THE KING'S SCHOOL
CHESTER

THE GARLAND

A CELEBRATION OF SCHOLARSHIP AT KING'S

2017 / 2018

THE KING'S SCHOOL
CHESTER

CONTENTS

EVERY OPPORTUNITY. ENDLESS POSSIBILITIES.

How important are the gods and religion to Herodotus' History?

Izzie Howell – Upper Sixth

The gods and religion, whether they are important to Herodotus' History or not, heavily feature in Herodotus' account of religion. However, it is questionable as to what their significance is within the account of his Histories; whether they are important to the account of his history or serve some other purpose.

Arguably, the gods and religion are important to Herodotus' account of history because, on some occasions, they appear to change the course of history. For example, Herodotus includes numerous oracles in his account of history that can be seen to be instrumental in the order of historical events. The oracle that Leonidas received that prophesied that either Sparta will, "be sacked by Perseus' sons" or that they "will mourn the death of a king of the house of Heracles" is said by Herodotus to be a motivator in Leonidas' decision to dismiss the other troops and stay to fight to the death. Arguably without such a motivation by the Oracle, the events of the battle of Thermopylae that followed, may not have happened. For example, Greece could have lost more troops than they actually didn't if it wasn't for the Spartan dismissal. Similarly, if it wasn't for the Oracle of the "wooden walls" about Salamis then the plan made my Themistocles to build ships to defeat the Persians may not have happened. Therefore, the success at Salamis seems to be motivated by the Oracle.

However, on both these occasions, Herodotus makes it clear that the oracles are not the only motivation and influence on the course of events. For example, Herodotus states that Leonidas also dismissed the troops to spare their lives but decided to stay as it would have been "unbecoming" for the Spartans to leave their post. Similarly, he argues that the Oracle "combined with his wish to lay up for Spartans a treasure of fame". In terms of Themistocles, it can also be noted how Herodotus tells us that Themistocles already had a plan to spend the money that the Athenians got from the mines of Laurium on the construction of 200 ships for use against Aegina which were, as he states, "not employed for purpose which they were built, but available for Greece in hour of need", meaning that the oracle didn't necessarily motivate the building of the ships and so was not essential to the historical events of Salamis. In both these instances the influence of the Oracles can be overrun by causes offered by Herodotus that don't include religion or the gods showing that they were not particularly important to his history.

If they aren't important to Herodotus' History, then it can be questioned as to why they are there. Arguably, gods and religion could simply be decorative features that aim to attract readers by emulating Homer and epic writing that would have been attractive to ancient readers. The inclusion of Oracles as presented before and divine intervention such as when the two Persians are told of the destruction of the Persian fleet by a floating cloud, could actually just be for entertainment purposes that reflects the type of writing of Homer. They are not necessarily important to the account of history; only decorative.

However, in contrast we do see instances where Herodotus suggests that divine intervention appears to have affected the outcome. For example, in the account of the death of Cleomenes, Herodotus notes "in my opinion is that Clemomenes came to grief as retribution for what he did for Demaratus" which strongly implies that his retribution came from the gods causing it to happen due to his bad actions. Similarly, divine intervention can also be seen as a genuine cause of events as after the Persians have been defeated at the Battle of Marathon a Persian general finds a religious artifact that had been stolen from the Island of Delos and puts the loss of the Battle down to this. This point can be strengthened by a constant theme of Hubris and Nemesis running throughout the account of his history. We see such a theme as the conference where Xerxes advisor states that "it is god's way to bring the lofty low" perhaps Herodotus hinting through over exaggeration of Xerxes' arrogance that the reason Xerxes failed was due to him being too arrogant that the gods didn't let him win. This is highlighted by Herodotus' emphasis on Xerxes whipping the sea. Therefore, divine intervention seems to have genuine causation within the account of history he offers.

However, divine intervention may just be a reflection of the religious culture that surrounded the ancient times; whether religion and the gods are real or not, it is the belief that the ancients had in them that makes them an important part of Herodotus' history. For example, the fact that Herodotus tells us of how the Persian general blamed the stealing of the religious item for the Battle of Marathon shows this is an anthropological account of what humans genuinely thought and how they valued religion, but it does not undermine the actual historical causes that Herodotus offers for the failures of Marathon such as his emphasis on Miltiades successful military speech and the type of fighting style the Greeks conducted. The theme of hubris and nemesis also highlights this since it was a common view that ancients took and so is important anthropologically to account of a history of human beliefs and motivations but does not overrun the causes of Xerxes failure that are offered such as his chaotic control of the army from being so far away as well as the Persian army "fighting out of fear for the King" rather than passion like the Greeks. This is strengthened by the fact that, whilst the burning of the temples at Sardis were a used as a reason to invade Greece by Xerxes as a result of religious belief, Herodotus hints himself that such a reason could have been used as a pretext for actual expansion reasons of Persia.

In conclusion, whilst gods and religion may not affect the outcome of historical events and so may not be important to his account of history, they are important to the anthropological account of history in terms of accounting ancient peoples' values and motivations, they run parallel to the actual reasons for causes and effects of the historical outcomes.

Syrian Rose

Miriam Littler – Lower Sixth

She once strayed from the boundaries of the garden to visit the men who plucked the Damask roses from the trees.

Her alabaster skin identified her as a foreigner, yet absorbed the atmosphere like parchment absorbing ink. Eager ears perked up at the sound of a language that she would never be able to learn.

The tanned men with their blushing and jade stained white shirts delicately plucked the roses off the trees. The sheer number of pink roses drowned out its natural colour, almost as if someone had spilled a tube of pink paint into a green palette. The girl watched the roses float into the large baskets below, like dreams getting caught in a dream catcher.

One of the men caught sight of the girl, and smiled slightly. She could be no older than four years old. He beckoned the girl towards him, and carefully selected a rose from one of the bushes to offer her.

Her eyes widened in the presence of the floral treasure, and she shyly took it from him. Her nimble, tiny fingers stroked the silky petals lovingly. A sweet, rich odour delighted her senses, that mixed and intertwined with the soft Syrian breeze.

That rose would later be discarded on a garden bench while her four-year-old attention span drove her to focus on something less important.

Now, that place outside the garden boundary is barren and lifeless. There are no men with easy smiles who hand foreign little girls roses.

Now, that girl is a young adult, and that hazy memory haunts her and dwells like a growing mould at the back of her mind.

From the safety of her British breeding, she sees the images of a catastrophic wasteland, she sees the debates about the people who live there, she sees the rubble and fear that seeps and stains the unrecognisable pavements. Scenes of smoke and fire flash across the screen quickly, years of suffering drowning in a second of film.

Then, she watches the English roses in her life exclaim in sadness and emotion at the war. They shake their heads in pity at the terrors people face, and tears mix with coal black mascara that set on their eyelashes. There was a time when she could sit in a church, her legs swinging behind her on a bench. There, an unknown girl would sing pleasantly to her in Aramaic. Now, that church is filled with debris and the shell of a vibrant culture.

Dragonflies would buzz around her ears and make her squirm with delight, now she watches happy children kick at pigeons in the streets. Her rose-less hands reach for a fly-killer spray when something undesirable buzzes into her home. She has swapped the suffocating Syrian heat for inconsistent British weather.

She sees advertisements for cheap rose perfumes, birthday cards with roses on them, a cake with delicate edible roses, blood coloured roses handed to infatuated women as a symbol of romance. Roses, roses, roses everywhere, diluted down to nothing.

Yet, she had held the Syrian rose in her hand, and she had let it go. She can still feel its sticky nectar on her fingers that mixed with the spots of blood from the prick of the thorns. These same roses which once adorned balconies, streets, gardens, window sills and people. Where are they now?

Baskets are torn by the gunshot fire, discarded by farmers who must flee to save their lives. Who has time for plucking roses anymore?

She thinks back to that man, that Syrian farmer who gave her the rose. Is he still alive?

Her passport says she is British, but sometimes she feels like a canvas. Each culture she's known has splashed a thick line of paint across the fabric, her life dyed with different languages, different people, different voices.

And as she forgets a world from the deep past, the colours on her canvas fade and tirelessly demand a new coating of paint.

The white building bleached by the sun and the archaic towers are no more. Damascus is now a city littered with shattered buildings and shattered lives.

The Damask rose is dying. It has been withered by a war spurred on by the country she lives in.

She can't go back there. The only places and people that she holds in her memories are long gone, and soon those memories will themselves dissolve over the years.

Soon, the only colours on her canvas will be blue, white and red.

Is it possible for a person to be entirely fulfilled by technology?

Annabel Swift – Remove

I don't think it is possible for a person to be entirely fulfilled by technology because people will always think of new things they want to do with it. People will want it to look more human-like and people might even marry robots. Robots could end up looking so realistic that they look exactly like humans, people might not even be able to tell the difference between robot and humans.

One argument is that, people will always think of new things to create and there will always be people thinking up new ideas of things to make. 50 years ago people thought the microwave was an ingenious invention but we take it for granted nowadays and we are thinking of even more spectacular inventions which in 50 years' time will probably be thought of as everyday life. People are always thinking of new ideas to make our life easier and more pleasant or inventing inventions of mass destruction. People will always find new ways to make technology even better and robots could become better than people for example they could have rocket boosters on their feet so they can fly and they might have x-ray vision to see through walls that means they could see if people have bombs hidden in their clothes or see if people have cancer tumours.

Another argument is that, people get a sense of fulfilment by having friends and family being around other people not with technology. Humans were made to communicate with other humans not with a phone, computer or a robot. People were made to communicate with other people not technology, when we were created there wasn't such a thing as technology which means we weren't intended to communicate with technology. People don't feel fulfilled with technology in the same way that they would with other people, technology doesn't make people feel truly happy like having fun with friends does. It takes interaction with other people to make humans feel contented not playing games or watching YouTube on an IPad or a tablet.

However, you could argue that technology helps people communicate with others therefore giving us a sense of fulfilment that is provided by other people even if you are on the opposite side of the world to someone else. Not only can technology help you communicate with other humans it means that you can talk to them even if you're nowhere near them which helps if a friend has moved away you can still talk to them and stay in touch. This could mean that technology makes it easier to feel fulfilled because you can connect with other people, it keeps us up to date with what is going on and playing games or watching videos can make us feel happy and cheerful.

But I would argue that, communicating with people online isn't the same as talking to someone in person you can't hug them or touch them. Also, technology is unreliable, you can't get WiFi everywhere and it could glitch during a very important conversation and people could end up not knowing what they are meant to do. It could glitch while someone is filling in an important form and they will have to start again or someone could lose a piece of work

and they might have to do the whole thing again. People communicating online will want the image of the person they are talking to to be more realistic, they will want to be able to touch the person they are talking to and might even want to teleport them to where they are to see them in person. This makes the whole using technology to communicate thing is pointless because all they would actually be doing would be going to where the other person is so using technology is pointless.

You could argue that, there is a limit to what we can create, we will get to the point where there is nothing more to invent because everything that is possible to invent has already been invented. Then people will have to be fulfilled because there is nothing else to invent and there is nothing else to think of to make our life better or help destroy things. In a million years' time we will be living in luxury and we might not need new inventions because we will already have everything we need.

However, I don't think there is a limit to what we can invent, there will always be people who find something that requires too much effort and an easier solution has to be found. Also there will always be clever people trying to find new ways to destroy their and their countries enemies without any traces of who it was, which can wipe out whole populations or have extremely good aim. People could be thinking about inventions that will help reach other planets instead of making our life more comfortable therefore helping with the increasing problem of earths increasing population and more powerful rockets will be needed to reach further away planets and more powerful telescopes will be needed to see further away planets.

One argument that I think is quite strong but not entirely related to the subject is that, if people want to be fulfilled then that would involve a lot of effort from inventors and it would involve making AI a lot cleverer which could potentially be dangerous. AI might become so powerful that it can think for itself and might want to overthrow the human race and create a robot society where the robots make other robots and if their population rises to much they can simply stop making robots. So people creating and programming AI should be careful about the amount of knowledge they give the robots to stop them becoming to intelligent.

In conclusion, I believe that people will never be entirely fulfilled with technology, we might sometimes feel slightly fulfilled with technology but we will never be truly satisfied. People are always coming up with new inventions to help us and people are always finding something to much of an effort to do and needs someone or something else to do it for us. Therefore, we will never be completely fulfilled because we will always find something else to create.

A Thousand Ways to Hate thy Neighbour

Hamish Strudwick – Upper Sixth

There is more or less a different individual accent, and dialect for every corner, nook, and cranny of these pastures green. A thousand different accents, a thousand different ways to hate thy neighbour.

Whether we like it or not, our speech is a marker for who we are and where we are from, and can show divides between groups even within the same city. In London, for example, the distinct patter of the cockneys can juxtapose rigidly the softly-spoken hum of the Queen's English, or, as linguists refer to it, Received Pronunciation. The Westminster bubble, a distinct contrast to the East End, divided by class and accent.

The defining effects of our personal idiolect are so important that they can be used to aid our cohesion in social situations: we can mould our speech to suit the climate. It has been shown by linguist Trudgill, that men are more likely to use what is known as covert prestige in social contexts. This means that they are likely to use non-standard grammar structures and slang terms in greater frequency then they would otherwise. This is especially seen if they perceive this lower-class culture to be cool or hip.

And the support gained by the Labour movement in the 80s has ensured that the conversational style of the proletariat is here to stay in defining coolness in our culture. Many have even attempted to unshackle themselves from the social burden of a 'posh' voice in order to ride this popular wave!

This linguistic manoeuvring ensures that how we speak defines the group we belong to. These days, when one refers to oneself in the passive voice, one is likely to be called a 'posh wanker'. Even if one will not be amused!

Essentially, it's down to economics: the northern powerhouses, have defined themselves as hubs of trade, and political strength, and their accents are helping to spread this message. There's a strong possibility that the next time you talk to customer service a Geordie greeting will caress your ears. We're more likely to hold for Garry Beadle and Stormzy, than Queen Liz and Vivaldi.

Many have said that it should be what you say that counts, and not the manner in which you say it. The social borders created by preconceived ideas of how people 'should' sound are artificial and indicative of economic or political turmoil.

Unfortunately, however, it's human nature that forces us to think this way. We have been given an evolutionary advantage in the ability to define friend from foe simply based on the way they sound; the ability to 'other' people based on this strengthens a group who sound the same.

It was thought that the advent of the internet would afford us the ability to remove ourselves from this linguistic prejudice, especially since all information shared was in written form. But the groups created in the form of 'Scottish People Twitter', and 'Black People Twitter' have given people the opportunity to connect and share the written word in a way that reflects their spoken word.

Whether we refer to a bap, bun, cob or bam, to the apples and pears or simply the stairs, the English language varies in myriad ways, creating tension and divide. One day we might acceptingly celebrate diversity; for now, however, the accent cannot be separated from the culture it represents and is a constant cause for contention. Truly, as GBS remarked, 'An Englishman only has to open his mouth, in order to make another Englishman despise him.'

Mia Hard af Segerstad-Smith – Fifth

Sadie Nathan – Upper Sixth

Los deportes en mi vida

(Free-writing on sport) Freya Walsh – Fourth

Me encanta el deporte porque me ayuda a descansar y estar en forma. Me gustan los deportes de equipo más que los deportes individuales porque pienso que son muy divertidos. Mis deportes favoritos son el tenis, la natación y el ciclismo – son todos muy emocionantes y sanos. Practico el deporte todos los días. Juego al tenis y soy miembro del equipo escolar; entrenamos dos veces a la semana. También, hago atletismo tres veces por semana y a menudo gano las carreras. Los lunes hago natación en mi colegio y me encanta; la hago desde hace cinco años. Si tuviera que elegir mi deporte favorito, diría que es el ciclismo porque es sano y bastante divertido. Me chifla hacer ciclismo en mi tiempo libre.

Cuando era joven, jugaba al ping-pong. Sin embargo, ahora creo que es bastante aburrido. A veces hacía gimnasia, pero era demasiado caro. Además, practicaba judo y era muy divertido. Si tuviera más tiempo, practicaría judo otra vez. Finalmente, de niña hacía patinaje sobre hielo con mi hermano e íbamos a la pista de hielo cada domingo.

El fin de semana pasado, fui a un torneo de tenis, pero desafortunadamente, mi y equipo y yo perdimos. Sin embargo, hace dos semanas, gané una carrera de natación y fue muy emocionante. También, el año pasado, fui a Barbados con mi familia e hice surf y jugué al voleibol. ¡Lo pasé bomba!

Me gustaría probar unos deportes de riesgo, por ejemplo, el parkour porque es muy impresionante. Lo veo en internet todo el tiempo. Sin embargo, otros deportes de riesgo son demasiado peligrosos y me dan miedo. ¡En mi opinión, la corrida de toros es demasiado arriesgada! También, si pudiera, haría escalada y buceo porque me encantan los peces y el coral.

En el futuro, voy a ser profesora de deporte, por eso, ¡podré hacer deportes para siempre!

Evaluate the impact a tropical storm has had on the character of a place that you have studied and how the storm has affected people's loved experience of this place after the storm.

The answer was produced under timed conditions in just 12 minutes. It is typical of an outstanding A Level answer, demonstrating strong subject knowledge, an ability to synthesise and apply information across both Human and Physical Geography and impressive critical analysis. The writing is succinct and academic.

Megan Gareh – Upper Sixth

Katrina was a category 5 tropical storm that hit the states of Louisiana, Mississippi and Alabama with 140mph and greater winds during August 2005. It caused $81b damage and left 1,800 dead, and 80% of New Orleans 15ft underwater. Katrina caused sever socio-economic impacts with 1.2m people evacuated.

New Orleans is now tied with Katrina and is viewed negatively and so the sense of place people have about it has reduced tourism as people fear a similar disaster and so avoid the area. The residents may have a negative experience and attachment to this place as not only were their homes destroyed but the insurance companies raised premiums and even refused future insurance. Little financial support was given and this has led to negative connotations surrounding the affected places, especially New Orleans. Applying Jon Anderson's cultural approach, New Orleans' trace is of the event and this makes it very difficult for residents to move on from the disaster, negatively affecting their lived experience of the place.

It could be argued that the disaster may have brought some communities together but overall the devastating impacts on the environment and the sense of abandonment from the government has resulted in a mainly negative affect on lived experience after the storm.

IHE BATTLE OF BACTERIA
by Nithikka Senthilkumar

Pathogens are micro-organisms that cause disease, for example bacteria + viruses. Once bacteria (pathogens) are inside the body, they release poisons or toxins that make us feel ill.

PATHOGEN —
TOXIN —

LET'S TAKE OVER!
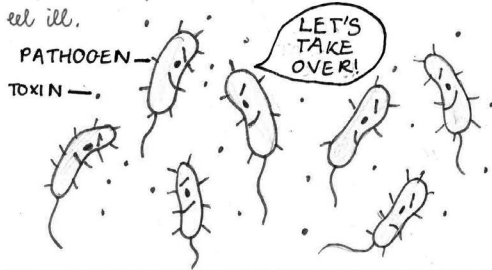
When Pathogens enter, white blood cells - phagocytes pass through the walls of the blood vessels & into the surrounding tissue. They produce glycoprotein to help them attach to the harmful pathogens.
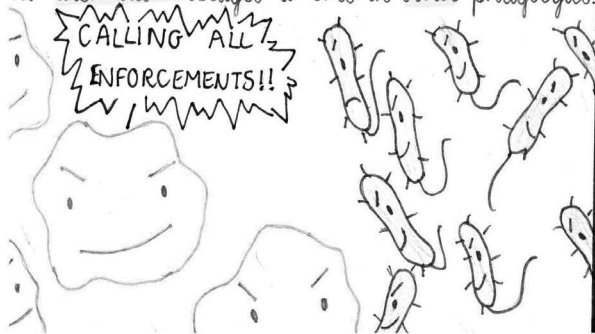
GLYCOPROTEIN
PHAGOCYTE
ATTACK!
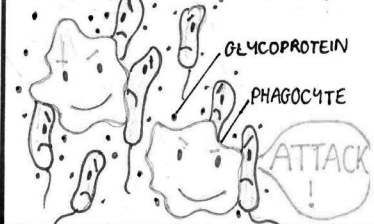
Phagocytes engulf & digest the pathogens and toxins, absorbing, killing & degrading them.
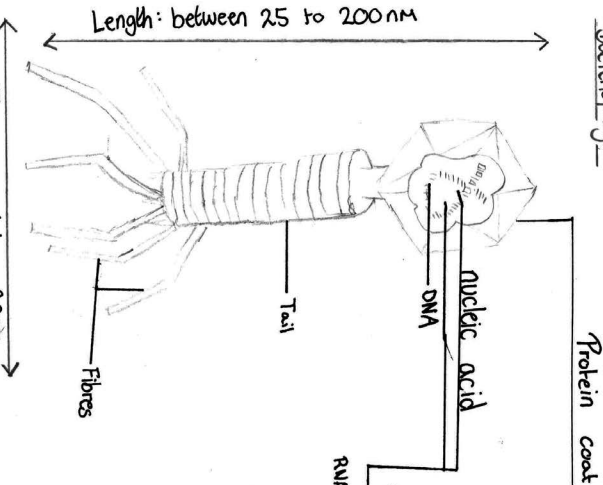
DESTROY!
!!

To destroy pathogens, phagocytes can also release enzymes, that kill the bacteria.

AAHH!
ENZYMES

Having absorbed a pathogen, phagocytes can send out chemical messages to call in other phagocytes.

CALLING ALL ENFORCEMENTS!!

VICTORY!
YAY!

Nithikka Senthil Kumar – Shell

Bacteriophage

Length: between 25 to 200 nm

nucleic acid
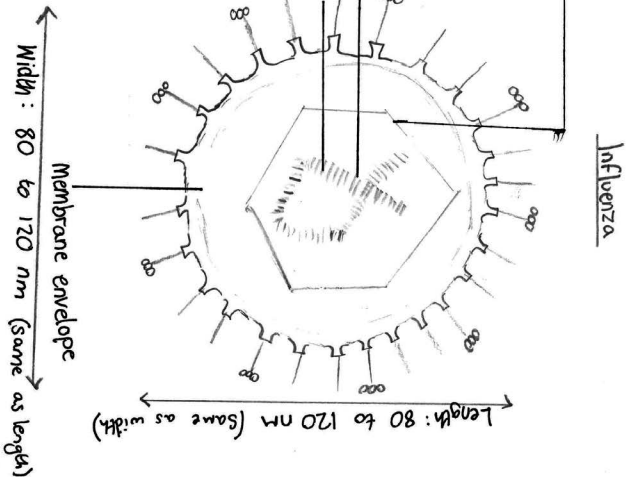DNA
Tail
Fibres

Protein coat

Width: approximately 90nm

10/10 Great

How does the Bacteriophage virus enter/invade living cells?
- It clings onto Bacterium, it then enters the phage DNA and this DNA reproduces and makes new phages. these then exit the cell/Bacterium and go again this is how they are transmitted.

Influenza

RNA

Membrane envelope

Width: 80 to 120 nm (same as length)

Length: 80 to 120 nm (Same as width.)

How does the Influenza virus enter/invade living cells?
- It invades the living cells by getting transmitted by someone coughing or sneezing (by someone who already). These tiny droplets of the virus when they come into contact with another person/host transmit onto them. It can be stopped by sneezing into a tissue or clothes.

Amy Ford – Shell

16

Nothing is more important than the rights of the individual

Jack Walker – Lower Sixth

The claim that nothing is more important than the rights of the individual is a distinctly Libertarian one which is likely not unfamiliar for many in modern, democratic, Western societies. This is chiefly because these types of societies were set up with individual rights at their forefront. For example, in the founding of the USA, the Declaration of Independence, written principally by Thomas Jefferson, states that "all men are created equal, that they are endowed by their Creator with certain unalienable rights, that among these are Life, Liberty and the Pursuit of Happiness." These rights were later compounded with the ratification of the first 10 amendments to the constitution i.e. the Bill of Rights which guaranteed the American people basic freedoms and rights. Other such compilations of basic rights for all individuals have since been established such as the Universal Declaration of Human Rights and the European Convention on Human Rights. However, before the statement that nothing is more important than these rights of the individual, can be addressed, we must first offer some definition of rights and what they encompass. Individual Rights in this sense refer to things that people are entitled to, either positively, referring to things people have the permission to do or to have e.g. the right to a family life, or negatively, referring to things people have the permission not to do or to be free from e.g. the right against being arrested without just cause.

The discussion of the rights of the individual is fundamentally important as both a political and a philosophical question as many would argue that the rights of the individual ought to be subservient to decisions of the state over matters of national security. This is further developed through the discussion of the social contract theory which asserts that in the state of nature, people had a right to all things however citizens have either actively or tacitly agreed to give up some of their rights in setting up a state, the purpose of which is to protect their remaining freedoms. On the other hand, some would argue that the imposition of the social contract goes too far and the state itself is intrinsically unfair because it infringes on our rights and so its influence ought to be as minimal as possible. Such is the position of the Minarchist, which argues that the only roles of the state should be to uphold people's basic rights and nothing else. This essay will argue that the importance of the rights of the individual is circumstantial and although significantly important, must sometimes be infringed upon to a degree for the greater good e.g. in the case of the setting up of the state itself as well as with matters of national security.

Firstly, some may argue that the rights of the individual are more important than anything else because they guarantee equality. Especially human rights, which are afforded to people equally simply by virtue of the fact that we are all human. John Rawls details this effectively in his book "A theory of Justice" when he describes his greatest equal liberty principle as follows "Each person is to have an equal right to the most extensive total system of equal basic liberties compatible with a similar system of liberty for all." This is backed up by his thought experiment of the "original position" which posits that if people were to decide what justice is in society from behind a "veil of ignorance", meaning they don't know any of the features of their own position in said society e.g. economic status, gender, religion etc., the rational person will decide upon principles which (like the one above) ensure fairness for all. This is

because since nobody knows what their position in society will be, it is potentially against their interests to design a system that is discriminatory as they may end up at the wrong end of said discrimination. Therefore, Rawls would argue that the system which rationally has been created from the original position in this manner, would be one which features the greatest amount of individual rights and protections as possible. This clearly illustrates why in essence we view having individual rights as important-because they by definition allow us access to things we deem important or protect us from things we deem dangerous and without them we risk being marginalised or oppressed by others. An example of this is the creeping removal of rights from the Jewish people in Nazi Germany which steadily removed their rights to things such as certain types of work, education property and freedom of movement. This shows that individual rights are the most important things in our society because they ensure our basic freedoms are guaranteed by the state, without which we cannot be assured of our safety in our interactions with others.

Additionally, individual rights may be deemed to be the most of all things because of the idea that they are in some way governed by a form of natural law and so not dependent on any kind of customs or laws of any particular society. Indeed, under social contract theory, the idea of inalienable rights refers to the rights which could not be surrendered to the state in the social contract, even if for some reason someone wanted to do so. John Locke suggests that these types of rights are principally the rights to "life, liberty and property." This supports the view that certain individual rights, i.e. the ones which can be viewed as inalienable are more important than anything else because these rights arguably aren't tied to the state for them to be seen as legitimate.

However, even though clearly the rights of people are important, some would argue that individual rights are not inalienable and so are only significant when they are guaranteed by the state, thus meaning they are less important than the state itself. Even in the example of natural rights, which supposedly aren't contingent upon the state, still require the monopoly of power provided by the state to ensure that these natural rights are actually upheld. To illustrate this, consider the position of the state of nature (as detailed before), in which people have a right to everything since there is no state in place to enforce what people can and can't do. This is significant because it seems counterintuitive to claim that people have rights to everything when there is no state to arbitrate this and enforce it. For example, in the state of nature, property, espoused by Locke as one of the few inalienable rights, would be in effect meaningless since the concept of ownership would be undermined if there was nothing in place to prevent theft and the "might is right" style of living. As Hobbes puts it, in the state of nature when "every man is enemy to every man," the lives of people would be "solitary, poor, nasty, brutish and short." This thereby seeks to show that the state itself is more important than individual rights, because individual rights are dependent on the existence of the state for their own existence (thereby denying the existence of natural or inalienable rights). This is because since the established definition of rights is what people are entitled to, either positively or negatively, the only thing that exists to decide the things we are entitled to and subsequently enforce them is the state, in the branches of the executive and the judiciary respectively. Additionally, the modern state is also more important than the rights of the individual because it has been supported by rational legal authority. According to Max Weber, the state is able to draw its authority from the fact that

the group in power has been placed into power by legal means, and that their actions are thus justified because of the twin doctrine of mandate and manifesto in fair elections. This shows that the state is more important than individual rights in a representative democracy because as citizens we choose to transfer sovereignty and decision-making power from ourselves and into the hands of our representatives.

Furthermore, many would argue that even if individual rights were not contingent upon the state for their existence, it would still not hold true that nothing is more important than individual rights. As acknowledged in the Huffington Post article[1] , entitled Security vs Civil Liberties, "Collective security requires compromising some individual freedoms." The article goes on to cite the US as an example in which the overall security of the nation, (not just threatening the rights of individuals) are being threatened because of a lack of restrictions on individual rights e.g. unfortunately topically the freedoms of almost everyone to purchase and carry firearms. Many would claim that this undermines the idea that individual rights are the most important things because, in these cases, the establishment of these rights results in fundamentally worse consequences than if they had not been established, even though they are widely held as important individual rights. Additionally, looking from a consequentialist perspective, it could easily be argued that the infringement on a small number of people's rights to privacy is a small price to pay in order to ensure the prevention of terrorist incidents. On the other hand, it is clear that there is a balance that needs to be struck between the unrestricted infringement of individual rights under the control of the government vs the distinct lack of national security if individual rights to things like privacy are never infringed upon at all.

In conclusion, it is obvious that it is an overly simplistic claim to say the nothing is more important than the rights of the individual. This is because even though individual rights are important because of the idea of natural law and, as established by Rawls, the idea that the rational society is one which is set up to maximise both equality and individual rights, this does not mean that they are necessarily more important than everything else. This is principally because of the fact that it is strange to describe something as a right if it is not guaranteed, and the only thing which is able to guarantee rights is the state. Therefore, it is reasonable to conclude that because individual rights are contingent upon the state for their existence, the state itself is more important. Furthermore, it is arguable that in the US at the moment the importance of individual rights has been vastly overestimated and so has resulted in a deterioration in the safety of the general population. Finally, when looking at circumstances from a teleological sense, it is obvious that there are circumstances in which it is justified for the state to infringe on people's potentially less important rights in order ensure national security is maintained for the greater good. Obviously, even though individual rights may not be more important than everything else, this is not to say that they are unimportant. In fact, it is clear that they ought to be maximised to as great an extent as possible so long as this does not for example result in impeding on the rights of other individuals or other negative consequences. Ultimately however, it is clear that in certain circumstances there are things which are more important than the rights of the individual and so to say that nothing is more important than them unilaterally is profoundly false.

[1] https://www.huffingtonpost.com/tom-mockaitis/security-vs-civil-liberties_b_9273478.html

Bibliography

Philosophy of Law A very short introduction-Raymond Wacks

Leviathan-Thomas Hobbes

Justice as Fairness: political not metaphysical-John Rawls

Security vs Civil Liberties-By Tim Mockaitis-https://www.huffingtonpost.com/tom-mockaitis/security-vs-civil-liberties_b_9273478.html-Accessed 26/2/18

$n!$ is defined as $n \cdot (n-1) \times (n-2) \times (n-3) \times \ldots \times 2 \times 1$

For example $6! = 6 \times 5 \times 4 \times 3 \times 2 \times 1$
$= 720$

This definition only works for n when $n \in \mathbb{N}$, and as if we try try a negative factorial, we have nothing to times it by as we are already past 0. The same goes for fractions as there is no clear point at which to stop.

Mathematicians have tried to solve this problem by ~~solving~~ finding an alternative definition for $n!$ (pronounced n factorial).

To do this they looked at the input and ~~domain~~ range of the function and tried to find an equation that would give them the same output for a given input.

So :

n	$n!$	$f(n)$
1	1	1
2	2	2
3	6	6
4	24	24
5	120	120
6	720	720
7	5040	5040
8	40320	40320
9	362880	362880
10	3628800	3628800
⋮	⋮	⋮

The equation they found for $f(n)$ to give the same output was:

$$n! = f(n) = \int_0^\infty x^n e^{-x} \, dx$$

This is known as the pi function and we write $\Pi(n)$ (pronounced pi of n)

$$\Pi(n) = \int_0^\infty x^n e^{-x} \, dx$$

Although this looks fairly disgusting, it is a fantastic formula as it allows mathematicians to find factorials that are not integers.

Asking what is $\left(\frac{1}{2}\right)!$ originally was a stupid question but after finding this formula we are now able to find this value.

So what is $\left(\frac{1}{2}\right)!$?

$$n! = \Pi(n) = \int_0^\infty x^n\, e^{-x}\, dx$$

$$\Rightarrow \left(\tfrac{1}{2}\right)! = \Pi\left(\tfrac{1}{2}\right) = \int_0^\infty x^{\frac{1}{2}}\, e^{-x}\, dx$$

Let $x^{\frac{1}{2}} = u \Rightarrow x = u^2 \Rightarrow \frac{dx}{du} = 2u$

$$\Rightarrow dx = 2u\, du$$

$$\Rightarrow \int_0^\infty x^{\frac{1}{2}}\, e^{-x}\, dx = \int_0^\infty u\, e^{-u^2} \cdot 2u\, du$$

$$= 2\int_0^\infty u\, e^{-u^2} \cdot u\, du$$

Let $p = u \Rightarrow \frac{dp}{du} = 1$

$$\frac{dq}{du} = u\, e^{-u^2} \Rightarrow q = -\tfrac{1}{2}\, e^{-u^2}$$

$$\Rightarrow 2\int_0^\infty u\, e^{-u^2} \cdot u\, du = 2\left(\left[-\tfrac{1}{2}\, u\, e^{-u^2}\right]_0^\infty - \int_0^\infty -\tfrac{1}{2}\, e^{-u^2}\, du\right)$$

$$= 2\left(-\tfrac{1}{2}\left[u\, e^{-u^2}\right]_0^\infty + \tfrac{1}{2}\int_0^\infty e^{-u^2}\, du\right)$$

$$= \boxed{\int_0^\infty e^{-u^2}\, du} - \left[u\, e^{-u^2}\right]_0^\infty$$

This is very similar to the Gaussian integral, $\int_{-\infty}^\infty e^{-x^2}\, dx$

Let $\int_{-\infty}^\infty e^{-x^2}\, dx = I$

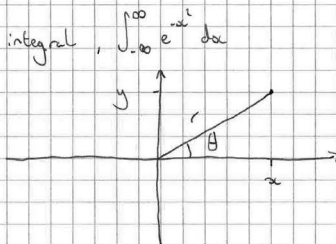$$\Rightarrow I = \int_{-\infty}^\infty e^{-y^2}\, dy$$

$$\Rightarrow I^2 = \int_{-\infty}^\infty \int_{-\infty}^\infty e^{-(x^2+y^2)}\, dx\, dy$$

Using polar coordinates:

$$x^2 + y^2 = r^2 \Rightarrow e^{-(x^2+y^2)} = e^{-r^2}$$

$$x = r\cos\theta$$
$$y = r\sin\theta$$

To find $dx\, dy$ we need to take the determinant of the matrix of all derivatives and multiply it by $dr\, d\theta$

$$dx\, dy = \left| DET\begin{bmatrix} \frac{dx}{dr} & \frac{dy}{dr} \\ \frac{dx}{d\theta} & \frac{dy}{d\theta} \end{bmatrix} \right| dr\, d\theta$$

$$\Rightarrow dx\, dy = \left| DET\begin{bmatrix} \cos\theta & \sin\theta \\ -r\sin\theta & r\cos\theta \end{bmatrix} \right| dr\, d\theta = \left| r\cos^2\theta - (-r\sin^2\theta) \right| dr\, d\theta$$

$$= \left| r(\cos^2\theta + \sin^2\theta) \right| dr\, d\theta$$

$$\Rightarrow dx\, dy = |r|\, dr\, d\theta = r\, dr\, d\theta$$

We also need to find the limits for r and θ. As r is always +, it can only go between 0 and ∞ (rather than $-\infty$ and ∞), and θ is to $(0 \leq \theta \leq 2\pi)$.

$$\Rightarrow I^2 = \int_{-\infty}^\infty \int_{-\infty}^\infty e^{-(x^2+y^2)}\, dx\, dy = \int_0^{2\pi} \int_0^\infty e^{-r^2}\, r\, dr\, d\theta$$

$$I^2 = \int_0^{2\pi} \int_0^\infty e^{-r^2} \, r \, dr \, d\theta$$

We can now integrate this as we have an r term in the integral

$$I^2 = \int_0^{2\pi} \left[-\frac{1}{2} e^{-r^2} \right]_0^\infty d\theta$$

$$\lim_{r \to \infty} \left(-\frac{1}{2} e^{-r^2} \right) = 0$$

$$r=0 \quad -\frac{1}{2} e^{-r^2} = -\frac{1}{2}$$

$$\Rightarrow I^2 = \int_0^{2\pi} \left(0 - \left(-\frac{1}{2} \right) \right) d\theta = \int_0^{2\pi} \frac{1}{2} d\theta$$

$$\Rightarrow I^2 = \left[\frac{1}{2} \theta \right]_0^{2\pi}$$

$$\Rightarrow I^2 = \pi - 0 = \pi$$

$$\Rightarrow I = \sqrt{\pi} \qquad \Rightarrow \boxed{\int_{-\infty}^\infty e^{-x^2} \, dx = \sqrt{\pi}}$$

Using the Gaussian integral, we can see that as we have taken away half of the value in the limits. $\int_0^\infty e^{-x^2} \, dx = \frac{1}{2} \int_{-\infty}^\infty e^{-x^2} \, dx$

$$\int_0^\infty e^{-x^2} \, dx = \frac{1}{2} \int_{-\infty}^\infty e^{-x^2} \, dx$$

$$\Rightarrow \int_0^\infty e^{-x^2} \, dx = \frac{\sqrt{\pi}}{2}$$

$$\left(\frac{1}{2} \right)! = 2 \int_0^\infty u \, e^{-u^2} \cdot u \, du = \int_0^\infty e^{-u^2} \, du - \left[u \, e^{-u^2} \right]_0^\infty$$

$$\Rightarrow \left(\frac{1}{2} \right)! = \frac{\sqrt{\pi}}{2} - \left[u \, e^{-u^2} \right]_0^\infty$$

$$\lim_{u \to \infty} \left(u \, e^{-u^2} \right) = 0$$

$$u=0 \quad u \, e^{-u^2} = 0$$

$$\Rightarrow \left(\frac{1}{2} \right)! = \frac{\sqrt{\pi}}{2} - (0 - 0)$$

$$\Rightarrow \left(\frac{1}{2} \right)! = \frac{\sqrt{\pi}}{2}$$

Alasdair Daniels – Lower Sixth

毛泽东思想胜利万岁

Catherine Sawidge

This China inspired piece was brought about by my interest in the rise and fall of Chairman Mao within the 20th century Chinese History I studied as part of my IGCSE History course. I chose to use Mao as the focal point of the piece, with wings and a crown to represent how central he was to Chinese culture, and the extent of deification his image underwent by propaganda around 1949-54; ultimately enabling him to be seen in a superior light. I have altered the flag of China to depict the symbol of communism – revealing the modifications in the political ideologies of the time. In turn this demonstrates how much the masses prioritised these beliefs that Mao promoted over their own. The presence of Mao's Little Red Book in the piece also emphasises the level of control and influence Mao had over the masses, for him to be idolised in this way.

Catherine Savidge – Lower Sixth

Set inspired by Apollo 13

William Jones – Upper Sixth

From the composer: I wrote the pieces for my EP as I was keen to try out writing to a story and to try to convey scenes and emotions purely through music, without any visuals. I also thought it would be great fun as I am so interested in creating different atmospheres with sound.

Can Economics tell us anything about how we can try to prevent war?

Aditya Iyer – Upper Sixth

With today's list of world problems, we need a war on poverty, drugs, and hunger, and not an armed deadly battle between conflicting nations. Economists have a lot to say about why nations engage in war, leading to specialised branches of study such as: peace economics and conflict economics. In this essay, I will be looking to provide an economic analysis of why war occurs and how economic concepts can help to prevent them.

Let us begin by examining the ongoing Kashmir conflict which started in October 1947. This territorial conflict is fought primarily between India and Pakistan, two nations which have fought three wars over Kashmir, leading to the loss of more than 47,000 lives. In September 2016, when Pakistani militants attacked the garrison town of Uri – which is controlled by India, Pakistan was looking to gain that territory by winning the battle, whilst India was only looking to defend its land and would not gain anything by winning. This leads to a simple game representing such a war where we can calculate the optimal game strategy for both nations.

Based on previous wars fought in Uri, we can assume that:

• Pakistan has a 60% chance of gaining the territory.
• The territory is worth ₹100,000 and can be split in any proportion.
• The battle will cost both countries ₹10,000.

There are two clear routes each country can pursue: conceding or going to war. In this game, Pakistan makes the first move. It can concede, in which case India keeps the territory and the payoff is zero for both countries.

Action: Pakistan Concedes	Pakistan	India
Payoffs	Zero	Zero

However, if Pakistan decides to go to war for the territory, India has two choices: to concede or to accept the war.

| India		Action: India concedes	Action: India goes to war
Pakistan	Action: Pakistan decides to go to war	Pakistan's Payoff: +₹100,000	Pakistan's Estimated Payoff: (0.4 x 0) + (0.6 x 100,000) − 10,000 = +₹50,000
		India's Payoff: -₹100,000	India's Estimated Payoff: (0.4 x 0) + (0.6 x -100,000) − 10,000 = -₹70,000

India's payoff is higher if it decides to go to war instead of conceding. Similarly, Pakistan's payoff is also higher if it decides to go to war, regardless of what India decides after that. Therefore, it would be irrational for either of India or Pakistan to give up its claim on territories of Kashmir. However, there is one more action the countries can take. They can both agree on making a settlement.

In this case, if India gave Pakistan some land with a value x, where ₹50,000 < x < ₹70,000, both countries can benefit from not going to war. Changing the variables of the game would still lead to the same conclusion, provided, there is some cost in going to war. Hence, game theory would suggest that most wars are inefficient and waste a lot of money and lives. A better alternative would be for the two countries to make a settlement on how much control each nation has over the land and resolve the conflict in the long-term.

Sample settlement	Pakistan	India
Payoffs	₹60,000	-₹60,000

Why then, do countries engage in war? Perhaps - it is due to the issue of indivisibility. Not everything that leads to a war could be split amongst nations as easily as land, money, or natural resources. For example, the United States invasion of Afghanistan was to capture Osama bin Laden – this is a conflict which cannot be settled, so the only options are to concede or go to war. The solution to this issue is to use side payments. This can be seen in the Treaty of Paris (1898) agreement, where the United States paid $20 million to Spain after it relinquished the remaining Spanish empire to the United States. This way the United States avoided any future conflict it may have because of Spain's sorrow. Side payments would work especially well if the object of conflict – which is indivisible – only has monetary value to both nations, as opposed to sentimental value.

There is also the issue of lack of trust. Many economic activities suffer from inefficiency due to missing trust in societies. We could stop spending any money on police and security and just trust everyone to obey the law. However, all it takes is one person to act untruthful and society resumes making inefficient systems to address the issue; trust is an unstable equilibrium. In his 1915 paper, "Rationalist Explanations for War", Fearon points out that another reason might be, what an economist would call, asymmetric information. Just like in any economic market, the buyer or seller with more information can exploit that information gap to their benefit. In conflict bargaining, one nation could easily suggest they have a higher military capability, increasing their chances of victory, changing the payoffs, and giving them a better deal as they get a higher value bargaining range, as shown in Figure 1.
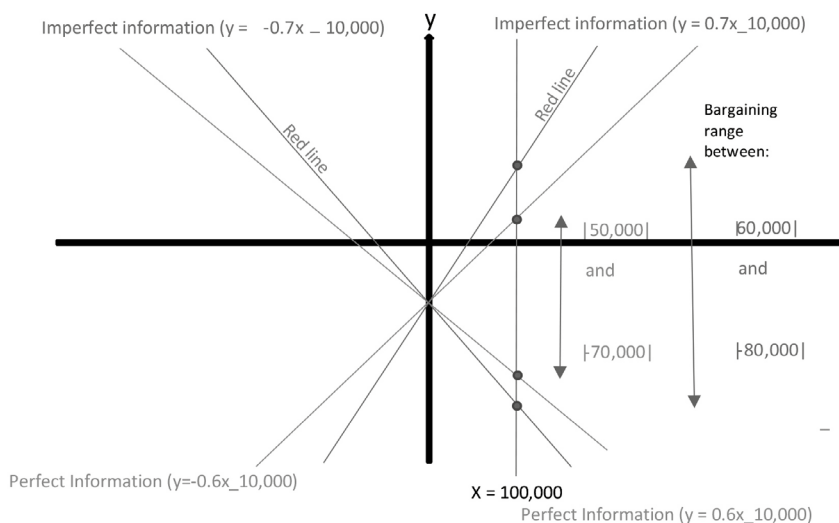
Figure 1: *Here, y is the payoff, x is the price of victory, the gradient of x is the probability of winning, and the subtraction is the cost of war. The red line shows increased probability of winning at 70% resulting from one party misrepresenting information.*

These two issues can only be resolved by forming an international organisation to deal with conflicts, and forcing nations to be transparent with it and display trust in obeying any conflict resolving deal agreed with the organisation. In her 2002 book[2], Walter identified that between 1940 and 1990, 55% of interstate wars were resolved through bargaining, while only 20% of civil wars resulted in settlements. The key to the settlement of those 1 in 5 civil wars was the presence of a third party to enforce the terms of the peace treaty. An international organisation is especially useful for resolving civil wars as the rivals cannot retain independent military forces, making commitment an issue. This can still only work with interstate wars if there is a strong incentive for nations to display trust and transparency when bargaining through the aid of such an organisation. Multilateral trade networks and integration, combined with economic sanctions, can provide such an incentive.

[2] *'Committing to Peace: The Successful Settlement of Civil Wars'*

Post World War II, the global economy has seen a striking growth in international trade by a factor of about 7 in real terms, whilst the number of wars per country has decreased ten-fold[3] (despite an increase in the number of countries). This increased in trade – which occurred mainly due to the introduction of containerization – has led to economic interdependence as one country relies on imports from several other countries to be able to consume all necessary goods and services efficiently according to the theory of comparative advantage. In their study, "Networks of Military Alliances, Wars, and International Trade", Jackson and Nei identify how military alliances alone are not sufficient in stabilising nations. There needs to be some economic incentive for alliances to be well maintained – which is created through trading. Two nations in war cannot also trade with each other at the same time, therefore, going to war has an additional cost in terms of lost surplus created due to trade. Referring back to the game, if we assume the extra value trade creates is around ₹20,000, Pakistan's estimated gain from the war would now only be ₹30,000, whilst India's loss would be ₹90,000. It is therefore even more likely that the two countries will bargain as the range is now 3 times more than the game without trade taken into account.

This concept can be clearly illustrated using the engine of European integration that is the Franco-German relationship. These two neighbouring countries have a long history of enmity which arose in the 16th century and inflamed with the Franco-Prussian war of 1870-1871. This inefficiency and bloodiness of frequent wars is what the founding fathers of the European Union (EU) had in mind as they began to unite European countries economically and politically to secure peace. It has now been 54 years since the Franco-German Friendship Treaty was established, and even though this tandem has been affected by things like France's rejection of the EU constitutional treaty and the change of government in Germany in 2005, they were always able to bargain and resolve the issue efficiently as concluded in the game earlier.

Such trade unions are not only useful in preventing conflict amongst member nations, but also in maintaining peace on a larger scale. In March 2014, Russia exhibited its aggressive foreign policy in annexing the Crimea and invading the Ukraine. This led both the EU and the US in imposing sanctions limiting trade with Russia. Asset freezing sanctions have been proven to be an excellent policy, Rogers (1996)[4] , as they target individuals, mainly in President Putin's inner circle, rather than directly affecting the majority of innocent citizens. These individuals on the list created by the EU are not allowed to buy and sell their assets in the EU with the freeze implemented. In 2014, $61bn (£46bn)[5] of capital left Russia sending a strong signal to Mr. Putin and other rich influencers in Russia to stop such aggressive policies. It aims to destabilise the target country's leadership and hopefully shift support from the current leader to a different leader who might be less objectionable.

Such sanctions work better with more countries involved as senders, as it forces Russia to be increasingly self- reliant, which is difficult. However, due to falling export prices of sanctioned countries, it becomes increasingly difficult to convince more countries to give up on cheap resources and impose sanctions, even if the conflict does not directly threaten them. In 2010, the United Nations imposed sanctions against Iran for their continued push towards nuclear development. Japan, Australia, South Korea, and other countries followed with more sanctions, but China did not. The Atlantic Council's Iran Task Force reported at the time that the sanctions would be unsuccessful as long as China continued trade with Iran.

Therefore, the effectiveness of sanctions depends on the sender's ability to coordinate all the main trading partners of the sanctioned country. The likeliness of such coordination and cooperation existing is again increased if the countries are economically integrated. It could be argued that in some extreme cases, the country not cooperating could be threatened to do so using sanctions itself.

It is difficult to measure empirically the efficacy of sanctions. This is because the strongest of sanctions are the ones which have an effect without ever being implemented. The threat of such a sanction alone should deter countries from acting in any unpleasant manner. The sanctions that do get implemented are against the countries which see themselves as being strong enough to resist the sanction and be better off by continuing to behave the same way rather than giving up and avoiding the sanction. The usefulness of sanctions is therefore, heavily underrated.

In conclusion, war is a matter of international relations and economics has a lot do with the behaviour of individuals and groups. War is best understood as driven by economic decision making, costs and benefits.

Therefore, peace can be achieved by realising the economic costs of war and the rationality in settlements. Highly integrated trade networks and strong sanctions are powerful tools for influencing those economic decisions, deterring countries from not cooperating with international authorities. In fact, economics has been informing governments and institutions about all the ways to prevent wars discussed in this essay, which is why we are seeing a lot less of them, despite of the abundance of unresolved conflicts.

References:
Anonymous (2002): The Kashmiri Conflict: Historical and Prospective Intervention Analyses. pg2. The Carter Center.

Fearon, J. (1995): Rationalist Explanations for War. International Organization, Vol. 49, No. 3.

Spaniel, W. (2014): Game Theory 101: The Rationality of War. Createspace, 201.

Walter, B. (2002): Committing to Peace: The Successful Settlement of Civil Wars. Princeton University Press.

Jackson, M. & Nei, S. (2014): Networks of Military Alliances, Wars, and International Trade. Stanford University.

Rogers, E. (1996): Using Economic Sanctions to Prevent Deadly Conflicts. CSIA Discussion Paper 96-02, Kennedy School of Government, Harvard University, May 199.

[3] Data from 'Networks of Military Alliances, Wars, and International Trade'
[4] From the discussion paper titled: 'Using Economic Sanctions to Prevent Deadly Conflict'
[5] Data from the: Congressional Research Service

How is mathematics like a language?

Oliver Williams – Lower Sixth

The idea that mathematics is a language is held among many mathematicians and linguists alike. For instance, Galileo says in his essay The Assayer that '[the Universe] is written in the language of mathematics' (Galilei & Drake, 1957). In order to establish the extent to which mathematics is like a language, we must first define 'language'. I choose to define 'language' by typical characteristics of a language: languages are a collection of sounds denoted by a collection of letters to form words, these words are split up into different types depending on their role in sentences, and the words can change to indicate specific nuances in their meaning to the reader or listener. I believe mathematics bears a considerable likeness to a language, albeit a rather odd one.

A common feature of language and mathematics is that they both have the ability to describe themselves, as evidenced by the fields of metamathematics and linguistics. Works of metamathematics, such as Principia Mathematica and the Peano axioms, attempt to provide axioms for mathematics, and build other mathematical principles, such as addition, using the pre-defined axioms. Linguistics is slightly less abstract, though operates on the same fundamentals: describing a language using a language. Despite this, the forms in which metamathematics and linguistics are described are alien to each other. In their Principia Mathematica, Bertrand Russell and Alfred North Whitehead offer definitions and proofs of the founding principles of mathematics (Russell & Whitehead, 1910). One such proof is the somewhat well-known proof that 1+1=2 (Proposition ✱54.43). The proof is written using esoteric symbols which would bamboozle the average reader. Complexity aside, the proof does indeed describe one of the simplest mathematical operations; it is joined by many other proofs of fundamental mathematical principles in the three-volume work. Linguistics, however, describes natural language in words rather than symbols (usually: exceptions include sound change notation and the International Phonetic Alphabet), meaning metamathematics and linguistics differ significantly in this respect. That said, on the basis that metamathematics has a natural language equivalent – in linguistics – I believe that mathematics does display characteristics of language in this area.

One may draw comparisons between existing natural languages, constructed languages, and the "language of mathematics". For example, all of the methods of expression below lead to the same result: a set of the even integers under 1000.

(1.1) 1. A set of the even integers under 1000.

(1.1) 2. Un ensemble des nombres entiers pairs moins que 1000.

(1.1) 3. Set = [(2*n) for n in range(0, 500)]

(1.1) 4. {2n:n ∈ N,n<500}

It is clear to see parallels between the four methods of expressing the concept above: the English (1.1) and French (1.2) examples are largely equivalent, and there is a direct correspondence between most of the words in each example. There is also a parallel between the third and fourth examples, (the third (1.3) being a programming language, Python, and the fourth (1.4) being mathematical set builder notation) in that they use the letter n to represent a number, they limit the value of n to 500, and they double n to build the set. Some may not consider programming languages to be languages, and these people would also likely not consider mathematics to be a language; however, some do in fact consider such constructs as Python to be languages, meaning mathematics could be considered to be one after all.

A failing of the "language of mathematics" is its exceedingly small domain of discourse: mathematics simply cannot express certain concepts. Edward Sapir, in trying to prove his infamous hypothesis, performed a study of Amerindian languages, specifically on translations of 'he gave it [a stone] to him'; Sapir found all of the languages he surveyed could express this idea fully (Crystal, 2014, p. 6). Mathematics, however, is utterly unable to express this concept: it has no pronouns, no verbs, no nouns, and no adpositions. It would seem, therefore, that all of the traditional components of language are missing. Indeed, this is true, yet there are languages which function without such components. One such example is Kēlen, the creation of Sylvia Sotomayor, which lacks verbs, and instead gets by with what Sotomayor dubs 'relationals' which inflect as nouns (Sotomayor, 2007). This could still allow mathematics to function as a language, merely as one with (at best) hazy word class distinctions.

By contrast, there are concepts which can be expressed in mathematical languages which certain languages simply cannot concisely express. For instance, the criterion for continuity of a function f within an interval I (Hunter, 2012):

$$\forall\varepsilon>0:\exists\delta>0:\forall x\in I:\exists c\in R:|x-c|<\delta\Rightarrow|f(x)-f(c)|<\varepsilon$$

If one were to try and express this in English, it would be highly convoluted[6]; the concepts expressed in the definition are impossible to put across in certain languages, such as Toki Pona, a minimalist oligosynthetic language with a lexicon of 120 words (Lang, 2014), and therefore no ability to express technical concepts. Despite the specificity of mathematical language, there are languages which echo this precision, such as Loglan and Lojban, constructed languages based on first-order predicate logic (Leith, 2007; "Lojban", 2015; Wikitongues, 2015). It therefore stands to reason that they would be able to express any concept which can be expressed with predicate logic (such as the one above). Loglan and Lojban are commonly considered to be languages, implying therefore that mathematics is also a language.

In my introduction, I defined language as 'a collection of sounds denoted by a collection of letters to form words'; this clearly does not apply to mathematics: mathematics is instead a collection of concepts (such as one-element sets, zero-element sets, and collecting sets to form bigger sets) denoted by a collection of symbols (in modern English: 1, 0, and +, respectively) to form numbers and other mathematical terms (e.g. an addend), collections of which form expressions and equations. One is therefore able to draw parallels between, for instance, words and numbers, conjunctions and mathematical operators, and sentences and equations. In this way, mathematics would seem to comply – in a way – with this definition of a language, and therefore would be a language.

Most natural languages feature irregularity; mathematics categorically does not. Nevertheless, natural languages vary in irregularity, from English with its many irregular verbs, to Japanese which has under a dozen, of which only 2 are significantly irregular (Bullock, 1994). There are also many constructed languages which are perfectly regular, such as Esperanto, and some agglutinating natural languages are said to not feature irregular verbs, such as Turkish.

Languages all must have some form of syntax, detailing the ways in which words go together to form cohesive clauses, phrases, and sentences. Mathematics also has a form of syntax. For instance, derivatives are denoted by one of the following notations, each proposed by a different mathematician ("Notation for Differentiation", 2006):

$$\frac{dy}{dx} = f'(x) = D@f(x) = \dot{y}$$

All of these are equivalent notations for differentiating the function y=f (x). Similarly, the integral of y=f (x) is always denoted by ∫f (x) dx, in which the ∫ and dx are part of the "syntax" of integration. These syntaxes are invariable, like the syntaxes of natural languages. The presence of syntax provides further evidence for the language-like characteristics of mathematics.

A potential non-language characteristic of mathematics is the difficulty in translating it to other languages. Examples of this include the aforementioned definition of function continuity, as well as many equations, such as Gauss' law for magnetism, one of Maxwell's equations, which states that there are no magnetic monopoles:

$$\text{div } \boldsymbol{B} = \nabla \cdot \boldsymbol{B} = 0$$

Incidentally, this is another example of mathematical syntax: divergence is denoted by ∇· or div followed by a vector. The implications of this law – that free magnetic poles do not exist – is easy to "translate" into English; yet, to translate the mathematics itself described by the equation is much harder. One possible attempt is to say the divergence of a mathematic field is equal to zero. This is a good start, but it includes the word 'divergence', which still must be translated; a revision is the change in density when modelling the magnetic field as a fluid in motion is equal to zero (Nykamp, n.d.). When abstracting this definition further and further, it is clear that the original meaning will be obfuscated. It is also clear that mathematics can express this concept far more concisely and simply than natural languages, such as English.

A feature shared by almost all languages, constructed or natural, is that they evolve and change over time. This is also true of mathematics. The earliest known system of mathematics was that of the ancient Mesopotamians, a sexagesimal system written in cuneiform, invented in around 2100 BC (Finkel & Taylor, 2015). This system, however, was ambiguous: ⟨𐎊 could be read as 11, 39600, or 0.167. The next major mathematical developments came from ancient Greece. Such inventions as x^2, denoted δ^v and x^{-1}, denoted ς^κ (Čižmár, n.d.). Then came algebra, devised by Arabic mathematicians (Kéchichian, 2013), and place value notation, devised by Indian mathematicians (Krajcsi & Szabó, 2012). These inventions, coupled with Brahmic base 10 numerals, as well as the concept of zero, and some revised notation, lead to modern mathematics (O'Connor & Robertson, 2000). This evolution of mathematics bears considerable similarity to the evolution of language: gradual changes culminating in a modern form. This fact provides further evidence for the fact that mathematics is like a language.

In summary, mathematics conforms in some way to all of my criteria for being a language as set out in my introduction: it is a collection of symbols which can be joined to make words, or expressions, of different classes, which mean something to the reader. Mathematics has evolved, like a language, into its modern form, which features elements of syntax; it could also be argued that mathematics features parallels to conventional word classes, with numbers as nouns, algebraic terms as pronouns, operators and functions as verbs, and parenthesis and equality symbols as punctuation.

To further confirm how far mathematics is like a language, we could use an alternative definition of a language; Chomsky defines a language to be 'a set (finite or infinite) of sentences, each finite in length and constructed out of a finite set of elements' (1957, p. 13). One shortcoming of mathematics in relation to this definition is that there are infinite natural numbers, and even more real numbers, not to mention complex numbers – this contradicts the fact that a language must have a finite set of elements. However, as all natural numbers can be expressed in many natural languages, this must be a shortcoming of the definition, rather than mathematics, as otherwise the definition would exclude English and several other natural languages.

Despite its apparent remarkable similarity to a language, mathematics would not be considered a fully-fledged natural language for the simple reason that it lacks aspects of naturalism: it cannot be pronounced without other natural language as it lacks phonemes and any phonetic system whatsoever, and it is likely too regular and immutable to be considered natural. These limitations are also present in sign languages, which are in fact considered languages as opposed to other forms of manual communication. This therefore suggests that mathematics could perhaps be considered very much like a language after all.

In my opinion, the single biggest failing of mathematics in terms of being classified as a language is that it cannot express a wide range of even the simplest concepts. This, for me, is the only reason why mathematics would not be considered a fully-fledged form of language, and instead is considered a restricted yet efficient and simple mode of communication for certain, specific ideas.

---

6 *For all values of some variable ε greater than 0, there exists a value of some variable δ greater than 0; for all values of some variable x in the interval I, there exists a real number c for which the absolute value of x minus c is less than δ, which implies and is sufficient for, the mapped value of x minus the mapped value of c to be less than ε.*

Bibliography

Bullock, B. (1994). *What Japanese verbs are irregular? Retrieved from https://www.sljfaq.org/afaq/irregular-verbs.html*

Chomsky, N. (1957). *Syntactic structures. The Hague: Mouton Publishers.*

Čižmár, L. (n.d.). *The origins and development of mathematical notation. (n.p.). Retrieved from http://math.unipa.it/~grim/mathnotation.pdf*

Crystal, D. (2014). *The Cambridge encyclopaedia of language. Cambridge: Cambridge University Press.*

Finkel, I., & Taylor, J. (2015). *Cuneiform. London: The British Museum Press.*

Galilei, G., & Drake, S. (1957). *The Assayer. In Drake, S. (Ed.), Discoveries and opinions of Galileo (pp. 231–280). New York, NY: Doubleday & Co. Retrieved from https://www.princeton.edu/~hos/ h291/assayer.htm*

Hunter, J. K. (2012). *Continuous functions. In An introduction to real analysis (p. 21). Davis, CA: (n.p.). Retrieved from http://www.wright.edu/~qun.li/MTH4320/4320S14/IntroAnalysis- -JohnHunter.pdf*

Kéchichian, J. A. (2013, September 19). *The father of algebra: Abu Jaafar Mohammad Ibn Mousa Al Khwarizmi. Gulf News. Retrieved from http://gulfnews.com/culture/people/the-father-of- algebra-abu-jaafar-mohammad-ibn-mousa-al-khwarizmi-1.1233076*

Krajcsi, A., & Szabó, E. (2012). *The Role of Number Notation: Sign-Value Notation Number Processing is Easier than Place-Value. Frontiers in Psychology, 3;463, doi: 10.3389/ fpsyg.2012.00463*

Lang, S. (2014). *Toki Pona: the language of good. (n.p.).*

Leith, A. (2007, January 22). *What is Loglan? Retrieved from http://www.loglan.org/what-is- loglan.html*

Lojban. (2015, May 25). *Retrieved from https://mw.lojban.org/index.php?title=Lojban&setlang=en*

Notation for differentiation. (2006, November 25). *Manchester: (n.p.). Retrieved from http://www. maths.manchester.ac.uk/~cds/articles/derivative.pdf*

Nykamp, D. Q. (n.d.). *The idea of the divergence of a vector field. Retrieved from https:// mathinsight.org/divergence_idea*

O'Connor, J. J., & Robertson, E. F. (2000). *Indian numerals. Retrived from http://www-history.mcs. st-and.ac.uk/HistTopics/Indian_numerals.html*

Sotomayor, S. (2007). *Verblessness in Kēlen. Presentation, Berkeley, CA. Retrieved from https:// www.youtube.com/watch?v=a8_9r3bwAx8*

Whitehead, A. N., & Russell, B. (1910). *Principia Mathematica. Cambridge: Cambridge University Press. Retrieved from https://quod.lib.umich.edu/cgi/t/text/pageviewer-idx?c=umhistmath&cc=um histmath&idno=aat3201.0001.001&frm=frameset&view=image&seq=401*

[Wikitongues]. (2015, October 4). *WIKITONGUES: John speaking Lojban [Video File]. Retrieved from https://www.youtube.com/watch?v=lxQjwbUiM9w*