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An Analysis of Propaganda Based upon the Rwandan Genocide

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Abstract

Throughout history, those in power have used propaganda as a powerful political tool to persuade the majority of a nation's people to align with an extremist point of view. The devastating effects of both the Rwandan genocide and the Holocaust were perpetrated by public conditioning that further divided two peoples. A comparison of these two events highlights the similar effects of propaganda on a nation. As division widens and hostility between groups intensifies, so do the messages promoted by hateful advertisement. Therefore groups on both sides of conflict develop more cohesion, which leads to a heightened sense of community among similar group members. This sense of society contributes to the deindividuation of a person within a group. Therefore one often loses a sense of responsibility in exchange for inclusion and safety. Evident throughout the Rwandan genocide and the Holocaust, deindividuation can lead to heinous, unapologetic acts of violence in the name of community. Propaganda is a dangerous political weapon that can have disastrous consequences for societies. A further analysis of both the Rwandan genocide and the Holocaust demonstrates the formulaic nature of propaganda, in which pre-existing division is exacerbated to accelerate conflict.

Keywords: Rwanda, Holocaust, genocide, propaganda, assertion, community, deindividuation

The analysis of history allows us to examine how heinous and violent acts, such as genocide, are permitted to occur against innocent peoples. Since the horrors of the Holocaust, well over fifteen genocides have taken place worldwide, including one in Rwanda (Genocides, 2008). Tutsi author Immaculée Ilibagiza describes the horrors she faced while trying to survive the Rwandan genocide as well as the progression of anti-Tutsi advertisement throughout the ethnic cleansing of the Tutsi minority. The spread of extremist Hutu beliefs contributed significantly to the success in initiating and intensifying the Rwandan genocide. An analysis of both the Rwandan genocide and the Holocaust proves that the success of hateful propaganda results from a 'ripple effect' of psychological manipulations, beginning with the affirmation of the general public's preexisting discriminatory beliefs and escalating with humanity's desire for inclusion and deindividuation. Through a comparison of the tactics, underlying motives, and results of extremist conditioning during the Rwandan Genocide and the Holocaust, one can identify the formulaic nature of propaganda and its effects on a society.

The establishment of propaganda in a divided community leads to discrimination against a population. In both the Rwandan Genocide and the Holocaust, cultural and economic conflicts exacerbated pre-existing tension between two groups of people. The Hutus' pre-existing distaste for the Tutsis derived from Belgian rule: "The Belgians favored the minority Tutsi aristocracy and promoted its status as the ruling class" (Ilibagiza, 2014). As a result of World War I (WWI), Belgium came to rule Rwanda as a League of Nations mandate (De Heusch, 1995). When Belgian missionaries entered Rwanda, they deemed Tutsis "Hamites", a superior race, due to the lighter pigmentation of their skin, while the Hutus were called "Bantus", the inferior race. Due to this distinguishment, Tutsis received positions and opportunities inaccessible to Hutus. Significantly, Belgian Colonial Administrations reduced the number of chiefs in the Belgian monarchy and declared that all chiefs must be Tutsi (De Heusch, 1995). Therefore, the increasingly evident

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favoritism of Tutsis led to frustration of Hutus. By the time the Belgian government left Rwanda in 1962, Tutsi resentment amongst the Hutus had solidified, creating division between the two groups. Tension between the different ethnicities intensified due to the distribution of resources and occupations within Rwanda. The favorable Tutsis often became wealthy cattle farmers while the Hutus merely farmed crops, a significantly less profitable vocation. The Belgian government enforced a division of ethnicities by separating professions by ethnicity. The term Tutsi came to be interchangeable with "cattle farmer" and the term Hutu interchangeable with "farmer" (Magnarella, 2002). The immense division and tension between Hutus and Tutsis was crucial for the subsequent success of anti-Tutsi propaganda.

Comparatively, in Germany, the aftermath of WWI led to friction between Aryans and Jews, even before the rise of Hitler. The conditions of the Treaty of Versailles made Germany's defeat in the war humiliating. Germany had to pay 132 billion gold marks (in addition to interest), around 400 billion dollars today. The nation was also forced to accept responsibility for the war and the losses that resulted from it by signing the war-guilt clause (Webb, 1986; Lu, 2008). In addition, France later invaded the Ruhr region: the center of coal, steel and iron within Germany. Though the seizure was intended to compensate for unpaid reparation debts, it only exacerbated German anger and left the nation increasingly unable to pay for reparations. In addition, Germany was forced to scale down its military substantially in fear of future attacks. By restraining the country's remaining economic and military resources, the Treaty of Versailles attempted to prevent Germany from ever becoming a major power again (Lu, 2008). These constraints created a nation unable to recover from the war. As a result, citizens began searching for a scapegoat for their troubles. This scapegoat came in the form of the Jews, who were often blamed for the financial trouble of non-jews due to their wealth and high profile occupations. Occurrences such as the boycott of Jewish small business became increasingly common (Kater,1984). Germany, similar to Rwanda, had created a divided environment between two groups of people due to the aftermath of a previous conflict.

In both Rwanda and Germany, division amongst citizens was enhanced through physical identity verification methods. In Rwanda, ethnic identity cards created by the Belgian government fueled disunity: "The Belgians introduced an ethnic identity card… deepening the rift they'd created between Hutu and Tutsi" (Ilibagiza, 2014). Division between the Hutus and Tutsis created vulnerability within the two ethnicities, each comparing one to the other. Both groups' desire to be the superior ethnicity resulted in the Hutus' discrimination of the Tutsis. The ethnic identity cards used in Rwanda directly parallel the gold star used to identify Jews before the Holocaust. The repeated use of physical identification as a means of disunion highlights formulaic methods that successfully divide cultural or ethnic groups. The pervasive division between groups allowed for the continued use and acceptance of more extreme forms of propaganda.

The success of propaganda stems from the assertion of a majority's nascent, discriminatory beliefs - rooted in preexisting division - rather than the persuasion of a new viewpoint. Propaganda affirms a hesitant population's budding convictions and encourages individuals to take action in support of it (Welch, 2004). In a study predating the Second World War, Aldous Huxley argues that "Propaganda gives force and direction to the progressive movements of popular feeling and desire, but it does not do much to create these movements. A propagandist is a man who canalizes an already existing stream. In a land where there is no water, he digs in vain" (Welch, 2004). The successful use of anti-Tutsi advertisement during the Rwandan genocide was attributed to the Hutus' animosity towards Tutsis preceding the massacre. Occurrences such as the suspicious death of a Hutu leader, Dominique Mbonyumutwa, strengthened tensions and sparked a Hutu revolution (Rohr, 2009). The Hutus rose to power on January 28, 1961, after overthrowing the Tutsi king. Soon after, Rwanda became a republic and separated from Belgium to gain independence, which left the Tutsis defenseless (Rwanda, 2016). On the evening of April 6, 1994, Hutu president Juvénal Habyarimana's plane was shot down. Many Hutus suspected involvement from the Rwandan Patriotic Force (RPF), a Tutsi rebellion group, which only intensified their anger. After this event, propaganda

began to take its shape and affirm the suspicion that many Hutus held. Radio stations in favor of Hutu mobilization began circulating anti-Tutsi sentiments and encouraging action against the Tutsis. Propaganda strengthened and justified the Hutus' nascent, discriminatory beliefs through affirmation, to instigate violence against the Tutsis. Through reassurance, propaganda created a sense of normalcy surrounding one's extreme beliefs.

Due to the Hutus' preexisting animosity towards the Tutsis, they quickly became susceptible to anti-Tutsi propaganda. Ilibagiza recalls several instances of ethnic segregation, highlighting the preexisting discrimination towards Tutsis. During Ilibagiza's first day of upper school, she becomes aware of the divide between Hutus and Tutsis due to her hostile teacher, Buhoro: "Immaculee Ilibagiza, you didn't stand up when I said Hutu… and you're not standing up now that I've said Tutsi. Why is that?" Buhoro was smiling, but his voice was hard and mean" (Ilibagiza, 2014). Before the circulation of anti-Tutsi propaganda even began, Hutus had a distaste for Tutsis but kept it suppressed, as Buhoro did. As this advertisement began to disperse, Hutus became more confident in outwardly displaying their contempt. When Ilibagiza ran to Pastor Murinzi's house at the beginning of the genocide for protection, she saw Buhoro and began to find comfort in a familiar face, only to discover his underlying hatred for Tutsis: "The first person I saw was Buhoro … he [clicked] his tongue in disgust and turning his back on me. I realized he was an extremist Hutu who had always hated Tutsis" (Ilibagiza, 2014). Though Buhoro had resented Tutsis in the past, he hid his disdain because he did not have any affirmation of his beliefs. However, due to extremist Hutu propaganda, he began to exhibit his contempt unapologetically. The spread of the Hutus' extremist messages validated anti-Tutsi beliefs and encouraged many to take action. The Hutu government's disregard for Tutsi education also indicated the preexisting divide between the two ethnic groups. Being a Tutsi, Ilibagiza struggled to get accepted into a public high school: "My name wasn't on the list of scholarship students… Despite my top marks, I'd been passed over because I was Tutsi" (Ilibagiza, 2014). Ilibagiza's rejection was based upon her ethnic profile, highlighting Rwanda's racial segregation preceding the genocide. The government's acknowledgment and approval of this divide indicates the Hutus' unanimous disdain for Tutsis. Ethnic discrimination instilled a general distaste for Tutsis which eventually led to the success of extremist propaganda. As a result of the confidence and assertion the Hutus receive from publicity, they act on their hate without fear of wrongdoing.

The tension in Germany predating the Holocaust between Jews and non-Jews created a pre-existing disdain towards Jews, which was essential to the success of Nazi propaganda. Preceding the reign of Nazi Germany, non-Jewish citizens anti-Semitism clearly demonstrated their anti-Semitism towards Jews. When the Weimar Republic decided to grant emancipation for German Jews in 1914, non-Jewish citizens raised several oppositions. In addition, many accused Jews of war profiteering and avoiding the front line of a battle (Kater,1984). Jewish citizens, such as Dr. Kaete Frankenthal feared college enrollment due to the fear of inevitable anti-Semitism, demonstrating the prevalence of discrimination predating Nazi rule. Once the Nazis gained a bit of power, they began using propaganda via the radio and newspapers to affirm anti-Semitic beliefs. Eventually they got national approval the Nuremberg laws, which created disadvantages for Jewish citizens. Nuremberg laws prohibited inter-marriage between Aryans and Jews and banned Jews from flying German flags (Bradsher, 2010). The government's support of the anti-Jew movement led to the justification of many civilian' anti-Semetic beliefs. This government support, coupled with powerful propaganda tactics, such as media control, films, and youth programs, led to the heinous acts committed during the Holocaust.

After affirming the beliefs of a majority, propaganda creates a community for those on the inside, but more importantly, for those generally on the outskirts of society to find a sense of unity and solace through inclusion. Once a community is established by those with propaganda driven beliefs, people outside of the population become attracted to the camaraderie within it (Morris, 1998). In a study of anti-Jewish advertisement, David Welsh finds elements of Nazi propaganda that remain true for all successful propagandized movements: "Fundamental in the propaganda presentation was the attempt to forge an awareness

of the notion of 'experience'… The conscious experience of 'inclusion' as a comrade of the community (as opposed to being an 'outsider') was a critical part of the pseudo-religious vision of a 'national awakening" (Welch, 2004). In Germany, the Nazis established this community, made up of German leaders, medical professionals, politicians, and regular civilians. The Nazi party also created popular programs such as Hitler Youth in order to train and condition the young to support the Nazi movement (Kater, 2009). Groups such as Hitler Youth made initial non-conformists outcasted by society. Therefore, the community created by the success of Nazi propaganda was essential for the party to garner maximum support.

In Rwanda, the Interahamwe made up the majority of the perpetrators in the massacre. Hutu killers within the Interahamwe scoured the streets of Rwanda to kill Tutsis or anyone against the Tutsi ethnic cleansing. The comradery formed within the community drew in both hesitant civilians simply looking to side with the majority as well as outsiders yearning to be a part of a community. Evident through the perspective of Ilibagiza, the human desire for inclusion was essential to the success of propaganda, "I saw Philip, a young man who'd been too shy to look anyone in the eye… completely at home in this group of killers" (Ilibagiza, 2014). Though once quiet, Philip found brotherhood and community by joining the Interahamwe. His yearning for inclusion and comradeship influenced him to conform to extremist opinions. Many conversions resulted from this concept. After Hutus joined the Interahamwe in search of inclusion, propaganda further instilled true hatred amongst the converted.

As a community, fueled by propaganda, grows in members, radical actions and violence escalate due to deindividuation. Deindividuation is the "phenomenon in which people engage in seemingly impulsive, deviant, and sometimes violent acts in situations in which they believe they cannot be personally identified" (Douglas, 2018). Most prevalent in large communities, "getting caught up in the crowd tends to increase the prospects for anonymity among perpetrators and encourage expressive violence" (Boyle, 2014)." Within the Hutus, the prevalence of deindividuation grew when larger masses of people agreed upon propagandic messages. When people gathered in large groups, as the Interahamwe did, they lost self-awareness and were more likely to engage in violent acts of expression due to their anonymous group setting. As the number of Hutu killers increased, people felt less accountable and more anonymous, resulting in the progression of violence during the genocide. The Hutu killers' savage methods of extermination began to intensify. Though violence began with one carrying a gun, it quickly escalated into torture and deliberately slow executions (Yanagizawa-Drott, 2014). Evident during Ilibagiza's brother Damascene's execution, the Hutu killers lacked self-awareness: "'What are you waiting for? Are you cowards… Kill Him.' Karera shamed the killers into committing murder… the first killer took another turn with his machete, this time slicing Damascene's skull open and peering inside." (Ilibagiza, 2014). The killers, "shamed" into murder, eventually partook in excessive violence during Damascene's execution due to the pressure of others. Though initially hesitant to kill, Karera's yelling forced them to do so; they slaughtered Damascene immediately afterward his words. Karera's commands were taken without hesitation because the other killers had lost their self-awareness from being in a group setting. Because the killers felt anonymous, their murder felt permissible. Even if they felt uncomfortable with murdering people, the pressures put on them by their community would have forced them to do so. Deindividuation within a community, created by those consumed in propaganda, escalates the violence that eventually leads to genocide.

Due to the Nuremberg laws, anti-Semitism quickly gained prevalence amongst Aryans. Germans increasingly listened to the propagandic radio broadcasts and newspapers circulated by the Nazis. As concentration camps opened, members of the Nazi party participated in the murder of millions of Jewish people, many without the guilt of murder attached to them. This was due to deindividuation. As the community of Nazis grew, people felt increasingly anonymous and therefore unaccountable for their actions (Vilanova et al., 2017). Most notably, the deindividuation of the participating guards allowed for the utilization of gas chambers to kill large masses of people in concentration camps. Men engaged in these acts of violence in exchange for acceptance into the Nazi

community and with the understanding that they would not be held accountable for their crimes (Vilanova et al., 2017). The successful use of propaganda to intensify the Nazi movement led to increased deindividuation and violence of the people within the movement.

During the genocide, the Rwandan media and the press contributed significantly in the distribution of propaganda, which precipitated much fear and tension amongst leaders and the ordinary citizens (Edmond & Chris, 2013). A prominent outlet for propaganda was the newspaper. Similar to the Nuremberg Laws in Germany, the Kangura successfully circulated anti-Tutsi messages around the country. In 1990, The Kangura published an article called the "Ten Commandments of the Hutus", deeming any Hutu having non-violent interactions with a Tutsi a traitor. The media received considerable attention from many scholars and professionals, including human rights activists. Rwandan media organizations incited members of the public to actively take part in the killings that ended with the loss of between five hundred thousand to one million citizens. The United Nations created a tribunal in response to the mass killings, and more than 70,000 individuals were prosecuted in a court of law for being bona fide members or accomplices of the armed militias. The extremist group had carried out over 433,000 attacks that engaged localized violence. The media contributed immensely to the anti-Tutsi propaganda messages and led to immense destruction within the country.

The Nazis had various methods of spreading their propagandic messages, from cinema to flyers. Movies such as *The Eternal Jew* slowly ostracize the Jewish people (Klug, 2003). In addition to this, flyers with anti-Jewish sentiments circulated across the nation. Similar to the Hutus, the Nazis also had control of the media and often made anti-Semitic radio broadcasts. The extreme distribution of propaganda by the Nazis heavily contributed to the Aryan support of the Holocaust. The strikingly similar propaganda methods used by the Hutus and Nazis, further highlights the formulaic nature of these divisive tactics.

Both the Rwandan genocide and the Holocaust caused extreme, long-term devestation within the nations. By the end of WWII around 15 to 20 million Jews died in concentration camps. After the Holocaust, the Nuremberg trials put merely twenty two Nazis to trial for their crimes (Owen, 2006). Though 22 individuals became accountable for their actions, the thousands of other Nazis remained blameless. Germany found difficulty in healing after the war due to the absence of proper punishment for all of the people involved in the Holocaust, including the thousands that had left the country to avoid responsibility (Steinacher, 2012).

In Rwanda, after 100 days of slaughter, approximately 85% of the Tutsi, which constitutes about 10% of the Rwandan population, had died (BBC, 2019). However, the lasting effects of the genocide go beyond death; the everyday lives of civilians reveal the process of healing. The Rwandan flag and national anthem, formerly associated with Hutu patriotism, has been changed to be more inclusive of all ethnicities. In 2003, the Rwandan constitution was reconstructed (Rwanda, 2016). In addition to this, Rwanda implemented the gacaca system among perpetrators of war crimes to reduce their sentences immensely. The gacaca system promoted healing within the country by bringing victims and perpetrators together on grass to discuss the faults of the perpetrator and the emotions of the victims (Zorbas, 2004). This system brought immense healing to the community and made it possible for Tutsis and Hutus to live side by side once more. Tutsi survivors worked alongside their Hutu perpetrators while struggling to reestablish a sense of unity within the nation. Rwanda's form of healing has proven to be quite successful and is seen as a model for reconciliation for areas where tragedy strikes.

Conclusion

The success of propaganda is rooted in the manipulation of human nature. As seen during the Rwandan genocide and the Holocaust, propaganda reinforces one's preexisting biases and escalates conflict through the manipulation of natural human traits such as one's desire for inclusion and the act of deindividuation (Hirshleifer, 1989). Because human nature remains unchanging, conditioning tactics also remain constant. The analysis of history proves a formulaic procedure for propaganda. Despite unchanging tactics, the prevention of conditioning seems unlikely, as history has repeated itself time and time again. Despite the

Holocaust and Rwandan genocide occurring decades apart from each other, they still followed the same formula of preexisting tension and resentful propaganda prior to violent conflict. Societies will always be susceptible to propaganda and the extremist messages it presents due to the rigidity of human nature.

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Cryptology using Transformation Geometry & Complex Numbers

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Abstract

The importance of cryptology for providing reliable communication between two parties increased rapidly in recent years with the increase of electronic data sharing and the spread of data theft. In this study, we aim to create a cryptology model using transformation geometry and complex numbers. To enhance the security of the cryptology, the model consists of two levels of transformation. The first transformation is used to obtain the coordinates of the point rotating around a second point which rotates around a fixed point. The other transformation is used to find the coordinates of a point before the rotation of that point. The usefulness of the cryptology model and how it is transmitted and analyzed is discussed. This encryption can be used by companies and programmers, and can play an important role in various fields such as the development of defense technology. In particular, by examining the rotation of a point around another moving point in the creation of the cryptology model, the findings can be developed and moved to three-dimensional systems. Thus, the movements of objects rotating in a three-dimensional environment such as planets and celestial bodies can also be examined.

Keywords: Cryptology, Complex Plane, Complex Numbers, Polar Representation, Transformation Geometry, Encryption, Decryption

1. Introduction

Cryptology is the science that enables communicating parties to exchange encrypted information and solve the hidden texts with mathematical formulas (Piper, 1997; Zekry, A., & Elbarbary, 2016; Kessler, 2019). It is now widely used in mathematics, optics, electronics and computer science. Cryptology has had a significant impact on history, especially in the fields of espionage and during wars (Frode & Zabell, 2019). The purpose of cryptology is to transmit the information in an encrypted manner. The transmitted information can be converted into its original form through decryption by the receiving party. The origins of cryptology is rooted in the times Julius Caesar, who used what he called "Caesar's Cipher" — one of the simplest methods of encryption. With the advancement of technology, today's encryption algorithms are much more complex and can convert sensible messages into an unintelligible format. These encrypted messages can be decoded using "Cryptographic Keys," which is essentially a password. There are two types of cryptographic keys: Symmetric Key and Asymmetric Key. Symmetric encryption is a straightforward technique in which the sender uses "Symmetric Key" before sending information and the receiver uses it in order to decrypt the encoded message. Caesar's Cipher is a conventional example of this type of encryption. Modern symmetric encryption algorithm include QUAD, Blowfish, DES and RC4. Asymmetric encryption is more complicated as it involves cryptographic keys: Public Key and Private Key. The public key can be deployed comfortably to everyone and is used for encryption. The encrypted message can only be decrypted with

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the receiver's private key by following a secret mathematical path. There can be different approaches applied to cryptographical algorithms.

The aim of this study is to examine the rotation of a point around a moving point by using the transformation geometry and complex numbers. The derived relationships are then used to create a secure cryptographical encryption model. Geometry and complex arithmetic have not been explored in the lens of cryptology as much as other mathematical fields (Singh et al. 2015). However, some recent studies include the work of Dimitrov et al. (2009), who proposed new algorithms for multi exponentiations based on complex arithmetic. The purpose of these algorithms was to speed the performance of earlier cryptology systems (Rivest et al., 1978; McLellan, 1986; El Gamal 1985). Additionally, Elsayed Mohammad et al. (2009) discussed the elliptic curve cryptography over Gaussian integers.

The set of complex numbers contains the set of real numbers. The solution set of the equation is, but the equation has no solution in real numbers. In order to solve it, we need complex numbers. In this case, the solution should be the square root of which is defined as. Complex numbers have the form, where and are real numbers; is called the real part and is called the imaginary part. As shown in Figure 1, we represent the real and imaginary parts by two axes. A complex number is visualized as a point in the complex plane which consists of the *argument* of the angle between the positive real axis, and the line joining the point to the origin, shown as in Figure 1.

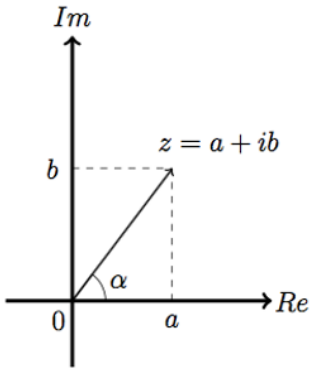

Figure 1: Complex Plane

The real and imaginary parts of a complex number are determined from:

$$a=|z|\cos\alpha \quad \text{and} \quad b=|z|\sin\alpha$$

where |z| is the length of the line joining the point to the origin. Therefore, we can represent the point z = a + bi as

$$z=|z|\cos\alpha+i|z|\sin\alpha$$

or equivalently

$$z=|z|(\cos\alpha+i\sin\alpha).$$

Denoting the term (cosα+isinα) by cisα, a complex number z can be written shortly as:

$$z=|z|\text{cis}\alpha.$$

The above expression is referred to as the polar representation of z.

2. Method

2.1 Rotation of Complex Numbers around the Origin

The coordinates of the new point formed by rotating a point (x,y) by and angle α^◦ on the coordinate system around the origin are known from the transformation geometry. These coordinates can be expressed as:

$$(x\cos\alpha - y\sin\alpha,\ x\sin\alpha + y\cos\alpha).$$

Alternatively, instead of this formula, the point (x,y) in the coordinate system can be considered to be in a complex plane, and the rotation can be done more readily using complex numbers. For this purpose, we represent the point (x,y) as the complex number x+yi. Then the product of x+yi and cisα gives the complex number representing the point obtained by the rotation of (x,y) by α^o around the origin. We can prove this relation as follows.

Let $z = |z|cis\beta$. Then we obtain

$$\begin{aligned} zcis\alpha &= |z|cis\beta cis\alpha \\ &= |z|(\cos\beta + i\sin\beta)(\cos\alpha + i\sin\alpha) \\ &= |z|(\cos\alpha\cos\beta + i\cos\alpha\sin\beta + i\sin\alpha\cos\beta - \sin\alpha\sin\beta) \\ &= |z|\,[\cos\alpha\cos\beta - \sin\alpha\sin\beta + i(\cos\alpha\sin\beta + \sin\alpha\cos\beta)] \\ &= |z|\,[\cos(\beta+\alpha) + i\sin(\beta+\alpha)] \\ &= |z|cis(\beta+\alpha) \end{aligned}$$

To sum up, the product of z=|z|cisβ and cisα gives the complex number |z|cis(β+α). In the complex plane, the increase of the argument of z

with α^o means that the complex number z is rotated by α^o around the origin. The real part of this complex number forms the abscissa of the point resulting from rotation, and the imaginary part forms the ordinate of the point. In our study, we will make inferences about how to find the point that occurs when a point is rotated around another point by developing the polar representation method.

2.2 Rotating a Point around Another Point

The next step in rotating a point around the origin in the complex plane is to rotate a point around another point. To rotate the point (a,b) around the point (c,d) shown in Figure 2, by α^o, the following steps are performed:

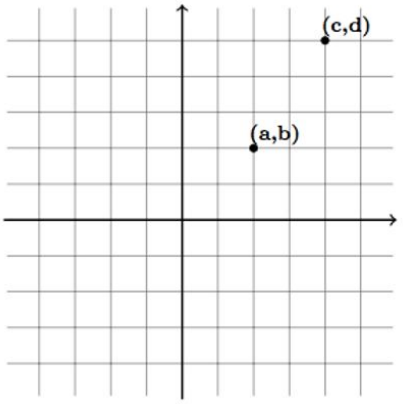

Figure 2: Location of points (a,b) and (c,d)

1) Firstly, we translate the point (c,d) to the origin. The point (a,b) is also translated by the same translation. The translation of the point (a,b) is denoted by (a',b') in Figure 3.

- (c,d) is translated to the origin: $(c+di)-(c+di)=0+0i$
- (a,b) is translated to (a',b'): $(a+bi)-(c+di)=(a'+b'i)$

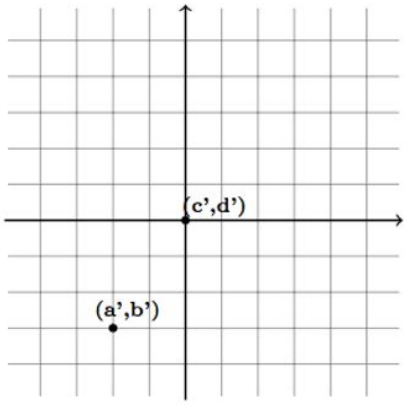

Figure 3: Location of the translated points

2) To rotate (a',b') around the origin by α^o, we take the product of $a'+b'i$ and $cis\alpha$. The new point is denoted by (a'',b'') as depicted in Figure 4.

- (a',b') is rotated and (a'',b'') is obtained.

$$((a+bi)-(c+di))cis\alpha=a''+b''i$$

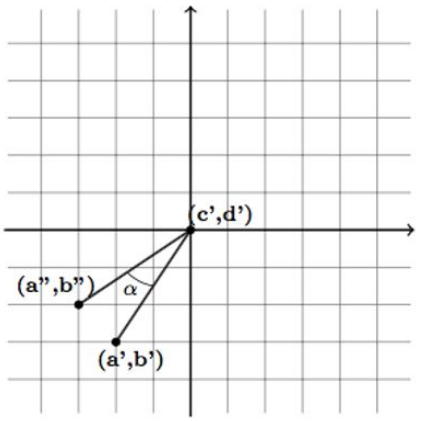

Figure 4: Rotation of point (a',b')

3) Finally, we translate again the origin to (c,d). Then the point (a'',b'') is translated by the same translation, and we obtain the point formed by rotation of (a,b) around (c,d) by α^o. We denote the point by (m,n) in Figure 5.

- (a'',b'') is translated to (m,n):
  $((a+bi)-(c+di))cis\alpha+(c+di)=m+ni$

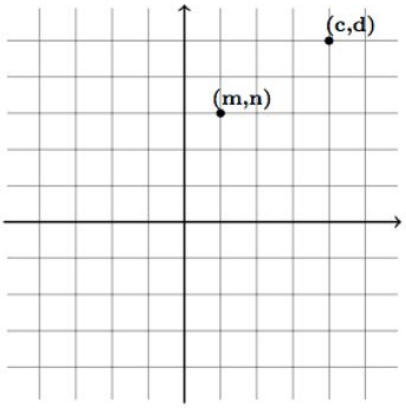

Figure 5: Location of the translated point

4) Therefore, the rotation of (a,b) around (c,d) by α^o is the point (m,n) is calculated by

$$m+ni=(a+bi)cis\alpha+(c+di)(1-cis\alpha).$$

2.3 Rotating a Point around Another Moving Point

Let (x,y) be the coordinates of the point obtained by the rotation of (e,f) by β^o around the point (a,b) which, in turn, rotates by α^o around a fixed point (c,d). In order to find x and y, we apply the following steps.

1. The rotation of (a,b) by α^∘ around (c,d) yields the point (m,n).
2. How far (a,b) is shifted compared to (m,n) is calculated.
3. The point (e,f) is also shifted at the same rate as in Figure 6. This point is denoted by (e',f').
4. Finally, (e',f') is rotated by β^o around (m,n) and we get the point (x,y).

In these steps, we will apply the formula obtained in the previous section:

$$m+ni=(a+bi)cis\alpha+(c+di)(1-cis\alpha).$$

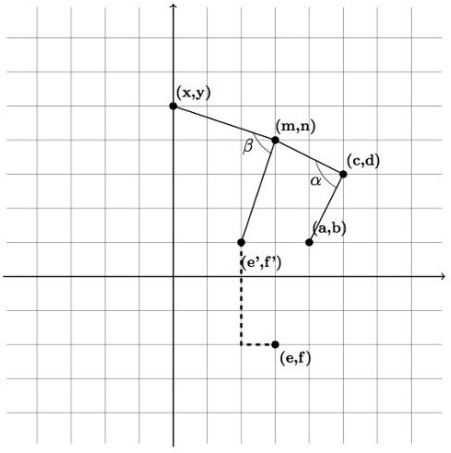

Figure 6: Location of original and transformed points

The point (e',f') is obtained as follow:

$$(e'+f'i)=(e+fi)+((m+ni)-(a+bi)).$$

After the rotation of (e',f') by β around (m,n), the coordinates of (x,y) is given below:

$$x+yi=(e'+f'i)cis\beta+(m+ni)(1-cis\beta).$$

When we write the expansion of e'+f'i to the equation above, we get:

$$x+yi=[(e+fi)+((m+ni)-(a+bi))]cis\beta+(m+ni)(1-cis\beta).$$

This means that

$$x+yi=(e+fi)cis\beta-(a+bi)cis\beta+(m+ni).$$

If we write the expansion of $m+ni$ to the equation above, we obtain:

$$x+yi=(e+fi)cis\beta-(a+bi)cis\beta+(a+bi)cis\alpha+(c+di)(1-cis\alpha).$$

Finally, we derive the formula for x+yi as follows:

$$x+yi=(e+fi)cis\beta+(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha).$$

We can rearrange this equation so that following the step above, the initial position of the given point can be found:

$$e+fi=\frac{(x+yi)-[(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha)]}{cis\beta}.$$

2.4 Example

To describe the above examples, a simple example is presented. Specifically, the point (2,4) is rotated by 32^o around the point (3,5). Also the point (1,1) is rotated by 40^o around the moving point (2,4).

a. Find the coordinates of the point obtained by the rotation of (1,1).

Consider $(e,f)=(1,1)$, $(a,b)=(2,4)$, $(c,d)=(3,5)$, $\alpha=32$, and $\beta=40$.
Using the relationship derived in the Section 2.2

$$x+yi=(e+fi)cis\beta+(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha),$$

This yields $x + yi = 3.8441 + 0.6811i$ which means $(x,y) = (3.8441,0.6811)$.

b. Find the initial position of $(x,y) = (3.8441,0.6811)$ before rotation.

Solution) Using the formula

$$e+fi=\frac{(x+yi)-[(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha)]}{cis\beta},$$

we obtain $e + fi = 1 + i$ This is equivalent to $(e,f) = (1,1)$ which is the initial point we started with before rotation.

This example shows that using these two equations, it is possible to find both the coordinates of the point formed after the two rotations and the initial coordinates of a point before the rotation.

3.Applications

3.1 Relation of Research with Cryptology

In this study it is shown that if we rotate a point at a certain angle around another point and rotate the system consisting of those two points at an angle around another point, it is possible to find the coordinates of the first point from the coordinates of the end point. If we associate this situation with cryptology, first a point with the required information is transmitted to the other party. The coordinates of that point can then be decrypted to obtain the original information. If the coordinates of the rotating points and the rotation angles are transmitted, many cryptographical passwords can be created. The desired point can be sent to the opposite side, and the coordinates of the initial point can only be understood by the other party. Formulas found in this study can be used for the other party to understand the message.

3.2 Sample Cryptology Model

Many cryptographical systems can be created by taking advantage of the rotation of a point around another moving point. In a sample cryptographical model created in this research, the point (c,d), the angle α, the point (a,b), the angle β, and (x,y) are the information which should be known. The information to be transmitted to the receiving party consists of the point (e,f). Table 1 summarizes the points and angles used in the cryptology model where $a, b, x, y, e, f, \beta, \alpha$ are real numbers.

Table 1: Points and angles that are used in the model

Fixed Point	(c,d)
The angle for the rotation around the fixed point	α
The coordinates of the point which rotates around the fixed point	(a,b)
The angle for the rotation around	β
The coordinates of the last point	(x,y)
The coordinates of the point which is transmitted	(e,f)

A sender may transmit the cryptographical message $(c,d,\alpha,a,b,\beta,x,y)$ to the other party. The first two data in the brackets are the coordinates of the fixed point; the third data is the rotation angle of the rotating point around the fixed point; the fourth and the fifth data are the first coordinates of the rotating point around the fixed point, the sixth data is the rotation angle of the point to be transmitted, the seventh and eighth data are the coordinates of the point after the rotation of the point to be transmitted. With this information, using the formula

$$e+fi=\frac{(x+yi)-[(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha)]}{cis\beta},$$

the receiver finds the coordinates of the point to be transmitted.

In order to write $(c,d,\alpha,a,b,\beta,x,y)$ with fewer data, we can use the message (c,d,a,b,x,y). This will get rid of unnecessary data and will make the code harder to understand by giving away less information. According to this notation, a prior agreement must be made for the party receiving the message to understand the angles α and β. For example, the angle α can be the product of c and d, and the angle β is the product of a and b. All the data to be known in this way are understood by the receiver and the coordinates of the desired point can be reached using the equation given above.

3.3 Sample Transmission by Model

The sender must make calculations to be able to write the coordinates (c,d,a,b,x,y) of the point (e,f) to be transmitted. To make these calculations, the points (c,d) and (a,b) are selected randomly.

The following angles are created with the selection of these points:

$\alpha = c \times d$

$\beta = a \times b$

To reach the desired point (e,f), the coordinates of point (*x,y*) must be calculated.

To demonstrate the applicability of the developed cryptology model, an example is presented in this section. Specifically, the example attempts to transform the point (1,2). Let (6,5) be the fixed point and (3,3) be the point rotating around the fixed point. In this case, we have $\alpha = 5 \times 6 = 30$ and $\beta = 3 \times 3 = 9$. These values are used in the formula below to obtain (*x,y*):

$$x+yi=(e+fi)cis\beta+(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha).$$

This yields:

$$(1+2i)cis9+(3+3i)(cis30-cis9)+(6+5i)(1-cis30) = 2.5829+0.4673i.$$

Hence, (2.5829,0.4673) is the coordinates of the point (*x,y*) formed.

According to this solution, if we apply the point to the model, the message sent to the other party can be written as below:

(6,5,3,3,2.5829,0.4673).

3.4 Sample Password Analysis

The party receiving the transmitted message (6,5,3,3,2.5829,0.4673) of the previous example needs to back calculate to reach the coordinates of the point which is desired to be transmitted. First, α and β must be determined. They are 30 and 9, respectively, obtained by the multiplication of 6 by 5 and 3 by 3, respectively. The receiver who is trying to decipher the message understands that (*c,d*) is (6,5) and (*a,b*) is (3,3) and (*x,y*) is (2.5829,0.4673). If one puts these data into the following formula

$$e+fi = \frac{(x+yi)-[(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha)]}{cis\beta},$$

then one gets the first point, i.e. the coordinates of (*e,f*):

$$e+fi = \frac{(2.5829+0.4673i)-[(3+3i)(cis30-cis9)+(6+5i)(1-cis30)]}{cis9} = 1+2i$$

According to this solution, the coordinates of (*e,f*) which is desired to be transmitted is found to be (1,2). Hence, the receiver has obtained the desired message.

3.5 Plain Text Encryptions

The coordinates of the points transmitted with this cryptology model can be used to refer to various words, enabling us to encrypt plain text. The proposed method can be extended to the encryption of text by adding two additional steps at the very beginning and end. The first step involves transforming the word into numbers using an agreed upon conversion. The number is then transformed according to the algorithm described above. The second step is done by the receiving party and involves converting the numbers to the desired word after using reverse encryption to determine the numbers.

For example, in a cryptology system to be used in war, (1,1) can stand for Attack! (2,2) can stand for Out of ammo! and (3,2) can stand for *The enemy is approaching!*. Hence, a meaningful expression can be transmitted in an encrypted manner rather than simply transmitting the coordinate of a point. In another example, we can define 0 = *space*, 1 = *a*, 2 = *b*, 3 = *c* etc. To deliver a message that says "hello," the letters of the word should be initially converted into numbers by the sender. In this case, $h = 8$, $e = 5$, $l = 12$, $o = 15$. The sender will have to send 3 different points (8,5), (12,12), (15,0) — using the proposed encryption model. Once the receiver decodes the message and finds the intended points, the conversion from numbers to letters can be applied. Therefore, when these points are converted into letters in the order they are sent, the receiver arrives to the word "hello."

4. A Comparison of the Research with the Caesar Encryption and Related Works

The cryptology model presented in this study is more complicated and more difficult to solve compared to Caesar encryption, a widely used cryptographical model (Christensen, 2010). For example, according to Caesar encryption, letters used in transmitting messages are shifted one letter. Hence, the letter a is replaced by the letter b; the letter *b* is replaced by the letter *c*, and so on. Caesar

encryption can be used to shift messages two letters: the letter *c* is written instead of the letter *a*; the letter *d* is written instead of the letter *b*, etc... This shifting is valid for all alphabet and because of this, secret messages can be sent. Considering the frequency of some letters, it is quite easy to decrypt the Caesar encryption by a computer that is programmed accordingly. In this study, the use of complex numbers and the transformation geometry in cryptographical systems complicates the formulas needed to decrypt and makes it difficult to decrypt the codes.

Kishore and Venugopal (2011) proposed another encryption algorithm based on complex bilinear transformation. This algorithm involves encoding the data onto a complex plane as a set of points and its bilinear transformation to a new set of points in another complex plane. Our proposed encryption method resembles to some extent this algorithm as they both consist of translation and rotation. A difference is that our method has two subsequent transformations and can be potentially extended to more.

Kumar et al. (2012) developed an encryption algorithm which uses properties of circles, principles of Cartesian geometry, and rotation and translation to encrypt data. Our encryption method uses complex arithmetic besides transformation geometry.

5. Summary and Conclusions

In this research, complex number relationships and transformation geometry were utilized to express the coordinates resulting from the rotation of a point around another point. Based on these developed relationships, a coding system which is difficult to be deciphered was formed. Senders and receivers that communicate with this encryption system will be able to send position in a Cartesian plane.

In this paper, three different formulas were obtained. First, the formula giving the coordinates of the point (m,n) obtained by being rotating a point (a,b) around another point (c,d) by α^o is developed:

$$m+ni=(a+bi)cis\alpha+(c+di)(1-cis\alpha).$$

The second formula gives the new coordinates of the point obtained by the rotation of (e,f) by β^o around the point (a,b) which rotates by α^o around a fixed point (c,d);

$$x+yi=(e+fi)cis\beta+(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha).$$

The third of these is the formula giving the initial coordinates (e,f) when we know the coordinates (x,y) obtained by the rotation of (e,f) by β^o around the point (a,b) which rotates by α^o around a fixed point (c,d) ;

$$e+fi=\frac{(x+yi)-[(a+bi)(cis\alpha-cis\beta)+(c+di)(1-cis\alpha)]}{cis\beta}.$$

With the help of the second and the third formulas, two parties can safely transmit encrypted messages to each other. In daily life, a number of useful passwords and codes can be created. Although a single model example is shown in this research, it is possible to use the same approach to design numerous models that will change from person to person or from party to party. The calculation of the point obtained by being rotated around a point which in turn was obtained by rotating it around another point can be used in wars and in the examination of the movements of the planets as well as in the cryptology.

In this research, an encryption model was created for the parties who desire to send numeric messages confidentially using the complex numbers and transformation geometry. This model is difficult to break and to be deciphered by others. It can be made even more complex. For example, in this research, one fixed point and two rotating points and angles were used. Hence, in total three points and two angles are used. Instead, more complex passwords can be created by increasing the number of points. In this case the message (c,d,a,b,x,y) is developed and can be extended by adding more points. This way, it becomes more difficult for the code to be deciphered by unintended parties. However, it may be difficult to decrypt the decoder, especially when the number of points is increased, a computer program would be needed for decoding of the transmitted message. Entering the data in the program is sufficient to decrypt the password and the decryption process is accelerated. Using a software environment such as R, Python, C, Fortran, we can code the formula we have proposed so that it is easier to use repeatedly

and that the parties can communicate in a faster way.

Besides encryption, the rotational formulas used in this study can be further developed and transported to three-dimensional systems and can be associated with planetary movements and how often lunar and solar eclipses occur. From the planetary movements, the coordinates of the points to be formed by rotating a moving point around another moving point at different angles can be found by the method described above. These relationships can be used to predict when a lunar eclipse or a solar eclipse occurs. In addition, information can be obtained about the location of planets and satellites revolving around each other in the space.

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The Muslim Conquest of Spain

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Abstract

Islamic Spain (711-1492) was a conflation mix of civilization of three major monotheistic religions: Jews, Christianity and Christians. The civilization came about as a result of Muslim defeat of the harsh Visigoth rulers against Christians in Spain. Even though the Jews and Christians lived in restrains, the three groups managed to coexist for much of the time and to benefit from the each other to some extent. Their interaction brought a great deal of civilization to Europe that matched the height of the Italian Renaissance and Roman Empire. This became one of the great Muslim Civilization. The Muslim force invaded in 711 and conquered the Iberian Peninsula for seven years. Following heir ascension to power in Spain, Islamic power was successful over the course of five significant periods of rule. Their power allowed for systematic control over Christians and Christian culture. However, due to internal struggle within the Muslim-ruling class, the Christian population took the opportunity to rise up. In 1942 the Muslin declined when Granada was conquered hence their reign ended. Ultimately, the Muslims were defeated and Christians were able to claim their land and restore their culture. The Muslim heartland rule was Andalusia and Southern Spain.

Keywords: Andalusia, Religion, Muslim, Christians, Conquest

1. Introduction

Islamic Spain (711-1492) was a major episode of Muslim rule between 711 and 1492 expressing the success and spread of Islam into Andalusia, Spain (Imamuddin, 1981). Here, the Muslims coexisted with the Jews and the Christians. This era of peace was known as *La Convivencia*, the Coexistence, with the large spread of ideas to people of different religions. The endurance of Islam in Spain was a result of five successful periods of rule: The Dependent Emirate, the Independent Emirate, the Caliphate, the Almoravid Era, and the Decline (BBC, 2009). This extended unification lasted 781 years, starting in 711 AD when the Visigoth Empire collapsed to Muslim invasions, becoming the Umayyad Empire. Under the rule of Christian Kings (1499-1526), during this period the Iberian Peninsula was conquered while areas in the North resisted Islam Although there was an extended time of peace, the Muslims mishandled their power and lost stability. Understanding the weakened Muslim control, the Christians unified their fighting forces and lead a series of revolts, called the Reconquista, and successfully reclaimed their land in 1492 AD from Muslim rule during the collapse of the Emirate of Granada (Fernández-Morera, 2016). The Reconquista did not happen spontaneously. Factors from both the Muslims and the Christians led up to the revolt and allowed the Christians to take back control of Spain. According to Vaughan (2003), the fall of Islamic control in Andalusia was due to several factors bust majorly due to the generous terms of surrender they presented to the people, their conditions mainly contrasted the harsh terms that was previously imposed by Visigoth rulers.

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2. Internal Instability of Muslim Rule

The Muslim Caliphates faced many internal problems regarding their quest for power, including how the large imperial state was separated into smaller states, dynastic feuding, and social division (James, 2009). These tensions were often spawned between future leaders who each wanted control. After more fighting broke out between the power-seeking dynasties, the empire began to divide, leaving them vulnerable to attacks; such lack of unification led to the fall of the Umayyad Empire. The major caliphate was responsible for taking over and spreading Islam to Andalusia. The destruction of the Umayyad Caliphate was caused by the division of the land and power to weaker rulers. No longer united, these leaders had difficulty fighting off both Christian's forces and other Muslims during periods of civil war (Campo, 2009). Previously the Umayyad was too powerful for anyone to defeat, but the fall left them in a damaged state. They were overpowered in 750 and replaced by the Abbasid Caliphate.

Despite their victory, the Abbasids faced problems similar to the Umayyad. Muhammad al-Mansur, the second caliph of the Abbasid, was a powerful military leader who led the caliphate to power. After his death, his absence caused the caliphate to collapse. The power distribution was unstable, and the land was, once again, divided into smaller kingdoms (Fernández-Morera, 2016). It was difficult for these kingdoms to maintain power because they didn't have enough strength to withstand the chaos from inside and outside attacks. Another major weak point in the Abbasid Empire was when Harun al-Rashid, the fifth caliph, divided the land between his two sons to prevent the collapse of the empire. However, the plan to split control backfired. Constant struggle for power between the two brothers resulted in civil war and disrupted Abbasid control (Armstrong, 2000). The animosity between the brothers and their determination to maintain strength led to the killing of prominent families to minimize opposition.

The societal impact on the weakening rulers further problematized the stability of caliphates. The diversity was also troublesome. Religious diversity was often viewed as an advantage; in reality diversity weakened the caliphate due to the inability to coexist with opposing religious beliefs. Overall, the search for unification resulted in a divided society, run by a divided caliphate, worsening internal conflicts and making the Muslims vulnerable.

3. Christian Solidarity overcoming Muslim Powers

As Christian solidarity grew, the Christian forces strengthened and became a major factor to the fall of Muslim Andalusia. The power of the united Christians was seen many times during the attacks of the Reconquista and the Crusades in November (1095), a series of Christians attacks against the Muslims united under the order of the Pope. The object of the Crusades was to recapture the Holy Land from the Muslims, similar to the Reconquista. The Reconquista lasted around 700-800 years from the capture of the Iberian Peninsula to the fall of Granada (1492). Christians who survived under the control of the Muslim Empire were supported by the power of the Pope and Christian knights to help fight. Through this, they were successful in reclaiming control and wealth from the Muslims.

Previously mentioned, the diverse society in Andalusia was a disadvantage for Muslims because everyone thought differently about religious devotion, expectations of society, and actions of those with power. The Christians had an advantage over this division since they unified. The Christians in Andalusia received further aid from allies in the north, ranging from peasant-soldiers to town militia. With additional fighting forces, the Christian society grew in number and strength (Fernández-Morera, 2016). Their strong religious belief helped them thrive in such a time of trouble. This shared faith was beneficial for Christians when they fought against the Muslims. Backed up by religious unification, the Christian forces were able to communicate easily and develop battle techniques, bringing them to victory (Fernández-Morera, 2016). Even though there were still a handful of Christians who remained strong in the Islamic State, the Christian population was more towards South Andalusa where aid could not be reached, drastically reduced. Only a few remained in Toledo, and none were found in either Valencia or Granada when the land was finally reclaimed (Fernández-Morera, 2016). The

population decrease was a result of Muslim control. Instead of accepting Christian's beliefs, Muslims ordered Christians to either convert or be banished. Many of them had fled to Northern Spain where they were accepted by allied forces.[4] However, their banishment was what allowed Christians to unite and increase their success in battle. First of all, there were more Christians gathering up in Northern Spain, an area under Christian rule, and the banishment and harsh life under Muslim control turned the Muslims into a targeted enemy.

4. Discrimination against the Christians

Christian hatred toward the Muslims was largely because of the severe life that the Christians were forced into living. Islamic society was carved out so that the Muslims were superior to the Christians. Economic differences further divided the gap between Christians and Muslims, starting with the Jizya tax which was imposed on all Non-Muslims. Christians argued that they didn't need to pay because they already had to give payment according to the 5-pillar (Fletcher, 2006). Christians viewed this tax as unrightly because they were paying for their own freedom. The unjustices continued through additional strict rules including Christians being unable to own bigger houses, banned from having Muslims servants, and being forced to move out of the way whenever a Muslim passed (Fernández-Morera, 2016). In other words, a Muslim couldn't be under the social power of a Christian, ensuring; Muslims would always remain at the top of the hierarchy. Another instance where Muslims asserted superiority was through criminal penalties. When a Christian killed a free Muslim, the murderer would face a death sentence. However, when a free-Muslim killed a Christian, there was a possibility that the Muslim would not be punished. The established laws under Muslim rule expressed Christian's inferiority, despite living in the same society as the Muslims.

These guidelines set an impossible standard for all Christians, which locked them into a life of hardship; Christians were the enemies. The Muslims viewed Christians as nothing but minions under the influence of the devil and should not be greeted with a peaceful interaction (Harvey, 2004). Christian animosity toward Muslims also triggered religious conflict. The Quran, the sacred text of Islam, goes against the beliefs of Christianity. The Quran disputes the Christian teachings and history of Jesus. As stated before, if the Christians refused to convert, they would be forced to leave. This hurt the Christian society and power in a Muslim land (Smith, 2011). The ability to read Latin inscriptions in churches was lost and young Christian dhimmis, non-Muslims living under the rule of an Islamic state, started learning to speak in Arabic. The Muslims rule had long-lasting effects on Christian life and culture. The damage further convinced other Christians that Muslims were not an ally or a protector; they were the enemy.

5. Conclusion

The internal conflicts in the Muslim Caliphates, the strength of Christians through solidarity, and the mistreatment of Christians under Muslim authority were all major factors that contributed to the overthrow of Islam. The internal conflicts were the most damaging because the caliphates were divided into separate regions, splitting their power and making them vulnerable. With this, the Christians were encouraged into turning against the Muslims due to religious intolerance and the severe conditions they lived through under Muslim rule. As a result, they left to join other ally Christians in the North with the same goal of defeating the Muslims to recapture the land that was once theirs to settle. With the Muslims in a weakened position, the united Christians attacked as one massive fighting force through the many years of the Reconquista, successfully taking back their land after the fall of Granada in 1492. A resurgent wouldn't have been possible when Muslim power in Andalusia was united and guided, restricting the possibilities for Christian revolt.

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