reminds us that, even in a world which has accepted Smith's arguments about governance and professionalism, the lasting power of the system of reputation continues to influence our perspective on the past and opinion of the "public-spirited citizens" who dominated the city's early history.

ENDNOTES

1. *The Federal Gazette*, November 12, 1800, as cited in Douglas F. Stickle, "Death and Class in Baltimore: The Yellow Fever Epidemic of 1800," *Maryland Historical Magazine 74*, Issue 3 (Fall 1979): 288.

2. James Smith, "The Additional Number to the Letters of Humanitas" (Baltimore, 1801), 5-6, 38; *The Federal Gazette*, November 23 and December 5, 1800, as cited in Stickle, "Death and Class in Baltimore," 289-290. Townsend, he specified, received one hundred dollars per year from the city. It is true that payment for their service was on the minds of the members of the Board of Health; in 1799 the entire Board resigned and requested that new members be elected. They suggested, tellingly, that "all future boards [be] allowed such Salary as might in some measure compensate them for the time & danger to which they are subjected" ("Correspondence. Health Board's report," City Council Collection (BRG16), Series 1 (Administrative Files), Box 1, item 217, Baltimore City Archives, Baltimore, Md.). However, it seems that this attempt to demand a salary went unanswered, as, when a new Board was created in 1801, their salaries were spoken of as a new development. Townsend had been paid a salary for his position as a Special Commissioner (Thaddeus P. Thomas, *The City Government of Baltimore*, Johns Hopkins University Studies in Historical and Political Science 14, no. 2 (Baltimore: The Johns Hopkins Press, 1896, Reprint New York: Johnson Reprint Corporation, 1973), 13-14), yet he had not been paid for his work with the Fell's Point Camp (David Meredith Reese, *Observations on the Epidemic of 1819* (Baltimore: Reese, 1819), 51). Overall, it is not the question of whether or not Townsend was actually paid for being on the Board that is important, but an appreciation of the fact that being paid would have damaged his reputation for selfless altruism.

3. "Letter from James Smith to Jesse Hollingsworth February 19, 1801" in Smith, "The Additional Number," 36-37; Stickle, "Death and Class in Baltimore," 290.

4. Stickle, "Death and Class in Baltimore," 293. His replacement in this executive position was George Keeports, a total newcomer who had become a Director only the year before. Although he would regain it the following year, the loss of the position (which he had held since the creation of the company) was keenly felt; he remembered the period bitterly decades afterward as the year in which the company had been "wrested from his control" (Amherst B. Hall, "First Draft of BES History," Baltimore Equitable Society Collection (MS 3020), Box 165, Maryland Historical Society, Baltimore, Md., 67-68).

5. Charles G. Steffen, *From Gentlemen to Townsmen: The Gentry of Baltimore County, 1660-1776* (Lexington, KY: University Press of Kentucky, 1993), 6-7, 163.

6. William Darlington, "Biography of Joseph Townsend (1756-1841)," *Chester County Notes: Of Men and Events*, no. 33; Dielman-Hayward Collection, Maryland Historical Society, Baltimore, Md.; Bruce E. Mowday, *September 11, 1777: Washington's Defeat at Brandywine Dooms Philadelphia* (Shippensburg, PA: White Mane Books, 2002), 53, 164; Hall, "First Draft of BES History," 21-22, Baltimore Equitable Society Collection (MS 3020), Box 165, Maryland Historical Society, Baltimore, Md.; Henry C. Townsend, "Notice of the Life of Joseph Townsend," in Joseph Townsend, *The Battle of Brandywine*, Eyewitness Accounts of the American Revolution (New York: New York Times, 1969), 15. Townsend came to Baltimore for the first time in the fall of 1783, leaving his family's farm in Chester County,

Pennsylvania which had been devastated by the Battle of Brandywine fought on September 11, 1777 between the American army of Major General George Washington and the British army of General Sir William Howe.

7. Edward C. Papenfuse, *In Pursuit of Profit: The Annapolis Merchants in the Era of the American Revolution, 1763-1805* (Baltimore: The Johns Hopkins University Press, 1975), 143; Thomas M. Doerflinger, *A Vigorous Spirit of Enterprise: Merchants and Economic Development in Revolutionary Philadelphia* (Chapel Hill: University of North Carolina Press, 1986), 44; Stuart Weems Bruchey, *Robert Oliver, Merchant of Baltimore, 1783-1819*, The Johns Hopkins University Studies in Historical and Political Science, Series 74, no. 1 (Baltimore: Johns Hopkins Press, 1956), 32; Mariana L.R. Dantas, *Black Townsmen: Urban Slavery and Freedom in the Eighteenth-Century Americas* (New York: Palgrave Macmillan, 2008), 45.

8. Dantas, *Black Townsmen*, 27-28.

9. Bruchey, *Robert Oliver*, 31; Dantas, *Black Townsmen*, 21-22.

10. The city's population doubled from 6,000 to over 13,000 from the 1770s to 1790, and doubled again during the 1790s to reach over 26,500 by 1800. Between 1790 and 1795, Baltimore handled two thirds of the state's exports. (Doerflinger, *Vigorous Spirit of Enterprise*, 364; Dantas, *Black Townsmen*, 29; Sidney Redner, "Distribution of City Populations, Baltimore," Boston University Physics; Richard J. Cox, ed., *A Name Index to the Baltimore City Tax Records*, 1798-1808 (Baltimore: Baltimore City Archives and Records Management Office, Department of Legislative Reference, 1981), i; Jacob Harry Hollander, *The Financial History of Baltimore* (Baltimore: The Johns Hopkins Press, 1899), 17; Thomas W. Griffith, *Annals of Baltimore* (Baltimore: William Wooddy, 1824), 148-149, as cited in Bruchey, *Robert Oliver*, 101-102; Jerome Randolph Garitee, *Private Enterprise and Public Spirit: Baltimore Privateering in the War of 1812* (PhD diss., American University, 1973), 35; Papenfuse, *In Pursuit of Profit*, 158.

11. Joanne B. Freeman, *Affairs of Honor: National Politics in the New Republic* (New Haven: Yale University Press, 2001), xiv-xv, xxi-xxii.

12. Dennis Rankin Clark, *Baltimore, 1729-1829: The Genesis of a Community* (PhD diss., Catholic University of America, 1976), 375, 383, 387.

13. Clark, *Baltimore, 1729-1829*, 370.

14. Many of the city's new power structures sprung up in response to the threat of fire - one of the most prevalent and ubiquitous in the new urban centers (Dalit Baranoff, "Shaped by Risk: The American Fire Insurance Industry, 1790-1920," Dissertation Abstracts International, 2004). The city's enlargement in 1747 came with a warning from the Maryland Assembly about fire safety, and catastrophes like the Great Conflagration of December 4, 1796 proved disastrous to the burgeoning city's economic and social growth (Scharf, J. Thomas, *History of Baltimore City and County, Part 1* (Baltimore: Regional Publishing Company, 1971): 237; *Federal Gazette* article, December 5, 1796, as found in *Historical Information of the Baltimore Equitable Society*, Baltimore Equitable Society Collection (MS 3020), Box 207, Maryland Historical Society, Baltimore, Md.; "History of Baltimore Fire Department is Linked With the Two Hundred Years of City's Life," *Municipal Journal*, September 20, 1929). In response to such dangers, parochial fire companies like the Mechanical Fire Company and many others organized citizens in some of the first examples of community engagement, while insurance companies such as Townsend's own Baltimore Equitable Society provided institutional support. According to Amherst B. Hall, historian of the Baltimore Equitable Society, " The early town and city's

war with the ever-present menace of fire goes hand in hand with the development of insurance," and the records of the first fire and insurance companies "reads like a roll of honor of Baltimore's worthiest sons" (Hall, "First Draft of BES History," 3).

15. Thomas, *The City Government of Baltimore*, 12.; Clark, Baltimore, 1729-1829, 170-171.

16. Clark, *Baltimore, 1729-1829*, 169-171; Hollander, *The Financial History of Baltimore*, 17, 21; Thomas, *The City Government of Baltimore*, 12.

17. *Historical Information of the Baltimore Equitable Society, Vol. 4, Treasurers and Ass't Treasurers*, Baltimore Equitable Society Collection (MS3020) Box 207, Maryland Historical Society, Baltimore, Md. The Board was, in fact, dissolved in 1796, just before the city's incorporation.

18. Sheryllynne Haggerty, *'Merely for Money'? Business Culture in the British Atlantic, 1750 - 1815* (Liverpool: Liverpool University Press, 2012), 99; Steffen, *From Gentlemen to Townsmen*, 4; *The Baltimore Underwriter* 45, no. 10 (May 20, 1891), 253; Whitehome, *The Battle for Baltimore 1814*, 164; Reese, *Observations on the epidemic of 1819*, 53; Doerflinger, *Vigorous Spirit of Enterprise*, 351-352; Steffen, *From Gentlemen to Townsmen*, 39-42

19. John Harvey Powell, *Bring Out Your Dead: The Great Plague of Yellow Fever in Philadelphia in 1793* (Philadelphia: University of Pennsylvania Press, 1949), 20, 63; Clark, *Baltimore, 1729-1829*, 370-373. As Adam Smith explained in his book *The Theory of Moral Sentiments*, a man who enjoyed prestige and power in a society but did not respond with any kind of concrete service was owed no loyalty or alliance from the members of the community (Adam Smith, *The Theory of Moral Sentiments*, 125, as cited in Haggerty, *'Merely for Money'?*, 151,160). Likewise, nineteenth-century city chronicler Thomas W. Griffith noted that "the title to superior wealth, when most legally acquired, might be shaken, if a state of suffering was permitted to arise" (Douglas G. Carroll, Jr. and Blanche D. Coll, "The Baltimore Almshouse: An Early History," *Maryland Historical Magazine* 66, no. 2 (Summer 1971): 149). It was understood among those who had wealth and power that it was necessary for them to engage in charity and philanthropy in order to secure their "title" to social superiority.

20. Seth Rockman, *Scraping By: Wage Labor, Slavery, and Survival in Early Baltimore* (Baltimore: Johns Hopkins University Press, 2009), 218.

21. *Baltimore Daily Repository*, December 20, 1792.

22. "The Potters Fields, Baltimore," *Maryland Historical Magazine* 12, no. 2 (1917): 187-191. John Brown was a Quaker, a member of the Acting Committee of the Maryland Society, and an incorporator of the Baltimore Equitable Society. John Hillen was a Special Commissioner and a Baltimore Equitable Director. John Mickle was a Baltimore Equitable Director. George Presstman had been called into the service of the Commissioners several times during Townsend's time with the Board, and was a member of the Electing Committee of the Maryland Society. William Trimble was a Quaker, on the Acting Committee of the Maryland Society, a Baltimore Equitable Director, and assisted the Commissioners several times. Elisha Tyson was a fellow Quaker, a Subscriber to the Baltimore Equitable Society, and on the Acting Committee of the Maryland Society. William Wilson was on the Electing Committee of the Maryland Society and a Baltimore Equitable Director ("Constitution of the Maryland Society for Promoting the Abolition of Slavery," (Baltimore, William Goddard and James Angell, 1789); Wilbur F. Coyle, ed., *Records of the City*

of Baltimore (Special Commissioners) 1782-1797 (Baltimore: Meyer & Thalheimer, 1909), 150, 154, 173-175, 209, 219-220, 230, 241; Griffith, *Annals of Baltimore*, 88; Wilbur F. Coyle, ed., *First Records of Baltimore Town and Jones Town 1729-1797* (Baltimore: City Library, 1905), 53; Barbara C. Mallonee, Jane Karkalits Bonny, and Nicholas B. Fessenden, *Minute by Minute: A History of the Baltimore Monthly Meeting of Friends, Homewood and Stony Run* (Baltimore Monthly Meeting of Friends, Stony Run and Homewood, 1992), 15, 31-33, 35-38, 42-45; Allison Ellicott Mylander, *The Ellicotts: Striving for a Holy Community* (Ellicott City, MD: Historic Ellicott City, Inc., 1991), 13; Francis F. Beirne, *The Amiable Baltimoreans* (Baltimore, MD: Johns Hopkins University Press, 1984), 269; John S. Tyson, *The Life of Elisha Tyson, the Philanthropist* (Baltimore: B. Lundy, 1825), 19; Richard H. Townsend, *Diary of Richard H. Townsend* (Oyster Bay, NY: Townsend Society of America, 2004), 25).

23. Clark, *Baltimore, 1729-1829*, 372.

24. Toby I. Ditz, "Shipwrecked: or, Masculinity Imperiled: Mercantile Representations of Failure and the Gendered Self in Eighteenth-Century Philadelphia," *The Journal of American History* 81, no. 1 (June 1994): 57; Haggerty, *'Merely for Money'?*, 107; Sherry Olson, *Baltimore: The Building of an American City*, Revised and Expanded Bicentennial Edition (Baltimore: The Johns Hopkins University Press, 1997), 44; Clark, *Baltimore, 1729-1829*, 372.

25. Haggerty, *'Merely for Money'?*, 99.

26. Union Manufacturing Company of Maryland, "Report of the Committee and Constitution of the Union Manufacturing Company of Maryland" (Baltimore: Niles & Frailey, 1808): 13.

27. Freeman, *Affairs of Honor*, xix.

28. Carroll, "The Baltimore Almshouse," 138-141.

29. Peter Lester Payne and Lance Edwin Davis, "The Savings Bank of Baltimore, 1818-1866: A Historical and Analytical Study," The Johns Hopkins University Studies in Historical and Political Science 72, no. 2 (Baltimore: Johns Hopkins Press, 1954), 24-32; Smith, "The Additional Number," Appendix 15-17.

30. Payne, "The Savings Bank of Baltimore," 15; C. Herbert Baxley, ed., *A History of the Baltimore General Dispensary, Founded 1801* (Baltimore: Baltimore General Dispensary Foundation, Inc., 1963), xvii.

31. Townsend began his entry into Baltimore society through the local meetinghouse of the Society of Friends. He began as a schoolteacher for the Baltimore Preparative Meeting, and through this position became involved in meeting's continuing efforts to grow Quaker education in the city, sitting on survey boards, contracting other teachers, and overseeing the creation of new schools (William C. Dunlap, *Quaker Education in Baltimore and Virginia Yearly Meetings with an Account of Certain Meetings of Delaware and the Eastern Shore Affiliated with Philadelphia* (Lancaster, PA: The Science Press Printing Co., 1936), 28-32, 36-41; "City Council. Applications and Petitions. Health Commissioner. Janney, Levis," Baltimore City Archives, City Council Collection (BRG16), Series 1 (Administrative Files), Box 7, item 295). Later, Townsend became the Clerk of the Gunpowder Monthly Meeting, and helped found a Lending Library for the Baltimore Monthly Meeting (Gunpowder Society of Friends, *Record Book*, 1656-1818, MS 377, Maryland Historical Society, Baltimore, Md.: 52; Mallonee, *Minute by Minute*, 35-36). While his faith gave him an opportunity to gain respect and make connections in the city, being a Quaker also complicated his participation in the financial world of the Baltimore elite.

The Quakers of Townsend's time had a complex relationship with worldly endeavors; while their leaders stressed the importance of industriousness, they were also repeatedly warned not to let worldly concerns corrupt them (Frederick B. Tolles, *Meeting House and Counting House: The Quaker Merchants of Colonial Philadelphia, 1682-1763* (Chapel Hill: University of North Carolina Press, 1948), 3, 53-55, 82, 241). That Townsend himself was personally concerned with this dilemma is shown by the contents of his "commonplace book" (a kind of scrapbook containing literary passages, quotations, and prayers), which included several sermons condemning the hypocrisy of Friends who claimed to be devoted to the faith while being consumed by worldly concerns (For an explanation of "commonplace book," see Swarthmore College's Friends Historical Library: http://www.swarthmore.edu/Library/friends/Albums.htm; see also Commonplace Books: Collections of Precious Gems," *Quaker Strongrooms: A blog from the Library of the Society of Friends*, April 29, 2013 (http://librarysocietyfriendsblog.wordpress.com/2013/04/29/commonplace-books-collections-of-precious-gems/)).

On September 8, 1789, Townsend helped found "The Maryland Society for Promoting the Abolition of Slavery." The first abolition society in the state, the fourth in the country, and the sixth in the world, the society, the society worked both to promote more restrictive legislation and to assist individual slaves in petitioning for their freedom (Beirne, *The Amiable Baltimoreans*, 269; Jeffry R. Brackett, *The Negro in Maryland: A Study of the Institution of Slavery* (Freeport, NY: Books for Libraries Press, 1969), 52-53). It also promoted the sale of Benjamin Banneker's almanacs, and participated in the American Convention of Abolition Societies, which met annually in Philadelphia beginning in 1794 (*Mail*, October 7, 1791; Litwack, *North of Slavery*, 18; Richard S. Newman, *The Transformation of American Abolitionism: Fighting Slavery in the Early Republic* (Chapel Hill: The University of North Carolina Press, 2002), 19). According to Richard, Townsend's son, his father's abolition society was responsible for securing the freedom of "several hundred" African Americans during its short existence of only a few years (Brackett, *The Negro in Maryland*, 184; Townsend, *Diary*, 25).

The Baltimore Equitable Society was perhaps the most important endeavor of Townsend's life. A fire insurance company which is still in existence today, it was founded at a meeting held in Townsend's home on January 21, 1794, and its Directors would come to encompass much of his web of contacts. Townsend was elected as the Treasurer of the company every year from its inception in 1794 until his death in 1841, with the sole exception of 1802, when he lost the position to George Keeports (Hall, "First Draft of BES History," 67-68).

32. Clark, *Baltimore, 1729-1829*, 181-182.

33. Richard S. Chew, "Certain Victims of an International Contagion: The Panic of 1797 and the Hard Times of the Late 1790s in Baltimore," *Journal of the Early Republic* 25, no. 4 (Winter 2005): 598-599; Stickle, "Death and Class in Baltimore," 284, 297.

34. *A Series of Letters and Other Documents Relating to the Late Epidemic or Yellow Fever* (Baltimore: William Warner, 1820), 115; Chew, "Certain Victims of an International Contagion," 598; "Baltimore Population 2014," *World Population Review*.

35. Stickle, "Death and Class in Baltimore," 282-283; Chew, "Certain Victims of an International Contagion," 599.

36. For Townsend's elections, see Clark, *Baltimore, 1729-1829*, 184-185. For the Potter's

Field, see Health Department Collection (BRG19), Series 1 (HRS Records), Box 1, Baltimore City Archives, Baltimore, Md., and "The Potters Fields, Baltimore," *Maryland Historical Magazine* 12, no. 2 (1917): 187-191. For quarantine measures, see Clark, *Baltimore, 1729-1829*, 181-184, 329-331; *Philadelphia Gazette*, August 24, 1797; J. B. Blake, "Yellow Fever in Eighteenth Century American Cities," *Bulletin of the New York Academy of Medicine* 44, no. 6 (June 1968): 677-679; Health Ordinance of April 7, 1800; *Federal Gazette*, July 22, 1800. The quarantine was enforced with greater or lesser stringency until approximately the turn of the century, by which time contention over the communicability of the fever had thrown the usefulness of quarantine into question. The opposing theory, which held that the disease was non-communicable (that is, not able to be passed from person to person), blamed the city's general lack of cleanliness for the onset of the fever (Clark, *Baltimore, 1729-1829*, 181-184, 329-331; *Philadelphia Gazette*, August 24, 1797; Blake, "Yellow Fever in Eighteenth Century American Cities," 677-679; Health Ordinance of April 7, 1800; *Federal Gazette*, July 22, 1800; *Federal Intelligencer*, May 4, 1795; *Federal Gazette*, September 15, 1797; Reese, *Observations on the Epidemic of 1819*, 83-85). Unsure of the true nature of the fever, the city compromised by instituting measures "based on the possibility that either view might be correct" (Blake, "Yellow Fever," 678). For the quarantine hospital, ship inspections, and information collection, see Ordinances and Resolutions of the Mayor and City Council, No. 11, April 3, 1797, as cited in Clark, *Baltimore, 1729-1829*, 326-327. Townsend also made use of the African Academy, a school for African American children which he had helped found a few years earlier, to house children orphaned by the fever (*Federal Gazette*, November 8, 1800).

37. The camp, just north of a quarantine hospital at Hawkin's Point, was composed of makeshift shelters constructed using two donated rope-walks, over one hundred tents, and sixty plank buildings, and was supported by the donations (of both cash and provisions) of local citizens and other towns. Townsend's own son, Granville (named after Granville Sharp, the famous English abolitionist), acted as physician for the camp. The camp was opened on September 3, and existed until October 25, housing and caring for between one and three thousand people for a total of fifty-three days, during which time eleven inhabitants died of the fever – an impressive figure, considering that the fever elsewhere claimed up to fifty percent of those who contracted the disease (Clark, *Baltimore, 1729-1829*, 329, Smith, "The Additional Number to the Letters of Humanitas," Appendix 1-2; Stickle, "Death and Class in Baltimore," 284, 286-288, 297; Reese, *Observations on the Epidemic of 1819*, 52-53, 52-60, 178-179; *A Series of Letters and Other Documents*, 178-179; *Federal Gazette*, September 10, 1800; *Philadelphia Gazette*, September 12, 1800; Townsend, *Diary*, 98).

38. *Federal Gazette*, November 12, 1800, as cited in Stickle, "Death and Class in Baltimore," 288.

39. Smith, "The Additional Number," 3-5; Stickle, "Death and Class in Baltimore," 291.

40. *Federal Gazette*, September 6, 1800; Stickle, "Death and Class in Baltimore," 286; Matthew Carey, *A Short Account of the Malignant Fever, Lately Prevalent in Philadelphia*, edited by Richard C. Wade (New York: Arno Press, 1970), 34.

41. Smith, "The Additional Number," 3-5, 7; Stickle, "Death and Class in Baltimore," 291-292.

42. Ditz, "Shipwrecked," 54-55; Freeman, *Affairs of Honor*, xxii.

43. Haggerty, *'Merely for Money'?*, 81.

44. Eventually called the "Father of Vaccination in Maryland" by the *Medical Annals of Maryland*, Smith founded the country's second Vaccine Institute in 1802 to promote vaccination among the poor, and in 1810 a Vaccine Society to accompany it. He would be a "Vaccine Agent" for the state from 1809 until 1813, at which time the Federal Government created a "National Vaccine Institution" under his direction, which he headed until 1822, when he became the editor of the new journal the Vaccine Inquirer. In addition to these efforts to promote the groundbreaking vaccination techniques, Smith also served as attending physician of both the Baltimore Almshouse and General Dispensary and Treasurer of the Medical and Chirurgical Faculty, as well as founding "the Beneficial Society for the prevention of hydrophobia" (Eugene Fauntleroy Cordell, M.D., *The Medical Annals of Maryland, 1799-1899* (Baltimore: Press of Williams & Wilkins Company, 1903), 48-50, 571, 673-674, 680).

45. "Report of the Joint Committee, November 8, 1797," in "Letter from James Smith to Jesse Hollingsworth February 19, 1801" in Smith, "The Additional Number," 30.

46. Smith," The Additional Number," 30; Cordell, *The Medical Annals of Maryland*, 669, 672

47. Smith, "The Additional Number," 36-37.

48. Joseph W.A. Whitehome, *The Battle for Baltimore 1814* (Baltimore: Nautical & Aviation Publishing Company of America, 1997), 164.

49. "Letter from James Smith to Jesse Hollingsworth February 19, 1801" in Smith, "The Additional Number," 35.

50. Smith, "The Additional Number," 8.

51. Smith, "The Additional Number," 293.

52. Townsend's son Richard claimed that his father's and Hillen's friendship was "proverbial" in the city (Townsend, Diary, 116).

53. *Federal Gazette*, January 23, 1801; Smith, "The Additional Number," 9-11.

54. *Federal Gazette*, January 24 and 26, 1801; Smith, "The Additional Number," 12-14.

55. Smith, "The Additional Number," 14.

56. A similar instance of this implicit assumption can be found in the "Sketch of 'Old Town' Meeting House" created by the Baltimore Monthly Meeting of Friends in 1881, in which the author claims that it was the elite Quakers' "prominence in the management of all benevolent and commercial bodies" of the city that gave proof of their "public spirit, prudence, and sound judgment" (Society of Friends, Baltimore Monthly Meeting, "A Sketch of 'Old Town' Meeting House, Baltimore; and Some of its Occupants, as Read in its One Hundredth Anniversary" (Baltimore: John W. Woods, 1881), 11).

57. Smith, "The Additional Number," 34-35. He regained his position as Treasurer of Baltimore Equitable the following year, and held it until his death in 1841.

58. Townsend continued his involvement in fire prevention, joining the Mechanical Fire Company (Scharf, *History of Baltimore City and County*, 244) as well as continuing his work with the Baltimore Equitable Society. He remained involved in public health efforts as a member of the "Executive Committee" of the Maryland Hospital (Baltimore City Archives, City Council Collection (BRG16), Series 1 (Administrative Files), Box 64, item 314), and supported various Turnpike Road Companies, including the York and Maryland Line Turnpike Road, Baltimore and Rock Run Turnpike Road Company (*The American Commercial and Daily Advertiser*, February 10

and 25, 1819), the York and Conewago Turnpike Road Company (*The Federal Gazette*, March 5, 1810), and the Baltimore and Yorktown Turnpike Road Company (*Federal Republican*, October 17, 1809, October 17, 1810, *American Commercial and Daily Advertiser*, October 23, 1811, October 20, 1814, October 20, 1818, *Baltimore Patriot*, October 17, 1815, October 24, 1821, *Baltimore Gazette and Daily Advertiser*, October 16, 1826, October 20, 1828, October 19, 1830, October 18, 1831, October 22, 1833, October 21, 1834, October 22, 1835, October 18, 1836, October 18, 1837). He became a Visitor and Governor of the City's Jail (Baltimore City Archives, City Council Collection (BRG16), Series 1 (Administrative Files), Box 35, item 436; Box 38, item 700; Box 39, item 449; Box 41, item 633), a member of the city's Committee of Relief during the War of 1812 (William D. Hoyt, Jr., ed., "Civilian Defense in Baltimore, 1814-1815: Minutes of the Committee of Vigilance and Safety," *Maryland Historical Magazine* 39, no. 3 (September 1944): 212), and was appointed again to the Board of City Commissioners in 1817 (*Board of Commissioners Minute Book*, 1816-1819, Baltimore Equitable Society Collection (MS3020), Box 192, Maryland Historical Society, Baltimore, Md). He received the Marquis de Lafayette during the latter's trip to America in 1824, and maintained a correspondence with him afterward (eventually sending him a turkey for his French estate) (Townsend, Diary, 115; *Baltimore Patriot*, April 18, 1826; *Eastport Sentinel*, April 29, 1826; see also http://www.mdhs.org/reminiscences-baltimore-1824).

59. *The Baltimore Underwriter* 45, no. 10 (May 20, 1891), 253; Whitehome, *The Battle for Baltimore 1814*, 164; Reese, *Observations on the epidemic of 1819*, 53. See also J. Thomas Scharf's *Chronicles of Baltimore* (Baltimore: Turnbull Brothers, 1874) and *History of Baltimore City and County*, and Thomas W. Griffith's *Annals of Baltimore* for more such perspectives on their contributions.

60. Olson, *Baltimore*, 44.

61. See Doerflinger, *A Vigorous Spirit of Enterprise*, and Steffen, *From Gentlemen to Townsmen*.

62. See Garitee, *Private Enterprise and Public Spirit*, Ditz, "Shipwrecked," and Haggerty, *'Merely for Money'?*.

63. Rockman, *Scraping By*, 218.

64. Townsend, *Diary*, 262. For sample obituaries see William Darlington, "Biography of Joseph Townsend (1756-1841)"; *North American*, October 2, 1841; *Daily National Intelligencer*, October 4, 1841; *Commercial Advertiser*, October 2, 1841; *Newark Daily Advertiser*, October 4, 1841; *Sentinel of Freedom*, October 5, 1841; *Richmond Whig*, October 5, 1841; and *Times-Picayune*, October 21, 1841.

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AUTHOR BIO

Hannah Jones is a history major with a double minor in English and medieval and early modern studies. A President's Fellow and an Undergraduate Research Award Scholar, she will be graduating in May 2015 and hopes to continue her studies by pursuing a Ph.D. in history. Her project was funded by an Undergraduate Research Award from the UMBC Office of Undergraduate Education, and was made possible by the invaluable support of Dr. Marjoleine Kars, her faculty advisor. Hannah would also like to acknowledge the contributions of the Baltimore Equitable Insurance Company, which introduced her to Joseph Townsend and gave her the opportunity to first study his life and the lives of his fellow elite philanthropists.

REANALYSIS OF MODERN COLLOQUIAL FRENCH SUBJECT CLITICS AS AGREEMENT FEATURES

RYAN **KOTOWSKI**

I decided to undertake this paper for the completion of the Honors Program in Modern Languages, Linguistics, & Intercultural Communication. My original vision for the paper was to do a purely syntactic analysis of the subject clitic in Modern Colloquial French dialects, analyzing their occurrence in children's speech. This approach proved to be unfeasible and I thence turned to historical linguistics for the framework to analyze French subject clitics, while not disregarding generative syntax altogether. Using historical linguistics to analyze the development of French subject clitics, a grammatical occurrence usually analyzed within the framework of generative syntax, revealed intriguing properties about the nature of language change and its implications for linguistic theory. In analyzing a language-specific occurrence, I was able to make claims regarding the nature of language itself. Writing this paper made me realize how valuable it is to use the framework of multiple theories and how seemingly unrelated fields can be intertwined and applicable to a single analysis. Using this research approach, I was able to analyze the issue of subject clitics on level more complex than I would have using one theoretical framework.

INTRODUCTION

The verbal morphology of Modern Colloquial French (hereinafter MCFr) has developed a divergent verbal system that has presented many ambiguities in determining the setting of its **pro-drop parameter**. The transitory nature of the subject **clitic** in MCFr suggests that the language is at a pivotal state of transition towards a new grammar. The field of syntax is divided on whether or not MCFr subject clitics are true **argument-bearing subjects** or if they are agreement features akin to conjugation. Historical analyses of this issue suggest that MCFr subject clitics are, in fact, best analyzed as agreement features. Such historical analyses provide insightful observations about the nature of language that often challenge the claims made in the syntactic literature.

The present investigation will go forth in this *esprit révolutionnaire* and will analyze French subject clitics as reanalyzed agreement prefixes. This investigation does not partake of any syntactic analysis, but examines the conclusions of both syntactic and historical linguistic research as a means to discover more about the nature of this linguistic peculiarity. First, the subject clitic debate in syntax is analyzed. Then, the historical development of the French subject clitic is analyzed. Then, the subject clitic paradigms of Swiss French (hereinafter SwFr) and Québecois French (hereinafter QbFr) is analyzed in regard to the mechanism of reanalysis. Finally, the implications that linguistic change has for linguistic theory and for the nature of language in general are discussed. Bolded terms will be defined in a glossary at the end of the paper.

OVERVIEW OF SYNTACTIC ANALYSES

CLITICS

Clitics are words that are in a transitional stage and that are, as Seuren (2009: 85) states, "in a process that leads from full word status to the status of morphological affix." Similarly, Zwicky (1977) states that a word seen as a clitic at one stage will be reinterpreted as a derivational or inflectional affix at the next. From a syntactic point of view, such an occurrence causes difficulty in the analysis of clitics since independent words and affixes behave differently

in the syntax. Transformations involving independent words only involve upwards movement, whereas morphology in the syntax involves downwards movement as in the case with affix hopping. Here, the issue of synchronic and diachronic analysis becomes evident. If one analyzes a language synchronically, then clitics pose a major problem because of their transitory nature. Accepting the above claims of Seuren and Zwicky, one must analyze the appearance of clitics in a language diachronically.

OVERVIEW OF THE SUBJECT CLITIC DEBATE IN SYNTAX

MCFr has been considered a non pro-drop language due to its lack of rich verbal morphology. The standard conjugation system of MCFr distinguishes only the first and second person plural conjugations, leaving the first and second person singular and the third person singular and plural conjugations homophonous for regular verbal paradigms. This analysis allows the claim that MCFr is non pro-drop; however, the occurrence of subject clitics complicates using this argument. We will see after a full analysis of MCFr subject clitics, that the rich verbal morphology argument (as presented in Rizzi, 1986) will be used to further the claim of this present investigation.

The field of syntax has provided rather exhaustive analyses of MCFr subject and object clitics and their representation in the syntax. The main question that these analyses address is whether or not MCFr subject clitics are full **DPs** in the syntax. Kayne (1975 and 1991) and Rizzi (1986) argue that French subject clitics are argument-bearing and occupy the canonical subject position in the syntax. They furthermore argue that cliticisation occurs only at the level of the phonology. Chomsky (1981:275) affirms these claims by stating that cliticization is independent of the pro-drop parameter altogether. Culbertson (2010), however, argues that MCFr subject clitics are agreement features and that from a syntactic point of view this argument can be supported.

ANALYSIS OF NE

Standard French (hereinafter StanFr) grammar requires that negation be formed using both a pre-verbal and a post-verbal adverb. Culbertson refers to this sort of negation as discontinuous. In regard to **finite verbs**, the *ne* in the StanFr discontinuous construction

always follows the subject clitic or DP subject. The second negative adverb, usually *pas*, follows the verb. Using this model, one can claim that because *ne* intervenes between the subject clitic and its host verb, the subject clitic must occupy some higher position in the syntax: the specifier of **IP**, a claim supported by Rizzi. The fault with this analysis is assumes that the particle *ne* is a feature of MCFr.

Ne is a required particle of StanFr grammar when forming negation. In colloquial dialects of French, however, *ne* has limited uses. The most common construction found in colloquial dialects of French does not include *ne*; instead only *pas* appears after the verb. De Cat (2007) argues that *ne* is still obligatory in some instances in MCFr as a marker of negative scope, which is syntactically regulated. The sentence given in (1) is an example of such an instance.

(1) Personne ne mange le gâteau.
Nobody NEG eat-3SG the cake
"Nobody eats cake."

Culbertson analyses the instances of *ne*-retention in child-directed speech in the Lyon dialect of French. These data show that *ne* is used in 83.3% of utterances that include a DP subject. When a subject clitic is present (either with or without a DP subject) the *ne*-retention rate is 7%. Culbertson argues that these data support the claim that *ne* is sensitive to the presence of a subject clitic. Culbertson argues that if subject clitics are agreement markers, then one can claim that *ne* may freely intervene between a DP subject and the verb, but not between a subject clitic and the verb.

SUBJECT-VERB INVERSION

Using evidence from yes/no and **wh-questions** in StanFr, De Cat claims that inversion of the subject clitic and verb is possible. An example of such a construction is given in (2).

(2) Mange-t-il le gâteau?
Eat-3SG he the cake
"Does he eat cake?"

The traditional syntactic explanation for this occurrence is that the verb moves upward in the syntax with the subject clitic undergoing no syntactic movement. Kayne (1975) argues that inversion with

subject clitics is possible, but syntactically distinct from the inversion occurring with subject DPs. Due to this difference, Kayne concludes that French subject clitics are a sort of nominal affix that are generated with a full subject that becomes deleted. Chomsky (1981:28) similarly claims that French has no surface pronouns due to their clitic nature. Rizzi and Roberts (1989) however maintain that subject clitics are DPs housed in subject position.

Using data from the Lyon dialect, Culbertson (2010) shows that clitic inversion is rare. In regard to yes/no questions, the inversion rate is only 0.1% when only subject clitics appear and only 2.4% when a DP subject is present. In regard to the Québecois dialect, as presented in Auger (1994), subject-clitic inversion appears only with the second person singular. The inversion rate for wh-questions when a subject clitic present is similarly low, and accounts for 0.9% of utterances. However, when a DP subject is present, the inversion rate increases significantly to 88.5%. Despite the smaller increase in the inversion for DP subjects in yes/no questions, the trend mirrors the results regarding the inversion rate for DP subjects in wh-questions. Inversion involving DP subjects seems to be fully available for the speakers of the Lyon dialect and these data mirror the data found in the retention rate of ne. Therefore a sentence such as (3), which involves a wh-question and a DP subject, would be deemed grammatical in Colloquial French, whereas (4) would not.

(3) Que mange Jean?
What eat-3SG Jean
"What does Jean eat?"

(4) *Que mange-t-il?
What eats-3SG he

CONJOINED VPS

The analyses of Kayne and Rizzi state that subject clitics need not be repeated in conjoined **VPs**. This occurrence in the syntax is called gapping and is grammatical in StanFr. An example of such a sentence is given in (5).

(5) Il mange le gâteau et boit le thé.
He eat-3SG the cake and drink-3SG the tea
"He eats cake and drinks tea."

Culbertson states that if this analysis were true, it would pose a serious hindrance to her claim. Turning again to empirical evidence from the Lyon dialect, Culbertson discredits the claims of Kayne and Rizzi. The data show a near 100% repetition rate for conjoined VPs. The percentage for first person and second person repetition is 99.2% and for third person is 96.5%. The data from the Lyon corpus in Culbertson (2010) demonstrate that gapping in conjoined VPs is not available in that dialect and that subject clitics behave similarly to object clitics in that they must be overtly present in each VP as demonstrated in the sentence given in (6).

(6) Il mange le gâteau et il boit le thé.
He eat-3SG the cake and he drink-3SG the tea
"He eats cake and drinks tea."

This also holds true for the Québecois dialect in which the subject clitic must be present in conjoined VPs (Auger 1994). This observation seem to contradict the claims of Hofherr (2004) who states, "Le clitique de 3sg se comporte différemment des clitiques de 1sg et 2sg par rapport à la coordination (The third person clitic behaves differently than the first and second person clitics in regard to coordination)." Hofherr proposes paradigms for the use of clitics in conjoined phrases, in which a language may allow for gapping of certain pronouns in conjoined VPs, but not allow for others.

SUBJECT DOUBLING

The occurrence of a subject DP along with a subject clitic serves as compelling evidence for the claim that French subject clitics are distinct from argument-bearing subjects. Rizzi claims that the appearance of a subject DP and a subject clitic is due to the left-dislocation of the subject DP. In accepting this hypothesis, it must be taken that subject clitics are argument bearing subjects and not agreement features. The sentence given in (7) is an example of a sentence with a doubled subject.

(7) Jean il mange le gâteau.
Jean he eat-3SG the cake
"Jean eats cake."

Using experimental evidence from Colloquial French, Culbertson presents data that dispute the claims of previous literature on doubled subjects in French.

In an experiment conducted to determine the prosodic nature of utterances with doubled subjects, Culbertson found that the prosodic signature is similar to that of non-doubled subjects. If the claim made in Rizzi were indeed true, the prosodic signature would bear a resemblance with left-dislocated objects. The conclusion of a grammaticality judgment test modeled after De Cat is that the occurrence of doubled subject in Colloquial French is sensitive to certain factors. The grammaticality judgment test conducted by Culbertson showed that subject doubling was less acceptable in narrowly focused subjects and when the subject is indefinite. This observation are in line with De Cat and Rizzi, respectively. However, subject doubling was found to be acceptable in broad-focus contexts. Culbertson states that in broad-focus contexts, utterances with a doubled subject should be considered simple IPs and not DPs. If subject clitics were true arguments, competition between them and full subject DPs would prevent their co-occurrence in broad-focus contexts.

In addition to the prosodic signature and grammaticality judgment tests, Culbertson also discusses the occurrence of strong pronouns with subject clitics and gives evidence from first language acquisition to support her claim that MCFr clitics are agreemetn features. In an analysis of data from the Lyon dialect, Fonesca-Greber and Waugh (2002) found that there was only one occurrence of a strong pronoun without a subject clitic in 589 occurrences of a strong pronoun. This suggests, according to Culbertson, that subject doubling is obligatory with strong pronouns. In regard to the acquisition of subject doubling in child speech, Culbertson (2010:119) states that "the vast majority of finite verb tokens occur along with a subject clitic must encourage learners to treat these elements as morphological markers of agreement."

INTERIM SUMMARY

I have thus far examined the nature of clitics and their problematic nature in regard to syntactic analysis. For the rest of this present investigation, I will accept the conclusions made by Culbertson that French subject clitics are agreement features, based on the fact that she analyzes colloquial dialects of French. As an academic and literary language, Standard French does not truly represent utterances produced in the colloquial language that are governed by the rules of mental grammar rather than convention. It must be borne in the mind that the present investigation is one of historical analysis, and therefore a diachronic look at the development of the subject in the history of the French language is necessary, as the syntactic analyses discussed in the above section are synchronic analyses. We will see that the syntactic analyses based on StanFr apply more to Middle French (hereinafter MidFr) than to MCFr.

HISTORICAL DEVELOPMENT FROM OldFr TO MidFr

NULL SUBJECTS AND V2 IN OldFr

Null subjects in Old French (hereinafter OldFr) manifested themselves differently from those found in other Romance languages, occurring predominantly in main clauses, but not in subordinate clauses. This occurrence is rather peculiar from a pragmatic point of view, as it seems unnecessary to overtly represent a subject when its antecedent is covertly represented. The example given in (8) (taken from Adams, 1987: 44-45), demonstrates the occurrence of null subjects in a main clause and its absence in a subordinate clause.

(8) Einsi corurent *pro*$_i$ par mer tant que ils$_i$ vindrent à Cademelée
Thus run-3PL *pro* by sea until they came to Cademelée
"Thus they ran by sea until they came to Cademelée."

One factor that licensed the use of null subjects is the rich verbal inflections, which were distinct for each of the six persons in OldFr. This is the rich verbal morphology principle developed in Rizzi which is used to claim MCFr is non pro-drop. Between the thirteenth and sixteenth centuries, distinct inflections for each person began to break down. Einhorn (1974) states that the first stage of this erosion

of inflection occurred with the loss of the final consonant of the third person singular suffix. This suffix was present in the early twelfth centuryand had disappeared by the end of twelfth century. The continued erosion of verbal inflection eventually led to the leveling of all verbal inflection in MidFr. The loss of pro-drop occured simultaneously with the leveling of verbal inflection. Adams argues that a loss of rich morphological agreement alone does not suffice to cause MidFr to become non pro-drop.

OldFr again differed from the rest of its Romance brethren in the fact that it used Germanic inversion (referred to as V2, "verb-second"), a property in which any constituent of a sentence may raise above the finite verb, thereby placing it into the second position in the sentence. The sentences in (9) and (10) give examples of V2 in German and OldFr, respectively (taken from Adams, 1987:101-102).

(9) Heute habe ich den Mann gesehen.
Today have-1SG I the-ACC man seen
"Today I have seen the man."

(10) Messe e matines at li reis escolét.
Mass and matins have the king heard
"The King heard mass and the matins."

As can be seen in (9), *Heute* 'today' has been permitted to rise above the verb *habe* 'have'. Similarly in (10), *Messe e matines* 'Mass and the matins' have been allowed to rise above the auxiliary verb *at* 'have'. The Romance languages allow for free inversion in both main clauses and subordinate clauses; however, the Germanic sort allows for inversion only in main clauses. If the pronominal subjects in OldFr had cliticized, as in MidFr, then they would not be able to satisfy the V2 requirement because clitics are phonetically bound to their host verb. Because the subject pronoun in OldFr had maintained full independence and was not phonetically bound to the verb, it allowed for other constituents of the sentence to appear before the verb.

DEVELOPMENT TOWARDS MidFr

MidFr is marked in contrast to OldFr by the loss of its verbal morphology, the loss of V2, and the development of a new prosodic system. It is the development of a new prosodic system that was the catalyst for the cliticization of the subject pronoun. The stress system of OldFr differed from that of MidFr and MCFr in that it included end stress and initial stress. By way of phonetic erosion (namely, the loss of the final schwa), the mixed system of stress eventually evolved into the oxytonic system present in MCFr, which is marked by rising pitch and final stress. As a result of this, the possibility of singling out words by stress alone was eliminated. This caused the weakening of the subject pronoun and, as argued by Adams, was one of the first steps towards the cliticization of the subject pronoun. The cliticization of the subject pronoun therefore had an effect on the Germanic inversion of OldFr. Because the subject became phonetically bound to the verb, it could no longer satisfy the requirements of V2 as it could not license the other constituents to rise, causing the clitic to separate from the verb. As a result, MidFr developed a fixed **SVO** order in both main and subordinate clauses.

It must be borne in mind that these changes had not occurred at one moment in time, but rather over many generations. MidFr was a period of indecision where, despite the move towards non pro-drop, the use of pronoun was optional (Vance, 1997). Null subjects during the early stages of MidFr were used in only limited circumstances. These circumstances,as described by Vance, include matrix (main) clauses and in conjunctional and non-conjunctional embedded clauses. By nature of the null subjects appearing in matrix clauses, one can assume that in these cases MidFr licensed V2. Only in the later states of MidFr did the language cease to license V2.

INTERIM SUMMARY

At some point in time the subject had fully cliticized, rich verbal morphology was lost, and V2 was lost. Because the subject clitic was bound to the verb, it lost the ability to license V2, since V2 requires that any constituent must be able to be raised. The loss of verbal morphology thereby caused the subject to be overtly expressed in all instances. The assumption that the subject is still independent in the syntax and is only a clitic in the phonology holds true for MidFr and for a certain developmental period for MCFr as well. Taking the

notion that linguistic change does not occur at a point in time, but rather across a period of time, it must be assumed that MCFr is in a period of transition.

The analysis of Culbertson has served to discredit the claims of the previous syntax-focused literature which state that French subject clitics still maintain their status as argument bearers. This was done by way of empirical evidence that demonstrated that certain grammatical forms were not present in the colloquial dialects of French. Turning to the Swiss and Québecois dialects of French we shall see data that support the notion that the French language is in a state of transition from having argument-bearing subject clitics to having pre-verbal agreement features that license pro-drop. Having oriented ourselves historically by analyzing how the French language has developed diachronically and by showing that French can be analyzed as syntactically capable of having pre-verbal agreement markers, we can now take our next set of data to complete our diachronic and synchronic view of the French language. In doing this we will apply the mechanisms of reanalysis to explain this change in these two dialects of French.

REANALYSIS OF THE FRENCH SUBJECT CLITIC AS AN AGREEMENT MARKER

DATA FROM SWISS FRENCH (SwFr)

Fonesca-Greber (2000) argues that SwFr has created a system of morphological agreement out of what were formerly independent subject clitics. Hereinafter, I shall refer to subject clitics when discussed as morphological agreement as "agreement markers." It is further argued that the disjunctive pronouns have become the true personal pronouns of this dialect, thereby filling the void left by the morphologized subject clitics. Fonesca-Greber proposes a paradigm of agreement markers (and their corresponding allomorphs) for SwFr, but maintains that certain subject clitics have not become fully morphologized. We will briefly examine the conclusions made by Fonesca-Greber about each of the subject clitics' corresponding agreement markers, their corresponding allomorphs and whether or not they have undergone complete morphologization.

Statistical analysis from a corpus of SwFr informants shows complete morphologization for 1SG, 2SG, 1PL, and 2PL subject clitics. However, for the 3SG and 3PL there are many instances

where the subject clitic still has not completely morphologized. Table 1 summarizes the morphologized form of subject clitics and their corresponding allomorphs that Fonesca-Greber (2000) proposes. The rate at which the informants used these agreement markers determined whether or not a certain subject clitic had fully cliticized. All phonetic transcriptions will be given in **IPA**.

TABLE 1. **SwFr SUBJECT CLITIC ALLOMORPHS.**

	SINGULAR	PLURAL
1st person	‹je› [ʒə] [ʒ] [ʃ]	‹on› [ɔ̃] [ɔ̃n]
2nd person	‹tu› [t]	‹vous› [vu] [vuz] [v] [vz]
3rd person masculine	‹il› [i] [il]	‹ils› [i] [il]
3rd person feminine	‹elle› [ɛ] [ɛl]	‹elles› [ɛl] [ɛlz] [ɛ] [ɛz]
3rd person neuter	‹ça› [sa] [s]	
Inflectional 'qui'	‹qui› [ki] [kj] [k] [ski]	
Indefinite 'on'	‹on› [ɔ̃] [ɔ̃n]	

For each of the above agreement markers, there exist full and reduced forms that are phonologically regulated. Most of the reduced forms occur before verbs that begin with a vowel. The agreement markers *qui*, *vous*, and *elles*, however, demonstrate more complex allophones. The notion of this high rate of allomorphy will be important during our discussion of reanalysis.

Fonesca-Greber reports a 100% occurrence rate for the agreement markers for 1SG, 1PL, 2SG, and 2PL, thereby indicating that these subject clitics have fully morphologized into agreement features. However, the 3SG and 3PL subject clitics seem to be in a transitory period. The 3SG agreement feature appears to be restricted to environments that do not include a definite NP. Fonesca-Greber states that this environment would most logically be the last to undergo morphologization because of the redundancy produced by having a definite NP and a subject clitic. However, the 3SG agreement feature does occur robustly in the corpus of data with indefinite NPs. This observation corresponds to the findings of Culbertson in regard to the conditions in which doubled subjects can appear. Fonesca-Greber also notes that agreement markers for the 3PL-FEM is becoming the marked form and is often replaced with the 3PL-MASC in many instances.

DATA FROM QUÉBECOIS FRENCH (QbFr)

Auger argues that from a strictly morphological analysis, QbFr subject clitics can be analyzed as morphological agreement markers. Auger states that syntactic analyses cannot explain morphology because the theory assumes that elements within the syntax are either base-generated in their position or are moved via syntactic transformations. Auger does not assume either of these positions, instead taking the position that morphology, not syntax, handles all inflection in a language. Auger states that object clitics in QbFr have become fully morphologized and that with the morphologization of the subject clitics, the structure of QbFr will become similar to the structures of agglutinating Native American languages. This notion, interestingly, has been previously stated in literature written in the early twentieth century. Unlike Fonesca-Greber, Auger does not present corresponding allomorphs for her paradigm of agreement markers. Auger does, however, discuss the variation in the pronunciation of the 3SG and 3PL agreement markers. Table 2 illustrates the agreement paradigm as proposed in Auger. The phonetic variations of the 3SG and 3PL agreement markers are indicated below.

TABLE 2. **QbFr SUBJECT CLITICS.**

	SINGULAR	PLURAL
1st person	Je	On
2nd person	Tu	Vous
3rd person masculine	Il [i], [j]	Ils [i], [j]
3rd person feminine	Elle [a], [al]	
Impersonal	On/Tu	
3rd person neuter	Ça	

GENERALIZATIONS ABOUT SwFr AND QbFr

The analyses of Fonesca-Greber and Auger have different purposes. Fonesca-Greber provided an analysis of the agreement marker system of SwFr and demonstrated how each subject clitic has or has not undergone complete morphologization. Auger analyzed French subject clitics from a solely morphological point of view, claiming that the issue is best handled not by syntax, but by morphology. Four important parallels can be drawn from these two analyses: 1) The development of the use of the tonic pronouns as personal pronouns where the tonic pronoun co-occurs with the subject clitic, thereby providing an important piece of evidence for the morphologization of the subject clitics, 2) the reassignment of the impersonal clitic *on* to indicate the third person plural, 3) the third person subject clitics' development of allomorphic variations before vowels and consonants in both dialects, and 4) the development of idiosyncratic forms for the present tense of *être* 'to be', most especially for the 1SG form. In both dialects, the agreement marker *je* becomes fully integrated into the verb creating the forms [ʃɥi] for SwFr and [ʃy] for QbFr. Auger argues that this must be a morphological change and not a phonological change. In StanFr, the conjugation of *être* in the 1SG is homophonous to that of the verb *suivre* 'to follow' which is *je suis*. The form *je suis* in both dialects is always taken to mean 'I follow' and can never be phonologically reduced to the aforementioned 1SG forms of *être*.

Both of these dialects are in a period of transition, which includes a simplification of their pronominal system (as can be seen with the marked nature of *elles*) and a move towards a paradigm of fully morphologized subject clitics. Both dialects show the development of irregular verbal forms based on this new pre-verbal agreement feature system, as can be seen with the present tense conjugations for the verb *être*. Having analyzed data from two dialects of French, we can now turn to reanalysis, the mechanism by which we will attempt to explain the phenomenon of the morphologization of the subject clitics.

THE NATURE OF REANALYSIS

The mechanism of reanalysis is a driving force for linguistic change as it causes the assignment of a grammatical feature to another, thereby causing a change in the mental grammar of a speaker. Over

time, this change in the mental grammar of a speaker is adopted by more speakers and spreads to other aspects of a language's grammar. This in turn leads to the creation of new dialects and eventually to new languages. Reanalysis at its most basic form can be understood as the interaction between **Universal Grammar** and linguistic input. When confronted with new linguistic input, there must be an ambiguity present which allows for a new generation of speakers to assign a new robust analysis to it, whilst remaining unnoticed by the older generation of speakers (Adams 1987). This causes a most peculiar occurrence: the presence of multiple mental grammars within one language that do not hinder comprehension between speakers. This is a crucial point in a language's development.

The actual process of reanalysis can be reduced to two stages (as discussed by De Smet, 2009): 1) the reanalysis of an ambiguous grammatical feature to a new category and 2) the actualization of this new grammatical category so that it no longer may be licensed by any speaker of the language. Between these two steps, the new mental grammar (G2) and old mental grammar (G1) become plausible analyses, which may become adopted in the mental grammar of new speakers (Adams 1987). Eventually, G2 will spread at the expense of G1, thereby causing the prevalence of a new mental grammar in the language (Adams 1987). At this point, linguistic change has occurred and the language is now distinct from an earlier form. If the catalyst for linguistic reanalysis is the occurrence of a grammatical ambiguity, then one must consider the catalyst for the occurrence of the ambiguity. De Smet (2009) considers the creation of a new grammatical analysis (especially a new syntactic form) *ex nihilo* to be illogical. Considering the nature of Universal Grammar, De Smet (2009) states that in order for an ambiguity to arise it must be assumed that children must have many syntactic representations available in their innate language faculty. If this interpretation is held then, "ambiguity between an existing and a 'future' interpretation is logically possible and affords a powerful mechanism for explaining syntactic innovations" (De Smet 2009: 1730).

De Smet expands on the simplified two-step version analysis discussed above, claiming that the mechanism of reanalysis can be divided into three fundamental mechanisms. The first of these is categorical incursion, which is also known as analogy. The prominent characteristic of this mechanism is its leap-like nature, which is commonly attributed to reanalysis in general. Like reanalysis, categorical incursion requires an ambiguity to be present. However,

in categorical incursion the new interpretation of the ambiguity is assigned to a construction that already exists. Because of the analogical nature of categorical incursion, both the ambiguous construction and the grammatical construction to which it is reassigned must be superficially similar. The second mechanism is gradual category-internal change. This mechanism causes a construction to undergo a new semantic interpretation without being reassigned to a new category. Instead, the boundaries of an existing category are expanded to include a new interpretation that had not been present at an earlier stage of a language. The mechanism of category-internal change is valid both diachronically and synchronically due to the abstract and flexible nature of categorical boundaries. The third mechanism is automation. This mechanism causes a construction to become gradually isolated from its parent construction. By way of repeated use, this more specific construction becomes increasingly independent requiring less cognitive access to the more abstract parent construction. Despite this deconstruction of reanalysis into more fundamental mechanisms, reanalysis can be viewed as a driver of linguistic change in certain circumstances whilst remaining epiphenomenal to the other three mechanisms (De Smet 2009: 1752). In the following section, we will analyze the ambiguities in SwFr and QbFr that would cause the subject clitics to be reanalyzed as agreement features. This is the traditional two-step approach to reanalysis. Then, we will use the mechanisms proposed De Smet to provide an alternative analysis for the morphologization of the subject clitics.

GRAMMATICAL AMBIGUITY IN SwFr AND QbFr

Using the two-step approach to historical reanalysis, we must first identify any ambiguities present in the linguistic data for SwFr and QbFr. Both dialects show a loss of post-verbal morphology causing a leveling of all conjugations, save for the 2PL vous form. This process of leveling had begun well before any cliticization of the subject pronoun. Let us recall the morphological erosion that occurred in twelfth century OldFr. If we consider the verbal paradigms for MidFr given in Table 3 and for SwFr and QbFr given in Table 4, we can see the evolution of an increasingly less rich post-verbal morphological paradigm.

TABLE 3. **MidFr CONJUGATION PARADIGM FOR SONNER.**

	SINGULAR	PLURAL
1st person	[sɔn]	[sɔ̃ˈnɔ̃]
2nd person	[sɔn]	[sɔ̃ˈne]
3rd person	[sɔn]	[sɔn]

TABLE 4. **SwFr AND QbFr CONJUGATION PARADIGM FOR SONNER.**

	SINGULAR	PLURAL
1st person	[sɔn]	[sɔn]
2nd person	[sɔn]	[sɔ̃ˈne]
3rd person	[sɔn]	[sɔn]

The loss of this post-verbal morphology presents speakers with the challenge of assigning the subject clitics a grammatical analysis. Here lies the ambiguity. The first grammatical analysis would be to simply continue to analyze the subject clitics as argument bearing subjects. This would thereby cause the language to continue to be non pro-drop. Let us call this grammatical analysis GA1. The second option would be to fill the linguistic gap left by the loss of post-verbal morphology by assigning the subject clitic the role of agreement feature. Let us cause this grammatical analysis GA2. There are major differences in the implications that the adoption of either GA1 or GA2 has. Lightfoot (1979) discusses this notion of cause and effect with regard to the adoption of a certain grammatical feature. He states that if a language undergoes a certain change, it will subsequently develop some other property. He gives the example that if a language develops a VO word order it will subsequently develop an AuxV order as well. If speakers adopt GA1, then linguistic change has not truly occurred apart from the furtherance of the erosion of the post-verbal morphology. GA1 allows MCFr to continue to be non pro-drop and the subject clitics remain argument-bearing subjects. If GA1 is adopted by a new generation of speakers, then their new mental grammar is indistinguishable from the mental grammar of the older speakers.

Let us consider the implications if GA2 is adopted and the effects it has on the mental grammars of new speakers. If the subject clitics are reanalyzed as agreement features, this leads to the creation

of a single verbal entity in the mental grammar. In adopting GA2, a speaker analyses a verb such as *il sonne* 'it rings' as affix+verbal root, thereby constituting a single word. Here we can see true linguistic change, which must have an effect on the mental grammar. If each of the subject clitics have been reanalyzed as agreement features, then SwFr and QbFr has reintroduced rich verbal morphology to their grammars. It can be said that these two dialects conjugate the verb at the beginning rather than the end. As proposed by Rizzi, rich verbal morphology is the main feature of a language, which allows pro-drop to be licensed. As a result of the reanalysis of the subject clitics, the mental grammars of speakers of SwFr and QbFr have a positive setting of the pro-drop parameter. One might ponder how it can be said with certainty that the adoption of GA2 has, in fact, occurred in the mental grammar. Let us call to mind the conclusions made in Culbertson (2010). The previous syntactic literature argued that MCFr could not be pro-drop because of three main grammatical occurrences: 1) the intervention of *ne* between the subject clitic and the verb; 2) gapping in conjoined VPs; and 3) the occurrence of subject-verb inversion. Culbertson dismisses each of these claims by providing counter-examples from colloquial dialects of French. The most important of the findings of Culbertson is that of the occurrence of subject doubling. Not only do definite DPs such as *Jean* or *ton père* 'your father' appear with the subject clitic; the disjunctive pronouns also appear with the subject clitics. This parallels the claim made by Fonesca-Greber that disjunctive pronouns have become the true personal subject pronouns of SwFr. This is another effect caused by the adoption of GA2. If the subject clitics, are reanalyzed as morphology it leaves a linguistic gap open for the category of argument-bearing subject.

BEYOND REANALYSIS

We have discussed the implications of the two analyses that can be made when speakers are faced with the ambiguity of assigning the French subject clitics to a new grammatical function. We have further claimed that speakers of SwFr and QbFr have reanalysed the subject clitics as agreement features and that based on the evidence given in the syntactic analysis of Culbertson, that this analysis best explains the occurrences in MCFr. We will now analysis the subject clitic issue in French using the three mechanisms proposed by De Smet.

The mechanism of automation fails to illustrate the development of the French subject clitics. The main function of this mechanism serves to disassociate the new grammatical construction from its parent construction. The grammatical function of the subject clitics in the mental grammars of older speakers is that of argument-bearing subject. Because MidFr did not feature rich verbal agreement, it therefore necessitated the use of the subject so that the person and number of the verb could be analyzed. In the mental grammar of GA2, speakers continue to use the newly morphologized subject clitics to represent person and number, in addition to tense. Instead of alienation from the parent form, the morphologized subject clitics have expanded the functions inherited from their parent construction. In fact, the difference between argument bearing subject and agreement feature is rather minute. Both serve to assign referential meaning to the verb and it seems languages can evolve to use both subject pronouns and agreement features to assign person, tense, and number. The development of the use of these two grammatical features is seen in the French language. OldFr relied solely on agreement features to assign person, tense, and number. In MidFr, the agreement features assigned only tense. Number also was assigned, albeit redundantly due the languages non pro-drop nature. In MCFr, especially in the dialects of SwFr and QbFr, the language has returned to the use of agreement features to do what the subject clitics had done: assign person and number. However, we have not considered the verb in tenses besides the present. We will revisit this important notion of the similarity between subjects and agreement features in the next section.

Grammatical incursion concerns the assignment of a grammatical construction to another already present in the mental grammar. In the previous section, we discussed the various linguistic gaps. The first of these linguistic gaps is the one left by the erosion of the post-verbal morphology of the MidFr verb. In the mental grammar of the previous state of the French language, verbal morphology was an active feature. In SwFr and QbFr, what were previously argument-bearing subject pronouns were reanalyzed as verbal morphology, thereby causing the need for the gap to be filled. Similarly, the reanalysis of the subject clitics causes a gap, which must be filled by a new set of subject pronouns. This gap has been filled by what were formerly disjunctive pronouns. As one can see, categories that had previously existed were not lost and categories that had not

existed were not created. Instead, grammatical features were shifted to accommodate the linguistic gaps caused by the reanalysis of the subject clitics. Let us now consider how the mechanism of category-internal change works. A new grammatical construction must undergo a semantically distinct analysis, which causes the category to which it belongs to become included in another category. This assimilation causes the merging of two grammatical categories with a semantic interpretation that was not present in an earlier form of the language. If we consider the reanalysis of subject clitics it seems that semantically the subject clitic lost its weight as a grammatical subject and the category of agreement feature expanded to accommodate it. Here again we can see the ambiguity regarding the distinction of subject pronoun and agreement feature.

INTERIM SUMMARY

Using data from Fonesca-Greber and Auger, we have claimed that French subject clitics have become agreement features by way of reanalysis. If one accepts the claim that speakers of these two dialects have accepted what I have called GA2, it further supports the syntactic occurrences observed by Culbertson. It also allows us to claim that these two dialects of French have become pro-drop languages by virtue of these agreement features constituting rich verbal morphology. In addition to analyzing the French subject clitic issue using the traditional two-step approach to reanalysis, we have also analyzed it in regard to the mechanism of linguistic change proposed by De Smet. This further analysis allows us to observe interesting properties shared by subject pronouns and agreement features.

IMPLICATIONS OF HISTORICAL ANALYSIS ON LINGUISTIC THEORY

GENERAL IMPLICATIONS

Lightfoot (1979) states that because language change is a manifestation of grammatical change, it can be used to create a theory of language. He states that such a theory should accommodate the following: 1) provide distinction between what is permissible and impermissible by the mental grammar; 2) relate simultaneous change and provide a grammar which can relate the historical development of linguistic change; and 3) account for the most

data with the minimal amount of machinery. Lightfoot (1979:12) proposes that the theory can provide a way to choose between competing synchronic hypotheses. Lightfoot states that historical research will be most profitable in a theory of restrictive grammar and that through historical change one can discover the various constraints on grammar. Optimality Theory, as developed by Prince and Smolensky (2004), seeks to provide a theory of language based around the hierarchy of grammatical constraints, which determine what constitutes well-formedness in a language. This theory assumes that all languages have a set number of constraints in their mental grammars, and that these constraints are in a constant state of reordering. Optimality Theory, despite being originally applied to phonology, is able to account for linguistic change by a simple reordering of rules. Lafond (2003) proposes a set of constraints that have been present in the French language since its OldFr stage. In order to account for the change in V2 word order and the change to a language, which accepts pro-drop, Lafond proposes different constraint orderings for each state of French.

The nature of reanalysis and the mechanisms proposed by De Smet suggest that all grammatical forms are present in the mental grammar of the speaker. I proposed in the previous section that no new grammatical forms had been created in SwFr and QbFr. Instead, the already present grammatical constructions were simply reassigned to different roles. The reanalysis of the French subject clitics from the point of view of Optimality Theory may be able to demonstrate that a simple reordering of constraints caused French to place verbal morphology at the beginning of the verb rather than the end. If the hierarchical ordering of constraints can be applied to phonology and to syntax, it should also be able to apply to the rules of morphology. In mainstream generative linguistics, morphology is assumed to be subordinate to syntax. Chomsky (1995) accounts for the occurrence of the English 3SG agreement feature as a downward head movement of the affix from I to V position in a process called affix hopping. It seems that morphology may not be as subservient to syntax as proposed by Chomsky (1995:133), who states that inflectional morphology is strictly a part of syntax. In the following sections, I will analyze what I perceive to be an interesting relation between morphology and syntax and the implications this more specific observation has on linguistic theory.

ON THE DISTINCTION BETWEEN SUBJECT PRONOUNS AND AGREEMENT FEATURES

This investigation has not taken into account verbal forms in other tenses apart from the present tense. For the imperfect, the morphological prefix is [ɛ] for all persons save for the 2PL where it is [je]. This bears a resemblance to the present tense paradigm, where only the 2PL has distinguishing prefix. The future tense differs slightly from the present tense as the prefix [e] is used for the 1SG, 2PL, 3SG, and 3PL. In addition to the different post-verbal morphology paradigm, the future also uses a different verbal root, in most cases the full infinitive form of the verb. If one were to analyze only the present tense, it would lead to the false assumption that verbal morphology of MCFr consists solely of pre-verbal agreement features. Post-verbal morphology continues in MCFr to indicate tense. In OldFr, the post-verbal morphology served to distinguish person, number, and tense. In MidFr, the post-verbal morphology served to distinguish tense for all verbal forms and only person and number for the 1PL and 2PL, albeit redundantly. As with MCFr, the subject clitics have been reanalyzed as agreement features, although only for person and number, not tense, thereby necessitating post-verbal morphology to assign tense. This leads one to consider the nature of subject pronouns and agreement features, whether pre-verbal or post-verbal. As I have shown with the historical development of French, the features assigned by either the subject pronoun or agreement feature have changed fluidly. This leads to the conclusion that subject pronouns and agreement features are variants of the same entity. In order for this claim to be valid, subject pronouns must be able to convey tense and aspect as well. For the purposes of my argument, I group tense and aspect together as many languages often prefer either a tense-based verbal system over an aspectual verbal system In order to support this claim, I must bring in linguistic evidence from outside of French. In the Wolof language, the verb is generally uninflected apart from a past tense marker (Ka, 1994). However, aspect is marked on suffixes attached to the pronoun (Ka, 1994). In Wolof, the pronoun is able to carry the referential meaning of person, number, and tense, which supports my claim that both verbal morphology and subject pronouns are indistinguishable.

ON THE DISTINCTION BETWEEN SYNTAX AND MORPHOLOGY

Subject pronouns in standard theoretical treatments are viewed as independent entities in the syntax and are able to undergo movement and transformations. In standard syntactic theory, it is assumed that all subjects are based generated in VP-internal position and undergo A-movement to their specifier position. For the purposes of my argument, I will associate subject pronouns with syntax. Agreement features, however, are not as mobile with regard to syntactic transformation apart from I to V movement that occurs in affix hopping. Morphology is considered in syntactic theory to be governed by the syntactic transformations. On this issue Chomsky (1995:133) states inflectional morphology is a part of the syntax proper and that derivational morphology is strictly a part of the lexicon. Since agreement features are considered inflection morphology, they are bound by the laws of syntax and therefore should not be able to act in the same fashion as subject pronouns. I disagree with the claim made by Chomsky and will argue that the distinction between syntax and morphology is unnecessary and that they are variants of the same entity, much the same as subject pronouns and agreement features are variants of the same entity.

Vendryes (1920/1950:202) noted a similarity between the constructions given in (15) and agglutinative constructions found in Amerindian languages and in Basque. The Chinook example in (16) (taken from Davies, 1986:147) demonstrates heavy morphological agreement on the verb for both the subject and the object. In the French examples in (15) and (16), object and prepositional pronouns are found which mirror the functions of their Chinook counterparts. In the latter languages, grammatical morphemes are grouped together at the beginning of the sentence with lexical arguments appearing at the end of the sentence.

(15) Il m' en parle.
He 1SG-DAT of speak-3SG
"He talks to me about it."

(16) Ko:wi ĩ- chi- pila –li –tok kiyo
lion 3SG-DAT 2SG-ACC throw 1SG-NOM PST not
"I did not throw you to the lions."

Auger (1994: 2-3) gives a further Québecois example given in (17) and discusses their similarity to the Basque example in (18) which is taken from Laka (1993:23). In the QbFr examples of the verb along with the subject clitics with their corresponding lexical referents occurring at the end of the sentence. In Basque, the same is true; however, the order in which the morphemes and lexical arguments are grouped is reversed being that it is a head-final language.

(17) Elle n'y a encore pas voyagé, ta cousine, en Afrique
She there has-3SG yet not travelled your cousin to Africa
"She has not yet travelled there, your cousin, to Africa."

(18) Zuk niri etxea eman d- i- da- zu
2SG-ERG 1SG-DAT house gave 3SG ABS 1SG-DAT 2SG-ERG
"You gave me the house."

Auger, reflecting on such similarities, asks whether the subject and locative pronouns in French should be analyzed as words or as morphemes. Throughout the historical development of French, it seems that the language never truly ventured far away from implementing morphology as an active part of its grammar. One could assume that as OldFr lost its rich verbal morphology, a syntactically overt subject filled void left by the lack of morphology. However, based on my claim that subject pronouns are a form of verbal morphology, one can assume that the rules of French morphology have changed and that, syntactically, the language has not changed. This leads me to conclude that the distinction between syntax and morphology is unnecessary as they both accomplish the same purpose. If language has heavy morphology, whether on the verb or the noun, it takes the importance of strict word order away. Similarly, if a language loses its heavy morphology, it must use word order to convey what the lost morphology had done. Either way, the languages accomplish the same goal: that is, to assign proper grammatical form. Here, we can see the ambiguous boundary between word and morpheme.

If words are bound by the rules of syntax, then the rules by which morphemes are bound must be accounted for. It seems that the agreement theory proposed in Chomsky regarding I to V and V to I movement holds only for English and French. The theory does not accommodate languages such as Basque which are heavily dependent upon morphology rather than syntax. My proposal that

syntax and morphology are the same entity provides a very interesting topic around which research can be based. If one assumes that all words and all morphemes are like subject pronouns and agreement features in that the boundary between them is ambiguous then the same must be true for syntax and morphology. This leads one to the conclusion that syntax and morphology must be governed by the same rules. This assumption further requires that morphology not be subservient to the rules of syntax. In addition to, bring up an interesting research notion, my claim also challenges current linguistic theory. Adams makes a major proposition that truly challenges the current linguistic theory claiming that pro-drop is not a true parameter and that it is reducible to other properties such as directional government and feature identification. Whether or not this claim is true is not of importance. What is of importance is that it challenges what is held to be true and forces the theory to be reviewed.

CONCLUSION

If this proposal that syntax and morphology are but the same entity or two different manifestations of a higher entity, then research of highly agglutinating languages such as Basque and Chinook is needed. The study of the historical development of such agglutinating languages will provide much insight regarding the nature of syntax and morphology. The French language, on the surface, seems to have gone through stages in which it had rich verbal morphology and ones in which it had not. However, as I have claimed, the changes have continued to have the same grammatical weight. If all languages are similar and adhere to the notion of Universal Grammar, then languages such as Basque and Chinook must also have historically shifted between different stages, which outwardly seemed to favour grammatical constructions based around syntax and those based around morphology. If, in fact, instances of reanalysis similar to that of French subject clitics are present in the historical development of other languages, it will prove to reveal much about the nature of the human language faculty.

GLOSSARY

Argument-bearing: having a theta role, that is a specific semantic purpose (agent, experiencer, theme, etc.).

AUX: *abbr.* 'auxilliary verb'.

Clitic: a word that is phonologically bound to its host.

DP: *abbr.* 'determiner phrase', a lexical phrase whose head is a determiner.

Finite verb: a verb specified for tense, person, and/or number.

IP: *abbr.* 'inflection phrase', a functional phrase whose head bears the tense of a sentence.

IPA: *abbr.* 'International Phonetic Alphabet'.

Null subject: a subject that is phonologically absent, but present in the syntactic representation.

Pro-drop parameter: the concept that languages can either covertly or overtly express the arguments of a sentence.

SVO: *abbr.* 'Subject Verb Object', a common word order typology found cross-linguistically.

Universal Grammar: the concept that all human languages share the same common properties that are hard-wired in the brain, making the acquisition of a language innate.

Wh-questions: interrogative words such as 'who', 'what', etc.

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RESIDENTIAL WASTE ANALYSIS AND ACHIEVING UNDERSTANDING OF WASTE MANAGEMENT INFRASTRUCTURE FOR IMPROVING SUSTAINABILITY AT A UNIVERSITY

ALEXA **WHITE**

My research started as conversations with Donna Anderson, Manager of Landscape, Grounds, and Recycling at Facilities Management. We talked about how UMBC could improve its composting program, which at the time was only present at True Grit's and with one small bin in the corner of The Commons. Ms. Anderson suggested collecting data to show the campus community that the problem exists to make a case for change. I was inspired to go to my academic advisor at the time, Dr. Erle Ellis. He guided me through how to do a literature review, develop methodologies, and complete statistical analysis. He also provided me with many of my materials. Donna Anderson and Glen Cook, a staff member of Facilities Management, were also always willing to provide materials and their time. My project reflects waste disposal practices that could be improved on our residential campus and suggests infrastructure and advocacy programs that could be implemented. Thanks to the many people who were eager to help, I learned a great deal about the various components that go into research, and produced a useful product that future UMBC students, faculty, and staff can use to improve campus sustainability.

ABSTRACT

The manner in which municipal solid waste is discarded and how individuals are educated about waste disposal are factors in determining overall sustainability. It is important to study waste disposal in a campus setting because campuses are locations with concentrated populations that function as models of society and provide educational settings for students to gain new information and transform habits. At the University of Maryland, Baltimore County (UMBC), a team of students conducted waste audits in UMBC's residential area to determine how much of the waste was really trash and how much could have been recycled. In this paper, "trash" will refer to landfill waste and "waste" will refer to everything that is disposed of no matter the category. By measuring samples extracted from dumpsters using a digital scale, it was determined that only 42 percent of this campus' residential waste stream was trash. The other 58 percent was separated into these categories: compostable (30 percent), plastics, metals, and glass (17 percent), paper (6 percent), and cardboard (5 percent). The fact that most of the waste could have been recycled or composted suggests the need for a composting program and adjustment of students' education and attitudes about recycling. This study found potential for improvement in waste disposal practices on the UMBC campus. It presents students, faculty, and staff with information regarding the composition and structure of UMBC's residential waste stream so that educational programs for students and waste disposal infrastructure may be improved.

INTRODUCTION

STATEMENT OF PROBLEM

In 2010, the US produced 250 million tons of waste (approximately 4.43 pounds per person per day). Based on trends seen from 1960 to 2010, this amount is projected to increase. Only 34.1 percent of the 250 million tons was composted or recycled (Environmental Protection Agency [EPA], 2010). Recycling and composting are essential waste disposal efforts, because each one is a main process in resource recovery. Recycling reduces the need to gather resources

like timber, water, and minerals that would normally be used in the production of plastics, metals, glass, paper, and cardboard. When these resources are not being sought or used, energy is saved and less pollution (especially that of greenhouse gas emissions (GHGs), the main contributor to climate change) is created. Composting has similar benefits with regard to pollution and energy (EPA, 2013). Twenty to thirty percent of the country's waste could be diverted from landfills and composted (EPA, 2010). This would save space and reduce the amount of methane that is emitted from landfill-occupying organic materials that are not properly degrading. When organic materials are composted, the soil that is produced has a wide array of uses including replacing chemical fertilizers, promoting higher yields of agricultural crops, facilitating habitat revitalization, and more (EPA, 2013). The current study analyzed the waste management infrastructure and waste stream in the residential area of UMBC to determine their potential for improvement.

Campuses are like small municipalities in terms of structure and consumed resources. There is increasing pressure on campuses around the world to improve their sustainability.[1] Education for sustainable development has been an increasingly influential topic since the Stockholm Conference of 1972, which established higher education as a crucial component of promoting sustainability on a global scale (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2008). Universities are centers for teaching and knowledge application aimed at developing our future leaders. Educational institutions play a crucial role in developing sustainable communities through the programs they make available to their students (Arbuthnott, 2009). One way that the University of Maryland, Baltimore County (UMBC) aims to achieve sustainability is through reduction of greenhouse gas emissions (Climate Change Task Force [CCTF], 2010). Waste minimization is part of the plan to reduce the campus' carbon emissions. In order to make this minimization a reality, waste audits are necessary to determine where improvement is needed (Mason, Oberender, & Brooking, 2004).

BACKGROUND

UMBC is located in suburban Baltimore County, Maryland, 15 minutes from Baltimore's Inner Harbor and 30 minutes from Washington, D.C. At the time of sampling, UMBC served about 2,700 graduate students and 11,000 undergraduate students.

Of those 11,000 undergraduates, about 3,900 lived on campus. UMBC has dual-stream recycling, meaning that it separates clean paper from other recyclables.[2] Composting was and is facilitated by The Commons and by the dining hall, True Grit's. Students living in the residence halls still have no way to compost unless they bring applicable materials to The Commons.

This study focused on the population of students that reside on campus during fall and spring semesters. The residential area is divided into four apartment complexes and six residence halls. Figure 1 displays the locations of the dumpsters that were sampled.

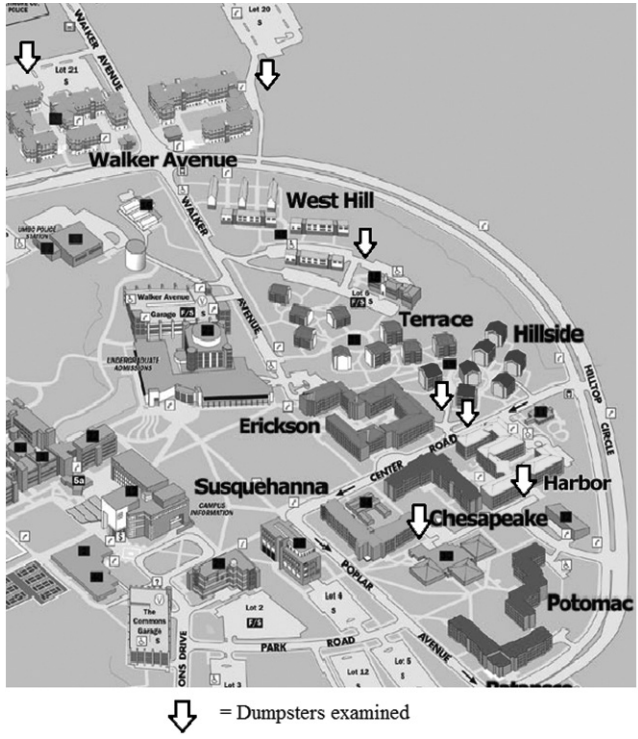

FIGURE 1. **SAMPLING SITES.** Map of UMBC's residential area with sampled dumpster locations indicated by arrows (UMBC Residential Life, 2013).

PURPOSE

The objective of this study was to determine the relative amounts of specific materials in residential waste based on weight. The study also offers recommendations for changes in practice that might help divert materials from landfills and instill more conscious waste

disposal behavior in UMBC students. The contents of the trash dumpsters were analyzed, and percentages of categorized materials (Table 1) were determined to see what needs to be improved in regard to proper disposal. Presence of materials that could be repurposed indicates that valuable resources are not being diverted from landfills and energy is being wasted.

TABLE 1. **COMPOSITION DESCRIPTIONS.** This is a list of categories used and the materials in each one. Descriptions are based on guidelines from waste-neutral.com, the document in Appendix B, and personal communication with Donna Anderson.

CATEGORY	COMPOSITION DESCRIPTION
Landfill Waste and Other	over-contaminated recyclables, soft plastic food wrappers, plastic bags, straws, plastic utensils, materials containing polystyrene (including, but not limited to, Styrofoam), anything that does not fall into the following categories, Other*
Compost	food scraps, fruit peels, biodegradable containers and Pepsi cups, tea bags, brown napkins
Plastics, Metals, and Glass	any glass, any aluminum and tin cans, plastic bottles and containers with recycling symbols 1 and 2
Paper	clean and dry paper and magazines
Cardboard	clean and dry corrugated cardboard and paperboard boxes (cereal boxes, snack boxes, etc.)

*Other: This includes electronics and ink cartridges. These items are recycled through Facilities Management and The Commons, respectively. They did not appear in all of the samples and the values were not large enough to warrant their own category. Appendix D lists the items that were found.

METHODOLOGY

CONTEXT OF RESEARCH

The research was conducted during spring 2013 on three days (Sunday March 31, Sunday April 7, and Tuesday April 9). These days were chosen based on Waste Management's pick-up days (Mondays, Wednesdays, and Fridays) and on student availability. The goal in choosing days before Waste Management's pick-up was to sample the dumpsters while they were at their fullest. Only eight-yard dumpsters within the residential area were sampled.

SAFETY PROCEDURES

Every student volunteer who sorted waste wore coveralls, a mask, and heavy-duty gloves. No one was permitted to fully enter the dumpsters. Waste was obtained by reaching through the side doors of the dumpsters and pulling out parcels of waste that had been bagged by residents or cleaning staff. Volunteers were instructed to fully wash their hands, faces, and clothes afterwards.

WASTE SAMPLING AND CATEGORIZING

At each dumpster site, a tarp was laid out and six boxes — five for each of the categories and one for the total sample to be extracted — were set up with color-coded bags (black=trash, blue=recyclable, green=compostable). The setup is shown in Figure 2. A sample from the dumpster was extracted, weighed on a digital shipping scale with an accuracy of ±0.1 pounds, and sorted on-site. After that, each box, filled with its specified material, was weighed. The sample size varied from 15 to 22 pounds per dumpster, owing to the need to extract full bags of waste.

The sample size was based on the conditions within the residential area at UMBC and factors that were identified in a review of scientific literature pertaining to waste audit methodologies. Researchers at Furman University, as part of a residential waste audit, took small samples (27-51 pounds per dumpster) that depended mostly on the accessibility and fullness of each dumpster (Baldwin & Dripps, 2012). The fact that time and person-power were limited warranted smaller samples in the current study. The assumption was made that the five predetermined categories would always be represented. This was verified, and a sixth category (electronics and ink cartridges) was discovered. This additional category was not represented in all of the samples, so it was grouped with "Landfill Waste" as "Other". Once the samples were sorted and weighed, the newly separated materials were disposed of properly. Plastics, metals, and glass were placed in the recycling dumpsters; paper, cardboard, and items to be composted were taken to The Commons' loading dock at the end of each day; and the remaining waste was returned to the trash dumpster.

FIGURE 2. **SAMPLING DESIGN.** The setup before categorization at one of the Walker Avenue apartment dumpster sites.

STATISTICAL METHODS

Sampling was completed over the course of three days. The research team collected six samples per day for a total of 18 samples. Both an analysis of variance (ANOVA) and a *t* test performed on the sum of the sample sizes for each day ensured that there were no significant differences among the weight values across sampling days. These same tests were performed for each day to confirm that there was no significant variation among the samples within one day. Each categorized percentage was produced by dividing the average for each category across all sampling days by the average of the sample sizes.

ANOVA was used to obtain p values for each category. The p values were not used to test a null hypothesis, but to determine the significance of variance in samples across the days. P values above 0.05 indicated that there were no notable differences. The closer the p value was to 1, the closer the percentage was to the mean for that category. Low p values indicated more variance among samples across the days. The "Plastics, Metals, and Glass" category had

a p value of 0.005. The other categories had values between 0.26 and 0.94, indicating that there was no significant variance among the three days. Since there was only one category out of six that had a very low p value, it was determined that there were no notable differences among the days.

RESULTS AND DISCUSSIONS

TABLE 2. **DISTRIBUTION OF WASTE.** All samples across the residential area were averaged and percentages were determined as shown. The 95% confidence intervals were determined using *t* tests.

CATEGORY	95% CONFIDENCE INTERVAL	PORTION OF TOTAL SAMPLE
Landfill Waste and Other	±3.82%	42.0%
Compost	±5.51%	30.1%
Plastics, Metals, and Glass	±4.11%	16.8%
Cardboard	±2.55%	5.2%
Paper	±3.38%	5.9%

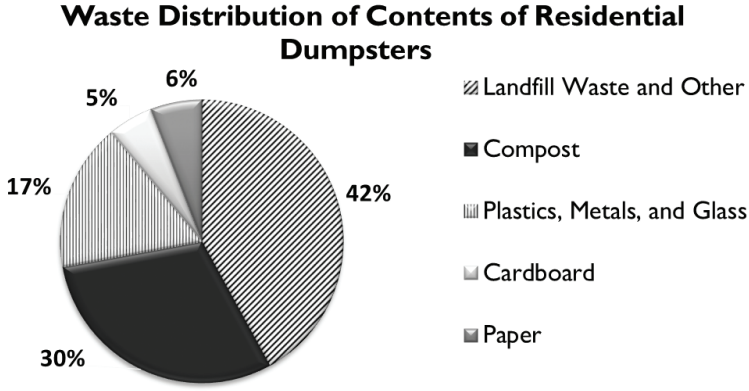

FIGURE 3. **VISUAL REPRESENTATION OF WASTE DISTRIBUTION.**

SUMMARY

More than half of the waste (~58 percent by weight) in UMBC's residential area consists of materials that could be repurposed through recycling or composting. This equates to 34,800 pounds of material per week from the population that was sampled. Approximately a third (~30 percent) of the waste stream could be diverted from landfills and composted. The next largest category was plastics, metals, and glass (17 percent). Paper and cardboard were the smallest categories with six percent and five percent respectively.

DISCUSSIONS

Compostables. At the time of sampling, a third of the campus residential waste stream was composed of compostables such as food scraps, biodegradable containers, and brown napkins. This indicates that, within the sample population of dumpsters, approximately 18,000 pounds of waste per week could be converted into soil and used for a multitude of purposes rather than take up space in a landfill.

Disposal of compostable materials on the UMBC campus is made possible by Waste Neutral. This company transports these materials from campus to a composting facility in Wilmington, Delaware (Hopkins, 2012).

Plastics, Metals, and Glass. About 10,200 pounds of plastic, metal, and glass could be diverted from landfills and recycled on a weekly basis from the dumpsters sampled in this study.

Paper and Cardboard. Although each of these two categories constitutes a small portion of the residential waste stream, at least 6,600 pounds of paper and cardboard from the residential area could be repurposed per week. Recycling paper and cardboard has environmental benefits and produces money for the university. Facilities Management sells UMBC's clean and dry recycled paper and cardboard. The money from these sales goes back into the recycling program (Anderson, personal communication, 2013).

Other. Appendix D gives a detailed list of additional items that were found in the samples.

Appendix A shows the calculations for the different weights, and Appendix E gives a communications plan for the different categories.

SOURCES OF ERROR

There was no notable variance of measurement within each category among the days except in the "Plastics, Metals, and Glass" category. This could have been due to varying student activities or random chance. This was the only category out of six — including the ANOVA of the total sample weight — that showed variance, so it was acceptable to compare results across the sampling days. Each measurement was statistically determined to be accurate to within ±2.55-5.51%. Accuracy at the initial stage — weighing the samples — could have been improved. The measurements that took place on the first day were done on a household scale, and these results were affected by the inability to correctly read the scale since it was not digital. Once a digital scale was acquired, there were occasional scale errors that occurred when the digital scale would re-calibrate if it was left on. This was not realized until the third day of sampling. At the start of sampling with the digital scale, the calculated total of all of the categories was greater than the original sample size. Once it was observed that the scale's tare value was changing without anything touching the scale, methods were altered to prevent this; each time a new category was weighed, the empty box was used to tare the scale. Despite these errors, statistical analysis of the weights across all days proved that variance was minimal.

FUTURE RESEARCH

For future studies, sampling technique could be improved and student behavior could be examined. If greater accuracy and depth of analysis is desired, the quantity and size of the samples should increase. This may help achieve greater understanding of any differences that may exist among housing complexes and among times of the year, which would allow Facilities Management to tailor any new programs to individual buildings or complexes or to different times of the school year. Tailoring dumpster infrastructure to the time of year is already done to some extent during the move-out process with the use of extra dumpsters and electronics disposal bins.

Related research could be designed and conducted on student behavior regarding waste disposal. There is work to be done in infrastructure (such as with paper and cardboard disposal in the apartments) and in education. The effects of educational efforts could be measured with before-and-after surveys that assess perspectives on

recycling, composting, the environment, and sustainability to see how students' outlooks and behaviors were affected, if at all. Facilities Management, Sustainability at UMBC, and Residential Life could act on the findings from the current study through structured educational programs, clear dissemination of information regarding proper waste disposal, and implementation of a composting program using signage and social media networks. The potential increases in rates of recycling and composting would lessen the greenhouse gas emissions of the university, which is a goal of the university's Climate Change Task Force, renamed the Climate Action Steering Committee in fall 2014. This group of individuals was tasked with advising the president, Dr. Freeman Hrabowski III, on how to diminish UMBC's negative impacts on climate and achieve carbon neutrality by 2075 (CCTF, 2010). A more structured waste disposal program could help significantly in accomplishing this goal. If these programs are successful, each student may reduce her or his negative environmental impact while on campus and retain a sustainable attitude toward the use and reuse of our resources.

CONCLUSIONS

This study found that there is potential for improvement in recycling and composting rates in the residential area of UMBC. An analysis of samples extracted from residential dumpsters revealed that less than half (42 percent) of campus residence hall waste is actual trash. Of the other 58 percent, almost one third (30 percent) could be composted and 28 percent could be recycled: plastics, metals, and glass (17 percent); paper (6 percent); and cardboard (5 percent).

ENDNOTES

1. Sustainability is determined by a balance of ecological, social, economic, cultural, and spatial factors (Seiffert & Loch, 2005). Creating this balance without negatively affecting stakeholders is the challenge in achieving campus sustainability (Alshuwaikhat & Abubakar, 2008). Since sustainability is multifaceted, focused projects and initiatives that study individual areas that require improvement can be combined to gradually improve current unsustainable conditions and behaviors.

2. The structure of the recycling program that was used during the study period in spring 2013 can be found in Appendix B. This list was only available to students on the UMBC website, meaning students had to take the time to look it up. There were no detailed instructions placed on or around the containers detailing how to dispose of one's waste. Appendix C shows the design of the fliers that were later made available to students, faculty, and staff through the myUMBC and sustainability websites and advertised electronically in The Commons. Ink cartridges had to be brought to the Campus Information Center in The Commons in order to be recycled. Electronics and batteries had to be delivered to Facilities Management located at the southwest side of campus, outside of the campus loop that encircles academic buildings and the residential area.

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APPENDIX A

CALCULATIONS

- Average estimated tonnage from Waste Management and Facilities Management: 4.995 tons per week per dumpster location
- 4.995 tons / dumpster = 9,990 lbs / dumpster
- 9,990 lbs / dumpster x 6 dumpsters in population = 59,940 lbs in sampled population
- 59,940 lbs x .58 = 34,765 lbs that can be repurposed
- 59,940 lbs x .3 = 17,982 lbs that can be composted
- 59,940 lbs x .17 = 10,190 lbs of plastics, metals, and glass that can be recycled
- 59,940 lbs x .11 = 6,593 lbs of paper and cardboard that can be recycled

*All poundage is rounded in the report**

APPENDIX B

This document was created by Donna Anderson in Facilities Management. It was applicable for the time of the project.

UMBC RECYCLING PROGRAM AT A GLANCE

The following is a summary of what can and cannot be recycled in the present community-based program. This is not an all-inclusive list. In addition, Facilities Management shops collect and recycle a variety of construction, building, and maintenance materials.

Glass, Plastic and Aluminum

Glass Containers	
We **Can** Recycle	We **Can't** Recycle

• Glass jars and bottles (any color)
  ○ Empty and rinse
  ○ Discard caps & lids
  ○ Labels & rings may stay on
	• Dishes and ceramics
	• Drinking glasses
	• Window glass
	• Light bulbs
	• Mirrors
	• Corningware or Pyrex
	• Trash of any kind

Plastic Jugs & Bottles	
We **Can** Recycle	We **Can't** Recycle

• Narrow-neck plastic bottles and jugs with a number 1 or 2 or no number at all on the bottom.
  ○ Empty and rinse
  ○ Discard caps
  ○ Crush if possible
	• Wide-mouth plastic containers (such as margarine or yogurt containers)
	• Plastic trays or film
	• Styrofoam
	• Plastic bags, film or wrap
	• motor oil or antifreeze bottles
	• Trash of any kind

Metal Cans	
We **Can** Recycle	We **Can't** Recycle

• Aluminum beverage cans
• Steel and tin food cans (cleaned)
  ○ Empty and rinse
  ○ Labels may stay on
	• Aluminum foil or trays
	• Lawn chairs
	• Pots, pans or other scrap metal
	• Trash of any kind

Paper

White Paper	
We **Can** Recycle	We **Can't** Recycle
• Writing and computer paper • Mail (plastic windows are O.K.) • Printer, Fax, and Copy Paper (White) • Letterhead • White tablet paper • Computer printout • Laser printer paper • Typing paper • Misc. white paper, Shredded paper (White) • Stapled or paper clipped paper is acceptable	• Color paper, Carbon paper, NCR paper, Paper ream wrappers • Envelopes , Ledger Paper, Coated, glossy, slick and waxed papers, Post-It Notes, Posters • Invoices, File Folders, Tablet backings • Paper Bags, Small Cardboard Items, Food wrappings, Paper towels • Phone books & Directories • Magazines, Books, Newspapers • Cardboard boxes
Mixed Paper	We **Can't** Recycle
• Newspapers (glossy inserts ore O.K.) • Magazines • Catalogs • Paperboard boxes (such as cereal and shoe boxes) • Color paper • Yellow tablet paper	• Plastic bags or wrappers • Paper towels or tissues • Paper laminated with plastic, wax or metal • Pizza Boxes • Waxed cardboard • Trash of any kind • Phone Book • Cardboard boxes

Cardboard

Cardboard	
We **Can** Recycle	We **Can't** Recycle
• Cardboard boxes (clean and flattened) • Paperboard boxes (such as cereal and shoe boxes) ○ Stack flattened boxes outside department office door for pick up	• Plastic bags or wrappers • Milk or juice cartons • Paper towels or tissues • Paper laminated with plastic, wax or metal • Pizza Boxes • Waxed cardboard • Trash of any kind

Ink Cartridge

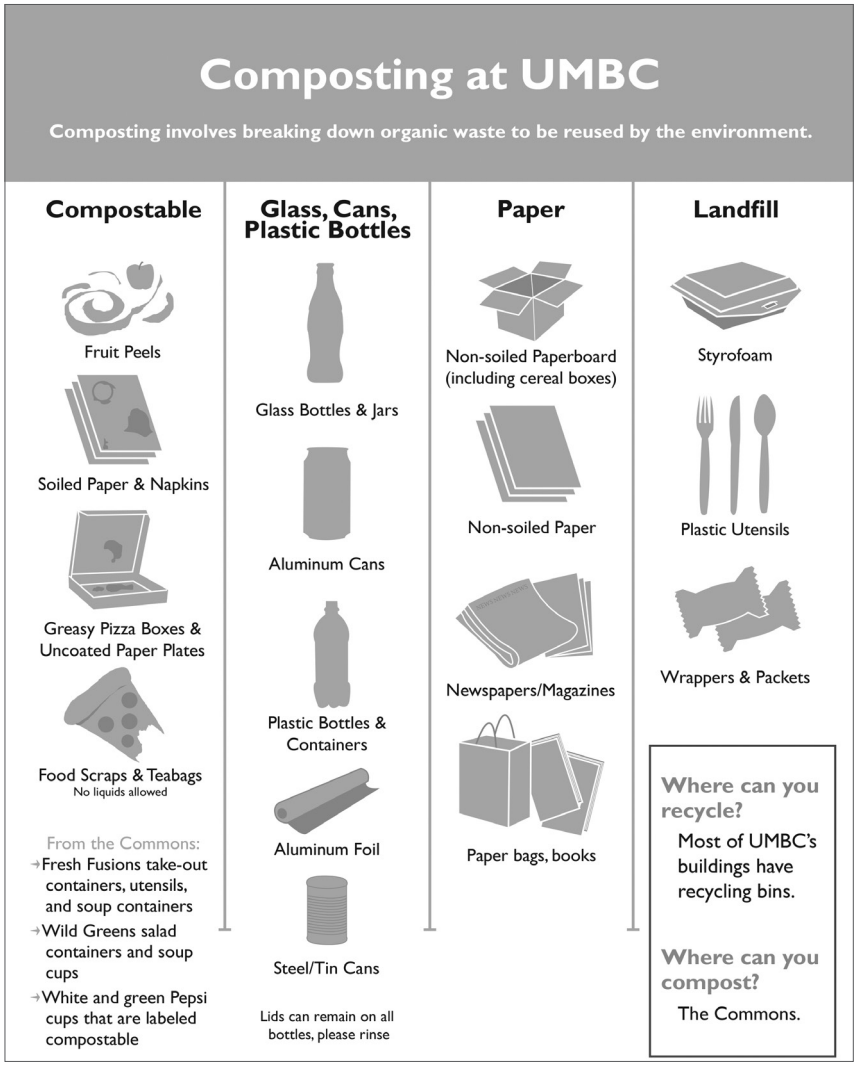
***We encourage users to utilize the mailing label to recycle directly with the manufacturer.*	
We **Can** Recycle	We **Can't** Recycle
• Inkjet cartridges only • Collection bins are located at the Campus Information Desk , UMBC Bookstore, The Comm. Store , Human Resources and Facilities Management	• HP 4600 • HP 9500 • HP 5500 • Tube type cartridges • Any cartridge larger than a shoebox

Computers and electronics

Any item with an electric cord or battery run	
We **Can** Recycle	We **Can't** Recycle
• Computers • PC's, • Apple • Telephone • Systems • Scanners • Terminals • Printers • Facsimiles • Circuit Boards • Key board • Mainframes • Monitors • POS Systems • Microwaves • Copiers • Test Equipment • Typewriters • A/V Equipment • Radios • Stereos • Speakers • Networking Equipment • Cables /Cords • Cell Phones • Hard Drives • Refrigerators • Televisions	• Any University purchased property that **has not** been removed from inventory • Items from outside the university community

APPENDIX C

This is a potential flier created to be posted near waste disposal systems. It was created by members of ReSET (Recycling Sustainability Events Team).



APPENDIX D

This is a list of electronic items and ink cartridges that were taken out of the sample after being weighed and have been recycled properly.

- Ten double-A batteries
- Three cords
- Five ink cartridges
- A pair of headphones
- A calculator
- A smartphone battery
- A water filter*

**not an electronic or ink cartridge but can be shipped back to the facility by the purchaser for proper disposal*

APPENDIX E

COMMUNICATIONS PLAN FOR RESIDENTIAL AREA AT UMBC

Composting

In the apartments, a composting dumpster could be placed at the central locations for trash and recycling so that all collection containers are together. Signs could be placed in and around the apartments so that students would be more aware of how to dispose of their waste, as there is not as much of a Residential Life staff presence in the apartments as there is in the residence halls. Composting in the residence halls, where waste is disposed of on a floor-by-floor or wing-by-wing basis, might be more complicated. To install composting bins on each floor could be cumbersome, but it is possible. Recently, UMBC switched from single-stream recycling to dual-stream recycling, so paper bins were installed on each floor. Facilities Management could complete the same process for composting bins. In order to alter the student culture in terms of waste disposal and sustainability, there would need to be an educational and motivational component overseen by Residential Life and its employees (such as Resident Assistants and Community Directors). A half-hour training about what and how

to compost could be incorporated into Residential Life employees' trainings at the beginning of the year to enable the employees to answer residents' questions. This could be a crucial step in changing the student culture.

Recycling

The details of recycling should be made more visible with signage and instruction. The fliers that were made available online (Appendix C) could have been helpful, but did not specify what is recyclable. A condensed version of Appendix B could be given to students or posted on floors.

Paper and Cardboard

There were paper disposal bins on the floors of the residence halls, but it was unclear what should be done with cardboard. Jimmy Reyes, supervisor of ABM, the cleaning company at UMBC, stated that students could place their cardboard beside waste bins in residence halls and the workers would dispose of it correctly. However, there were only two cardboard dumpsters in the entire residential area, and there was no way for any student to know how to properly dispose of their cardboard. If the recycling program continues to improve, there should be a better-defined disposal area for cardboard on each floor. In the apartments, there was not a way to dispose of paper or cardboard.

Final Recommendations

With a combination of social and quantitative analysis, better-structured educational programs could be implemented in the residential area of UMBC. Students could learn about the university's waste disposal system and become more environmentally conscious. More awareness and encouragement of action, such as in separating and disposing of waste properly, could instill habits in the residential students that they take with them when they leave the university, bringing sustainability beyond the campus and into society.

AUTHOR BIO

Alexa White is an environmental science major graduating in May 2015 with Spanish and music minors and an Honors College certificate. She aims to work as an environmental educator in Mexico or Panama through the Peace Corps.
She thanks the student volunteers for all of their contributions: Marina Nicholas, Kei Ellerbrock, Zoe Gensheimer, Valentino Wiebel, and Helen Twigg. She would also like to express her utmost appreciation to Glenn Cook and Donna Anderson of Facilities Management; Jimmy Reyes from ABM; Dana Boswell of the Ecosynth lab; her editor, Cameron Rhode; and her mentor, Dr. Erle Ellis.

EVALUATING THE SUCCESS OF QUESTION 6

A CASE STUDY OF ABORTION POLITICS IN MARYLAND, 1990-1992

CAITLYN **LEITER-MASON**

My interest in this topic was piqued by chance. As a sophomore, I interned in the Maryland House of Delegates during the session when the legislature passed marriage equality. After its passage, I was still worried that the upcoming referendum campaign would undo this progress. Trying to assuage my concerns, the delegate I worked for brought up the Question 6 campaign. "Marriage equality will pass on the ballot," she assured me, "Just look at how progressive Maryland voters were about abortion in 1992." This simple comment started my interest in 1992's Question 6 campaign which I had never heard of before. Two years later, when given the opportunity to pursue my own original research in my capstone class, I decided to come back to this story. Through books, journal articles, data, newspaper articles, and, most interestingly, oral histories, I was able to answer my own questions about this period in Maryland's political history and produce a work of original research that contributes to the ongoing conversation about abortion policy and direct democracy.

"Question 6, Chapter, Statewide Referendum, Abortion Law Revision: Revises Maryland's abortion law to prohibit State interference with woman's abortion decision before fetus is viable, or, under certain conditions, at any time and to provide certain exceptions to the requirement that a physician notify an unmarried minor's parent or guardian prior to minor's abortion; repeals pre-abortion information requirements about abortion alternatives; repeals some, and clarifies other, provisions related to abortion referral; requires that abortions be performed by licensed physicians; provides good-faith immunity under certain conditions to physicians performing abortions; authorizes State to adopt abortion regulations; repeals certain penalty and disciplinary provisions related to the performance of abortions."

Ballot Language of Question 6

INTRODUCTION

On November 3, 1992, 1.1 million Marylanders voted for Question 6 at their local polling place, making Maryland one of only seven states to have codified *Roe v. Wade* into their state laws ("State Policies" 1). The successful campaign waged by Maryland Democrats and pro-choice activists ensured that, even if the Supreme Court were to reverse *Roe*, women in Maryland would maintain the right to choose abortion during their first trimester. Despite its historic significance, the story of this campaign has been lost over the past two decades. With the resurgence of direct democracy being used to decide abortion policy at the state level in recent years, the story of Maryland's campaign can offer critical, reflective lessons on the topic.

This paper begins by connecting Question 6 to larger academic conversations about direct democracy and abortion policy and explaining the methodology that I use to approach this case study. I then explore the major developments and themes emerging from this research about the legislative and electoral processes from 1990 to 1992 that led to Maryland's current abortion policy. Ultimately, I argue that the Question 6 win in Maryland was the result of the

Democratic Party's advantage among voters in the state and the national political developments of the late 1980s and early 1990s. However, despite the temptation to cast the pro-choice win of Question 6 as a feminist victory, I plan on challenging that narrative by suggesting that the ostensibly supportive political establishment complicated and undermined pro-choice efforts. Without minimizing the importance of the protections that were gained in 1992, this case study elucidates a larger tension between feminist activists and systems of traditional political power that is still present in the pro-choice movement today.

METHODOLOGY

While a variety of sources helped me to investigate and illuminate this historical event, this paper's methodology is most significantly influenced by the research tradition of oral history. Oral histories in critical historical research are important sources because they "allow evidence from a new direction" (Thomson 28), expanding our understanding of the past to include lives and events beyond the usual dominant focus on political events and leaders. Research based on oral history generally delves deeper into social and cultural observations that are not captured by other methodologies. Practically, oral history interviews are longer than interviews used in other methodologies, lasting approximately two hours for a single session with some oral histories taking place in multiple sessions over the course of weeks or months (Oral History Association). Rather than asking interviewees to recount facts or provide objective analysis as researchers might in a structured interview, oral historians seek to extract knowledge and insight from the personal, subjective experiences of their interviewees.

The use of oral history in this project differed from the usual conventions in two ways. First, this research was on political history, while most oral histories delve into the social and cultural phenomena that have been previously overlooked in academia. However, I found that oral history brought out that "new direction" to our traditional understanding of government and politics (Thomson 28). My oral histories added a human element to the electoral data, legislative language, and newspaper articles. They provided insight into behind-the-scenes machinations, were more critically reflective than any official sources, and allowed the "opening up of important new areas of inquiry" (Thomson 29), which ensured that

this research paper would be contributing new knowledge, rather than aggregating and regurgitating official records and popular narratives. Second, due to the specificity of my project and the time constraints of my interviewees, my oral history interviews lasted for less than an hour. While my interviews were shorter than most interview sessions, they adhered to the most important principle of an oral history interview: their goal was "an in-depth account of personal experience and reflections" (Oral History Association).

My first oral history was with former state senator Barbara Hoffman, the lead sponsor of the pro-choice legislation (referred to as SB 162) that became Question 6 when petitioned to the ballot. I was connected to Senator Hoffman by a professor at UMBC who knew the former state senator. Senator Hoffman and I spoke on the phone for a little over 30 minutes. My questions for her focused on the legislative processes of 1990 and 1991, especially the filibuster of 1990 and the change in strategy between the two legislative sessions. Her insights about the role of the political establishment in eventually passing SB 162 and the political climate of the time were invaluable.

My second oral history interview was with Dr. Carole McCann, chair of the Gender + Women's Studies Department at UMBC, who was a volunteer with the Maryland chapter of the National Abortion and Reproductive Rights Action League (NARAL) during the campaign. We connected through my adviser when Dr. McCann expressed an interest in my project. We met in person at her office for about 45 minutes. My questions for her focused on what she remembered from the news and from NARAL Maryland about the passage of SB 162, as well as her memories from her Election Day volunteer work. Her experience was connected to the pro-choice activists in the state and provided more critical feminist insight into the tension between activists and the political leadership than did Senator Hoffman's institutional perspective.

In addition to these oral histories, my research is influenced by several accepted methodologies from political science. First, I analyzed regional newspaper articles from 1990 through 1992 about the legislative and electoral developments of SB 162 and Question 6. These articles mainly came from *The Baltimore Sun* and *The Washington Post*. The news coverage was helpful to both confirm and clarify the sequence of events as presented by my interviewees and to get a sense of the popular narrative about the issue at that time. Additionally, I examined campaign materials from 1992 provided by staff at Maryland NARAL.

I also cite secondary data, collected from two main sources: electoral data from the State Board of Elections and public opinion poll results from Gallup. The electoral data provides important information about the success of Question 6 in different counties across the state. The polling data from Gallup compares the public's opinions on *Roe v. Wade* and the legality of abortion from the late 1980s and early 1990s to the present day. This data is important to situate my research in the historical moment.

This diversity in sources ensures that this project does not simply reproduce a conventional narrative about the political process but critically engages different types of knowledge to produce a complicated but holistic view of the historical events between 1990 and 1992. From this new understanding, I could better identify the themes and lessons of the campaign.

LITERATURE REVIEW

While my original research draws on an oral history framework, much of the literature reviewed came from the disciplines of political science and legal studies. These bodies of research helped me to understand the historical context and many of the macro-structures that influenced the object of my case study.

Before 1973, there was no national standard for states' abortion policies. The majority of states prohibited abortion under any circumstance, while a few states were beginning to liberalize their laws. However, in their ruling on *Roe v. Wade* (1973), the Supreme Court asserted that state governments could not interfere with a woman's right to an abortion during the first trimester of a pregnancy. Many state governments opposed this decision and continued to try and restrict women's access to abortion through regulation. Between 1973 and 1989, the Court rejected these attempts in a series of cases.

This pattern changed in 1989 with *Webster v. Reproductive Health Services*, when the Court started to back away from the trimester standards that were key to the *Roe* opinion, ruling instead that they would consider abortion restrictions under a new, and less strict, fetal viability standard (Segers and Byrnes 5). This ruling scared many pro-choice activists who believed that this change in precedent might eventually culminate in the outright reversal of *Roe v. Wade*. Such a fear inspired a wave of efforts — including one in Maryland — to codify the 1973 protections into state law so that if the Supreme

Court ever fully reversed their decision, women in individual states would still have some protections (Arceneaux 376). Maryland's codification referendum closely followed similar successes in both Nevada in 1990 and Washington in 1991 (Ballot Initiative Strategy Center 1-2).

DIRECT DEMOCRACY AND POLICY-MAKING

An important theme in this history is the use of direct democracy to set abortion policy. The initiative and referendum are two tools of direct democracy: an initiative allows citizens to propose legislation for voters to approve or reject, and a referendum allows citizens to petition a piece of already passed legislation to the ballot in hopes of overturning it. Both tools have been used to legislate reproductive health policy in a number of states, most often by anti-choice activists seeking to place limits on women's access to abortion.

While the citizen approval of SB 162 on election day in Maryland is considered a pro-choice victory, the fact that the issue appeared on the ballot was a victory for abortion opponents. The referendum was meant to undermine and overturn the pro-choice progress made by legislators. In theory, the initiative and referendum are meant to increase opportunities for citizen engagement and improve public policy; however, there are serious problems with using direct democracy to set abortion policy. In her legal analysis, Carter identifies many arguments against the use of referenda on issues of abortion, including the "dangers of majoritarianism," "lack of education and participation," "lack of deliberation," and "danger to minority rights" (317-320). While proponents argue that direct democracy allows public opinion to more significantly impact public policy, Carter counters that "government was not set up to automatically implement the will of the people" (317), particularly when that majority will is used to limit others' rights, which is what often happens when a woman's right to an abortion is put on the ballot for voters to decide.

In a study of the link between the presence of direct democracy tools in a state's constitution and that state's abortion policy, Arceneaux finds that simply the presence or absence of referenda and initiatives in a state's constitution makes a difference, writing, "the majority of these non-direct democracy states are predicted to have abortion politics that are significantly different from what they would be if initiatives and referenda existed. Most, but not all, of these statistically significant deviations from public opinion resulted in abortion policy

that was less restrictive than predicted" (Arceneaux 383). States that do not allow for referenda are more likely to protect a woman's right to an abortion, whereas states that have direct democracy tools available to citizens are less likely to have these protections in their laws.

NATIONAL INFLUENCES ON STATE ISSUES

National influence on state elections comes in two major forms: national interest groups and national events (Roh and Haider-Markel 19). The decision in *Webster* influenced the timing of Maryland and other states' pro-choice codification efforts. In 1992, the Supreme Court continued their pattern of amending *Roe v. Wade* in *Planned Parenthood v. Casey*, allowing for even more restrictive abortion regulations. The outrage around this case was a rallying factor, especially because Maryland's referendum held that November was the first one after the ruling earlier that year (Carney 52). Another important factor was that 1992 was a presidential election year. Abortion received attention in this national contest along party lines, with the Republicans adopting a strongly anti-abortion platform and the Democrats, a pro-choice platform. The presidential election also meant that voter turnout was much higher than it would have been in 1990 or in 1994 (Roh and Haider-Markel 21).

Another significant influence comes from national special interest groups. The idealistic view of direct democracy often gives way to a less pure reality; referenda campaigns can be "an insidious form of elite manipulation in the guise of citizen-based democracy" (Arceneaux 373). Carter also refers to this phenomenon as the "professionalization of direct democracy, by which consultants and firms run initiative and referenda campaigns as they do candidate races" (319). This danger did not seem to have had a significant impact in Maryland. The pro-choice campaign was spearheaded by the Maryland chapter of NARAL, which raised over two million dollars for the campaign, recruited over 7,000 volunteers for Election Day, and worked with allies like the the state American Civil Liberties Union and local labor unions (Carney 54). The anti-choice Vote kNOw Coalition raised three million dollars, of which a significant amount was from the Catholic Church in Maryland. However, the same kind of national pro-life force that has been key in other abortion referenda campaigns, particularly in current electoral battles in the southern and western states, was absent in this race.

This research, which focuses specifically on the legislative and electoral processes of Maryland's codification, is a case study, compared to the broader theoretical research of the academic literature on abortion and direct democracy. In addition, my use of oral histories pulls in original evidence and experiences that add new knowledge to the conventional narrative. Looking at these sources together provides a critical understanding of Maryland's abortion politics and a more in-depth look at the way academic theories about abortion and direct democracy manifested in a specific state contest.

EVIDENCE

Examining both oral histories and secondary sources, I was able to extrapolate themes that explain why the Question 6 campaign turned out as it did in Maryland. I have divided these themes into enhancers and spoilers. Enhancers were factors that contributed to the pro-choice electoral success, including the political culture in Maryland, a disjointed opposition, and the historical context. Spoilers refer to the challenges that the pro-choice campaign faced, including the hesitant support from the Democratic establishment and a disconnect between pro-choice activists and political leaders. While Question 6 ultimately won by a landslide, by studying both enhancers and spoilers, a more complicated story emerges that illustrates tensions between feminist activism and political institutions and leaders.

ENHANCERS: POLITICAL DYNAMICS OF MARYLAND AND THE ERA

On November 4, 1992, the supporters of Maryland FOR Choice could breathe a sigh of relief. The pro-choice coalition had won the contest by 23.4 percentage points, with 61.7 percent voting for Question 6 and 38.3 percent voting against it. Question 6 won in 17 of Maryland's 24 county jurisdictions, including in 12 counties that supported Republican George H. W. Bush in the concurrent presidential election. While the Maryland FOR Choice coalition did not take victory for granted and organized a massive field operation, many factors inherent to Maryland's political culture, the historical context of 1992, and the state of public opinion on abortion contributed to this success.

POLITICAL CULTURE OF MARYLAND

Two main aspects of Maryland's political culture are relevant to the abortion politics of the early 1990s. First is the state's history on abortion policy. Maryland was one of 18 states to have laws supporting some level of abortion access before the Supreme Court's ruling in *Roe*. Maryland was not among the four states that repealed all restrictions to abortion, but it was among the 14 states that allowed abortion in cases of rape, incest, fetal deformity, or a risk to the woman's mental or physical health (Seegers and Byrnes 4). While this policy would ultimately be criticized and cited by pro-choice advocates in the 1990s as the reason the state needed stronger abortion protections, Maryland's early, if limited, embrace of abortion rights is worthy of note.

Second, Democratic dominance in Maryland politics is an accepted and persistent reality. The majority of Maryland's population lies in Baltimore City and four central counties: Baltimore, Howard, Montgomery, and Prince George's. The Democratic voters in these five jurisdictions largely control the result of statewide elections, which boded well for the pro-choice coalition because, while not perfect, there is a strong correlation between Democratic and pro-choice identification. In these five major jurisdictions, Question 6 scored huge wins: 70.1 percent of voters in Montgomery County voted for Question 6, and in the other counties and Baltimore City, the pro-choice cause scored at least 60 percent of the vote ("1992 Presidential Election Results" n.p.).

The statewide victory for Question 6 was further strengthened by some wins in Maryland's Republican counties. A majority of the other 19 smaller counties, which all supported Bush in the presidential election, voted for Question 6. In Frederick County, where Bush won 59 percent of votes, Question 6 won with 53 percent of the vote. In Talbot and Queen Anne's counties, Bush won nearly 60 percent of the vote — and so did Question 6 ("1992 Presidential Election Results" n.p.).

Maryland's Democratic advantage on its own probably could have carried the victory, but it was the additional successes in Maryland's rural counties that ensured the overwhelming win. Senator Hoffman (D-Baltimore City), the original sponsor of SB 162, explained the importance of these additional wins:

> I think it's [the Question 6 victory] fascinating because even in some counties that surprised me, like Calvert County, there was more for than against. Caroline County was split. Carroll County was a little bit more…Cecil County was a dead heat!…Unless you [the opponents] were going to rack up huge votes in the rural areas, you [the opponents] were not going to be able to win. And so it was actually the kind of victory that was needed in order to have this question [of abortion] not come up again.

Because the Question 6 win ended up effectively settling the question of abortion rights in Maryland, the referendum, which was initiated by anti-abortion activists, actually ended up benefiting Maryland's pro-choice movement. Over 20 years later, Maryland's abortion policy has not been significantly challenged. However, in today's political climate, many states where abortion rights are being put on the ballot do not have Maryland's advantage. While Question 6 may have been successful in Maryland, it would be irresponsible to suggest the referendum as a pro-choice tool in most other states.

DISJOINTED OPPOSITION

Contributing to the Question 6 win was the disorganization of the anti-Question 6 campaign. At first glance, the Vote kNOw campaign seemed like it could have gained traction among Maryland voters. The opposition did not present themselves as staunchly anti-abortion. Instead, they sold themselves as the reasonable alternative to extreme, pro-abortion advocates. Perhaps because of this nuance, the coalition, funded by the Catholic Church, was disconnected from both the Maryland Right to Life Committee and the more extreme Citizens Against Radical Abortion Laws (CARAL). The Right to Life Committee claimed to be too busy focusing on Bush's reelection efforts, and Vote kNOw intentionally distanced itself from CARAL (Carney 59-60).

Despite the anti-Question 6 campaign spending roughly three million dollars, a full million more than the pro-choice side, the money was not enough to overcome divisions among the already comparatively small numbers of anti-abortion voters in Maryland. And while the campaign was funded by Catholic leadership, it is less clear whether Catholic voters, who make up a significant portion

of Maryland voters, were similarly supportive. Senator Hoffman observed this in the initial debate in the General Assembly:

> I served in the legislature with…a very good Catholic and he was a pro-choice vote! He said, "Look, I know what the church tells me, and I know that the same grandmas that are in church cheering at the sermon about no abortion are the same ones that call me at midnight when their granddaughter gets in trouble." So he said, "You know, I just don't think that the government should put somebody's religious philosophy into law." So that was what was so interesting is that people tended to look at this issue, women certainly tended to look at it as what it would mean to me, and a lot of men looked at their daughters and their wives and their own life experiences and they either had compassion or sympathy or understanding or empathy for women's decisions or they didn't. And they did — I have to say most of them did.

The opposition campaign rejected the coalition approach that the pro-Question 6 campaign successfully embraced. Instead, Vote kNOw depended almost solely on Catholic money and separated from other anti-abortion organizations with greater grassroots reach.

Another example of the disjointedness among the opposition came in October 1992. The Vote kNOw campaign filmed an advertisement with renowned surgeon Dr. Ben Carson. The advertisement was an obvious appeal to African-American voters in Baltimore City, in which Carson, dressed in scrubs, encouraged voters "'not to be duped' when they vote on Question 6" with a tagline at the bottom of the screen that read "Vote Against Question 6" (Banisky n.p.).

Dr. Carole McCann, a volunteer with the Maryland FOR Choice campaign, described the memorable television advertisement:

> The other thing I really remember was the commercial that Ben Carson did…I remembered it because it was surprising. He, of course, is a hero of African American achievement in Baltimore. It was a very simple commercial, him just sitting on a stool, but you know it did the, "I've operated on newborn babies and…I know this is wrong."

Yet shortly after, Carson appeared at a press conference with Maryland FOR Choice to recant his apparent support of the anti-choice campaign. "My intention was not to make a campaign commercial. And, in fact, I did not understand that the tag line 'Vote Against Question 6' would be included in the ad," Carson told *The Baltimore Sun*, adding that he simply wanted to encourage citizens to research the issue before voting. The Vote kNOw Campaign fired back, alleging that Carson knew the intent of the commerical throughout the process and must have been "greatly pressured" to recant (Banisky n.p.).

Regardless of Carson's actual beliefs, the advertisement was "a major embarrassment for the Vote kNOw coalition" (Carney 62), a highly visible example of the campaign's, at best, disorganized and, at worst, deceitful operation. Combined with their smaller numbers of potential supporters, even before the results came in, the prospects for success of the anti-Question 6 campaign did not look strong.

HISTORICAL CONTEXT

Maryland's legislative and electoral battles for protected abortion rights took place at a time when many thought that the Supreme Court was poised to overturn *Roe v. Wade* in the near future. As explored in the literature review, the rulings in *Webster v. Reproductive Health Services* and *Planned Parenthood v. Casey* added to this growing concern. The Supreme Court had previously guaranteed the right to abortion during the first trimester and with some exceptions during the second trimester. With these new rulings, it was permitting a host of new restrictions that could delay or completely eliminate a woman's ability to get an abortion. Activists began to worry that the next abortion case might be decided in a way that revoked the rights established in *Roe v. Wade* altogether. The legislative sponsors of SB 162 were catalyzed to action by this realization as lead sponsor Senator Hoffman (D-Baltimore City) explains:

> What motivated me and Senator Hollinger was a really strong fear that the only thing that was providing women in Maryland access to abortion in reasonable time was *Roe v. Wade* and that there was this unease that the Supreme Court would in effect come back and alter *Roe v. Wade* and we would be stuck with our 1968 law that was pretty

> dreadful…My sense was that we had [a] really strong pro-choice majority in the House and Senate and it was worth trying to codify [the rights of *Roe v. Wade*].

This fear was also reflected in public opinion polling from the time. In 1989, Gallup reported that 61 percent of those surveyed did not want to see *Roe v. Wade* overturned, with 33 percent wanting the decision reversed and six percent with no opinion. In the late 1980s and early 1990s, the public was worried that the Supreme Court would reverse this popular decision.

The alignment of this referendum campaign with the 1992 presidential election led to a significant increase in voter turnout compared with non-presidential-election years. In 1992, nearly two million Marylanders went to the polls, a turnout of about 81 percent. However, in the election just two years earlier, barely 1.2 million voters cast a ballot, a turnout of only about 55 percent ("Abortion" n.p.). The increased turnout in 1992 is important because in heavily Democratic Maryland, a greater voter turnout means a greater Democratic turnout, which was important for the pro-choice coalition.

SPOILERS: TENSION BETWEEN THE POLITICAL ESTABLISHMENT AND FEMINIST LEADERSHIP

Despite ultimately succeeding, the pro-choice leaders and activists in Maryland still faced challenges during their fight for codification. Surprisingly, these obstacles came not from the anti-abortion movement but from internal struggles with ostensible allies. Tensions among Maryland's political leadership, pro-choice female senators, and feminist lobbyists and activists were significant. While these strained relationships did not ultimately doom the legislation, they did complicate and frustrate efforts.

WARY SUPPORT FROM THE DEMOCRATIC ESTABLISHMENT

Senator Hoffman and co-sponsor Senator Paula Hollinger believed that they had the votes in the House and the Senate to pass pro-choice legislation in the 1990 legislative session. And technically they did. However, they lacked one key asset: the support of Democratic leadership. Neither Governor William Donald Schaefer nor the powerful Senate President Thomas V. "Mike" Miller,

Jr. took a public stance on the issue. Their attempt at neutrality on this important women's issue "paved the way for a legislative fiasco" (Carney 55). Without their support, opposition in the Senate gained traction and Republicans held up the bill for eight days in what would become one of the longest and ugliest filibusters in Maryland's legislative history. Senator Hoffman recalls one of the worst days of the filibuster:

> It was personal… I came in one day, and there was a flier on everybody's desk with photographs comparing an aborted fetus to the death camps, to the gas chambers. That's beyond the pale…as it went on and got uglier and uglier…. it [the filibuster] was personally so wounding and so awful to be called names and have the Holocaust imagery and the baby killer, you know, all that. It was tough.

Eventually the filibuster ended and the bill was tabled until the next year. During the 1990 elections, NARAL Maryland and other pro-choice activists worked hard to ensure that four anti-abortion Senators lost their seats, securing a supermajority of pro-choice votes. Additionally, by January 1991, the legislative strategy for the bill had changed. Senators Hoffman and Hollinger were taken off of the bill and the Senate leadership took over the process. After the embarrassment of last year's filibuster, neither man — especially the Senate President — wanted to see a repeat performance by the opposition. The strong support of Senate President Miller and Governor Schaefer, combined with the new Senate, ensured passage. By the end of February 1991, SB 162 has passed and Maryland women had gained the right to an abortion regardless of the national verdict on *Roe v. Wade* (Carney 56-57).

However, the initial neutrality of the political leadership had delayed success for a year, and McCann remembers feeling skeptical about the true motivation of the leadership, even once they had come out in support of the bill. She explained, "I'm not sure how the referendum came about. I just felt that the powers that be conceded the referendum to get the heat off of themselves … and they wouldn't be implicated in the cost of supporting abortion rights" (McCann). While not a likely scenario, the fact that an involved and aware citizen felt this way implies a palpable ambivalence communicated by the leadership's neutrality and later reluctant support.

McCann also recalled Democratic officials actively trying to interfere with her poll work for NARAL Maryland on Election Day. "The Democratic Committeeman tried to do two things, engage me in conversation so I wouldn't be handing things to people…and then actively discourage me from participating," she explained. Combined with the hands-off approach by Democratic leaders in 1990, this anecdote raises questions about the sincerity of support by the political establishment for a cause that they ostensibly favored.

DISCONNECT BETWEEN POLITICAL LEADERS AND FEMINIST ACTIVISTS

While pro-choice lobbyists and operatives were instrumental in facilitating the defeat of key anti-abortion senators in the 1990 election that led to the 1991 success and did the bulk of the organizing in the 1992 campaign, they came into conflict with the sponsors of the bill and the political leadership in the legislative process. Part of this conflict came from a disconnect — the perspective from inside the system is different than the perspective of those pushing from the outside. Hoffman remembers this tension well:

> There was a funny scene that happened in the lounge when a lobbyist from NARAL, and I know her name but I'm not telling it… It's already halfway through [the filibuster], and she was saying our strategy was all wrong and we needed to do this and this and I looked at her and said, "Listen if you want to make policy, then run for office. Because right now we're the ones in the middle of this and you're not. So unless you have something useful to add, go away."

The conflict was not just over political strategy but also about the substance of the bill. In 1991, when the Democratic leadership took the bill away from Hoffman and Hollinger, they also gave in to a compromise provision that required parental notification for minors seeking an abortion unless waived by the medical provider (Carney 57). While generally understood to be a fairly weak notification law, there was still some concern from the feminist community about whether the compromise represented a larger problem with the change in strategy from 1990 to 1991.

In an opinion piece in the *Washington Post* entitled "The Proper Role of Men in the Abortion Debate," Feminist Majority Foundation president Eleanor Smeal was incredibly critical of the move that took leadership away from women in the Senate and that added this parental notification clause (Mann n.p.). She is quoted responding to the political events:

> It's a matter of men negotiating the rights of women and girls. The citizens have said they want it to be the decision of women. So who gets to vote on this? Men. In Maryland we have more women than in typical state legislatures and now the common wisdom is women should be quiet this year so they don't irritate the men…Of course we feel strongly about it [the parental notification clause]. We know that but for the grace of God there goes us at 17 or 18. Men can't feel that.

However, the women in the Senate and the leadership at NARAL responded less strongly to the clause and were even grateful that the bill was being championed by the leadership this year. Senator Hoffman responded to the critique by Smeal and others by explaining, "Sometimes your friends don't help. Like I told the NARAL lady to go away, I didn't care who the sponsor was. Did it make any difference? It didn't. It signaled that the leadership was going to push really hard on this, and this was a good thing." The Chair of the Women's Caucus, Senator Mary Boergers (D-Montgomery County), responded similarly in the press at the time, arguing that this shift in strategy was better for the women involved and for the bill, saying that "[The abortion debate] got to be a macho, male-female thing last year, and we don't need that again" (Tapscott n.p.). Even the NARAL Maryland President agreed, conceding that "It's unfortunate but it's still a man's world out there, and the General Assembly is very reflective of that" (Tapscott n.p.).

Ultimately, the pro-choice feminist establishment supported the Senate leadership and the bill, even with the parental notification clause. McCann remembers a NARAL meeting when they were talking about this decision:

> I remember being at a meeting where Maryland NARAL people were talking about whether or not the parental notification clause made a difference. Or if it was more

> show and less teeth, you know that it was worth it to get the rest of it in because it was a fairly mild notification — medical personnel were exempted if they thought it was not in the best interest.

In fact, the most skepticism that McCann came across was from her students:

> We made ourselves annoying by also arguing for Medicaid coverage which was totally not on it [the agenda]. So at UMBC with the students, the whole politics was around should we participate because this isn't radical enough, it doesn't go far enough because it doesn't support full access.

The Feminist Student Union at UMBC along with the many other pro-choice activists in Maryland ended up supporting the new bill during the 1991 legislative session and when it was brought to referendum in 1992. The criticisms and tensions that did arise were representative of the larger conflict between the perspective that comes from working inside the system for change and the perspective of those pushing from the outside.

CONCLUSION

In a political sense, there is no question that Question 6 was a victory for the pro-choice movement. As Senator Hoffman explained, the win was so large that it effectively settled the abortion issue for Marylanders. We have not had another serious challenge to abortion rights in our state since 1992. However, upon further examination, the success is bittersweet. The initial legislation only passed when the male political establishment put its weight behind the effort, and the bill only made it into law with a parental notification clause attached, even though Maryland is one of the most liberal states in the country. Divisions threatened relationships between elected officials and feminist interest groups and between state-level feminist organizers and the national feminist establishment. These divisions were never destructive because they were never too deep and because success was practically assured based on Democrats' political advantage in Maryland. In other states, however, these rifts could be much more damaging.

Across the country, abortion policies are being petitioned to the ballot. Over 20 years later, the same tensions explored in this paper

still exist. These tensions are understandable — there is a difference in the work that is done to bring change to an existing system and the work done to push that system to change from the outside. However, this case study illustrates that feminists should recognize that the issue of abortion access is too important to their cause to let these differences and tensions paralyze action. Feminists cannot and should not stop recognizing and negotiating this tension both in the field and in academia but must become more comfortable living in the tensions, acknowledging the limitations of both perspectives, and finding ways to bridge the divisions in their pursuit of the best public policy.

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AUTHOR BIO

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THE ROLE OF RpS9 IN RIBOSOME ASSEMBLY AND rRNA PROCESSING IN *SACCHAROMYCES CEREVISIAE*

ALANA **LESCURE**

Upon transferring to UMBC in fall 2012, I quickly determined that I wanted to participate in undergraduate research in the biology department. Shortly after I contacted and met with Dr. Lindahl, he agreed to mentor me. Dr. Lindahl introduced me to the project of graduate student Brian Gregory, who was studying ribosomal proteins in yeast. I collaborated with Dr. Lindahl and Brian Gregory to design a project that related to the lab's interests. This paper was written as part of my Honors Capstone Course thesis requirement, and it describes the research that I conducted on ribosomal protein S9 (RpS9). Ribosomes are molecular machines that translate mRNA sequences into proteins. The yeast ribosome is composed of four ribosomal RNAs (rRNAs) and 79 ribosomal proteins. Repression of individual ribosomal protein expression has been shown to inhibit ribosome biogenesis, and the focus of my research has been to determine the role of RpS9 in ribosome biogenesis. Using various molecular biology techniques including western blot, northern blot, and sucrose gradient fractioning on yeast strains in which RpS9 expression is repressed, I have been able to identify the need for RpS9 in rRNA processing and ribosome subunit formation.

ABSTRACT

RpS9, which is encoded by the gene *RPS9*, is one of 33 ribosomal proteins in the small subunit of the yeast ribosome. Previous studies have shown that ribosome biogenesis is severely inhibited when individual ribosomal proteins (r-proteins) on either the large or small subunit are depleted. However, the characterization of the exact roles of the different r-proteins in rRNA processing and ribosome assembly remains incomplete. This study shows through northern blot analysis and methylene blue staining of total RNA transferred to membranes that the depletion of RpS9 in the yeast *Saccharomyces cerevisiae* (*S. cerevisiae*) leads to a buildup of rRNA precursors as well as a loss of mature 18S rRNA. Additionally, sucrose gradient profiling and growth curve characterization show that RpS9 depletion leads to a loss of small subunit formation and a decrease in growth rate.

INTRODUCTION

Ribosomes are molecular machines that translate mRNA sequences into proteins and are composed of two subunits. In eukaryotes, the small 40S subunit (SSU), composed of one rRNA (18S) and 33 r-proteins, and the large 60S subunit (LSU), composed of three rRNAs (5S, 5.8S, and 25S) and 46 r-proteins, assemble to form the complete 80S molecule. The SSU is responsible for decoding the genetic code by bringing mRNA transcripts and tRNAs together, while the LSU catalyzes peptide bond formation and the extension of the peptide chain in the forming protein.

Research over the last several decades has provided significant insight into the biogenesis of ribosomes in bacteria, and more recent studies have begun to describe the process of ribosome biogenesis in *S. cerevisiae*. Some 200 proteins and small RNAs that do not become part of the mature ribosome are involved in converting pre-rRNA into mature rRNA, assembling ribosome structures, and transporting ribosome precursors out of the nucleus (Fatica and Tollervey, 2002; Fromont-Racine et al., 2003; Henras, 2008; Woolford and Baserga, 2013). The complexity and number of ribosomal factors, including the additional 79 r-proteins of the mature ribosome, make fully understanding ribosome biogenesis multifaceted, and warrant ongoing research.

Ribosome biogenesis is highly conserved in eukaryotes (Tafforeau et al., 2013). It begins with transcription by RNA polymerase I of a 35S precursor molecule that includes the sequences for the mature 18S, 5.8S, and 25S rRNA as well as transcribed spacers. The 5S rRNA precursor is transcribed separately by RNA polymerase III. Most of the steps of rRNA maturation occur in the nucleolus of cells. Further processing occurs in the nucleoplasm and subsequent processing occurs in the cytoplasm. The maturation process involves a series of cuts in the 35S precursor to remove the transcribed spacers that are not part of the mature rRNAs. These sequences include the 5′external transcribed spacer (5′ETS), internal transcribed spacers 1 and 2 (ITS1 and ITS2), and the 3′external transcribed spacer (3′ETS) (Figure 1) (Woolford and Baserga, 2013). The roles of the 200 non-ribosomal protein factors involved in rRNA processing have been studied, and many of their functions have been identified (Woolford and Baserga, 2013). For example, the early processing step of creating the 3′end of the 35S rRNA precursor is completed by the RNase III endonuclease Rnt1p (Kufel et al., 1999). The exonuclease Rat1 is responsible for trimming the 5′end of the 25.5S rRNA precursor to form the mature 25S rRNA (Geerlings et al., 2000). The proteins Nop15 and Cic1 have been shown to be important in preventing premature formation of the hairpin structure of ITS2 (Granneman et al., 2011). Interestingly, some studies show that one processing step enables another while other studies show that some early steps are not required for later processing to proceed (Lamanna and Karbstein, 2011; Vos et al., 2004; Torchet and Hermann-Le Denmat, 2000).

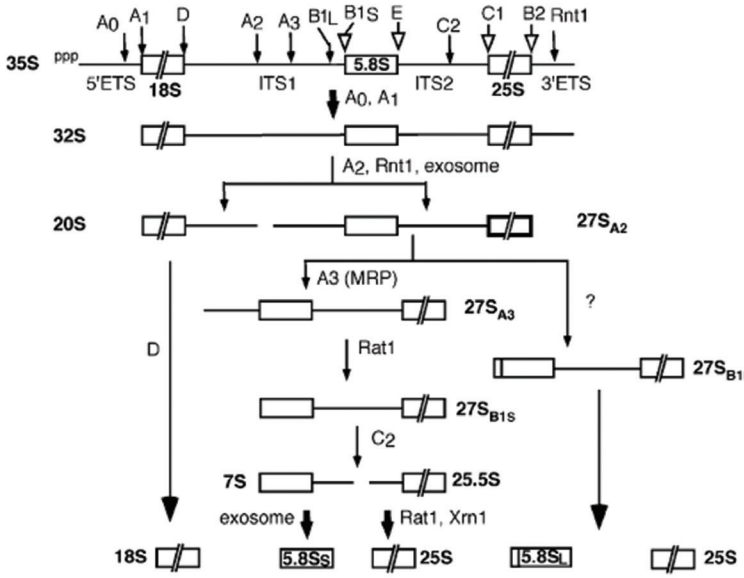

FIGURE 1. **SCHEME OF rRNA PROCESSING IN *S. CEREVISIAE* (MODIFIED FROM VENEMA AND TOLLERVEY, 1999; LINDAHL ET AL., 2009).** RNA polymerase I transcribes the 35S transcriptional unit that contains what will become the mature 18S, 5.8S, and 25S rRNA. RNA polymerase III transcribes the 5S precursor separately in the opposite direction. Much of the rRNA maturation occurs in the nucleolus of the cell with further processing occurring in the nucleoplasm and the cytoplasm. Sites of processing are indicated in the top row and include A0, A1, D, A2, A3, B1L, B1S, E, C2, C1, and B2. Arrows with solid heads denote processing sites that occur through endonucleolytic cleavage (Faber et al., 2006). Arrows with open heads denote exonucleolytic cleavage. Processing sites are labeled with standard nomenclature.

As with non-ribosomal protein factors, research on the role of the 79 r-proteins in ribosome biogenesis is incomplete. According to Steffen (2012), 64 of the 79 r-proteins are essential for cell growth. Based on this information, it is likely that r-proteins are important for rRNA processing, ribosome assembly, transport of ribosome precursors, stabilization of the subunits, and proper ribosome function. Various studies have repressed the expression of one or more r-proteins and observed the effect on ribosome biogenesis and cell growth. Thapa et al. (2013) found that after individually repressing 54 r-proteins, 18 60S r-proteins and 22 40S r-proteins resulted in cell cycle arrest and, in some cases, abnormal cell morphogenesis. Additionally, upsetting the production of r-proteins and other ribosomal factors alters the formation of one or both of the ribosome subunits as well as prevents the proper processing of rRNA precursors (Woolford and Baserga, 2013).

Repression of the r-protein RpL10 revealed that RpL10 is required for the export of the large subunit from the nucleus (Johnson et al., 2002). RpL5 and RpL11 interact in such a way as to stabilize 5S rRNA (Tsay et al., 1994; Mager et al., 1997). Furthermore, RpS15 was found to be required for late maturation steps in the nucleus that make SSU precursors competent for nuclear export (Leger-Silvestre et al., 2004). Repression of r-proteins has also been associated with rRNA precursor buildup, suggesting r-proteins are involved in the processing of rRNA (Ferreira-Cerca et al., 2005). Thus, it is hypothesized that many r-proteins of the SSU and LSU play important roles in ribosome biogenesis in addition to mature ribosome function and stability. Questions still remain as to what additional r-proteins, in addition to those already studied, participate in rRNA precursor maturation and whether they play a role at distinct steps in the maturation process.

It is important to understand the role of r-proteins and other factors in ribosome biogenesis because of both the importance of ribosome function for cell survival and the importance of understanding the various human diseases resulting from ribosome defects and deficiencies. Neurological disorders such as Huntington's disease (HD), Parkinson's disease (PD), and spinocerebellar ataxias (SCAs), as well as disorders associated with aging, are associated with defects in ribosome biogenesis. Additionally, cardiovascular disease and rare human genetic disorders such as Diamond-Blackfan Anemia (DBA) and Shwachman-Diamond syndrome (SDS) all have associations with rDNA and ribosome deficiencies (Lee et al., 2014; Hallgren et al., 2014; Tsoi et al., 2014; Hariharan and Sussman, 2014; Parlato and Liss, 2014; Woolford and Baserga, 2013). Research on ribosome biogenesis and specific r-protein function using *S. cerevisiae* as a model organism may provide insight into the causes, propagation, and treatment of disorders and diseases linked to ribosome defects. The study described in this paper provides a better understanding of the role of RpS9 in ribosome biogenesis by depleting RpS9 from yeast cells for 16 hours.

MATERIALS AND METHODS

YEAST STRAINS AND GROWTH CONDITIONS

The yeast strain Y259, as described by Ferreira-Cerca et al. (2005), was kindly donated by Dr. John Woolford (Carnegie Mellon University). In Y259, both chromosomal genes encoding RpS9 were deleted and replaced with a plasmid-borne *RPS9* gene expressed from a galactose promoter. To verify that expression of this gene was under the control of the galactose-inducible promoter, PCR amplification of the DNA between the galactose promoter and the r-protein gene was performed (Md. Shamsuzzaman and Lasse Lindahl, unpublished results).

Cultures for northern blots, western blots, and sucrose gradient analysis were grown overnight at 30ºC in a YEP-Gal medium (1% yeast extract, 2% peptone, 2% galactose). These cultures were then diluted to an OD^{600} of 0.2 and grown at 30ºC to an OD^{600} of ~0.8-1.0. OD^{600} was measured with a Hitachi U-1100 spectrophotometer. Depletions of RpS9 were achieved by shifting each of the cultures to a YPD medium (1% yeast extract, 2% peptone, 2% glucose) with a starting OD^{600} of 0.2 and incubating them for 16 hours. 10-mL aliquots of each culture were spun at 8,000 rpm for 10 minutes at 4ºC for use in RNA preparation. The remaining volume of each culture was spun down with ice at 8,000 rpm for 10 minutes at 4ºC. The resulting pellets were washed with 10 mL of cold, sterile water, transferred to a new 15-mL Falcon tube, and spun at 8,000 rpm for 10 minutes at 4ºC. All pelleted cells were stored at -20ºC.

Cultures for growth curves were grown for 16 hours at 30ºC in YEP-Gal medium, diluted to an OD^{600} of ~0.1 (as measured with a Hitachi U-1100 spectrophotometer), and grown at 30ºC to an OD^{600} of ~0.35. Aliquots of 5.0 mL of 2% YEP-Gal as well as 5.0-mL aliquots of YPD were inoculated with yeast cultures to a starting OD^{600} of ~0.05 as measured with a SPECTRONIC 20+ spectrophotometer. The cultures were grown for 16 hours with OD^{600} readings taken every 2 hours. At the 8-hour time point, the controls (YEP-Gal cultures) had absorbances of ~0.7 OD^{600} and were diluted to absorbances of ~0.1 OD^{600} by transferring 0.714-mL aliquots of each culture to new tubes containing 4.286 mL of YEP-Gal medium. To account for this during statistical analysis, the absorbance for each of the control readings after 8 hours was multiplied by the dilution factor of 7.

SUCROSE GRADIENTS

Sucrose gradients were prepared by layering 1.9 mL of 50% sucrose in gradient solution (50 mM Tris acetate pH 7, 50 mM NH_4Cl, 12 mM $MgCl_2$, 1 mM DTT, d_2H_2O) under 2.5-mL layers of 40%, 30%, 20%, and 10% sucrose, each in gradient solution, in Beckman SW40 tubes. After the addition of each layer, the tubes were stored at -20ºC for 15 minutes prior to application of the following layer. Yeast polysomes were prepared by resuspending pelleted cells in 1.25 mL of lysis buffer (50 mM Tris HCl pH 7.5, 30 mM $MgCl_2$, 100 mM NaCl, 50 µg/mL cycloheximide [in EtOH], 200 µg/mL heparin) containing 62.5 µL of 10 mM VRC. Cells were then lysed by vortexing the cell suspension at maximum speed with 3.0 g of Sigma 0.5-mm acid-washed glass beads. The lysates were further diluted with another 1.25 mL of lysis buffer and centrifuged for 5 minutes at 4ºC at 6,500 rpm in a Beckman J2-21 centrifuge with a JA-17 rotor. An aliquot of lysate corresponding to 20 A_{260} units as measured by a NanoDrop Lite spectrophotometer was pipetted on top of each of the 10-50% sucrose gradients. The gradients were centrifuged at 40,000 rpm for 4 hours at 4ºC in a Beckman Optima XL-100 K ultracentrifuge with a SW 40 Ti rotor. Fractions were collected using an ISCO gradient collection system equipped with a flow colorimeter set to 260 nm. The A_{260} trace was collected using PeakTrak software.

RNA PREPARATIONS AND NORTHERN ANALYSIS

Total RNA from yeast cultures was prepared by harvesting 5 mL of culture, pelleting the cells by centrifugation for 5 minutes at 8,000 rpm at 4ºC in a Beckman J2-21 centrifuge with a JA-17 rotor, decanting the liquid supernatant, and resuspending the pelleted cells in 1 mL of water. Cells resuspended in water were added to a tube containing 1.5 g of Sigma 0.5-mm acid-washed glass beads, 2.0 mL of water-saturated phenol, and 1.0 mL of TSEI-SDS (20 mM Tris HCl pH 7.4, 200 mM NaCl, 40 mM Na-EDTA pH 8.0, 10 g of 2.0% SDS) (Lindahl, 1992) preheated to 90ºC. The tubes were reheated in a 90ºC oil bath and vortexed at the highest speed 3 times for 30 seconds each time. The top ~1.5-mL layer was transferred to a 15-mL Falcon tube for EtOH precipitation. Nucleic acids were precipitated by adding 400 µL of 10.5 M NH_4OAc and 5.0 mL of EtOH and storing the solution overnight at -20ºC, or for 1 hour at

-80°C. The precipitate was collected by centrifugation at 4°C for 20 minutes at 8,000 rpm in a Beckman J2-21 centrifuge with a JA-17 rotor. The liquid supernatant was decanted, and the pellet was resuspended in 400 µL of water. The RNA was purified by adding 400 µL of a mixture of phenol, chloroform, and iso-amyl alcohol to the resuspended RNA. This mixture was vortexed for 20 seconds at high speed and centrifuged at room temperature for 5 minutes in a Heraeus Biofuge Pico microcentrifuge. The top layer was transferred to a 2-mL tube with 400 µL of a chloroform and iso-amyl alcohol mixture. The solution was vortexed for 20 seconds at high speed and spun at room temperature for 5 minutes in a Heraeus Biofuge Pico microcentrifuge. To further precipitate the RNA, the top layer was transferred to a 1.5-mL tube and mixed with 80 µL of 10.5 M NH_4OAc and 1 mL of EtOH. The tube was stored overnight at -20°C, or for 1 hour in -80°C, and then centrifuged for 20 minutes at 13,000 rpm at 4°C in a Heraeus Biofuge Fresco centrifuge. The liquid supernatant was removed, and the pellet was washed with 400 µL of 70% EtOH. The tube was then centrifuged for 15 minutes at 13,000 rpm at 4°C in a Heraeus Biofuge Fresco centrifuge. The liquid was decanted, and the remaining pellet was vacuum dried for ~15 minutes in a Savant SpeedVac concentrator. The pellet was resuspended in 50 µL of water. A spectrophotometer reading was done on samples using a NanoDrop Lite spectrophotometer. 20-µL samples containing 3.0 µg of purified RNA, the volume of which was calculated using the spectrophotometer reading, 2 µL of loading dye, and water (to bring reaction up to 20 µL) were placed in a BIO-RAD C1000 Touch thermal cycler to incubate the reactions for 10 minutes at 95°C. The samples were then cooled on ice for 5 minutes. The reactions were loaded and run on a 1% agarose gel for ~20 minutes at 250 V.

RNA was transferred under vacuum from the gel to an Amersham Hybond-N membrane for 2 hours using a Boekel Appligene Vacuum Blotter and kept moist by pipetting 20x SSC (3 M NaCl, 300 mM trisodium citrate, HCl pH 7.0) onto the gel during the transfer. Crosslinking of the RNA onto the Amersham Hybond-N membrane was done in a Fisher Biotech UV Crosslinker (model FB-UVXL-1000) for 2 minutes on the "optimal crosslink" setting.

After crosslinking, the membrane was washed with ~20 mL of a methylene blue mixture (0.02% methylene blue, 0.3 M sodium acetate pH 5.5) for 3 to 5 minutes and then rinsed with deionized water until the water was no longer blue after rinsing. Following

methylene blue staining, the membrane was incubated for 1 hour at 37°C in a Hybaid oven with 10 mL of hybridization buffer (0.3 M NaCl, 20 mM $NaPO_4$ pH 6.8, 2.5x Denhardt's Solution, 10% PEG 6000, 1% SDS, d_2H_2O), which had been warmed for ~3 minutes in a 60°C water bath. The probe was made by combining 2 µL of 10x TME, 1 µL of 20 mM spermidine, 1 µL of 50 mM DTT, 2 µL (50 µCi) of γ^{32}P ATP, 12 µL of water, 1 µL of 30 units/mg T_4 Kinase, and 1 µL of 80 ng/µL oligonucleotide. The oligonucleotide probes that were used were O1660, O1663, and O1680 (Figure 6B). The reaction mix was run in a Techne Genius thermal cycler for 30 minutes at 37°C and for 2 minutes at 68°C. 30 µL of 1x TME STE was then added to the reaction mix. 1 µL of the reaction mix was reserved for a radioactivity reading. The remaining 49 µL of the reaction mix was layered onto an illustra MicroSpin G-25 spin column and spun for 2 minutes at 2.8 rpm in a Heraeus Biofuge Fresco centrifuge. About 5 million CPM of radioactive probe (radioactivity measured by a Beckman LS Analyzer) was added to the hybridization tube with the membrane and returned to the Hybaid hybridization oven to probe overnight at 37°C. The membrane was then washed twice with 20 mL of oligonucleotide wash (0.05 M NaCl, 0.02 M $NaPO_4$ pH 6.8, 0.5% SDS) for 10 minutes in a hybridization oven at 37°C. After being wrapped in plastic wrap and placed in a sealed plastic bag, the membrane was exposed to a phosphor screen for a minimum of 4 hours.

YEAST PROTEIN EXTRACTION AND WESTERN BLOT ANALYSIS

The pelleted cells that had been stored at 80°C were thawed on ice. Yeast protein was extracted by washing cells twice with 1 mL of Buffer A (20 mM Tris HCl, 150 mM KCl, 5 mM NaCl, 0.1% Triton X-100, 10% glycerol, H_2O), resuspending the cells in 200 µL of Buffer A, and vortexing them with glass beads for 15 minutes at 4°C. The lysate was then spun at 13,000 rpm for 2 minutes, and the liquid supernatant was transferred to a new tube and spun for 20 minutes at 13,000 rpm. 22.5 µL of protein extract was combined with 7.5 µL of 1.6x sample buffer (20 mL of 100% glycerol, 5 mL of 2-mercaptoethanol, 30 mL of 10% SDS, 12.5 mL of upper Tris [4X]) in an Eppendorf tube and heated for 10 minutes at 95°C. 30 µL of each sample was run on a 12% polyacrylamide lower gel (d_2H_2O, lower Tris [4X], 30% acrylamide, 0.2% bisacrylamide, 10%

ammonium persulfate, TEMED) and stacking gel (d_2H_2O, upper Tris [4X], 30% acrylamide, 0.8% bisacrylamide, 10% ammonium persulfate, TEMED) in running buffer (25 mM Tris base, 190 mM glycine, 0.1% SDS) at 30 mA. The gel was then transferred to a PVDF membrane at 4ºC for 1 hour at 400 mA in transfer buffer (25 mM Tris base, 190 mM glycine, 20% methanol) in a PAGEgel transfer cell. After transfer, the membrane was rinsed in methanol followed by 5 five-minute washes with 20 mL of TBST (137 mM NaCl, 2.7 mM KCl, 19 mM Tris base, 0.1% Tween 20, HCl pH 7.4). The membrane was blocked using 20 mL of TBS, 0.1% Tween 20, and 5% dry milk for 1 hour on a rocker followed by incubation with either RpS9 or RpL5 primary antibodies (rabbit) and TBST in 5% dry milk for 1 hour. Next, the membrane was washed twice for 10 minutes with 20 mL of TBS and incubated with the secondary antibody (goat anti-rabbit) for 1 hour in TBS, 0.1% Tween 20, and 5% dry milk. The membrane was then washed 4 times for 20 minutes with TBS. CDP-Star substrate was applied to the membrane, which was then incubated for 3 to 5 minutes. The blot was exposed to a phosphor screen for at least 4 hours and scanned using a STORM 860 phosphorimager and STORM Scanner Control software.

RESULTS

GAL-PROMOTER CONTROL OF RpS9 EXPRESSION DISRUPTS Y259 GROWTH IN THE PRESENCE OF GLUCOSE

In the strain Y259, the chromosomal genes for RpS9 were deleted, and a gene for RpS9A was placed on a plasmid under the control of a galactose promoter. In order to characterize the growth and ribosome formation of this strain, Y259 was streaked onto agar plates containing either galactose or glucose as a carbon source. The plates were incubated at 30ºC for 48 hours. As was expected, colonies formed on the galactose medium, but there was no growth on the glucose plate (Figure 2). Further analysis of the effects of galactose-negative medium on the growth of Y259 was done by constructing a growth curve. Cultures in galactose medium showed regular doublings every 1.5 to 2 hours for the entire 16-hour experiment. In contrast, cultures that were shifted from galactose to glucose medium doubled once after the first ~2.5 hours and then had a decrease in the growth rate over the rest of the 16 hours (Figure 3).

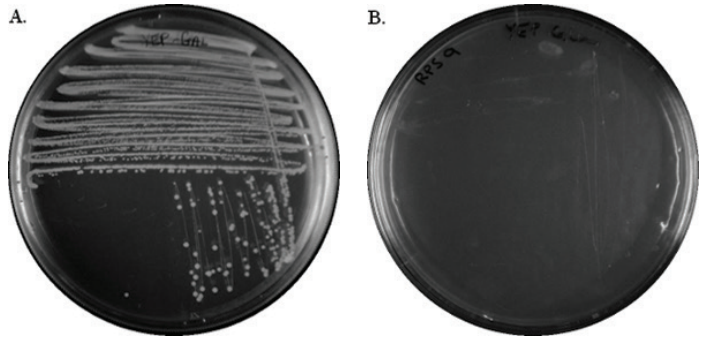

FIGURE 2. **DISRUPTION OF RpS9 EXPRESSION INHIBITS COLONY GROWTH.** Strains with RpS9 expression under the control of the galactose promoter were cultured either on a YEP-galactose medium (A) or a YPD (glucose) medium (B) for 48 hours at 30ºC. (B) Cells streaked on a plate with glucose as a carbon source did not grow colonies.

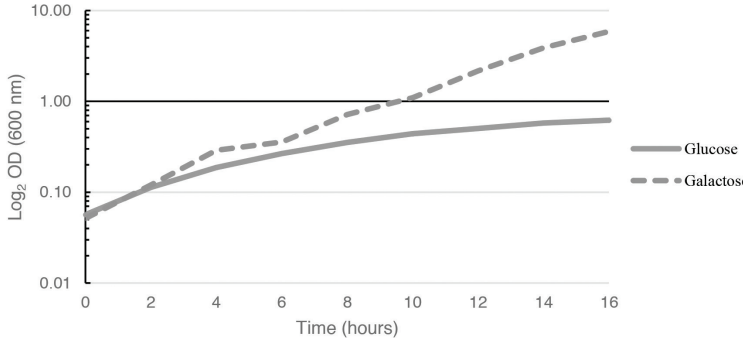

FIGURE 3. **GROWTH CURVE OF *S. CEREVISIAE* STRAINS WITH GALACTOSE PROMOTER CONTROL OF RpS9.** Y259 cultures were grown in either a YPD or a YEP-galactose medium for 16 hours. Optical density (OD) was measured every 2 hours at a wavelength of 600 nm. The $\log_2$ of the OD was plotted along the y-axis. Galactose cultures were diluted after 8 hours from an OD_{600} of ~0.7 to an OD_{600} of 0.1. The OD_{600} measurements of points plotted after 8 hours for galactose cultures were multiplied by the dilution factor of 7 to normalize the data. Each data point represents the average OD of three trials. Time 0 on the x-axis is the time of dilution into glucose medium.

REPRESSION OF RpS9 ALTERS THE SEDIMENTATION PROFILE OF Y259

It was hypothesized that the absence of RpS9 would cause a disruption in the formation of 40S subunits and would therefore disrupt the formation of the 80S ribosome complex. To examine the effects of inhibition of RpS9, cultures of Y259 growing in galactose medium were switched to a glucose medium for 16 hours, and the contents

of ribosome particles from each sample were displayed on a sucrose gradient (Figure 4). Extracts of Y259 grown in galactose medium produced a sedimentation profile with distinct peaks for the 40S and 60S subunits, 80S ribosome, and polysomes (Figure 4A). Repression of RpS9 expression by growing cells in glucose for 16 hours resulted in an unusual profile (Figure 4B) compared to the control profile. There was an apparent loss of 40S subunit production and a possible buildup of free 60S subunits. Interestingly, a peak in the RpS9-depleted cells appeared in the density region corresponding to the area between the 40S and 60S subunits in the control profile. Further analysis of the gradient fractions is needed to characterize this peak.

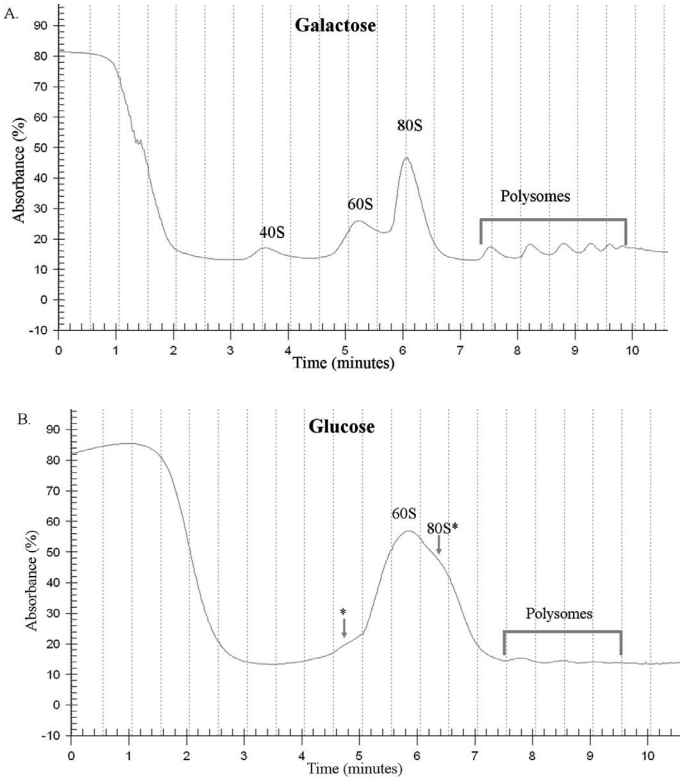

FIGURE 4. **EFFECTS OF RpS9 DEPLETION ON RIBOSOME SUBUNIT FORMATION IN Y259 STRAINS.** Whole-cell lysates from cells grown in either galactose (A) or glucose (B) were sedimented in 10% to 50% sucrose gradients and subjected to sedimentation analysis. (A) Peaks that represent fractions containing the 40S and 60S subunits, 80S ribosome, and polysomes are indicated. (B) Asterisks denote fractions that require further study because of their variability from the peaks seen in the control (galactose) cultures.

NORTHERN ANALYSIS REVEALS A BUILD-UP OF rRNA PRECURSORS IN RpS9-DEPLETED CELLS

To further investigate the effects of RpS9 depletion, the total RNA from cells grown in either a galactose or a glucose medium was run on an agarose gel and transferred onto a membrane. Prior to incubating the cross-linked membrane with radiolabeled oligonucleotides, the membrane was washed with methylene blue to characterize total RNA transcription levels (Figure 5). Odd-numbered lanes show total RNA levels from Y259 cultured in YEP-galactose, and even-numbered lanes show total RNA levels from cells cultured in YPD. Cultures of Y259 in glucose medium (even lanes) show a loss of the 18S rRNA, but they also show that rRNA transcription remains active because bands for the 25S rRNA remain. rRNA precursors were detected by probing the membrane with radiolabeled oligonucleotides complementary to different nucleotides within the 35S transcript (Figure 6B) (Lindahl, 2009). All three probes revealed a loss of rRNA processing in Y259 cultures after having repressed expression of RpS9 for 16 hours (Figure 6A). Lane 2 showed a loss of the 7S rRNA precursor as a result of RpS9 depletion. Similarly, lane 4 showed a loss of the 20S rRNA precursor, and lane 6 lacked the 27S precursor.

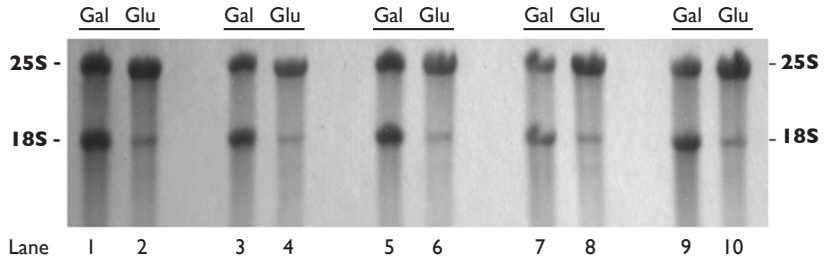

FIGURE 5. **METHYLENE BLUE STAINING OF TOTAL RNA EXTRACTS REVEALS A LOSS OF THE 18S rRNA.** Y259 strains were cultured in either galactose (odd-numbered lanes) or glucose (even-numbered lanes) for 16 hours, and total RNA was extracted. RNA was run on an agarose gel and vacuum transferred to a membrane. Prior to northern blot analysis, the membrane was stained with methylene blue. Methylene blue staining revealed that rRNA transcription continues when RpS9 is repressed, but also that the 18S rRNA was depleted (even-numbered lanes).

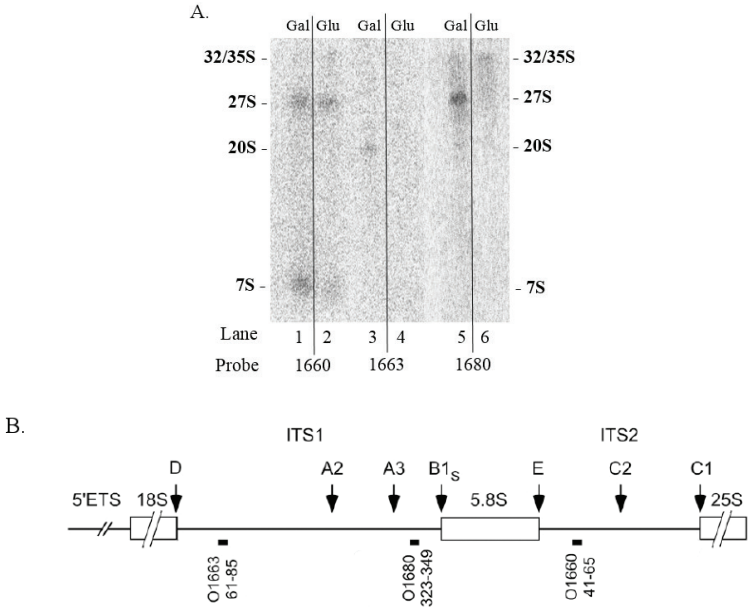

FIGURE 6. **PROBING FOR rRNA INTERMEDIATES REVEALS A LOSS OF rRNA PROCESSING AND A BUILDUP OF rRNA INTERMEDIATES.** Northern analysis of Y259 strains was performed using radiolabeled oligonucleotides complementary to segments of rRNA precursors according to the nucleotides indicated in (B). (A) Y259 cultures were grown in either YEP-galactose (odd-numbered lanes) or YPD (even-numbered lanes) for 16 hours, and total RNA was analyzed. Lane 2 shows a loss of the 7S rRNA precursor, lane 4 shows a loss of the 20S rRNA precursor, and lane 6 lacks the 27S precursor. Significant background noise is apparent, and it causes the bands to be less clear. It is possible that the buffers used were not optimal, and steps will be taken in future trials to improve the clarity of the bands. (B) A map of the complementary binding sites of the oligonucleotide probes on the 35S pre-rRNA transcript (as presented by Lindahl, 2009).

REPRESSION OF RpS9 PRODUCTION LEADS TO A LOSS IN OVERALL AVAILABILITY OF EXISTING RpS9 IN THE CELL

Western blot analysis was performed on the proteins purified from whole-cell lysates of Y259 cultured in either YPD or YEP-galactose for 16 hours (Figure 7). A decrease in RpS9 signal was observed in cultures grown in YPD after probing with anti-RpS9 antibodies (Figure 7B). Probing with anti-RpL5 antibodies, however, did not reveal any decrease in the amount of RpL5 in the cell extracts (Figure 7A).

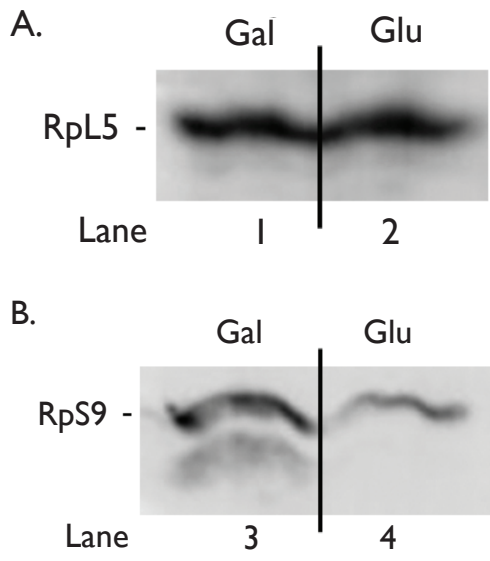

FIGURE 7. **WESTERN BLOT ANALYSIS OF PROTEIN EXTRACTS FROM WHOLE-CELL LYSATES OF Y259.** Cultures of Y259 were grown in either YPD (lanes 2 and 4) or YEP-galactose (lanes 1 and 3) for 16 hours. Anti-rabbit RpL5 (A) and anti-rabbit RpS9 (B) primary antibodies were used. (A) Repressing RpS9 expression had no effect on RpL5 detection by the antibody. (B) Repression of RPS9 through the galactose promoter led to a decrease in RpS9 protein (lane 4). The lower band in lane 3 is thought to be non-specific due to cross-reaction with the S9 epitope (the N-terminal 20 amino acids).

DISCUSSION

R-proteins play an important role in the growth and survival of cells (Steffen, 2012). A few of the 33 small subunit r-proteins in *S. cerevisiae* are reportedly dispensable, but the majority of the 40S proteins are required for the processing and maturation of the 18S rRNA as well as for ribosome assembly and nuclear transport of the ribosome precursor particles (Ferreira-Cerca, 2005; Woolford and Baserga, 2013). The current study provides evidence that the small subunit protein RpS9 is among the eukaryotic r-proteins required for cell growth, ribosome assembly, and rRNA processing.

In Y259, the gene for RpS9 is under the control of the galactose promoter, and work done prior to the current study confirmed that expression of RpS9 ceases in the absence of galactose (Thapa et al., 2013). Y259 colonies did not form on a solid YPD medium after 48 hours, revealing that RpS9 is essential for the growth of *S. cerevisiae* (Figure 2B). Growth in liquid YPD was monitored over

the course of 16 hours after the colonies were shifted from liquid galactose medium. While the number of Y259 cells in YEP-galactose continued to double every 1.5-2 hours, the growth rate of Y259 decreased gradually after the shift to YPD (Figure 3). The initial doubling and continued growth of the YPD cultures was likely due to the presence of ribosomes that were synthesized before the shift to glucose.

The results presented here agree with those of previous studies in that they demonstrate the importance of small subunit r-proteins, particularly RpS9, in the formation of the small subunit and mature ribosome (Pérez-Fernandez, 2007; Woolford and Baserga, 2013). Sucrose gradient profiling of Y259 cultured in YEP-galactose yielded distinct peaks for the 40S and 60S subunits, complete 80S ribosome, and polysomes (Figure 4A). In contrast, Y259 grown in YPD for 16 hours showed a loss of the 40S subunit and a buildup of free 60S subunits (Figure 4B). Furthermore, extracts of Y259 grown in glucose yielded an abnormal peak that corresponded to the fraction between the 40S and 60S subunits in the control profile (denoted by an asterisk in Figure 4B). The 60S peak in Figure 4B also contains a "shoulder" that is of interest (denoted by 80S*). Further analysis of these fractions is needed to classify their composition. It is possible that they contain an unidentified small subunit precursor that does not undergo complete processing without RpS9. Future experiments will involve flow cytometric analysis and probing gradient fractions for rRNA and protein components to identify these structures.

Methylene blue staining and northern blot analysis of RNA extracted from cells in which RpS9 expression had been repressed permitted study of the effects of RpS9 on rRNA processing. Methylene blue staining revealed a consistent loss of the 18S rRNA in all of the cultures grown in YPD (Figure 5, even-numbered lanes). This result is in agreement with results of previous studies in which knocking out individual small subunit r-proteins led to a decrease in 18S rRNA (Ferreira-Cerca et al., 2005). The 25S rRNA levels did not change when the cultures were shifted to YPD, which suggests that rRNA transcription remained on and that rRNA processing was inhibited.

Using probes mapped to nucleotides on the 35S pre-rRNA transcript (Figure 6B), it was determined that depletion of RpS9 results in a loss of several rRNA processing steps (Figure 6A). When expression of RpS9 was shut down for 16 hours, processing of the 7S, 20S, and $27SA_2$ intermediates occurred less frequently, which

suggests that RpS9 has more than one role in rRNA processing and ribosome assembly (Figure 6A, lanes 2, 4, and 6). The 27S transcript probed with O1660 is unchanged when RpS9 synthesis is repressed, while the 27S band visualized by O1680 is strongly reduced under RpS9 repression. Comparison with the processing scheme in Figure 1 shows that the abundance of $27SA_2$ goes down, while the abundance of 27SB does not. This finding agrees with previous studies that suggest that RpS9 and other SSU r-proteins associate with the 18S region of the 35S pre-rRNA transcript and help the rRNA fold into the proper conformation, particularly in ITS1 (Woolford and Baserga, 2013). In this study, the loss of newly synthesized RpS9 appears to affect the cleaving of ITS1, possibly at sites A_2 and A_3, by changing either the pathway or the kinetics of the canonical pathway.

Western blotting for RpS9 revealed a loss of stable RpS9 in the Y259 cultures (Figure 7B). It has been suggested that healthy cells form a reserve of free ribosomal proteins that are not immediately associated with an active ribosome. According to this hypothesis, when the cell undergoes stress, such as loss of RpS9 expression, the cell degrades its r-protein reserves to make better use of the amino acids elsewhere (Bursać et al., 2012). This is a possible explanation for the results seen in Figure 7B. The second r-protein, RpL5, was chosen because of previous studies finding RpL5 linked to pathways other than ribosome biosynthesis pathways, such as the apoptosis pathway (Bursać et al., 2012). Because RpL5 is known to associate with other pathways in the cell, it was expected that its levels would not decrease upon repression of RpS9 expression. As expected, RpL5 levels were the same in YPD and YEP-galactose media (Figure 7).

In summary, these findings confirm the importance of RpS9 and its continued expression for rRNA processing, small subunit formation, and cell proliferation. Discontinuing RpS9 expression causes a decrease in the abundance of existing RpS9; interruption of or change in 7S, 20S, and 27S rRNA processing; the loss of the 40S subunit; and cell death. Further studies will be necessary to elucidate the exact function of RpS9 in ribosome biogenesis. Future work will involve probing RpS9-depleted cultures for other regions within rRNA precursors to identify exactly which processing sites are affected by the absence of RpS9 (Figure 1). Additionally, western and northern blot analyses of sucrose gradient fractions will be performed to determine the protein composition of the abnormal particles described here (Figure 4B).

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AUTHOR BIO

Alana Lescure transferred to UMBC during her sophomore year from Harford Community College. In May 2013, Alana began working in the lab of Dr. Lasse Lindahl under the guidance of Ph.D. candidate Brian Gregory, both of whom she thanks for their training and mentorship over the past year and a half. She graduated from UMBC in December 2014 with a Bachelor of Science in Biological Sciences. She is currently employed as a Research Associate at the Lieber Institute for Brain Development in Baltimore, Maryland. Alana thanks Dr. John Woolford at Carnegie Mellon University for donating the yeast strain Y259, Dr. Lasse Lindahl and Brian Gregory for their mentorship throughout this project, and Drs. Richard Wolf and Thomas Cronin for their critical reading of this document. She would also like to thank Dr. Cynthia Wagner for her excellent advising and support during her time at UMBC. Finally, Alana would like to thank Dr. Laurie Host for introducing her to research and encouraging her to pursue it further.

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BENJAMIN WOODWORTH

EDITOR

Benjamin Woodworth is a member of the Honors College at UMBC and a student in the department of Modern Languages, Linguistics & Intercultural Communication where he focuses on the study of the Russian and French languages. As the editor for the arts, humanities and social sciences in Volume 16 of the *UMBC Review*, he has developed an interest in the editorial process and publishing in general, and will continue to pursue these along with his research after graduating in May 2015. Benjamin would like to thank Janet McGlynn, Devon Fick and the entire staff of the Office of Undergraduate Education for their technical support and guidance throughout the editorial process. His co-editor in STEM, Cameron Rhode, has also been very helpful in all aspects. Finally, he would like to thank the editors' faculty mentor, Dr. Susan McDonough, whose advice and guidance was crucial to working out problems great and small that arose during the editorial process.

CAMERON RHODE

EDITOR

Cameron Rhode is a junior biological sciences major, Spanish minor, and member of the Honors College. In addition to the *UMBC Review*, he has worked for two federal government agencies: the National Institutes of Health and the Consumer Product Safety Commission. Cameron could not have asked for a more capable, dedicated, and enthusiastic team with which to work during his first year as STEM Editor. He first thanks his faculty advisor, Dr. Susan McDonough, for her thorough knowledge of the entire process and eagerly-given support throughout it. He also greatly enjoyed working alongside, and is thankful to, fellow editor Benjamin Woodworth, whose amiability and diligence led to a natural, effective collaboration. Cameron is extremely thankful to the Office of Undergraduate Education (OUE) for its tremendous pride in this publication. This includes Janet McGlynn, whose mastery of the logistic and technical aspects of the publication process — including valuable and substantial insight during editing — was always welcome. Another colleague to whom Cameron extends his gratitude is Michael Mower, who works as the website technician for OUE. Michael's hard work on the *UMBC Review* website greatly facilitated the creation of this volume and is very much appreciated. Cameron looks forward to working as STEM Editor again next year.

DANIEL GROVE

DESIGNER

Daniel Grove is graduating in May 2015 with a Bachelor of Fine Arts in graphic design and a certificate in web development. Daniel was the design assistant for the previous edition of the *UMBC Review*, and is grateful for the opportunity of being this year's student designer, as it has been a challenging, yet rewarding experience. He wishes to thank everyone involved in the creation of this edition for all of their hard work. He would also like to extend his thanks to mentor Guenet Abraham for her dedication, persistence, and guidance, as well as giving him the chance to further learn and strengthen his design skills. He hopes that readers will enjoy this edition of the *UMBC Review*, and that students will continue to submit their work for future editions to come.

A Note from the Editors

As you have seen in this edition,
undergraduates on this campus carry out meaningful,
interesting research, and they enjoy doing so.
If, like the authors featured here, you are eager to share
your discoveries, please contact us at
umbcreview@umbc.edu
for information about submitting
to the *UMBC Review*.

We look forward to seeing your work.