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FROM OUR FACULTY

Writing is hard. Don't believe anyone who tries 3. to convince you that writing is effortless and easy for them! Whether it be scientific writing, creative writing, or journalism, writer's block is real and procrastination is a huge temptation. When I think about writing, I sometimes revisit a core memory of myself as a sophomore at Texas A&M in 2003, sitting in front of a blank computer screen with a 5-page term paper due for an English class the next day. That night was a coffee-fueled blur, but I got the job done well enough to pass the class. In the ensuing twenty years' journey from an undergraduate to a professor, I have come to learn that writing doesn't have to be scary and intimidating—it does get easier! Here are four tips and tricks I have learned along the way:

- Read more. The more you read, the more your writing will improve. I'm not just talking about specialized scientific literature or scholarly tomes (although your research advisor would probably like you to be familiar with those). Read whatever you enjoy! I like George R. R. Martin, Stephen King, and Cook's Illustrated, among others. Reading well-constructed prose expands your vocabulary and strengthens your ability to create an interesting narrative. Reading journal articles will give you an idea of how scientific "stories" are structured in your particular sub-field.
- 2. **Start with the Methods section.** For me, the easiest section of a manuscript to write is the Methods section. If you performed the experiments and/or analysis yourself, you can probably type out most of this section from memory, then go back and fill in the minor details later. You might even be able to write one or two whole pages in a single session. The dopamine surge that you get from making progress on an "easy" section of your work will lower your brain's motivational activation energy to tackle the "harder" sections (Trust me, I'm a neuroscientist).

- Are you a perfectionist? If so, I'm sorry—I know the struggle. Try to get into the habit of setting aside your perfectionism during the initial stages of writing. It is not a good use of your time to spend 10 minutes constructing a perfectly elegant, grammatically impeccable sentence. A better approach is to use the "stream of consciousness" method, getting all your thoughts down on paper without fretting over sentence structure. First, make sure you are communicating the essential points that you want to communicate. Later, go back and refine your grammar and style. Walking away from your writing for a few hours or days can give you fresh perspective when you return.
- 4. **Control your environment.** An environment free of noise and other annoyances is conducive to the most stress-free writing—if you have loud roommates or needy pets, find another writing sanctuary where you can get the most work done. These days, I like to write in my home office with my dogs lounging next to me, but as an undergraduate I loved working in Evans or the Medical Sciences Library.

Last but not least, remember to have fun. Writing can sometimes be a chore, but the payoff is always worth it. Now, get writing!



DR. JENNIFER DULIN Assistant Professor Biology, Texas A&M University

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ALLANDA DA

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By William J. Lourcey

"The province of Narbonensis . . . is a part of Italy rather than a province." So said Pliny the Elder about Gallia Narbonensis, today's South of France, containing the French provinces of Languedoc and Provence, including the French Riviera and the Lower Rhone Valley that were once core components of the Roman Empire.¹ Now the territory of yachties and impressionist painters, two thousand years ago the modern areas of Languedoc and Provence were home to key Roman ports, roads, and cities that left their mark on the landscape in the form of some of the best-preserved walls, temples, amphitheaters, and aqueducts in the Roman world. So integrated was this area into the Roman sphere of influence that they called it simply, Provincia, or the Province, which is the linguistic origin of the modern name of Provence.² After early Roman expansion and the assertion brought by Caesar during the Gallic Wars, colonization intensified, and by the end of the first century AD, Gallia Narbonensis practically became a part of Italy.

PREDECESSORS

Narbonensis was not always a core Roman area. For at least half a millennium it was the realm of the Gauls, the local Celtic tribes. The Romans called the place Gallia Comata (long-haired Gaul) in reference to the natives' bizarre hairstyles.³ Within a span of 200 years, the area was subdued and incorporated into Rome. However, this was not accomplished through sheer conquest, the Gauls themselves were an integral part of the process in incorporating themselves into Roman society. The example of Gallia Narbonensis' absorption typifies the Roman talent for adapting and assimilating foreign cultures into their own, using the resources and traditions of conquered peoples to not only control them but to make them Romans themselves. Both Romans and Gauls were active participants in this gradual process of assimilation, a so-called "Romanization" with Romans adapting Gallic elements and the locals becoming not Gauls but Gallo-Romans. Three aspects of Gallic society that Romans were able to adapt to their own advantage were strategic siting, the ability to provide drinking water, and co-option of the cultural elite.

"FOR AT LEAST HALF A MILLENNIUM [NARBONENSIS] WAS THE REALM OF THE GAULS, THE CELTIC TRIBES WHO LIVED THERE"

GEOGRAPHY

In real estate and warfare, the deciding factor is location, key for both trade and communication, two critical functions of the Roman Empire. When Rome entered the area known variously as Gallia Comata/ Transalpine Gaul/Gallia Narbonensis/Provincia (this place has seen its share of name changes), it encountered the Gauls, dozens of tribes from the umbrella of Celtic culture living in the vicinity.⁴ The primary outpost of Mediterranean civilization was Massilia (Marseille), a port established in 600 BC, which satiated the Gauls' taste for wine. Besides that, most Gallic settlements took the form of Iron Age hillforts, which were known as *oppida* (s.g -*um*).⁵ Once the Romans took control of Narbonensis between 123-118 BC, things changed. The Romans decided to construct major settlements in or near the former oppida, taking advantage of the Gauls' decisions of selecting defensible locations near ample water resources. The confluence of the Rhone and Saone rivers were a natural meeting point where the Celts traded with the Greeks, a fact upon which the Romans would capitalize. The Romans decided to use the previously established settlements, likely because there was no need to replace what had already been selected by the locals as optimal places for living.⁶ The town of Nimes, known to the Romans as Nemausus, was originally a Celtic oppidum constructed around a hill and a natural spring.7 The Romans built other future cities on the foundations of the Gauls. The town of Aquae Sextiae, modern Aix-en-Provence, is notable because it was the first Roman city founded in Provincia not established over Gallic foundations.8 Although the modern city of Lyon was not an oppidum by the time General Lucius Munatius Plancus founded Lugdunum in 43 BC,9 Greek potsherds and animal

fragments consistent with Celtic ceremonies have been located on the site, indicating pre-Roman presence.

WATER

Another reason why Nimes and Lyon were selected to become Provence's largest colonies boils down to the necessity of clean, fresh water. Fresh water would be essential for building a basis of urbanization for any Roman settlement: temples, baths, sewage, and decorative fountains, all key components of Roman culture and society. It just so happened that freshwater was a value shared by the Celtic peoples of Gallia Narbonensis.

In the oppidum that would become the city of Nimes, the Celts built the living spaces around a natural spring, which can still be seen bubbling from the Jardins de la Fontaine today. Taking advantage of this natural resource, the Gauls occupied the area and attributed the bubbling aquifer to a Celtic water goddess. When the Romans entered the picture, they adopted the name of this deity and incorporated it into the town's name—Nemausus. They also honored the sanctity of the spring, building a *nymphaeum*—an architecway that the Celts could not.

To satisfy Nemausus' needs, the Romans constructed an aqueduct of massive size. The nearest suitable aquifer to Nemausus was a mere 20 kilometers away. However, the presence of mountains and the Gardon River complicated the matter. The result was a diverted aqueduct, 50 kilometers in length, from the source to the settlement. Its centerpiece was the Pont Du Gard, a three-tiered trestle-like structure spanning the gorge in such an incredible manner that the structure is included on the cover of virtually every Latin textbook and guidebook to Provence. The Romans, however, barely looked twice at monumental works such as this-to them they weren't architectural marvels but mere solutions to natural obstacles—a pattern they repeated throughout their empire. The Romans took the resources first harnessed by the Celts, capitalized on them, and used that as a baseline to assert their own talents.

ASSIMILATION

The third, and perhaps the most important, way the Romans brought the Gauls into their fold was

tural sanctuary to water nymphs—on the site. The Romans saw the utility of the Gallic spring and used the groundwork laid by the Celts to build their new city, inspired by, and working alongside of, the Celtic tradition and adapting it for their own urban needs. However, Nemausus soon experienced expansion, outgrowing the water supply the spring could provide. The Romans had capitalized on the pre-existing Gallic infrastructure, but now it was time to implement trademark Roman engineering to quench the growing colony's thirst in a



Figure 1. Pont Du Gard. Photo by Will Lourcey.



stakeholders in the empire's wellbeing, and by extension, the rest of the Gauls would become invested in the empire's success. This is a significant demonstration of Rome's cultural power, seeing the conquered peoples willingly integrating themselves into the empire, no doubt influenced by Rome's excellent infrastructure, cultural sophistication, and advanced legal system.

In his speech, recounted on the Claudian Table, Claudius pleaded for the Gauls' inclusion into Roman society, citing their loyalty. Although they had fiercely combatted Julius

Figure 2. Claudian Table, Lugdunum Museum, Lyon. Photo by Will Lourcey.

convincing the local upper class of the benefits of Roman civilization. Say what you want about trickle-down economics, but the principle works perfectly in terms of culture. The behaviors and customs adopted by the elite often become mimicked by those lower down in the societal hierarchy, and this notion was utilized to full effect by the Romans. In the museum of Lugdunum, located in the city of Lyon that once bore that name, is a gigantic pair of bronze tablets in lostwax Latin text. This is the Claudian Table, a physical transcription of a speech given to the Roman Senate by Emperor Claudius, a native of Lugdunum, in 48 AD. In it, he proclaims his support for giving the Gallic elite full Roman rights that come alongside citizenship, access to the Roman judicial system, in particular.

This appears to be a calculated move on the part of Claudius and is consistent with Rome's policy of Romanization. This is a classic example of topdown diffusion, and if deliberately orchestrated by the Romans, shows a knowledge of how to use the Gallic elders' cultural dominance to assimilate the whole native population into the empire. By giving Gauls access to the perks of the Roman Empire, namely the legal system and the Senate, the Gallic elite would be Caesar's conquests, he concedes, "let also be put into the balance their unfailing loyalty of a hundred years, together with sorely-tried obedience in numerous critical circumstances for ourselves." The fact that this tablet exists and was probably posted at the federal sanctuary of the Three Gauls in Lugdunum implies that Claudius' efforts were successful, and this act likely earned the goodwill of the Gauls as well as ensnaring them deeper into imperial control.

"THE ASSIMILATION OF SOUTHERN GAUL WAS SO THOROUGH AND SUCCESSFUL THAT, BY THE FIRST CENTURY AD, IT WAS CONSIDERED AN EXTENSION OF THE ITALIAN HOMELAND ITSELF."

CONCLUSION

The process of Romanization is one that remained standard throughout Roman conquests across three continents and over half a millennium. The assimilation of Southern Gaul was so thorough and successful that, by the first century AD, it was considered an extension of the Italian homeland itself. This was accomplished by Rome's inherent ability to adapt and adopt the aspects of conquered cultures that they found practical and useful and in exchange offering its own sophistication and benefits of its civilization, so that people would willingly become a part of it. When Rome conquered a new territory, they did not seek to burn it all down and rebuild from scratch-they were much too pragmatic for that. They adopted the settlements the Gauls had already established in Gallia Narbonensis and used the pre-existing water supplies to fuel their growing cities. When the local springs became over-subscribed, the Romans used their own expertise to implement sweeping aqueducts. Finally, to secure influence over the general population, they gave the Gallic elite the full benefits of Roman civilization, ensuring that the populace that heeded their influence would be subservient and acknowledge their own place in the empire. The genius of Roman empire-building was so apparent that now, two thousand years after the fact, we see the people of this period who lived in Southern France not as Gauls who happened to be controlled by Romans but as Gallo-Romans.

ACKNOWLEDGEMENTS

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WILLIAM LOURCEY '25

Will Lourcey '25 is a History major with dual minors in Anthropology and Art History from Fort Worth, Texas who went to RL Paschal High School. Will works for the Department of Defense POW/MIA Accounting Agency as a History Research Assistant. He hopes to become a university-level history professor in the future.

Investigating the Role of ERBB2 in Mouse Colon Tumors

By Meghan Si

Photo by National Cancer Institute on Unsplash.

INTRODUCTION

Colorectal Cancer (CRC)

Colorectal cancer (CRC) is a worldwide epidemic. It is the second leading cause of cancer-related deaths in both men and women in the United States and its incidence is rapidly increasing in individuals under the age of 50.¹ By the end of 2023, approximately 153,020 individuals will be diagnosed with CRC with more than half dying from the disease, and out of all the individuals with CRC, 19,550 cases and 3,750 deaths will be from individuals below the age of 50.² Unfortunately, in addition to the shift in CRC diagnoses to a subset of younger individuals, the risk of CRC increases with age, broadening the age range of CRC

patients across the board. Age is one of the most important risk factors in many cancers, which holds true for CRC as well. Within a span of four years from 2011 to 2019, CRC rates increased by 1.9% per year in individuals who are younger than 50 years of age and in those aged 50–54 years.³ How-

ever, age is not the only factor that poses risk to the development of CRC. Many lifestyle-related factors have also been linked to CRC, including obesity, lack of physical activity, pro-inflammatory diets, smoking, and alcohol use.⁴ Most of these risk factors can be addressed by lifestyle changes, but there are risk factors that cannot be altered to increase CRC prevention such as age, personal history of CRC, inflammatory bowel disease, inherited gene mutations, racial and ethnic background, and type 2 diabetes.⁵

Epidermal Growth Factor Receptor Family (EGFR)

The epidermal growth factor receptor (EGFR) family consists of proteins that span the entirety of the cell membrane and mediate cell processes, namely receptor and signaling pathways. The EGFR family contains four family members, EGFR/HER1, ERBB2/

"AGE IS ONE OF THE MOST IMPORTANT RISK FACTORS IN MOST CANCERS, WHICH HOLDS TRUE FOR CRC"

HER2, ERBB3/HER3, and ERBB4/HER4, which have attracted interest due to their over-expression and involvement in tumor growth and progression in a variety of human cancers, including prostate,⁶ lung,⁷ breast,⁸ and CRC.^{9,10}

Although there has been a substantial clinical focus on EGFR over-expression in CRC patients, 85% of CRC patients are unresponsive to EGFR inhibitory treatments, suggesting that an alternate mechanism contributes to the continued tumor growth. A previous study in our lab investigated the environment of the intestinal epithelium in EGFR knockout mice and found that the mice developed fewer intestinal and colonic polyps but displayed a more aggressive growth phenotype than those developing with EGFR.¹¹ In that

> same study, it was found that the absence of EGFR triggered upregulation of ERBB4, which may result in signaling via alternate pathways that contribute to the increased growth and proliferation of polyps. A follow-up study in our lab investigated the role of ERBB3 in CRC, and it was found that the increase

in polyp number following a deletion of ERBB3 was caused by increased EGFR and ERBB4 expression.¹²

Compared to EGFR, ERBB3, and ERBB4, the involvement and molecular signaling pathways of ERBB2 that results in continued tumor growth in the intestinal epithelial of the colon remains largely unknown. To continue building on the established foundation of study of the EGFR family from our lab, we aimed to identify the process responsible for the continued tumor growth and proliferation in the absence of ERBB2.

Epithelial Mesenchymal Transition (EMT)

Normal epithelial cells are asymmetrical and are composed of a top edge, known as the apical surface, that is exposed to the open space within the in-



Figure 1. Structure of epithelial cells and progression of EMT from epithelial to mesenchymal state

testine or the external environment, in addition to a bottom edge, known as the basal surface, that sits on top of the basement membrane (Figure 1). Both sides define the polarity of the epithelial cells. Healthy epithelial cells are held together by cell junctions that link cells together, regulate homeostasis required for critical cell processes, and allow for normal cell proliferation.¹³ In contrast, mesenchymal cells are multipotent cells that self-renew, differentiate, and migrate throughout the body.¹⁴ The loosely organized nature of mesenchymal cells in the extracellular matrix of the cells adjacent to the epithelia contribute to and allow for its motile nature. Epithelial mesenchymal transition (EMT) is the transition from normal epithelial cells to mobile mesenchymal cells and is a critical process that occurs during embryogenesis and is silenced in adulthood. However, later on in life, certain circumstances can induce the reactivation of EMT, such as acute injuries, scars, collagen synthesis, and cancer.¹⁵ If induced, epithelial cells will undergo a series of changes to assume a mobile spindle mesenchymal cell phenotype, characterized by enhanced migratory capacity, invasiveness, increased resistance to apoptosis, and increased extracellular matrix components during growth and development.¹⁶ Once cancer cells with mesenchymal properties migrate to their new destination, they colonize the area by

METHODS

Animal Experiments

All animal studies were conducted under protocols approved by the Texas A&M University Institution Animal Care and Use Committee (IACUC) guidelines. The mice (n=30) were obtained from The Jackson Laboratory and were used in previous studies with EGFR and ERBB3.^{18,19} The mice were housed five per cage, fed the Purina Mills Lab Diet 2919 *ad libidum* and maintained at 22°C under a 12-hour light cycle. Prior to tissue collection, the mice were euthanized by CO_2 asphyxiation. Tumor tissue and its adjacent normal tissue was collected for downstream analysis.

Organoid Isolation

Fresh intestinal crypts from the colon of 100-day-old wild-type control ($Apc^{Min/+}$, $Erbb2^{ff}$, Tg(Vil1-Cre) and ERBB2-deficient ($Apc^{Min/+}$, $Erbb2^{ff}$) mice were isolated. The colonic tumors were removed, isolated crypts were suspended in Matrigel® Matrix, and 25µL of the matrigel-organoid mixture was plated into eight wells of a pre-warmed 24-well plate. IntestiCultTM Organoid Growth Medium supplemented

reverting back to their epithelial phenotype.¹⁷ Given that the plasticity of carcinoma cells works to their advantage to escape apoptosis (or cell death) during the stages of tumor progression, this is an avenue in ERBB2-deficient tumors our study aimed to explore.

Using previous research in our lab as a foundation, this current study aimed to determine: 1) if EMT is displayed and is the cause of tumor growth in the absence of ERBB2; and 2) other potential mediators of ERBB2-deficient tumor growth in mouse intestinal epithelial tissue. with penicillin/streptomycin mixed at a 1:1000 ratio was added to each well containing a matrigel-organoid dome. The medium was changed every other day, and the organoids were passaged by mechanical disruption one week after isolation or when they demonstrated dark, necrotic cores due to growth.

Transcriptomic (RNAseq) and Gene Set Enrichment Analysis (GSEA)

Ingenuity Pathway Analysis (Qiagen) and Gene Set Enrichment Analysis (GSEA) were used to analyze differentially expressed genes between wild-type and ERBB2-deficient mice.

RNA Extraction and cDNA Preparation

A total of 16 RNA samples from ERBB2 knockout (n=4) and control (n=4) mice were isolated from flash frozen tumors for downstream analysis. Total RNA for tumors was isolated. Total RNA was converted to cDNA to be used in quantitative polymerase chain reaction (qPCR).

Quantitative Polymerase Chain Reaction (qPCR) of EMT Markers

In general, polymerase chain reaction (PCR) is used to amplify target DNA sequences. Quantitative polymerase chain reaction (qPCR) allows us to visualize the amplification or level of expression of a particular target using a fluorescent marker. We performed qPCR analyses to validate EMT markers between ERBB2-deficient and wild-type littermate control mice. In this study, we examined the expression of two epithelial markers (E-cadherin and ZO-1), one intermediate marker (TWIST1), and three mesenchymal markers (TNF- α , N-cadherin, and Vimentin) with GAPDH serving as the control. The qPCR reactions (**Figure 2**) were

set up on 384 well plates and all the samples were run in triplicate. The level of expression of each EMT-signaling marker was quantified by $2^{-\Delta\Delta Ct}$ method. The significance of the data between the wild-type littermate control and ERBB2-deficient mice was validated via an ANOVA test, and significance between the adjacent normal tissue and tumor tissue samples were validated via the Tukey HSD test.

RESULTS

ERBB2 Intestinal Polyp Development

To investigate the role of ERBB2 in tumor growth in the colon, we used the $Apc^{Min/+}$ mouse model with an intestinal epithelium specific deletion of *Erbb2*. *Vill-Cre* and the conditional knockout allele of *Erbb2* (Apc^{Min/+}, Erbb2^{ff}, Tg(Vill-Cre)) and wild-type littermate controls (*Apc^{Min/+}*, *Erbb2^{ff}*) were used. At 100 days of age, all *Apc^{Min/+}* mice developed visible polyps (>0.5 mm in diameter) in the small intestine, regardless of genotype. It is known that most tumors in the *Apc^{Min/+}* mouse model occur in the small intestine with fewer tumors developing in the colon,²⁰ as seen in (Fig**ure 3A**); however, although the tumors that develop in the colon are fewer in quantity, they are larger and grow more aggressively in comparison to the tumors in the small intestine (Figure 4A and 4B), making this a promising mouse model to utilize.

Morphological Differences Between Wild-Type ERBB2 and ERBB2-deficient Organoids

Upon culturing and viewing the colonic epithelial organoids under a microscope, we observed a clear morphological difference between the wild-type control



Figure 2. Stepwise process of qPCR



Figure 3. Polyp number of wild-type ERBB2 compared to ERBB2-deficient in mouse intestinal epithelium. (A) Overall intestinal polyp number separated by region of the intestine; (B) Polyp number separated between the large intestines (colon) and small intestines (ileum, jejunum, and duodenum). Each dot represents polyp number in each 100-day-old mouse. Ns denotes no significant difference. **p-value<0.01, ****p-value<0.001.



Figure 4. Intestinal polyp size in mice lacking ERBB2 compared to wildtype ERBB2 in intestinal epithelium. **(A)** Average polyp size throughout each region of the intestine; **(B)** Polyp fraction by size. Black bars represent mean polyp size in Erbb2 wild-type mice and gray bars represent mean polyp size in Erbb2 intestinal epithelial-specific knockout mice. *p-value<0.05, **p-value<0.01, ***p-value<0.001.



Figure 5. Colon tumor organoids of Apc^{Min/+}, Erbb2^{f/f} mice

and ERBB2-deficient organoids. Typically, colonic epithelial organoids appear spheroid (**Figure 5**) in shape. However, the ERBB2-deficient organoids demonstrated an abnormal branching (**Figure 6**) phenotype in comparison to the wild-type organoids which is a sign of epithelial mesenchymal transition (EMT) signaling.

Transcriptomic Analysis (RNAseq)

To narrow down the potential mechanisms underlying the continued growth of tumors in the presence and absence of ERBB2, transcript data from colon polyps lacking ERBB2 was compared to polyps from littermates with wild-type levels of ERBB2, revealing 1157 genes characteristic of ERBB2-deficient colon polyps (**Figure 7**). Transcripts from the littermate



Figure 7. Transcriptomic analysis of ERBB2-deficient colonic polyps. Venn diagram of differentially expressed genes between wild-type and ERBB2-deficient colonic polyps compared to adjacent normal epithelium.



Figure 6. Abnormal branching of colon tumor organoids of Apc^{Min/+}, Erbb2^{f/f}, Tg(Vil1-Cre) mice

control and ERBB2-deficient mice were uploaded into the Ingenuity pathway analysis (IPA) (**Table 1**), a computer algorithm that indicates potential differentially expressed genes of interest.

Gene Set Enrichment Analysis (GSEA) Indicates Potential EMT Signaling

Gene Enrichment Analysis (GSEA) was performed, revealing differential expression of EMT markers between wild-type littermate control and ERBB2-deficient mice. The enrichment plot (**Figure 8**) for the $Apc^{Min/+}$, $Erbb2^{I/f}$ wild-type mice demonstrates that there is no significant EMT marker activity in both the adjacent normal tissue and the tumor. The enrichment plot (**Figure 9**) for the $Apc^{Min/+}$, $Erbb2^{I/f}$, Tg(Vil1-Cre) highlights significant EMT marker activity, specifically in the tumor tissue, alluding to the possibility of EMT signaling serving as the mechanism of ERBB2 independent tumor growth.

Quantitative polymerase chain reaction (qPCR)

The qPCR data indicates significant increase in expression of the mesenchymal marker Vimentin in the ERBB2 knockout tumor tissue compared to the wild-type tumor tissue. Additionally, there is over-expression of the mesenchymal marker TNF- α in the ERBB2 knockout tumor tissue compared to the wild-type tumor tissue with a p value of 0.11. Due to

Upstream regulator	Molecule type	Predicted activation state	Activation z-score	p-value of overlap		
EGFR	Kinase	Activated	3.822	3.22E-06		
AGT	Growth factor	Activated	3.756	2.25E-06		
Kianic acid	Chemical toxicant	Activated	3.647	3.59E-06		
TGFB1	Growth factor	Activated	3.597	5.75E-12		
NPM1	Transcription regulator	3.153	7.28E-06			
SP600125	Chemical drug	Inhibited	-3.331	1.23E-04		
NR3C1	Ligand-dependent nuclear receptor	Inhibited	-3.306	3.29E-07		
PTEN	Phosphatase Inhibited		-3.296	5.18E-04		
HNF4A	4A Transcription Inhibited		-2.969	7.09E-04		
Immunoglobulin	Complex	Complex Inhibited				

Table 1. Top activated and inhibited upstream regulators involved in progression of ERBB2-deficient polyps predicted by Ingenuity Pathway Analysis (IPA)

EGFR, epidermal growth factor receptor; AGT, angiotensinogen; TGFβ1, transforming growth factor beta 1; NPM1, nucleophosmin 1, NR3C1, nuclear receptor subfamily 3 group C member 1; PTEN, phosphatase and tensin homolog; HNF4A, hepatocyte nuclear factor 4 alpha







Figure 9: Enrichment plot for Apc^{Min/+}, Erbb2^{f/f}, Tg(Vil1-Cre): Hallmark Epithelial Mesenchymal Transition



Figure 10. Quantitative polymerase chain reaction (qPCR) data expression of EMT targets in adjacent normal tissue and tumor tissue of wild-type littermate controls and ERBB2-deficient mice. Apc^{Min/+}, Erbb2^{f/f} denotes wild-type ERBB2 mice and Apc^{Min/+}, Erbb2^{f/f}, Tg(Vil1-Cre) denotes ERBB2 knockout mice.

the nature of EMT progression, there was a subsequent decrease in expression of epithelial markers E-cadherin and ZO-1 in the tumor tissue of the ERBB2 knockout mice compared to the wild-type tumor tissue with p values of 0.34 and 0.96 respectively. Contrary to our hypothesis, mesenchymal marker TWIST1 was significantly overexpressed in the adjacent normal tissue of the wild-type mice compared to the tumor tissue of the ERBB2 knockout mice. On the same plane, mesenchymal marker N-cadherin, was overexpressed in the wildtype tumor tissue compared to the ERBB2 knockout tumor tissue with a p value of 0.89.

CONCLUSION

The process of EMT is highly stepwise in

nature and involves a spectrum of dynamic changes in response to various signaling pathways and transcriptional regulators. The hallmark of EMT is downregulation of E-cadherin, which is a major epithelial cell marker. The loss of epithelial cell markers, such as E-cadherin and ZO-1, and gain of mesenchymal cell markers, such as N-cadherin, $TNF-\alpha$, TWIST1, and Vimentin, are indicative of active EMT signaling and increased invasiveness of tumor growth.

Although the significant over-expression of the mesenchymal marker Vimentin is evident in the tumor tissue of the ERBB2 knockout mice, EMT signaling may be a potential mechanism for the continued tumor growth and proliferation in the colon. Further testing is needed due to the observed increased expression of mesenchymal markers, TWIST1, and N-cadherin in the wild-type tumor tissue. Additionally, upregulation of mesenchymal marker, TNF- α , and downregulation of E-cadherin and ZO-1, lacked statistical significance. Thus, further tests and experimental changes are necessary to definitively attribute polyp growth in the absence of ERBB2 to EMT signaling. Due to the progressive nature of EMT, it may have not been able to fully manifest in the colonic epithelium due to the euthanizing of mice at a young age of 100 days. Future directions include aging out the mice by waiting until they are a bit older to euthanize them and revalidating the chosen EMT markers by performing qPCR once again.

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Social Vulnerability and Policy: Changes Associated with Local Land Use in Kampen, the Netherlands

By Tyler Eutsler

Photo by Teunard Droog on Unsplash.

INTRODUCTION

Between 1980 and 2021, the estimated average cost per flooding event in the United States was \$4.6 billion.¹ The frequency, severity, and price tag associated with these billion-dollar disasters are increasing as climate change forces even inland areas to anticipate increased riverine flooding events. Over the last century, researchers and practitioners who work in hazards and disasters have come to understand that social vulnerability must be included in hazard-reduction research.² Empirical case studies have shown that socially vulnerable individuals and communities are disproportionately subjected to flooding catastrophes.

The Federal Emergency Management Agency (FEMA) defines social vulnerability as "the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood."³ Socially vulnerable populations also face greater challenges mitigating hazards and recovering from disasters.⁴ The societal need to protect socially vulnerable populations is unequivocally a concern that will have to be addressed within the U.S. as unprecedented disasters are expected to exacerbate inequities in the coming years.

Planning, specifically preventative land-use planning, plays a strong role in reducing vulnerabili-

"THE FREQUENCY, SEVERITY, AND PRICE TAG ASSOCIATED WITH THESE BILLION-DOLLAR DISASTERS ARE INCREASING AS CLIMATE CHANGE FORCES EVEN INLAND AREAS TO ANTICIPATE INCREASED RIVERINE FLOODING EVENTS" ty to hazards.⁵ Effective planning is a tool capable of increasing resilience—which is the "ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events."⁶ However, spatial incongruities and contradictions can exist amongst a community's network of plans, potentially exacerbating existing vulnerabilities or creating new ones, both physical and social.⁷ For example, a community's hazard mitigation plan could outline the need for reducing development in areas within proximity to flood plains. Meanwhile, comprehensive plans could guide future development into the same hazard zones.

The Netherlands stands at the forefront of flooding mitigation, where approximately 60% of the country is prone to flooding. With 26% of the Netherlands below sea level, the country not only has to deal with frequent flooding from the sea but riverine flooding as well.⁸ Comparatively, coastal counties in the U.S. are home to over 127 million people, nearly 40% of the nation's total population. To assess a communities' network of plans, the Plan Integration for Resilience Scorecard (PIRS) can be used to identify incongruities within networks of plans, integrate and improve local plans in ways that reduce losses from hazard events, and provide a guidance framework to reduce future hazard exposure.

METHODS

The data utilized in this study is from 2015 and 2020. Data was collected from several sources, including the Municipality of Kampen, the Ministry of Infrastructure and Water Management, and The Netherlands Central Bureau of Statistics (CBS). The study aims to identify and assess changes associated with local land use and zoning policy on socially vulnerable populations in Kampen, the Netherlands, using an adaptation of the PIRS method in additional community contexts. PIRS is the first of its kind utilized by planners and their communities to "reveal spatial incongruities in planning policies by mapping and overlaying policy districts with hazard zones."7 Using the same procedures of the PIRS method, this study deviates by spatially evaluating a single policy rather than a comprehensive list and then compares the change in assessed social vulnerability before and after the policy implementation in 2016 as an additional lens to determine the policy's associated effect on social vulnerability.

The goal is to highlight effective strategies that coastal regions of the U.S. could replicate in an effort to lessen the social and economic impact of flooding. The methods used in exploring the study consisted of five distinct steps:

- 1. Generate lists of applicable policies and select one for evaluation.
- 2. Determine planning districts, delineate flood zones, and map selected policy.
- Create tables, maps, socially vulnerable index (SVI), and policy scorecard. SVI is created by identifying the frequency that the thirty-two districts of Kampen report the eleven census variables in the highest quantile of occurrence within the municipality.
- 4. Assess social vulnerability to determine the effect of policy using **Equation 1**:

$$[V_{2020}{}^{\rm T}-V_{2015}{}^{\rm T}]-[V_{2020}{}^{\rm C}-V_{2015}{}^{\rm C}]$$

The single policy selected for evaluation is the "Deprogramming Housing 2016 Plan," the boundary of which encompasses twelve of the thirty-five districts of Kampen. These twelve districts are the "treated" districts and by comparing their change in SVI before and after the policy implementation (2015 and 2020, respectively) with the change in the 23 districts held "constant," the associated effect of the policy can be determined.

5. Compare the assessed effect on SVI with the policy of PIRS.

Step 1: Generate lists of applicable policies and select one to evaluate

At the time of the study, the network of plans for the municipality of Kampen had 190 destination plans, environmental permits, zoning amendments, and project decisions in effect, as well as nine preliminary plans in preparation for adoption by the Municipal Council. In selecting a single plan to evaluate, three criteria had to be met: the plan should be relevant, the plan must intersect with a hazard zone, and the plan must impact the way a community develops.⁹ The Deprogramming Housing 2016 Plan was selected as it met all criteria and was an "umbrella plan" that updated seven zoning plans currently in effect.

Step 2: Determine planning districts, delineate flood zones, and map selected policy

In step two, the 35 boundaries of Kampen's districts were identified and mapped via ArcGIS Pro software to understand social vulnerability change over time within the municipality. The administrative boundary of "district" is utilized for comprising the SVI and is a smaller geographic boundary of the municipality of Kampen, a province of Overijssel. Indicators in this study that contribute to the social vulnerability index are available at the district level via the Netherlands Statiskik de Bureau. Evaluating inequities at a municipality level of scale would be too broad to observe change across Kampen concerning local policy. The spatial information of flood probability was obtained through the Ministry of Infrastructure and Water Management and indicates flood chance per year from a possibility of less than a 1/30 to 1/30,000. The Deprogramming Housing 2016 Plan boundary was manually mapped within ArcGIS Pro to indicate which neighborhoods would have been directly affected by the plan's implementation. Of the 35 districts of Kampen, 12 were within the boundary and were primarily residential and downtown districts (Figure 1).



Figure 1. Kampen Districts and Boundary of the Deprogramming Housing 2016 Plan. 12 of the Kampen Districts are within the Boundary of the Plan and are considered the "treated" districts. The 22 outside the Boundary of the Plan are the untreated, or "constant" districts in this study.



Figure 2. Social Vulnerability Index (SVI) Illustrative Graphic. Although eight are shown, 11 indicators of Social Vulnerability utilized by the U.S. Center for Disease Control were taken and adapted (as necessary) to the Dutch Context. Each variable was evaluated individually via a choropleth, and the districts with the highest quantile (i.e. highest twenty-five percent of households around minimum income) received a "flag." The darker the shade of blue, the higher the quantile. All districts "flag counts" for each indicator of Social Vulnerability were then summed to create the SVI.

Step 3: Create tables, maps, socially vulnerable index (SVI), and policy scorecard

Creating the social vulnerability index of Kampen in Step 3 was done using 11 indicators of vulnerability that the U.S. Center for Disease Control utilizes. Adapted to the Dutch context, these indicators include the percentage of people 65 years of age or older, the percentage of non-western immigrants, and average income. Data from the Netherlands CBS was collected and spatially joined to the 35 districts previously established. Each of the 11 indicators of social vulnerability were ranked separately with the neighborhoods in the 75th percentile or higher receiving a "flag count." As Figure 2 illustrates, all social vulnerability variables were combined into a composite score and each district's "flag count" was summed to identify neighborhoods with higher proportions of social vulnerability (for illustrative purposes, only eight of the

11 indicators are shown). Due to data limitations on income variables, economic indicators were utilized from results in 2019 instead of 2020. Across the five years of 2015 to 2020 (on which the study is focused), neighborhoods with the lowest income and lowest average income remained constant. Additionally, by using the economic data of 2019, impacts of COVID-19 are removed as a disruptor to these findings.

The Deprogramming Housing 2016 policy was reviewed and evaluated based on whether the policy was exposing people or structures to a greater likelihood of flooding. Every district within the boundary of the policy received one of three scores depending on whether it increased vulnerability (-1), reduced vulnerability (+1), or had no perceived effect (0). As the selected policy is an umbrella housing policy updating seven existing zoning plans, the question asked in creating the scorecard was, "Does this policy encourage greater residential population density in flood zones?" **Figure 3** illustrates the procedure in which the adaptation of the PIRS method for the Deprogramming Housing 2016 plan was created and evaluated.

Step 4: Assess social vulnerability to determine the effect of policy using Equation 1

To determine the effect of the policy, it is necessary to establish a pre-intervention baseline before implementation of the Deprogramming Housing 2016 Plan. For the study, a comparison of the SVI was conducted between the years 2020 and 2015 for both the 12 "treated" districts within the policy boundary $[V_{2020}^{T} - V_{2015}^{T}]$ and the 23 "constant" districts outside



Figure 3. Plan Integration for Resilience Scorecard (PIRS). By combining the 35 districts, or neighborhoods, of Kampen with the municipalities flood risk and the boundary of the Deprogramming Housing 2016 plan the PIRS for the selected policy was created.

the boundary $[V_{2020}^{\ \ C} - V_{2015}^{\ \ C}]$. The average "flag count" was determined and the difference between the treated and constant values is the determined effect of the policy resulting in **Equation 1.**

Step 5: Compare the assessed effect on SVI with the policy PIRS

Lastly, the determined effect of the policy using the formula above was compared with the PIRS result of the Deprogramming Housing 2016 Plan in Step 3. As there is only one plan being evaluated using the PIRS method in this study, this comparison between policy score and effect of policy will provide an additional lens for validating the associated changes of the policy while also identifying contradictions potentially influencing vulnerability in the remaining 189 networks of plans within Kampen.

RESULTS

Figures 4 and **5** indicate the 11 indicators utilized for creating the SVI in 2015 and 2020 respectively, as well as the sum of the indicators each district received. In 2015, there were 27 districts with at least one flag count of social vulnerability. The number of districts with at least one indicator of vulnerability decreased to 22 districts in 2020. Since the Deprogramming Housing 2016 Plan went into effect, five neighborhoods have been removed from the index completely, indicating a reduction in social vulnerability for those neighborhoods.

2015 SVI Flag Count Table											
	0-15	65+	NonWestern	Multifamily	Rentals	Homes Occupied	Vehicles per household	Homes Before 2000	General Social Assiatance Benefits Lowest % of Household Income	Mean Income	2015 SVI TOTAL
Neighborhood Name											
Piecesta d Kamaan			X	x	×	x	×	x	x	x	~
Binnenstad Kampen			X	x	x		×	x	x	x	-
Ruppene		X	X	x	x		x		x	×	-
Collectrook			x		×		×		×	x	3
De Maten	~		×			×	x		× ×		4
Het Opderdijks	X		~			<u></u>			×		4
Usselmuiden-Centrum	X		^	~	~				^		3
Stationsplein		~		~	· ·			×			3
Oosterholt	×			^		×		^	×		3
Polder Drontben	^				x	x			^		2
De Melm					x			x			2
Kampereiland	x							x			2
Mandieswaard						x		x			2
Losselanden						x		x			2
Industrieterrein Usselmuiden	x			x							2
Kampen-Zuid						x		x			2
's-Heerenbroek						x			x		2
Verspreide huizen polder Mastenbroek	х					x					2
Bovenbroek		х									1
Hagenbroek						x					1
Stationskwartier			x								1
Verspreide huizen Zalk	х										1
Wilsum						x					1
Verspreide huizen Wilsum		х									1
Grafhorst	х										1
Kamperveen	x										1

Figure 4. 2015 SVI Flag Count Table. Each of the districts with at least one "flag" indicated in creating the SVI are listed and their corresponding flag counts are shown for the year 2015.

2020 SVI Flag Count Table												
Neighborhood Name	0-15	65+	NonWestern	Multifamily	Rentals	Homes Occupied	Vehicles per household	Homes before 2000	General Social Assiatance Benefits	Lowest % of Household Income	Mean Income (from 2019)	2020 SVI TOTAL
Hanzewijk en Greente		х	х	х	х		x		x		x	7
Binnenstad Kampen			х	х	х		x	х	x		x	7
Flevowijk			х	х	х		x	х	x		x	7
IJsselmuiden-Centrum		х		х	х				x			4
Brunnepe					х		x		x		x	4
Cellesbroek			х		х				x			3
De Melm		х			х			х				3
Stationsplein		х		х			x					3
Stationskwartier	х				х	х						3
Het Onderdijks	x					х				х		3
Bovenbroek		х				х						2
Hagenbroek		х						х				2
Kampen-Zuid					х			х				2
De Maten						х				х		2
Mandjeswaard						х		х				2
Oosterholt	х									х		2
Losselanden						х		x				2
Polder Dronthen			х									1
Kampereiland								x				1
Industrieterrein IJsselmuiden				х								1
Kamperveen	x											1
's-Heerenbroek										х		1

Figure 5. 2020 SVI Flag Count Table. Each of the districts with at least one "flag" indicated in creating the SVI are listed and their corresponding flag counts are shown for the year 2020.



Figure 6. SVI for Districts within Boundary of Deprogramming Housing 2016 Plan (i.e. the 12 "treated" districts).

Figure 6 shows the SVI flag count in 2015 and 2020 for all Kampen Districts within the boundary of the 2016 Deprogramming Housing Plan (2015^T and 2020^T) and **Figure 7** displays the SVI flag count for districts outside of the policy boundary in the same years (2015^c and 2020^c).

To determine the effect of the policy, social vulnerability is assessed utilizing **Equation 1**. In 2020, the 'treated area', or the 12 districts within the boundary of the policy, had a collective total of 35 flag counts. These 35 flag counts are divided by the 12 districts within the boundary average of 2.92 flags. In 2020, the same 'treated area' of 12 districts totaled 38 flags with an average of 3.17. The difference in social vulnerability within the policy boundary ($V_{2020}^{T} - V_{2015}^{T}$) is -0.25. The difference of -0.25 between 2020 and 2015 for the treated area indicates a slight reduction in average vulnerability for all 12 districts within the boundary.

The same method is used in assessing the change in average social vulnerability for the 23 "con-

stant" districts outside the boundary of the policy. In 2020, the 23 districts outside the policy boundary had a collective 28 flags, averaging 1.22 per district. In 2015, the same 23 districts had 36 flags: an average of 1.57 flags per district. The difference in social vulnerability outside the policy boundary $(V_{2020}^{C} - V_{2015}^{C})$ is -0.35. Similar to the treated districts, these 23 districts saw a decrease in average social vulnerability but at a stronger incidence of decline.

Using **Equation 1** to determine the associated effect of the policy on social vulnerability, the result is [-0.25] - [-0.35] = 0.10. The measured effect of the policy is a positive 0.10 which indicates the policy increased vulnerability. The 12 districts within the boundary saw a reduction in vulnerability by steering development away from the higher flood-risk districts except for two: Kampen-Zuid and Stationskwartier.

Both of these districts were to receive additional housing and redevelopment per the policy and thus encouraged greater residential population density in flood zones. These two districts are colorized as red



Figure 7. SVI for Districts outside Boundary of Deprogramming Housing 2016 Plan (i.e. the 23 "constant" districts).



Figure 8. Plan Integration for Resilience Scorecard (PIRS): Deprogramming Housing Plan 2016. The districts that encouraged greater residential populations in flood zones as a result of the implementation of the policy are shown as red, while the green districts discouraged residential populations in flood zones.

Policy Integration for Resiliency Scorecard (PIRS) for Depgrogramming Housing 2016 Plan

District	Social Vulnerability Reduction (-1), Increase (+1) or no perceived effect (0)	Explanation from Deprogramming Housing 2016 Plan
Flevowijk	-1	"To be elaborated area, 112 homes have already been worked out in the development plan Residential Areas Kampen"
Hanzewijk en Greente	-1	"the maximum permitted housing numbers for the Hanzewijk will be adjusted downwards"
Brunnepe	-1	"in the Brunnepe district, the Residential designation for the municipal land is being converted to the Green designation"
Cellesbroek	-1	"To be elaborated area, 112 homes have already been worked out in the development plan Residential Areas Kampen"
De Maten	-1	"To be elaborated area, 112 homes have already been worked out in the development plan Residential Areas Kampen"
Het Onderdijks	-1	"In the zoning plan 'Het Onderdijks 2013', the maximum number of homes to be built in the residential area - To be developed is reduced from 250 to 135."
Kampen-Zuid	+1	"This zoning plan includes an amendment authority to make 7 additional homes possible"
Bovenbroek	-1	"To be elaborated area, 112 homes have already been worked out in the development plan Residential Areas Kampen"
Hagenbroek	-1	"To be elaborated area, 112 homes have already been worked out in the development plan Residential Areas Kampen"
Stationskwartier	+1	"Three neighborhoods are being (re)developed in Kampen, namely and the Stationskwartier."
Wilsum	-1	"For this reason, part of the Residential designation is being converted to the Agricultural designation, so that a maximum of 19 homes have been built"
De Venen	0	(No specific line item in the umbrella plan addresses this district)

Figure 9. Plan Integration for Resilience Scorecard (PIRS): Deprogramming Housing 2016 Plan Evaluation. Comprehensive analysis of the plan, and how (if at all) the 12 "treated" districts within the boundary of the plan were impacted.

"AS DISASTERS AND FLOODING EVENTS CONTINUE, MUNICIPALITIES SIMILAR TO KAMPEN WITHIN THE UNITED STATES COULD BENEFIT FROM IDENTIFYING THEIR NETWORK OF EXISTING PLANS AND POLICIES USING THE PIRS METHOD."

and received a PIRS of +1 on **Figure 8** and **Figure 9** respectively, contributing towards social vulnerability.

The remaining ten districts involved with changes associated with the Deprogramming Housing 2016 plan reduced vulnerability (+1) or had no perceived effect (0). The district of Hanzewijk en Greente, for instance, reduced the maximum permitted housing numbers, and the Brunnepe district had municipal land converted to "Green Designation." These two changes from the policy discouraged greater residential population density in flood zones and contributed to a decline in social vulnerability, accordingly.

CONCLUSION

Results of comparing the assessed effect on SVI with the PIRS suggest policy implementation influences social vulnerability. The PIRS method is a validated tool for identifying harmony between plans and the capacity to identify districts where resiliency is needed most. While the measured SVI changes may not align exactly with the PIRS of the Deprogramming Housing 2016 Plan, it is essential that the comprehensive network of plans in Kampen is to be evaluated to understand previously mentioned incongruities so that a holistic evaluation of policy can be conducted to improve resiliency. Only one policy was selected for evaluation from the 190 plans for Kampen.

Nonetheless, results of this study must be interpreted with caution and some limitations should be noted. Evaluating the single policy using PIRS-derived methodology does not account for additional disruptors or historic threats such as flooding events, economic activity, immigration, etc. Additionally, "the question of whether or not a policy will affect community is an important, though potentially subjective, one."⁹ Interpretation of the Deprogramming Housing 2016 Plan was done without a "policy team" and was self-judged on its potential effects on vulnerability in the community.

As disasters and flooding events continue, municipalities similar to Kampen within the United States could benefit from identifying their network of existing plans and policies using the PIRS method. League City, Texas, for instance, has a similar proximity to the Gulf of Mexico as Kampen does to Ijsselmeer. If League City, or any other municipality near a large body of water, was to exhaustively utilize the PIRS method for their networks of plans, the decision makers and urban planners could identify districts or neighborhoods with the greatest need of intervention. To increase resiliency for those that unconditionally need it the most, PIRS is a powerful tool to mitigate potential disasters.

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Validation of Electronic Board Upgrades

By Jessica Williams

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Photo by Antonio Vivace

INTRODUCTION

The European Organization for Nuclear Research, known as CERN, has a long history of creating new frontiers in computing. They first gave rise to the Internet to connect members across countries. They invented distributed computing where different computers partially process the data, and many ideas in parallel processing (multiple programs running at the same time) came from implementations of CERN's work. The high-luminosity upgrades are the latest in this long history of computing at the edge of what is possible, and working on ways to capture, process, and store as much data as possible will lead to better accuracy of physics done at the collider and more clear answers about the laws governing the universe.

The Large Hadron Collider (LHC) was built in Geneva, Switzerland at CERN to collide proton beams at high energies and discover new physics by tracking and detecting products from collisions.¹ The number of collisions requires a large amount of computing power to process the data. Protons travel through the ring in dense bunches and pairs of these bunches collide every 25 nanoseconds. Each bunch crossing, as they are

"THE HIGH-LUMINOSITY UPGRADES ARE THE LATEST IN THIS LONG HISTORY OF COMPUTING AT THE EDGE OF WHAT IS POSSIBLE"

called, has many proton-proton collisions that create a cascade with a variety of decay particles depending on the energy of the collision. To look for evidence of new physics, detector and electronics upgrades are underway to increase the instantaneous luminosity by five times in a series of upgrades known as the High-Luminosity LHC.² The increased luminosity will increase the data rate by a similar factor, so the electronics handling the data need to be upgraded as well.

The Compact Muon Solenoid experiment (CMS) is one of the main experiments on the LHC. CMS contains several detectors for reconstructing the



Figure 1. A diagram of the layers of the CMS Experiment.³

direction and energy of the particles that pass through, such as the muon detector system, silicon tracker, and electromagnetic and hadronic calorimeter, as shown in **Figure 1**.⁴ Each layer has its own types of detectors and measures charge, energy, and direction of particles passing through. There are electronics systems and software tools to interpret the data from each layer of detectors into localized tracks and systems to blend the data from the layers into a global picture.

To support upgrades in the muon finding system, the X2O board was developed. The X2O, shown in **Figure 2**, is a backend system board for the chambers that detect muons.⁵ Chief duties of the board are providing clock and control signals to the detectors and reading out their precision data to the rest of the data system. The board performs partial data reconstruction using signals sent from the detectors, performs zero suppression and data packing, and transmits data using high speed optical links.

The electronics and computing systems handling all this data must be carefully designed and their capabilities proven to ensure efficient synchronization when processing data from multiple detectors. The custom backend system designed for accumulating and processing data from the muon detectors is the X2O board.⁶ It is one roughly 12 inch by 12 inch board with three dedicated modules: one for power, another to support a powerful Field-Programmable Gate Array (FPGA), and the last to support the high-speed optical links. The power module contains a Xilinx Zynq system on a chip, which allows control of the X2O from the control computer without the main FPGA being programmed. The key utility of FPGAs is the firmware can be changed by the user and adapted over time at low time cost and that FPGAs have real-time processing because the pipelining allows for fixed latency. The FPGA used is a Xilinx VU13P. The optical module has 30 slots for four-channel optical transceivers for a total of 120 links and dozens of custom high-speed cables connecting them internally. The high capability and customization of the board presents the challenge of validating its performance.

METHODS

Validating the X2O prior to installation in CMS requires a series of tests. Stringent standards must be met to ensure the X2O board's fitness for use at the LHC, both in terms of data collection and sustainability. This method of research is creating software to analyze different functioning parameters of the X2O, then running that software to collect data. This data will be used as a baseline to diagnose performance issues while running at the LHC, as well as for quality control and production testing before installation in the endcap.



Figure 2. Labeled photograph of the parts of the X2O board.

The X2O validation test is run from one central script and is fully automated. It is integrated into the repository for the endcap muon electronics and is portable. The test script is run on the X2O itself. The main script executes various smaller scripts, primarily in Python, to test and record different performance characteristics, and uses exit statuses to determine failures. This allows for a modular flow where one set of parameters is checked and evaluated before moving on to the next set. Modular testing also allows the data to be kept together as different sub-tests of a single run. The test will
also stop and power off the board if there is a critical safety error, such as temperature or voltage out of range, which is also helped by using exit statuses.

The test is run in a series of steps that evaluate different aspects of the board. The first step is checking the physical data such as voltages and temperatures. Running it first allows any critical failures to be detected immediately to minimize risk to the board. Temperature, voltage, current, and power for various chips and parts of the X2O are tested. Any optical transceiver parts that may be attached are also tested for

"THE ELECTRONICS AND COMPUTING SYSTEMS HANDLING ALL THIS DATA MUST BE CAREFULLY DESIGNED AND THEIR CAPABILITIES PROVEN TO ENSURE EFFICIENT SYNCHRONIZATION WHEN PROCESSING DATA FROM MULTIPLE DETECTORS."

cycle takes about two minutes. If the chip-to-chip connection is down, the test attempts a reset and checks the connection status again. If the chip-to-chip connection is still down, the step fails.

The next step is checking the register access speeds. Registers enable control and monitoring of the board. This is an important step to ensure the board can be quickly configured. It tests twice—once with static reads and once with random reads and writes. The random read/write should take about twice as long since it is doing twice the operations, and acceptable values for the average of each operation is around the 50-microsecond

voltage and temperature. The test waits until the physical data stabilizes to ensure long-term safety. If the test detects a temperature that is too high, it will exit the test, shut down the X2O, and increase the fan speed. Basic temperature checking was integrated throughout the test as well. The full data generated by this step is written to a physical test data file and the average stabilized values written to the summary data file.

The second step checks the programming of the FPGA. The FPGA is loaded with standard operating firmware, then checked to see if the chip-to-chip connection is stable. The chip-to-chip connection is a link between the operating system for the X2O on the power module and the FPGA chip on the FPGA module that allows for control and monitoring. Throughout this step, both firmware to support both types of muon detectors in the LHC were used. In the future, there will be other types of firmware to implement trigger algorithms further along the data path, although this research group is more concerned with the backend detector support implementation. If the chip-to-chip connection is transferring data, the step is successful. The programming process is done ten times, and each range. Therefore, the test results in a total average of 50 microseconds for the static read and 100 microseconds for each random read and write.

The fourth step is checking the stability of clock frequencies. One clock is at 40 MHz and the rest are at 156.25 MHz. Passing is defined as all clocks having less than 25 parts-per-million deviation from the stated value. This is an especially critical parameter, as the clocks are used to control the operation of the optical links and the timing constraints are very tight.

The final step is a stress test. The purpose is to establish that the X2O can handle firmware updates in the future that may increase the power and to further characterize the acceptable bounds of operation. The X2O is programmed with firmware that draws more power and performs more intensive calculations that would be beyond the expected operating needs. Unlike the regular FPGA programming test, the stress test does not check the chip-to-chip connection since this firmware version does not support that. The fan speed is increased, and the physical test is rerun. Again, the stress test checks to make sure that the temperatures, voltages, powers, and currents all fall in acceptable ranges. If a temperature is outside the acceptable range, the process shuts down the X2O board to prevent damage. The data is written just as the regular physical test with all data written to one file and the averages to the summary file. The filenames reflect the type of firmware that was used, generally "hot," "csc," or "gem," in addition to the usual date and run number.

RESULTS

The software tools to test physical characteristics have been developed, tested, and shown to record values accurately. The purpose of the software is to test different parameters and it fulfills that purpose. The conditions in the lab are similar to those after installation, so the testing is a good approximation of expected operating ranges.

Because the board used is still a prototype and not the final production board, some small parameters will change in the final board version. Small, measured variations provide a way to define acceptable variations during production testing of the actual boards.

The voltages showed extreme consistency. They were all within five percent of the nominal value, as shown in **Figure 3**. Further, there was less than one percent difference between most reads, even among different days, firmware, and fan levels. It will be interesting to see if the small deviations are consistent between boards or are products of the commercial components of the board. Notably, the oscillator voltages varied almost not at all.

Temperature of the FPGA is expected to vary based on firmware and fan speed. The maximal temperature for safe operation is 90 degrees Celsius, although ideal for long term operation is 70 degrees Celsius. For full operation, the fan speed should likely be increased from testing conditions since noise will not be an issue and temperature will also likely increase with a full crate of X2O boards. **Figures 4 and 5** show temperature stabilization over time.

The FPGA programming test was to program the FPGA with firmware and then check the chipto-chip connection. This test was not applied to the high-power stress firmware, only the regular firmware intended for physics operation. The test passed if the chip-to-chip connection was working after programming. This test also does not have a separate log file for the test—its result of the number of passed and number of total cycles is simply stored in the summary file. It is also possible to program the FPGA once as part of the software suite.

There were two subtests within the register



access speed—one that simply reads a static value and one that writes and reads a random value. The average time for a static read was 38 microseconds and 66 microseconds for a random read and write. The operating constraint is that a read operation must be less than 50 microseconds and the read and write operation must be less than 100 microseconds. so this test was well

Figure 3. Voltage value error from nominal.



Regular Temperature Stabilization





Figures 4 and 5. *Temperature stabilization for regular and stress test firmware.*



Figure 6. Histogram of errors for reference clocks.

within range. The specific register used for reading was simply the board ID number. The random numbers were generated before the timing began to ensure the highest accuracy. It has been noted that reading a value takes longer than writing a value, perhaps because it must send a request and receive data rather than just sending data over.

On the X2O board, there are 60 reference clocks at 156.25 MHz and one at 40 MHz. The 60 reference clocks correspond to two clocks for each optical transceiver. On this prototype board, only 30 of the reference clocks were installed. In future production boards, all 60 will be installed, and the software will easily adapt to that. The factory specification is the specification for the clocks, which is a tolerance of 25 ppm error in frequency. The tight frequency bound is important to have high-time resolution from the detector to connect data to the appropriate bunch crossing. As shown in Figure 6, the error for most clocks was less than one part per million.

CONCLUSION

The X2O board is a custom electronics board that will go in the Large Hadron Collider at CERN. As the beam will be upgraded to have higher luminosity, faster data processing is needed. Additionally, new detectors are being installed in the Endcap Muon System of the Compact Muon Solenoid. Both the new detectors and the increased data flow necessitate new electronics to be designed and added into the data path so that more of the data can be captured and processed, leading to more physics information.

A collection of tests for comprehensively testing the X2O board was created. It is modular and portable, and easily adaptable to new firmware. A prototype X2O board was tested in a variety of operating conditions, and most of the parameters were well within the operating specifications.

The testing suggests that the X2O is ready for use in the LHC. Future integration will be needed to validate the performance of the board when connected to the detectors in the final configuration. The board will be a critical part of the infrastructure to support greater accuracy in the experiments done at CERN and potentially lead to new physics discoveries.

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Christianity, Queerness, and Comics: Fantasy as the Ideal Genre for Intersectionality

By Lauren Head

MOTIVATION

It is no secret that the past several decades have found the Christian and LGBTQ+ (interchangeably, "queer") communities increasingly at odds with each other in the scope of American politics. As the people groups continue to grow both in numbers and in polarization against the other, it becomes necessary to find a way to encourage cooperation between the often radically opposed communities. As someone who identifies with both groups, establishing some sort of amiability between Christians and the queer community has become important to me. Thus, I turned to what I know-literature-to consider how I could use my own passion and experience to make an impact towards my goal. I explored genre, form, characterization, and other elements of story to determine what sort of narrative could perhaps not fully reconcile, but create space for mutual respect between the dissimilar communities.

BACKGROUND

Early in my research process, it was made abundantly clear that there is a necessity in the literary realm for work which examines the intersectionality between the Christian and LGBTQ+ communities. It was not until the late 1990s that prominent (though minimal) research began to emerge surrounding the increasing discourse between the two communities. Even this research, however, was primarily focused on the discourse within the church on how to handle the growing cultural voice of the queer community. It documented the battle "between, on the one side, the 'orthodox' claiming to uphold the Bible and the tradition, against, on the other, straight liberals (also claiming to be within the tradition) and their gay allies, each struggling to prove the other wrong."¹ All the while, the conflict between Christian and queer peoples continued to grow.

It was not until the mid-2010s that experts in the fields of both Christian theology and queer theory began to notably release books and papers that addressed how the two communities could and should coexist. One of the leading voices in this conversation is Dr. Preston Sprinkle, a professor of theology, Presi-

dent of The Center for Faith, Sexuality & Gender, and New York Times best-selling author. To date, Sprinkle has written three books and over a dozen articles addressing what the Bible says about queer identities, as well as how Christians should respond to those in the queer community. He takes a compassionate stance, interviewing and taking into account the experiences of LGBTQ+ identifying people. His work, as one of the most highly recognized contributors, fairly clearly marks where this conversation stands today. Other Christian contributors that have had a large impact on this conversation are Vaughan Roberts, a Church of England clergyman and author of *Transgender*, which promotes themes similar to those of Sprinkle's work, and Jackie Hill Perry, poet, hip hop artist, and author of Gay Girl, Good God.

Perry's autobiography, released in 2018, is one of the first in this conversation to be written by a queer author. It is also one of the only notable works of *prose* that exists in the realm of this conversation. Perry took a significant first step in reaching the general public with her book when she moved outside of the academic realm, but not many have followed. In fact, upon further research, I was only able to discover two pieces of fictional prose of any genre that address the

"IT WAS NOT UNTIL THE MID-2010S THAT EXPERTS IN THE FIELDS OF BOTH CHRISTIAN THEOLOGY AND QUEER THEORY BEGAN TO NOTABLY RELEASE BOOKS AND PAPERS THAT ADDRESSED HOW THE TWO COMMUNITIES COULD AND SHOULD COEXIST." Christian and LGBTQ+ communities in conjunction. Consequently, though the conversation surrounding these people groups is steadily increasing, not much of it is actually being circulated to those who are not specifically searching for it. This led me to be extremely thoughtful when selecting the genre through which I wanted to tell my story. Trying to reach two (typically) very different demographics at the same time with the same message requires strategic planning, but I decided that the fantasy genre could rise to the challenge of becoming an effective foundation for my story, entitled *Revenant*.

Fantasy seemed like a natural choice, as it has such deep roots in conveying both Christian symbolism (such as C.S. Lewis' *The Chronicles of Narnia* series and J.R.R. Tolkien's *The Hobbit*) and queer representation (as seen in Rick Riordan's *The Heroes of Olympus* series and Ursula K. Le Guin's *The Left Hand of Darkness*). When plotting my story, I knew that I also needed to be intentional about the medium through which I planned to convey it. I wanted to create new literary content through a medium proven to be effective in reaching young adult audiences. Thus, because of its radically increasing popularity with this age demographic, I was drawn to choose the graphic novel.

Though the media is still lagging in a lot of ways when it comes to mainstream queer representation (as opposed to stories exclusively branded as "queer"), comics have held a strong queer presence for decades. This presence has only increased with time and is "happening now with new force."² In her book, *Why Comics*?, Hillary Chute discusses the presence of Archie Comics' first gay character, Kevin Keller, writing that in 2010 "the first issue in which Kevin appeared was so popular it sold out, and the company reprinted an issue for the first time in their history."³ It's no secret that as the LGBTQ+ community continues to grow, there are increasingly more people who are "very hungry to see visual images of people like [them]."⁴ Comics provide an incredibly reliable space for that.

I appreciate the creator of *Barefootz*, Howard Cruse's, perspective on the possibilities that are available to queer comic creators. He notes that "each artist speaks for himself or herself. No one speaks for any mythical 'average' homosexual."5 This is made very clear just by browsing Chute's several-page-long list (which she calls "very, very short") of notable queer comics. Consisting of a wide variety of subjects, characters, sexualities, gender identities, genres, etc., these works all draw from the individual experiences of the authors who created them. In response to this, Chute discusses an encouraging aspect about comics: they "inspired that kind of creative practice: if you perceived a gap, you could fill it yourself."6 She writes that "comics can be a space for sophisticated storytelling about the complexities and joy of queer life."7 This holistic, down-to-earth, and realistic adaptation of the queer experience is something I've sought to show in my work through my diverse characters, even if the inclusion of Christian themes differentiates it from those who have come before.

Though Chute offers good insight on the possibility of comics, Scott McCloud is arguably the most highly esteemed author when it comes to the technique of the graphic novel. One of my biggest takeaways from his renowned work, Understanding Comics, is his theory of "masking." He defines masking as "amplification through simplification," a technique in which illustrators intentionally use non-realistic character designs with the idea that more people will be able to see themselves in said characters.⁸ This allows readers the ability to more "safely enter a sensually stimulating world," connecting with the story in a deeper way than may be possible without an illustrative element.9 The graphic novel is unique in this way, but this ability to "mask" is also what allows it to work so well as a vessel for a fantasy narrative.

Though this connection hasn't yet been made in the scholarly conversation, I believe that the genre of fantasy seems to use a version of this technique, which I will refer to as "thematic masking": the use of rhetorical technique to make a given subject or theme more approachable to a desired audience in a work of prose. Fantasy as a genre is unique in that it utilizes other-worldliness intentionally, often to convey specific messages to readers effectively. Because the goal of my graphic novel is to encourage Christians to compassionately approach members of the LGBTQ+ community and vice versa, I would argue that masking (both of the visual and thematic veins), is the ideal way to do so.

To exemplify my theory, I have combined each of the aspects of my research to create an effective young adult fantasy graphic novel. Revenant features a diverse set of characters all hailing from different backgrounds as they are united on a quest to reconcile their two nations, Marakh and Merred. Throughout the story, they not only learn what aspects of themselves are more similar than they may have thought, but also how to gain a wider perspective from better understanding their differences. Rather than being explicit about either the biblically-based worldbuilding or the queer identities of my characters, though that could certainly be an approach, I have utilized the masking technique in both my dialogue and illustrations. In this way, I seek to make both the topics of Christianity and the beliefs that come with it as well as queer lifestyle, struggles, and joy more approachable to a reader of any background.

EXHIBITION/FOLLOW THROUGH

When deciding how to best portray queer and queer-coded characters in my story, I relied heavily on Preston Sprinkle's work. As a Christian author, he takes a non-affirming stance, but explores the implications of the queer experience in an open-minded and empathetic manner. From the preface of his first book, People to Be Loved, he implores readers to "listen to the pain and joy of real people who are gay" and "hold our views with a humble heart and an open hand-inviting God to correct us where we have been wrong" in our prejudice.¹⁰ He considers every possible angle of the presence of either affirming or non-affirming passages in the Bible, ultimately discussing the way that Christians should respond to queer and transgender folk today. He reminds readers of the inclusionary gospel, remarking that "if the gospel is not good news for gay people, then it's not good news."11

To create my transgender main character, Quinn, I looked to my own experience with the understanding that there is no singular "queer lifestyle." Each queer person is radically different in their beliefs, "I SEEK TO MAKE BOTH THE TOPICS OF CHRISTIANITY AND THE BELIEFS THAT COME WITH IT AS WELL AS QUEER LIFESTYLE, STRUGGLES, AND JOY MORE APPROACHABLE TO A READER OF ANY BACKGROUND."

culture, practices, orientations, etc., just like every cisgender and heterosexual person is different. Thus, I also looked to the experiences of Jackie Hill Perry, as told in her book.

While Perry has never publicly identified as genderqueer in any sense, the gender euphoria that she describes when discussing the first time that she intentionally dressed in masculine clothing is very reminiscent of the transgender experience.¹² She expresses her (and many others') frustration with gender norms and the struggles that come with not fitting into them, which resonates with Quinn in his discomfort with the gendered expectations he has been subjected to growing up.¹³ In this moment, Perry makes similar commentary to Sprinkle that the gender expectations that we set, both in society as a whole, but especially in the church, can make it difficult for people to feel comfortable being who they truly are while identifying with their assigned-at-birth gender.

I capture this experience through the characterization of Quinn's birthplace, Marakh. Marakh is a kingdom symbolic of the Christian community, or "the church," and Quinn's experience in it is very similar to that which Perry and Sprinkle describe as he struggles to conform to the standards of and relate to others in it. In *Revenant*, I take the same stance as Perry and Sprinkle do in their respective books when I make clear that there truly is no "way" that everyone in Marakh (or, the church) has to be; thus Quinn, and any member of the LGBTQ+ community, can be an integral member in the Christian community. I think that this will be a good reminder to readers (Christian or queer or neither) that the foundation of Christianity is the idea of welcoming everybody, even if followers of the faith do not always reflect that well.

Deciding on the place where Quinn's faith and gender identity/sexuality intersect was also a large step in creating my story. I knew that I wanted his faith, which in my story, is symbolized by his connection to Marakh, to be his largest source of motivation. Though his origin is kept a secret for most of the book, Quinn's dedication to the kingdom is one of the clearest parts of his identity. Consequently, though both his nationality and gender identity are revealed later in the novel, his gender identity is not what is focused on by those around him—it's his drive to reach the kingdom's center and save it from destruction that becomes most prominent about his character.

I believe that the impact of deemphasizing Quinn's gender identity as his primary identity is twofold. First, it will promote the idea that queerness is just one of many aspects of one's personhood. Thus, it will encourage Christians to view LGBTQ+ people as whole beings rather than solely their queer identities when pursuing discipleship. Similarly, living in a culture in which queerness is still so stigmatized, especially in the Christian community, queer people seeking Christ can also forget that there are other ways they must be refined in their spiritual journey outside of just their struggles with sexuality/gender identity. This not only emphasizes to all readers that queerness does not have to be the only (or even most defining) part of one's identity, but it reminds queer readers (whether they are exploring Christianity or not) that queerness does not have to be an unmoving obstacle to attaining faith. Of course, the impact that this story is able to have is heavily dependent on the means through which it is depicted.



Figure 1. Characters Silas and Iris in the Merred army headquarters



Figure 2. From left to right: Norah, Quinn, Iris, Silas, and Henry in the forests of Merred

To effectively utilize the fantasy graphic novel form, I relied on many of Scott McCloud's techniques. In my character and world designs, I use masking in the way that I depict simplistic characters over more complex, detailed backgrounds (**Figure 1**).

I use heavy shading and high contrast to approach realism with my panel backgrounds, as seen in the dark forest setting of **Figure 2**.

This greatly juxtaposes my characters, who are illustrated in flat, neutral-toned colors. They remain, unlike my backdrops, relatively textureless, and I use no more than a few lines to compose each character's face. I am hopeful that this technique, combined with my effort to convey a diverse cast, will allow for as many readers to relate to my characters (and consequently, connect with my story) as possible.

McCloud also discusses the "emotional impact" and "expressive potential" of deliberate color choice, expressionism, and synaesthetics: how elements such as line or color can be used to convey a specific tone.¹⁴ Taking inspiration from this, I created two separate color and texture palettes for each nation in my story, which can be seen juxtaposed in the images below (Figures 2 and 3).

For the nation of Merred, I have chosen darker, more neutral tones as well as rougher textures and shading, as exemplified in the cave background of Figure 1. Alternatively, to represent the kingdom of Marakh, I have chosen a brighter and lighter color palette with softer lines and textures. This can be seen in the greenery in front of the castle as well as in the sky behind it in **Figure 3**. I also use minimal shading in my depiction of Marakh. This further differentiates it from the society with which it is opposed, creating more tension for readers as I seek to ultimately bring the two nations together.

REFLECTION

Since the start of this project, I have been able to witness both my knowledge and compassion grow. Through my research and the creation of *Revenant*, I have been privileged to encounter the histories of so many different people, each with radically different backgrounds. From this opportunity, I have gained a significant amount of perspective and empathy for oth-



Figure 3. The castle at the center of Marakh

er people. In the progression of my characters' quest, I, myself, have felt challenged to reconsider what my preconceived notions of others might have been, as well as open my eyes to the ways in which those different from myself may perceive the ideas that I put forth.

Being both a Christian and a member of the LGBTQ+ community has given me a unique viewpoint when approaching the creation of the first queer Christian piece of graphic fiction. I hope that my ability to understand (at least to some extent) the perspectives of members of both groups will allow for not a polarizing, but a mind-opening experience for those who read *Revenant*. I hope that this story has a positive impact on how readers perceive those different from (or even entirely opposed to) them, but ultimately, I want this project to be a safe space for people to come and explore, to challenge their beliefs, and to leave more compassionate than they came.

"BEING BOTH A CHRISTIAN AND A MEMBER OF THE LGBTQ+ COMMUNITY HAS GIVEN ME A UNIQUE VIEWPOINT WHEN APPROACHING THE CREATION OF THE FIRST QUEER CHRISTIAN PIECE OF GRAPHIC FICTION."

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The Legacy of the Classical World: Greek Mythology in Pop Culture

By Hannah Eckenfels



RESEARCH QUESTION

Pop culture has long been captivated by mythology, adapting famous ancient stories into various forms of media, such as video games, stories, and movies, much like how it was conveyed through plays and poems in antiquity. Mythology is one of the most versatile forms of storytelling, used by ancient civilizations to define the origins of the natural world and the human condition.

The study of classical reception examines how the Ancient Greek world has been received, portrayed, and represented throughout history. The reception of mythology and mythological elements in modern times has been extensively studied; it is widely recognized that these stories have a significant presence in contemporary society.

Why is mythology such a popular thematic element in pop culture? How have the stories of the classical world evolved to reflect the perspective of contemporary culture, and how does this relate to the interpretation and representations of marginalized groups in mythology? How have the stories of antiquity changed to reflect the perspective of contemporary culture?

The study of classical reception is a valuable avenue to understand the biases and beliefs of modern society and investigate how mythological characters have been rewritten to share the beliefs, opinions, and morals of modern society. The reception of mythology in contemporary culture has resulted in the rewriting and adaptation of classical characters to serve as a vessel of modern beliefs and morals.

BACKGROUND

A significant portion of classical culture has assimilated elements from, and been influenced by, the progression of Abrahamic religion followed by the development of contemporary society. Ancient art and literature from classical antiquity are still impacting modern society over two thousand years later. Our rapid technological development within the realm of entertainment has resulted in a wave of mythologically-centered movie, novel, and video game adaptations. Familiarity with mythology creates a unique opportunity for creators to form adaptations and present their own perspectives on stories the public is already acquainted with. Thus, the complex relation between monotheistic religion and ancient polytheism has resulted in a mosaic of syncretic beliefs and practices, reflecting the dynamic and evolving nature of human spirituality.

The syncretic nature of Greek mythology gives it a malleable quality that promotes thinking about change. Reimagining classical heroes and figures is a popular subject within novels. Modern authors writing about mythology frequently use ancient settings and figures to create works that convey timelessness and grandeur. Or, in the case of Percy Jackson—a popular young adult novel series by Rick Riordan—the author uses a modern setting to relate to younger audiences and reimagines how Greek mythology could exist in the modern world.¹

Madeline Miller, author of the adaptations *The Song of Achilles* and *Circe*, enjoys adaptations of classic myths which "stand brilliantly on its own," as a separation from the original work, "while inspiring a fresh look at the original."² Elements of Greek influence remain present in pop culture and entertainment despite centuries of technological development. Classical reception reveals the disparity of "changing desires" between the modern and classical world, which "give rise to moments of communion and of forging community, both in and across time."³

"THE STUDY OF CLASSICAL RECEPTION EXAMINES HOW THE ANCIENT GREEK WORLD HAS BEEN RECEIVED, PORTRAYED, AND REPRESENTED THROUGHOUT HISTORY."

The present-day media landscape has ushered in a new age of myth-making, where mythology, once confined to the realm of ancient Greek plays and literature, has now taken a new form in video games, films, and other forms of entertainment. This phenomenon can be referred to as neomythology or myth-making, where traditional mythological elements are restored into a modern perspective.⁴ The deities, heroes, and prominent figures of antiquity who appear in neomythology have been reimagined to reflect the values and ideologies of contemporary society. Technological advancements have given mythology the ability to reach a wider audience than ever before, transcending cultural and language barriers. The presence of neomythology in modern entertainment means that even thousands of years later, mythical elements are still culturally important. As a result, mythology has become an integral part of our collective consciousness, shaping our understanding of the world and our place in it.



Figure 1. Helen of Troy for creative artifact.

CREATIVE ARTIFACT

This research consolidates modern retellings of myths and combines written, as well as visual, representations into a creative artifact. Motifs and imagery in each illustration are tailored to the modern interpretations of each myth. The modern lens, or the Western classical reception of select Greek myths, is represented to gain a deeper understanding of the modern mythological characters and story elements.

The general research process used throughout this project involved the analysis and interpretation of modern adaptations of mythology. While developing the creative artifact, questions arose: how are classical figures portrayed by modern society? How are women and marginalized groups depicted today, especially by members of these groups?

I decided to address these questions in my

creative artifact. Certain contexts and motifs are communicated in my creative artifact that describe how modern figures have changed throughout antiquity, specifically in contemporary literature and video games. The artifact visually demonstrates the importance of the research done in this project. Analyzing the classical reception of mythology in modern culture highlights it as a tool to understand the biases, morals, and beliefs that are important to contemporary Western culture. Neomythology serves as a vessel of truths, a reflection of how we view and understand the world today. This project builds upon the importance of women, marginalized groups, and their perspectives in interpreting mythology.

This illustration was submitted for the cover art of this volume as Helen of Troy serves as one of the most famous examples of the multi-dimensionality of modern classical reception. In this illustration, the combination of the perspectives of Helen as a beautiful woman, lounging in fine clothes, and of Helen as a victim of war, with a sad expression while a thousand ships approach on the horizon, is illuminated (**Figure 1**). Story elements of mythology from the past and mythology in pop culture are compared using the theory of classical reception. The myths examined in this research are selected from a variety of entertainment sources, video games, and movies that utilize Greek mythology as a central theme of the work.

Helen of Troy (**Figure 1**) has largely been a romanticized figure throughout time. Perhaps the quote from Marlowe's *Dr. Faustus* is the most well-known one: "Was this the face that launch'd a thousand ships, and burnt the topless towers of Ilium—Sweet Helen, make me immortal with a kiss."⁵ In movies, she is often still portrayed as a romantic figure, the "terrible beauty" described in Homer's *Iliad*.⁶

Perhaps one of the most famous 19th-century representations of Helen of Troy is by Rossetti (**Figure 2**). Written within the painting is the inscription "Helen of Troy, destroyer of ships, destroyer of men, destroyer of cities." The perspective of the artist is clear, though the intention he had with her representation is debated. This depiction represents her ambiguous responsibility for the destructive Trojan War; her failure to meet the viewer's eye gives her a distracted, contemplative quality.⁷ Her "Hellenistic beauty" was praised for representing her dangerous desirability, which cements her status as an "abstraction of beauty."⁸

The Helen shown in the illustration (**Figure** 1) reflects the ambiguity of her responsibility similar to her representation in Rossetti's painting (**Figure** 2). She averts her gaze slightly from the viewer, and a melancholy expression personifies the Western female perspective that Helen is a tragic character who suffered the consequences of a bloody war.

Another famous example of the reception of mythology by marginalized groups lies in the myth of



Figure 2. Helen of Troy. Dante Gabriel Rossetti. 1863.

Achilles and Patroclus, which queer creatives gravitate towards. After Patroclus donned Achilles' armor and led the Myrmidons into battle all the way to the walls of Troy, he was mistaken for Achilles and died in the fight. Achilles swore revenge, asking that in death his ashes would share an urn with Patroclus' so that they may be one forever: "such spectacular expressions of love are difficult to match anywhere in literature."⁹

Although this story is beloved by romantics, it has many critics. Some view the interpretation of the pair as lovers as an obstruction of the true intentions behind Homer's words; some believe that, with no explicit mentions of love or sexuality in *The Iliad*, they were nothing more than spectacular friends. The assumption that sex and sexuality are what equate people to lovers is a surface-level understanding, an understanding that Homer should be read literally.

To conclude the brief dive into my creative artifact, the classical reception and study of the goddess Persephone (**Figure 4**), a tragic character throughout



Figure 3. Achilles, for creative artifact.

antiquity and the goddess responsible for the origin of the seasons. Persephone, the goddess of the spring, was kidnapped by Hades after Zeus gave him permission to take her as his wife. After kidnapping her and bringing her to the underworld, Persephone ate pomegranate seeds, sealing her fate. After working out a deal, Persephone would be allowed to return to the surface for six months but would have to return to Hades for the other half of the year. So great was Demeter's grief at losing her daughter that the bountiful harvest of the summer soured into fall, then into winter.

Modern adaptations seem to follow the same thread of romanticizing the relationship between Hades and Persephone. Had Persephone been stolen by Hades, or was the goddess willingly escaping her overbearing mother? The romanticized relationship between the goddess of the spring and her kidnapper, Hades, has led to many modern spin-offs of the myth.

Her popularity as a character has made her story one of the most well-known myths. Western versions of this myth represent Persephone in two aspects: the goddess of the spring and the queen of Hades. The juxtaposition of these two aspects is portrayed in this illustration. Persephone, the goddess of the spring, falls from the warm and inviting earth and is slowly falling into the black depths of the underworld. Her hesitation can be interpreted in two different ways: Is she hesitating to return to Hades and filled with the grief of leaving her mother Demeter? Or is she simply saying goodbye to the surface world, ready to cast aside her title as the goddess of spring and become the queen of the underworld?

DISCUSSION

The study of women's perspective in mythology is complex. Mortal women's presence in mythology, in the classical context, was generally passive. *A Thousand Ships* by Natalie Haynes

is told through the perspective of Calliope, the muse of poetry, who wishes to speak of the impact of the Trojan War because she is dissatisfied with the way it has been told.¹⁰ Haynes retells the events of *The Iliad* to highlight often-overlooked female characters, exposing the mistreatment they faced by both men and the gods in the ancient world. The gods in this story are shown in a ruthless light, indifferent to the plight of mortal women.

Creative adaptations of mythology generally follow a similar format in that they depart from the commonly accepted mythos by substituting knowledge with imagination and by promising the audience their version of events is the one true version. Haynes, for example, accomplishes this by taking on the role of Calliope and promising the readers that the truth behind the Trojan War will be revealed as the previous versions of the story are inadequate. Often the familiarity of mythology brings with it explanations that the author does not need to linger on; by removing the need to include worldbuilding in their story, the author may focus on the characters, their thoughts, their feelings, and how it may captivate their audience into believing in their version of mythology.

The popularization of drama began in classical Greece, which was renowned for its impressive theaters and the origins of dramatic elements. Video games share certain characteristics with Greek plays, although they have some notable differences. While audiences play a passive role in observing dramas, video games expect a more active role in shaping the story. The interactive nature of video games has changed the traditional perception of narrative and the typically passive role of a viewer. Rather than simply observing the story unfold, players engage



Figure 4. Persephone, for creative artifact.

with the game and affect the outcome, creating a unique and personalized experience. Video games, at the intersection between art and technology, have opened up an entire realm of possibility when viewed with the framework of classical reception.

As a form of reception, video games offer unparalleled versatility in delivering immersive storytelling and experiences to their audience. Narrative-driven games boasting multiple choices and endings have become increasingly popular with consumers who now have autonomy over shaping the outcome of the story and become a key piece of the narrative themselves. In this interactive paradigm, each decision made by the player is filtered through their own life experiences and perspectives, resulting in a personalized new myth that the player now has ownership over. The player becomes a creative force, a co-author, and a participant, making every playthrough an exclusive and irreplicable experience.

Literature, novels, and video games have already been discussed in detail, yet there remains a discussion of how it has impacted society. Classical reception reveals the disparity of "changing desires" between the modern and classical world, which "give rise to moments of communion and of forging community, both in and across time."¹¹ Such comparisons can be drawn and studied as a method to understand changing desires and beliefs in society, even if the medium does not expressly use a mythological theme. In almost all forms of entertainment, especially the storylines of novels or films, "it is possible to see the dominance of the mythical element," although not explicitly related to classical antiquity, "plots employed in these products are of a mythical character."¹³

There is difficulty in comparing the perspective of marginalized groups and women of the past with that of contemporary culture, especially with historical context, and even more so with that of queer history. In truth, many queer writers who contribute to pop culture "looked back as a way to look forward," motivated by the sense of justice to empower characters of classical mythology and rewrite them to harmonize with their own reception of mythology.¹⁴ Aligning the lens of classical reception studies with that of queer history reveals "the proper study of Greek sexuality must begin by rejecting much of its nineteenth- and twentieth-century reception and recognizing that modern homosexuality and ancient pederasty . . . have nothing to do with one another."¹⁵

It is worth noting that, while I found modern adaptations of mythology in entertainment to be popular, some reject the idea of modern reception as a "disturbing way of doing Classics: decidedly un-disciplined."¹⁶ Among critics of modern reception are those who seek to reject modern reinterpretations and portrayals as "our own anachronistic acts of ventriloquizing and embodying the classical past."¹⁷ Even Madeline Miller, the author of several famous mythological adaptations, was among those who rejected modern reception and adaptations before becoming an author.¹⁸

Doubtless, connecting the queerness of the past and the queerness of modernity is a deliberate act of bending time "and momentary or sustained transitions from temporal normativities into osmotic temporalities," which is common among modern adaptations.¹⁹ The desire of contemporary queer literature and entertainment to commit these acts of bending time reveals an important truth: the gods, heroes, and important classical figures serve as a vessel for the opinions and beliefs of the poets, authors, and artists who represent them and will continue to grow and adapt to the lens of contemporary society—including that of queer communities.

"THE PLAYER BECOMES A CREATIVE FORCE, A CO-AUTHOR, AND A PARTICIPANT, MAKING EVERY PLAYTHROUGH AN EXCLUSIVE AND IRREPLICABLE EXPERIENCE."

Mythology serves as a vessel of truth and familiarity, as the stories are well-known and widespread. The purpose of this research was to explore the way that storytellers have adapted classical reception to their own bias and perspective. The modern interpretations of certain famous figures are represented in the creative artifact, which depicts characters from a contemporary perspective. Frequently, adaptations will either put a spotlight on, or omit altogether, the darker aspects of classics, which is reinforced by the inclination of creators to selectively borrow from more positive aspects of mythos while dismissing those that are less palatable to their interests. This metamorphosis caused by the rewriting of mythology has created a new modern mythos, one which serves the modern imagination and reception. Rather than serving as a center of culture, mythology is now central to storytelling used as the basis for countless spin-offs, adaptations, and ideas for various forms of entertainment. The use of and understanding of mythology is more widespread than ever before.

Myth-making and neomythology in modern society seeks to explain the events, elaborate the emotions, and enact justice for the mythology surrounding the characters the storyteller wishes to depict. We are familiar with the famous quote of Achilles gazing at the wine dark sea before him; the same sea which the Helen of the cover art contemplatively averts her eyes from. Wine dark, the color that the blind poet Homer inexplicably used to describe the sea *in The Iliad* after Achilles lost his dear friend Patroclus, has driven much research into what the word oînops póntos (oĩvoψ π óντος) could mean; was it simply that Homer was blind, was the sea *in The Iliad* red, or could it simply be that there was no word for blue? Mythology has a wine-dark quality, which may explain its allure as a thematic element—myth offers authors and creators the ability to put into words what cannot be explained.

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Hannah Eckenfels '23 is a Visualization major with a minor in Anthropology from Spring, Texas who went to Klein Collins High School. As a lover of mythology, Hannah was motivated to explore the popularity behind myths and how they have been adapted to pop culture. After graduation, Hannah will work for an animation studio and help create movies.

The Phantasms of Fantasy: What Fantasy can learn from Greek Rhetorical Tradition

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By Lilia Elizondo

Photo by Patrick on Unsplash

INTRODUCTION

Magic is real, and it is hidden underneath our fingertips as we clutch a book in our hands, sneaking in-between our ears as we listen to stories, and bursting from our pens and our lips as we create the unreal. Ultimately, fantasy literature is the exploration of magic, imagination, and change. Although fantasy literature is often criticized, it serves an important function that no other genre can achieve. Unfortunately, a plethora of fantasy literature is obsessed with defining itself and, consequently, limits both the reader and writer's experience in the genre. However, through fantasy's relationship with the Greek rhetorical tradition, we can address and resolve these issues. Greek Rhetoric, or the Greek practice of oratory, philosophy, and its study, is an ancient and monumental tradition in Western society. Thus, it is easily one of the most respected aspects of writing and literature in sharp contrast to fantasy, which has a long history of being dismissed as nothing but cheap entertainment because of its lack of perceived realistic usage. What is described as the "definitional urge" and fantasy's obsession to categorize only perpetuates this criticism and is the reason the genre is not taken as seriously as it should be. It is also the reason it does not receive enough praise for its fantastical elements that share just as much power or "magic" as Greek Rhetoric. In fact, fantasy literature and Greek rhetoric share more history than people know and these similarities can overcome the issues regarding the constant need to define fantasy. Therefore, in my research, I focus on the similarities between fantasy and Greek rhetorical tradition, why people feel distant from modern fantasy, rhetoric, and magic, and how fantasy literature can improve through its relation to Greek rhetorical tradition.

METHODS

My research deals with comparative textual analysis and my methods include encompassing comparison. This method looks at similarities within separate groups of texts (fantasy and rhetoric, respectively) and compares these sets of similarities within each group. I am using a comparative textual analysis

"FANTASY LITERATURE IS THE EXPLORATION OF MAGIC, IMAGINATION, AND CHANGE"

because the information to be uncovered revolves around reading the texts and using these readings in an in-depth comparison to understand the relationship between two seemingly unrelated topics. To mediate certain issues in fantasy, I use Kenneth Burke's definition of "true" rhetorical magic. To look at Greek Rhetorical tradition, I use texts briefly discussing its history. I highlight the connection that many studies have found between pagan tradition, magic, and rhetoric, and analyze ancient Greek texts and platonic dialogues. The texts I used to do so include Michael Naas's Turning: From Persuasion to Philosophy, William Covino's Magic, Rhetoric, and Literacy, and Jacqueline de Romilly's Magic and Rhetoric in Ancient Greece. As for the investigation of fantasy, I use texts analyzing the different genres of fantasy, the history of fantasy, what makes it so unique, and its issues. The texts for this include Farah Mendelsohn's Rhetorics of Fantasy and A Short History of Fantasy, James Gifford's A Modernist Fantasy, and Katherine Hume's Fantasy and Mimesis: Responses to Reality in Literature. Through Naas's and Romilly's works, I look at well-known ancient rhetorical texts and how they relate to the history of rhetoric, mythology, and the origins to the connection of magic. Through Mendlesohn, I analyze the set "definitions" of fantasy and its history. From there, I will transition to criticisms against fantasy described by both Hume and Gifford. Then using Hume again, I will talk about what makes fantasy such an important genre. Finally, to address the criticisms against fantasy, I will use Covino's Magic, Rhetoric, and Literacy.

RESULTS

Greek Rhetoric and its Foundations in Relation to Magic

Essentially, through de Romilly's *Magic and Rhetoric in Ancient Greece*, we learn that one of the

first practitioners of Greek rhetoric, Gorgias, was heavily inspired by healers and philosophers. In fact, Gorgias was a follower of Empedocles, a healer known for his "magical" cures and purifications, which both used poetry and oration as their medium. In addition, Gorgias was a follower of Pythagorean teachings which emphasized charms, incantations, and drugs to alter emotions and states of consciousness. Through the poetry used in healing and "magic"1-practices, Gorgias found a style that he'd use for a set or oral techniques to strengthen persuasion and create the foundations for rhetoric. These poets in turn created poems that are now known to us today as mythology. Their magical influence is still seen as certain words within these poems or stories contain magical spells and commands. Pindar, a Greek playwright, uses music as a means of magical charms. He tries to lull away all anger in the beginning of "Pythian I", with the word $\theta \epsilon \lambda \gamma \epsilon \iota$ and uses the word ριπαΐσικατασγόμΐνος to enact the notion of being possessed by something cast upon you. We also hear that poets would attempt to brush away fatigue or persuade people through the word $\varphi(\lambda \tau \rho ov)$. Thus, because of its deep ties with magic, poetry, mythology, and rhetoric were harshly criticized. In Plato's Republic and numerous other dialogues, he denounces mythology and rhetoric for being devoid of logic and reason and as only a false sense of reality. This magic is viewed as an act of deviant trickery, luring all those under its spell away from what is real. He explicitly criticizes Homer and The Iliad, both serving as foundations of oration and rhetoric for its detachment from the real world. De Romilly explains that one of the first appearances of a connection between magic and voice is seen through Homer and his poetry. In fact, even ancient Greek philosophers described Homer as the father of sophistry, the practice of persuasion and rhetoric. It was particularly through The Iliad that we got to see in action the relationship between mythology and persuasion. In Turning: From Persuasion to Philosophy, Naas takes an intense look at The Iliad's characters, settings, and how they relate to rhetoric. Through various character's orations, Naas establishes The Iliad as a rhetorical tool exploring complex values and questions related to Greek society, particularly regarding obedience, actions, and humanity versus divinity.² Therefore, it serves as one of the first instances of oral storytelling or a fictional reality questioning and reflecting the ethical values of society.

Fantasy's Beginnings and Rhetorical Functions

Mythology continues to be talked about explicitly in fantasy, too. In A Short History of Fantasy, Farah Mendlesohn argues that some of the earliest forms of written fiction-including the Epic of Gilgamesh as well as, once again, Homer's works-help us understand the beginning of fantasy.³ Homer's The Odyssey itself is about the travels of a hero through a world filled with giants, sorcerers, and other supernatural creatures, a plot eerily familiar to some fantasy works today. Additionally, she mentions that many of the foundations for modern fantasies, like Tolkien's Lord of the Rings, were heavily inspired by a series of Icelandic and Celtic mythologies, like Beowulf and Snorri Sturluson's Prose Edda. These mythological stories inspired the first genre of fantasy as well as its most popular form: portal quest fantasies. This timeline is easily summarized through Figure 1.

Farah Mendelsohn's *Rhetorics of Fantasy* takes an expansive view of fantasy. Beyond portal quest fantasies, Mendlesohn describes each category of what is described as a blurry series of stories that are classified as fantasies, which include:

Mendlesohn, rather than trying to focus on the subcategories of fantasy, is more concerned with the rhetoric or intended message behind an observed set of patterns within fantasy stories.⁴ These rhetorical functions go back to what Naas establishes in his observation of The Iliad; it's a demonstration of fantasy providing commentary on reality, individual identity, and society through its non-real elements. Each of these categories reveals an important storytelling narrative meant to influence how the reader can see themselves or their surroundings. Readers are asked to go through their own personal journeys of transformation, explore what it means like to be a part of another world than our own, challenge the deviant, and savor the wonder in discovery. All these functions reveal fantasy to be a much more expansive genre with various types of books counting as fantasy. However, its taxonomic



Figure 1. The History and Connection between Rhetoric and Fantasy

Fantasy Category	Definition	Rhetorical Function	Examples
Portal Quest Fantasy	Stories on a protagonist from our "normal" world transports to a fantastic world through a type of portal, either literal or metaphorical	Discusses the transformation of the individual from naive to competent through the exploration of the fantastic new world	C.S Lewis's The Lion, The Witch, and the Wardrobe Lewis Carroll's Alice in Wonderland
Immersive Fantasy	Stories on a fantasy world that are fully functioning and complete with both reader and protagonist having full knowledge of how it works	Discusses the complexity surrounding world building and fantastical societies	Tolkien's <i>The</i> <i>Silmarillion</i> Gregory Maguire's <i>Wicked</i>
Intrusive Fantasy	Stories on chaos and disruption brought upon by fantastical elements entering the "normal" world	Discusses the challenges against overcoming other worldly elements that threaten the order of the "normal world"	Bram Stoker's Dracula Shirley Jackson's Haunting of Hill House
Liminal Fantasy	Stories on fantastical elements within our "normal" world that are treated with normalcy and indifference	Discusses elements that make us question our reality and disorient the reader	Hope Mirrlees's Lud- in-the Mist
The Irregulars	Hybrid format of previous categories	Displays a hyper awareness of fantasy, reformatting many of the previous categories	Steve Cockayne's The Legends of Land

Figure 2. Mendlesohn's categories of fantasies from Rhetorics of Fantasy

framework seen in **Figure 2** encapsulates a glaring problem with the genre: the need to define.

The Definitional Urge

In The Modernist Fantasy, James Gifford describes the genre as benefiting from a "structuralist enterprise",⁵ a formation focused on defining a genre. Gifford even cites Rhetorics of Fantasy as an instance of this structuralism. He describes the need to define fantasy as so long-standing that it is now universal. He cites an important aspect of this issue regarding the mass popularity of The Lord of the Rings. Indeed, although Lord of The Rings has come to legitimize the genre, it has also come to define it. When people think of fantasy now, there is the belief that it must revolve around elves, dragons, dwarves, etc. People think fantasy must essentially use the same worldbuilding as Lord of The Rings and portal-quest stories like it. Fundamentally, this problem inhibits both reader and writer from critically analyzing the genre. This ability to critically analyze fantasy is the cause of misunderstandings and misjudgment of the genre. Mendlesohn also delves into this criticism through A Short History of Fantasy and comments on critics who refuse to see fantasy as legitimate, adult literature. In truth, Western society has had a long history of harshly criticizing fantasy, which leads us to the next issue regarding the genre. Because mythology is a starting point for both rhetoric and fantasy, many of the criticisms against mythology apply to both. According to Hume, Plato viewed mythology and the foundations of fantasy as a "shadow away from shadow"⁶ and as demonstrations of unwanted emotions. The criticism is essentially the same for rhetoric, which Plato saw as a practice of false illusions and flattery. As a result of Plato's disdain for the foundations of fantasy, philosophers and scholars continue to delegitimize the genre. Important scholars that explicitly did not like fantasy include Aristotle, David Hume, and George Granville. David Hume best summarizes the common critique when he attributed literary fantasy to a form of insanity. Simply because fantasy is not in the realm of reality, critics automatically demean it by claiming it is not applicable to the real world and rather only a distraction. Even major religions themselves dislike fantasy, with some Christians disliking the genre for its religious deviation with its apparent false sense of cre-

"RHETORIC HAS EVOLVED FROM ITS MYTHOLOGICAL FOUNDATION AND HAS SUCCESSFULLY MANAGED TO REMAIN UNTETHERED TO STRICT DEFINITIONS"

ation. Essentially, this second issue of fantasy not being taken seriously is really one perpetuated by the need to define fantasy. Although readers should learn to view fantasy critically and realize it doesn't have to follow certain definitions, writers also don't help when they reuse the same tropes for the sake of following a certain self-imposed definition. The same contrite tropes limit fantasy's best quality: magic.

Modern Rhetoric, Phantasy, and Magic

Rhetoric has evolved from its mythological foundation and has successfully managed to remain untethered to strict definitions by many. In Magic, *Rhetoric, and Literacy*, Covino provides an in-depth examination of the relationship between magic and rhetoric. Beyond just its association to Gorgias's poetic style and fascination with healing, rhetoric has dialogue influencing society and culture through "magic-like" qualities. As Covino states, "words make real things happen."⁷ To be more specific, rhetoric through its magical properties can unleash potential and unheard-of possibilities surrounding society. Covino tells us that throughout the Renaissance, humanists theorized that the concept of "phantasy" was central to the connection between rhetoric and magic. For the ancient Greeks and Medieval rhetoricians, phantasy dealt with the mind and cognition or a "contemplation of what is nonexistent in the sensible world."8 Covino describes rhetoric as a means of elaborating on the phantastic. In fact, words themselves are considered a form of this unreal cognition because at some level all words began as an internal abstraction that are then transformed into the identification of what is real in the external world. Again, this positive attribute of rhetoric eerily mirrors fantasy. Fantasy, too, is a journey of identification enacted by the creation of words. In this instance, the

ability of identification is so profound because it is the discovery of fictional worlds far beyond the reason of our own. Kathryn Hume credits fantasy as a necessary genre for a multitude of reasons. However, the most important deals with how fantasy helps people envision possibilities that transcend material existence and normal elements that we associate with our reality. Additionally, she describes fantasy as a source of meaning, like science and religion. We find again another reference to fantasy's connection to mythology and how it was one of the first instances of fantasy helping people find meaning through stories. Like science, fantasy gives the reader the power of discovery and naming as they can uncover completely new possibilities and gain the power to essentially explore a new world. And like religion, fantasy is a form of an imitative reality, a set of ritual stories or tropes and a goal. Ultimately, what Hume describes is phantasy and the power it entails to inspire social acts. Covino even acknowledges this influence, describing books like J.K Rowling's Harry Potter as inspiring real-life Quidditch teams and books teaching languages in the Lord of the Rings and Ursula Le Guin's The Wizard of Earthsea. As a matter of fact, fantasy can do far more than inspire new languages, sports, and other social practices. It can inspire interpersonal and societal reflection. However, the limitation of what kind of stories must be told only restricts the effect that phantasy has on social acts. At some point, enough stories about the same concepts with the same restrictions no longer become imaginary but instead a new, inflexible reality.

Thus, through Covino's description of Kenneth Burke's principles of magic that originally reference rhetoric, we can use "magic" to resolve these issues. According to Burke, magic is a coercive force intrinsic to language. True magic is a generative expansion of the possibilities of human action while false magic is described as an enforced doctrine that reduces possibilities. To elaborate, Covino describes Burke's true magic as "action that creates action, words that create words."⁹ It's about using language that inspires change—a discussion with a coercive force that inspires novelty. On the other hand, false magic is seen as a standardized formula that only controls and limits. The entire history behind rhetoric and fantasy and their connection to magic and myth demonstrates that Burke's principles are just as applicable to fantasy as they are to rhetoric. The need to define is inarguably an attempt to suspend and control, inhibiting both the writer and reader from truly understanding the full capabilities of the fantasy genre. Following Burke's definition of generative or true magic gives fantasy writers an idea of being able to write without fear of formula and explore the possibilities of other worlds as Hume states. Real magic is about the words of the author in turn inspiring new ideas of worlds. Because we also know that rhetoric shares a foundation, and, therefore, the same purpose as fantasy, Burke's definition is applicable. As seen in Gorgias and mythology, fantasy and rhetoric are both mediums of verbal genesis. Thus, Burke's true magic helps both accomplish this goal. The exploration of the unreal unleashes the power of phantasy, which in turn can influence society.

DISCUSSION

Fantasy has no exact definition and the attempts at finding it only worsen its quality. The exploration of the unreal or phantasy is the purpose of fantasy. All that makes fantasy what it is, is the exploration of the unreal—an exploration of phantasy. The need to define is inarguably an attempt to suspend and control, limiting the reader and writer in critical analysis of what is reality. Following Burke's definition of generative or true magic gives fantasy writers an idea of being able to write without fear of formula and explore the possibilities of other words as Katheryn Hume states. Real magic is about the words of the author in turn inspiring new ideas of words. The exploration of the unreal unleashes a form of magic onto the world which in turn can influence society. To fully understand and

"THE NEED TO DEFINE IS INARGUABLY AN ATTEMPT TO SUSPEND AND CONTROL, LIMITING... CRITICAL ANALYSIS OF WHAT IS REALITY" uncover the unreal, it is essential to explore the similarities between both rhetoric and fantasy, which include mythology, magic, and phantasy. These similarities can all be summarized with the association of creation. Therefore, what Gifford describes as the obsession with definition limits the idea of unreal creation and only perpetuates an idea that fantasy must fit into a certain category. However, it is through these very same similarities that Burke's generative magic is applicable to improve this restrictive urge.

CONCLUSION

Magic is real-just as real as when Gorgias utilized poetic incantations and just as real as Rowling's Quidditch, Tolkien's Elvish, and Le Guin's Old Speech. The sooner we realize that fantasy is far beyond just a set of contrite tropes belonging to a taxonomic category, the sooner the genre can inspire both writers and readers to participate in modern rhetorical practices. It means that our society can learn that our dreams, imaginations, and cognition have command over our reality. Our words always had the potential to change the world, but through fantasy and rhetoric, our words have the power to create new possibilities for what our world can be. It doesn't just require promises in the realm of the real to enact progress. Dreams are far too encouraged to be followed for fantasy and magic to be considered nonsensical. Therefore, through these studies we can apply our truest form of magic seen in rhetoric to one of the most influential literary genres of the twenty-first century—a genre that encourages both reader and writer to partake in uninhibited creation.

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Evaluation of Passive Low-back Exoskeleton for EMS Lifting Tasks

By Eshan Manchanda, Tiago Do Vale, and Vishal Gottumukkala

view of the

Photo by Joyce Hankins on Unsplash

INTRODUCTION

EMS workers have higher rates of fatal and non-fatal occupational injuries, mainly due to musculoskeletal disorders (MSDs) caused by overexertion in their line of duty. About 34.6% of full-time EMS workers experience work-related injuries, with the lower back being the most affected area. These injuries often result in lost workdays.¹ EMS tasks such as patient lifting, carrying, and handling heavy stretchers involve awkward postures and unpredictable positions, posing a high risk of spinal compression injuries based on cumulative damage estimates.

Alternative techniques like squat lifting to address injuries and MSDs among EMTs have shown limitations in diverse cases. Lower back strain and injury risks still exceed acceptable limits.² To mitigate these issues, passive low-back exoskeletons (LBEs) have gained popularity. LBEs use springs, levers, pulleys, and elastic components to reduce strain on the erector spinae during lifting tasks.^{3,4} They are adaptable to various work environments, making them a viable solution for emergency response occupations.⁴

Systemic evaluations of exoskeletons primarily focus on their impact on muscle activity, fatigue, spine loading, and posture.^{3,5,6} While exoskeletons show promise, their ease of use is rated as moderate due to physical constraints and discomfort caused by straps and cuff designs.3,4,6 Passive exoskeletons have been found to reduce spinal compression and increase user endurance for repetitive lifting tasks. However, the benefits diminish with asymmetrical lifting. Exoskeletons also decrease completion time for ladder or stair climbing tasks and load carrying. Users report reduced perceived exertion, fatigue, and task difficulty with exoskeleton use.^{3,4,6} Considering the unique nature of EMS tasks, which involve high loads and non-repetitive movements in confined spaces, the existing evaluation tasks may not fully capture their requirements. Therefore, it is necessary to evaluate the effectiveness of LBEs for lifting and carrying tasks that are more ecologically valid for EMS work. This study addresses this gap in the current literature by evaluating a passive LBE for EMS workers.3 Additionally, a systematic

"EMS TASKS... INVOLVE AWKWARD POSTURES AND UNPREDICTABLE POSITIONS, POSING A HIGH RISK OF SPINAL COMPRESSION INJURIES"

review of 74 papers on exoskeleton use found that only five studies considered subjective data, suggesting there may be a research gap in the subjective evaluation of LBEs.⁵ This paper has increased focus on subjective data because it may provide insights into how exoskeletons can be adapted to meet specific work demands in the emergency response domain.^{3,5}

In the study, participants performed a six-task circuit of symmetrical and asymmetrical lifting tasks with a cardiac monitor pack. These tasks included various ankle-to-hip, overhead, and shoulder-lifting tasks. Participants were fully trained EMS workers who performed the lifting tasks with (exoskeleton condition) and without (control condition) the support of a lowback exoskeleton. This study evaluated and compared the changes in muscle activity of the lower back muscles, measured via electromyography (EMG), posture, measured via joint angle data, and changes in perceived workload, discomfort, and exertion and perception of the exoskeleton between the control and exoskeleton conditions. The first hypothesis of this study is that passive LBE use will reduce muscle activity in the L5-S1 during EMS tasks compared to the control condition. The second hypothesis is that there will be significant posture modifications between the exoskeleton and control conditions. The third hypothesis is that EMS workers will perceive benefits to their work performance through reduced perceived exertion, discomfort, and mental demand (RPE, RPD, MD).

METHODS

Participants

18 male and two female participants from the Cypress EMS District 9 warehouse volunteered for the research experiment. All participants were trained EMS workers with an average experience of 10.5 ± 3.5 years. The mean body mass index for the men and women was 74.4 ± 22.8 and 29.0 ± 8.0 kg/m. The participants self-reported no low-back MSDs, revealing no major occurrences for the past five-plus years outside of temporary back pain.

Exoskeleton Description

The exoskeleton used for this study was the HeroWear Apex Exosuit (**Figure 1**). This passive lowback exoskeleton assists the user during lifting, bending, and reaching tasks to reduce the risk of strain-related injuries. The Apex Exosuit was selected due to its soft design, in contrast to hard exoskeleton designs, due to significantly higher discomfort scores associated with hard designs.^{3,5,6} The device consists of a back pad with straps to enable users to secure the device around their torso, while the left strap contains a clutch that can be used to activate and deactivate the exoskeleton. The back pad connects to high-resistance rubber

bands, which connect to leg straps that wrap around the wearer's thighs. There are six sizes of bands (1: Smallest; 6: Largest), three sizes of leg pads (Small, Medium, and Large), and four sizes of the backpack, two for each sex (Small, Large). Participants went through a sizing calculator that asked for the participant's chest circumference, thigh circumference, and back measurement to determine the participants' exoskeleton sizing. When the device is activated. the rubber band translates

a portion of the strain placed on the lower back to the user's legs via tension in the rubber bands. HeroWear claims that the device, which weighs 3.4 lbs can reduce the strain on back muscles by over 75 lbs.

Experimental Design and Study Protocol

A within-subject design was adopted for this study to detect correlations between biomechanical markers, subjective data, and heart rate variability for smaller sample sizes. All participants performed lifting tasks carrying a 45 lb cardiac monitor with and without the assistance of the passive low-back exoskeleton. The conditions (control, exoskeleton) were counterbalanced to remove the fatigue or perceptual bias accumulation. During the symmetrical lifting tasks, participants lifted the cardiac monitor from ankle to hip, ankle to shoulder, and ankle to overhead. Participants also performed asymmetrical lifts: left ankle to right hip, right ankle to left hip, and left hip to right hip. Participants were instructed to complete these EMT-specific tasks as they typically perform in the field. Stim markers were taken whenever the participant reached the N-pose (hands at the participant's side while standing straight) before and after each subtask.

At the start of the experiment, the participant signed a consent form; answered a demographic/anthropometry survey regarding sex, age, weight, and



Figure 1. HeroWear Apex Exosuit.

body proportions; and watched an informational video on exoskeletons. Next, EMG and XSENS IMU sensors were placed on the participant to measure muscle activity and motion capture joint angles, respectively. The EMG sensors were placed on the upper trapezius, erector spinae, anterior deltoid, biceps femoris, and vastus lateralis muscles. XSENS sensors were placed on the participant's head, shoulders, upper arms, forearms, hands, sternum, pelvis, upper legs, lower legs, and feet. Before starting the circuits, the participant was asked to complete a Technology Acceptance Model questionnaire. The first participant started with the control condition, and the second started with the exoskeleton condition. The following participants followed this pattern. Rates of perceived exertion and mental demand were collected after each subtask on a scale of 6-20and 1–21, respectively.^{7,8}

Subjective Measures

Subjective variables included a Technology Acceptance Model survey (TAM) to assess usability and acceptability, rates of perceived exertion, discomfort, and mental demand (RPE, RPD, MD) to understand user perception of how exoskeletons enhanced or restricted task performance. Consenting participants watched an introductory video and completed the TAM survey. The survey was completed at three distinct intervals: once after the video, once after the control condition, and once after the exoskeleton condition. A seven-point unipolar Likert scale was used to score the TAM questionnaire, with ordinal values assigned as follows: 1 = "Extremely Likely," 2 = "Quite Likely," 3 = "Slightly Likely," 4 = "Neither" 5 = "Slightly Unlikely," 6 = "Quite Unlikely," and 7 = "Extremely Unlikely." Wilcoxon signed-rank tests assessed response changes after the video, control, and exoskeleton conditions. All values with a p-value of less than 0.1 were considered significant.

After the participant completed a task, they would be asked about their perceived exertion from a scale of 6–20, and their mental demand from a scale of 1–10. After the participant completed a circuit cycle, they would be asked their rate of perceived discomfort on a scale of 0–10, and they would complete the NA-SA-TLX questionnaire survey on its 0–21 scale. After the control and exoskeleton conditions, the participant took the TAM again.

The Exosystem Use Intent (EUI) model was used after the exoskeleton condition to gauge the EMT worker's inclination to use the exoskeleton for work specific to their field.^{11, 12} A survey consisting of 31 questions was administered, evaluating the operator's attitude, ease of use, usefulness, individual context, social context, and task context in the interaction between the human and the exoskeleton. Each question was rated on a unipolar Likert scale with ordinal values ranging from 1 ("Negative") to 5 ("Positive"). The sum of individual question scores for each user determines an operator's level of intention to use the exoskeleton. The maximum EUI score that can be achieved is 155. A higher total score indicates a greater likelihood that the user intends to use the exoskeleton. In addition to the EUI score, the percentage of people scoring low (average ≤ 2), medium (2 < average < 4), or high (average \geq 4) on each of the subscales (attitude, ease of use, usefulness, individual context, social context, and task context) was calculated.

Bioinstrumentations

Electromyography (EMG)

EMG electrodes were placed on the participant over five different muscles: the right and left upper trapezius, erector spinae, anterior deltoid, biceps femoris, and vastus lateralis muscles. EMG data was recorded at 2000 Hz. Time markers were used to track the beginning and end of each subtask in the EMG recording. The task data was first bandpass filtered using a sixth-order Butterworth filter with a range of 20–450 Hz to eliminate noise in the signal data. Next, the task data were full wave rectified by taking the absolute value of the data to find peak magnitudes. Third, the data went through a root mean square (RMS) envelope with a window of 100 ms to normalize the data. A mean of this normalized data between the stim markers signifying a task was taken to find the rmsEMG data of each task.

Motion Capture

All participants were equipped with XSENS

wireless inertial motion capture systems to measure their full body motion kinematics. XSENS MVN Record software was used to record the data at 60 Hz. The system was calibrated at the beginning of each circuit task. The calibration was performed with an N-Pose orientation and a designated spot to maintain consistency among all participants. To improve the quality of the collected data, each circuit trial's data was HD processed in MVN Analyze Pro software. HD files were exported, and MATLAB scripts were developed to extract Joint Angle data for the lower back region.

Statistical Analysis

The subjective measures dataset consists of NASA-TLX, RPE, and RPD scores. The NASA-TLX survey reports mental workload in temporal demand, effort, performance, physical demand, mental demand, and frustration, while RPE & RPD signify the rate of perceived exertion and discomfort. A Shapiro-Wilks-test was used to test the normality of subjective measures datasets. The RPE and RPD subjective measure data had a p-value greater than 0.05, so a paired t-test was used. The NASA-TLX Data had a p-value less than 0.05. Hence the Wilcoxon Rank Test (non-parametric) test was used.

Wilcoxon signed-rank tests were performed to analyze TAM data for assessing responses after watching a video, after the control condition, and after the exoskeleton condition. All values with a p-value of less than 0.05 were considered significant. To analyze EUI scores first, the sum of individual question scores for each participant was calculated to determine an operator's cognitive flow and level of intention to use the exoskeleton. Subparts of the EUI model have been analyzed by calculating the percentage of the users who reported a score.

RESULTS

Objective measures

Joint Angles

The L5-S1 maximum & minimum joint angles were measured. No significant differences were found between the exoskeleton and control conditions for L5-S1 maximum (p > 0.637) and minimum (p > 0.622) L5-S1 angles.

EMG

EMG measured muscle activity as electric activity. Using an exoskeleton significantly reduced muscle activity in the L5-S1 low-back region (p < 0.05) compared to the exoskeleton and control conditions.

Subjective measures

NASA-TLX

Participants reported significantly lower scores in the exoskeleton condition than the control condition for: 1) temporal demand (p = 0.006; exoskeleton: 2.41 ± 2.20 ; control: 3.41 ± 3.47); 2) effort (p = 0.036; exoskeleton: 5.55 ± 3.45 ; control: 7.22 ± 4.08), and 3) physical demand (p = 0.044; exoskeleton: $7.24 \pm$ 3.77; control: 8.31 ± 3.37) were also significantly lower in exoskeleton condition (5.55 ± 3.45) than control condition (7.22 ± 4.08). No other significant differences were reported for performance, frustration, and mental demands in the NASA TLX since all p > 0.154.

RPE

No significant differences were identified in the ratings of perceived exertion (RPE) score in any of sub tasks of the circuit task since all p > 0.067.

Discomfort

Participants reported significantly lower scores of discomfort for the lower back (p < 0.001) for the exoskeleton condition (1.700 ± 1.688) compared to the control condition (3.017 ± 2.300). Discomfort for shoulder (p = 0.015) was also significantly lower for the exoskeleton condition (1.617 ± 1.472) compared to the control condition (2.283 ± 1.704). No other significant differences were reported in the ratings of perceived discomfort (RPD) for the thigh and lower leg since all p > 0.059.

Perception

TAM

Participants reported more likeliness to use the exoskeleton condition compared to their responses for

the control condition for "*I would find an exoskeleton* easy to use (p = 0.076; Control: 2.1 ± 1.0 ; Exoskeleton: 1.6 ± 0.9)." More likeliness after exoskeleton condition as compared to before condition was reported in "*My interaction with an exoskeleton would be clear and understandable* (p = 0.015; Before: 1.7 ± 0.7 ; Exoskeleton: 1.3 ± 0.4)"; "*Learning to operate an exoskeleton would be easy for me* (p = 0.016; Before: 2.0 ± 0.5 ; Exoskeleton: 1.5 ± 0.9 ." However, a decrease in likeliness to use an exoskeleton after the exoskeleton condition than before condition was reported for "*Using an exoskeleton would enhance my effectiveness on the job* (p = 0.08; Before: 2.5 ± 0.9 ; Exoskeleton: 2.5 ± 1.2)."

EUI

The average EUI score for the participants was 110.47 ± 13.4 out of 155 (maximum possible score), indicating a positive intention toward using an exoskeleton for EMS-specific tasks.

DISCUSSION

Due to the non-repetitive, dynamic nature of EMS work, designs that allow for more mobility must be coupled with guidelines for task-specific exoskeleton usefulness before widespread adoption becomes a possibility. Through future research and design, LBEs can be developed to meet the mobility demands of EMS workers while offering support during risky lifting situations.

Perceived Discomfort

Participants reported significantly lower discomfort scores in their low-back and shoulder regions (p < 0.001, p < 0.015) while wearing an exoskeleton. This finding suggests that the HeroWear Apex exoskeleton may effectively reduce discomfort in these areas for EMTs. However, it is worth noting that previous studies have reported increased discomfort while wearing an exoskeleton⁴. The positive perception of comfort while wearing the HeroWear Apex may be attributed to its unique "soft exoskeleton" backpack design, which differs from the "hard exoskeletons" used in previous studies^{6,9}. The success of a more mobile, lightweight exosuit highlights the importance of task-specific design for domain-specific applications.

Intention to Use

EUI scores, which measure potential use for the exoskeleton, were high, with an average score of 110.47 ± 13.4 out of 155 (**Figure 2**). However, despite the high EUI score, participants reported lower effectiveness on the job when using the exoskeletons (reported through the TAM survey). This perception may be attributed to the exoskeleton's design limitations, which could impede the work performance of EMTs. These results suggest that exoskeletons may not be sufficiently integrated into the workflow or environments of specific users. This also highlights the need for further research to optimize the design and integration of exoskeletons for specific work environments.¹⁰



Figure 2. EMT Exosystem Use Intent Rating Scores.

"DESIGNS THAT ALLOW FOR MORE MOBILITY MUST BE COUPLED WITH GUIDELINES FOR TASK-SPECIFIC EXOSKELETON USEFULNESS BEFORE WIDESPREAD ADOPTION..."

Limitations

Despite the insights provided by these findings, several limitations to this study must be acknowledged. Firstly, this research did not effectively counterbalance gender to ensure enough data was collected for female participants due to recruitment constraints at the Cy-Fair EMS Department. Two out of 20 participants identified as female compared to the Texas female EMT population, which comprises 24.5% of the total EMTs in Texas. Future studies should examine how perceived discomfort and usability change with female participants. Only a single data intervention was collected for a passive low-back exosuit. Future studies should consider more mobile and less mobile exoskeletons for different task-specific applications to determine what design features are well-suited to EMS work. Finally, future research should conduct long-term evaluations of exoskeletons for domain-specific tasks to assess user acceptance, musculoskeletal health, fatigue, habituation, etc., over a longer period to gain more generalizable results.

CONCLUSION

This study contributes to the growing body of research on exoskeleton technologies in the context of EMS work. The findings underscore the potential benefits of task-specific exoskeletons, particularly LBEs, in addressing the mobility demands and reducing the risks associated with lifting tasks for EMS workers. However, further research is needed to validate these findings and refine the design and implementation of LBEs in real-world EMS settings. By combining advancements in exoskeleton design with evidence-based guidelines for task-specific exoskeleton usefulness, the widespread adoption of these technologies can be realized, enhancing the safety and well-being of EMS professionals while optimizing their operational safety.

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Aidan '24 is a forensic and investigative science and entomology double major from San Antonio, TX who went to William J. Brennan High School. He plans to join the Toxicology PhD program at Texas A&M after graduation.



MICHAEL LORD '24

Michael Lord '24 is a biochemistry major with a chemistry minor from Waco, Texas who went to Waco High School. After graduation, he plans to get a PhD in biological sciences and pursue tenure.



AYESHA NAGARIA '23

Ayesha Nagaria '23 is a public health major from Katy, Texas who went to Seven Lakes High School. After graduation, she plans to pursue a career in healthcare and continue involvement in population health.



SHIVAM A. PANCHOLY '25

Shivam Pancholy '25 is a biomedical sciences major with a minor in psychology from Sugar Land, Texas who went to Elkins High School. After graduation, he plans to attend medical school.

BOARD BIOGRAPHIES



NIDHI PAWATE '23

Nidhi Pawate '23 is a nutrition major from Allen, Texas who went to Allen High School. After graduation, she plans to attend medical school in order to become a physician.



ANANYA PILLAI '24

Ananya Pillai '24 is a biomedical sciences major from Frisco, Texas who went to Liberty High School. After graduation, she plans to go to medical school while participating in research.



VISHAY RAM '24

Vishay Ram '24 is a molecular and cell biology major from Katy, Texas who went to Obra D. Tompkins High School. After graduation, he plans to go to medical school to pursue a career as a physician.



NUSHRAT JAHAN RASHID '24

Nushrat Rashid '24 is a biochemistry and genetics double major from Plano, Texas who went to Plano West Senior High School. After graduation, she plans to go to graduate school to earn a PhD in plant genetics.



TRAVIS RICHARD '25

Travis Richard '25 is a biochemistry major with a minor in chemistry from Dallas, Texas who went to Cistercian Preparatory School. After graduation, he plans to pursue a career in academic research or industry research.



SUBIKSHA SANKAR '25

Subiksha Sankar '25 is a biology major with a minor in business from Frisco, TX who went to Wakeland High School. After graduation, she plans to go to medical school.

BOARD BIOGRAPHIES



SUCHITAA SAWHNEY '24

Suchitaa Sawhney '24 is a biomedical engineering major from Flower Mound, Texas who went to Flower Mound high school. After graduation, she plans to attend medical school to earn a MD. and pursue a career in healthcare.



MIRIAM C. STEIN '24

Miriam Stein '24 is a molecular and cell biology major with a minor in bioinformatics from San Antonio, TX who went to BASIS San Antonio High School. After graduation, she plans to pursue a PhD in biomedical research.



JEREMY THOMAS '23

Jeremy Thomas '23 is a biomedical engineering major with minors in chemistry and mathematics from Highland Village, Texas who went to Marcus High School. After graduation, he plans to attend Duke University to earn a PhD. in biomedical engineering in Dr. Tatiana Segura's Lab.



ANDREA "ANDIE" CELESTE VAN RAVENSWAAY '23

Andrea van Ravenswaay '23 is an applied mathematics - actuarial science major with a minor in Art and Architectural History from Houston, Texas who went to Mirabeau B. Lamar High School. After graduation, she will attend the University of Texas at Dallas to receive a MS in Business Analytics with a concentration in Data Science.



LESLEY VILLAFUERTE '24

Lesley Villafuerte '24 is an English major from Crosby, Texas who went to Crosby High School. She currently participates in humanities research and plans to go to law school and work in Health Policy after graduation.



EBER VILLAZANA '23

Eber Villazana '23 is a biochemistry and genetics double major from Pearland, TX who went to Shadow Creek High School. After graduation, he plans to go to medical school.



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