COMENIUS UNIVERSITY IN BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS

The evolution of techno-social systems: from the clock to the cyborg

Diploma thesis

2022 Rohil Jethmalani

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Rohil Jethmalani

Declaration

I hereby declare that I have written this diploma thesis independently, using the cited sources, under the supervision of Doc. RNDr. Martin Takáč, PhD.

Rohil Jethmalani

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Abstract

Technology is often considered to be a tool. A tool being something that is neutral and lacks its own inherent values and biases. Through this thesis, I posit that technology and the values of the individuals or groups that created it, are inseparable. Every technology, whether new or old holds some implicit assumptions about how human societies ought to function. Additionally, technologies are embedded in society; that is they are shaped by societal values and also shape them in return. Thus, as is revealed in the title of my thesis, technologies must be studied as techno-social systems that go beyond the framework of 'technologies as tools'. To do this concept justice, I look at the evolution of one important historical technology, on which much of human society today, depends upon. This is the evolution of linear time, or more precisely the science of timekeeping through the use of various clocks. Today, we take for granted that our days are comprised of 24 hours of 60 minutes each and so on. It was not always that we ordered our days/ months/ years in this way. Time itself might be thought of as an objective phenomena, but its measurement by humans makes it a human construct - laden with human values. The techno-social system of timekeeping is composed of technologies, individual horologists, timekeeping institutions, religious establishments, governments and so on.

I extend insights gained from the study of timekeeping to a more modern techno-social system - the internet of things. Apart from studying these two technologies as techno-social systems, I also study their impact on human cognition. Human cognition is extended through the tools we use. These tools belong to larger techno-social systems, influence and mould our cognitive abilities. I argue that the type of tool used to extend cognition must also be considered. For instance, using an atomic clock to measure the time of day versus using the sun's movement through the sky have differing effects on cognition. Both of these are effective at getting us to the end result of bringing order to our day. While we may achieve bringing order and predictability to the passing of time, the tools we use to do so affect the way we cognise and interact with the world.

I conclude by exploring the assumption that technology can provide the solutions for various problems or challenges we find ourselves in. Is it that we can address the environment, economy, happiness and improvement in cognition simply by using better technology? I explore ethical dimensions of these new technologies, along with philosophical questions that are both timeless and prescient. My intention with this thesis is not to proselytise a particular point of view or moral perspective, but rather to open up further discussion on these important topics.

Abstrakt

Technológia sa často považuje za nástroj. Nástroj je niečo, čo je neutrálne a nemá vlastné hodnoty a predsudky. V tejto práci uvádzam, že že technológia a hodnoty jednotlivcov alebo skupín, ktoré ju vytvorili, sú neoddeliteľné. Každá technológia, či už nová alebo stará, v sebe nesie určité implicitné predpoklady o tom, ako by mali ľudské spoločnosti fungovať. Okrem toho, technológie sú zakotvené v spoločnosti, to znamená, že sú formované spoločenskými hodnotami a na oplátku ich tiež formujú. Ako teda vyplýva z názvu mojej práce, technológie treba študovať ako techno-sociálne systémy, ktoré presahujú rámec "technológií ako nástrojov". Aby som tomuto pojmu učinil zadosť, pozriem sa na vývoj jednej dôležitej historickej technológie, na ktorej veľká časť ľudskej spoločnosti dnes závisí. Ide o evolúciu lineárneho času, resp. vedu o meraní času prostredníctvom rôznych hodín. Dnes považujeme za samozrejmé, že naše dni pozostávajú z 24 hodín po 60 minút a tak ďalej. Nebolo to vždy tak, že sme si takto usporiadali dni/mesiace/roky. Samotný čas môžeme považovať za objektívny jav, ale jeho meranie ľuďmi ho robí ľudským konštruktom - zaťaženým ľudskými hodnotami. Techno-sociálny systém času sa skladá z technológií, jednotlivých horológov, časomerných i náboženských inštitúcií, vlád, atď.

Potom rozšírim poznatky získané pri štúdiu časomiery na modernejší techno-sociálny systém - internet vecí. Okrem štúdia týchto dvoch technológií ako techno sociálnych systémov, skúmam aj ich vplyv na ľudskú kogníciu. Ľudská kognícia je rozšírená prostredníctvom nástrojov, ktoré používame. Tieto nástroje patria do väčších techno-sociálnych systémov, ovplyvňujú a formujú naše kognitívne schopnosti. Tvrdím, že typ nástroja používaného na rozšírenie poznania musí byť tiež braný do úvahy. Napríklad používanie atómových hodín na meranie denného času v porovnaní s používaním pohybu slnka po oblohe majú odlišný vplyv na poznávanie. Obidva tieto spôsoby sú účinné pri dosahovaní konečného výsledku, ktorým je zavedenie poriadku do nášho dňa. Hoci môžeme dosiahnuť zavedenie poriadku a predvídateľnosti do plynutia času, nástroje, ktoré na to používame, ovplyvňujú spôsob, akým poznávame a komunikujeme so svetom.

Na záver skúmam predpoklad, že technológia môže poskytnúť riešenia rôznych problémov alebo výziev, v ktorých sa nachádzame. Môžeme vyriešiť

problémy životného prostredia, hospodárstva, šťastia a zlepšenie kognitívnych schopností jednoducho pomocou lepšej technológie? Skúmam etické rozmery týchto nových technológií spolu s filozofickými otázkami, ktoré sú nadčasové a smerujúce do budúcnosti. Mojím zámerom v tejto práci nie je propagovať konkrétny názor alebo morálne hľadisko, ale skôr otvoriť ďalšiu diskusiu o týchto dôležitých témach.

Chapter 1: Introduction

“When parts of the environment are coupled to the brain in the right way, they become parts of the mind.” - David Chalmers

By attempting to understand how technologies affect us, one is engaged in a cross-study of various seemingly separate fields. To make sense of this, we must first understand the technologies themselves; what they intend to do, and how they transform our cognitive process. We must also understand the environments in which humans interact with technologies. This is because different environments offer us different affordances. By affordances I mean that our capability to act and cognize is shaped by the environment we inhabit. Different environments allow for the creation of different kinds of technologies that in turn change the environment. In this thesis, I endeavor to study briefly this three way relationship between humans, technologies and the environment. I would like to add emphasis to the word relationships here. Different technologies (even if used for the same aims), create differing effects on human cognition. Different societal and cultural values affect technologies as well, and lastly not all humans are affected by technology in the same way.

1.1 Aims

Through an interdisciplinary approach, I endeavor to understand the interactions between society, culture, technology and its effect upon the evolution and change of human cognition. In my approach I look at two key technologies through two interconnected frameworks:

1. The extended cognition framework, which views technology as an extension of human cognition. This framework posits that we extend our cognitive capabilities through various tools around us. For instance, we extend our memory through the use of certain aids like pen and paper. Solving a mathematical problem on a piece of paper, is a way in which we extend our limited working memory with the use of the paper. The tool or medium that we use to extend our cognition is not neutral. What I mean is: different mediums or tools, affect our cognition in different ways. Using a hand drawn map to extend our navigational capabilities is very different from using a GPS enabled satellite map. Using a pen and a piece of paper to extend our memories is different from using our laptops to do the same thing. We use technologies to enable us to reach certain goals, but we often overlook what the technologies do to us on the way there. Linear time and timekeeping devices are crucial to the functioning of our modern economy, but we often don't think about how these technologies have affected and continue to affect human cognition.
2. Technologies as techno-social systems: I borrow from the work of (Frischmann, B. & Selinger, E., 2018) who posit that technologies can never be neutral. Technologies being embedded in socio-cultural environments are the product of the human cognitive process that is partially aided by the environment. Cognition is distributed amongst various stakeholders, and so are technologies. Technologies enable us to act in the environment in certain ways. These affordances offered by technologies are limited and shaped by the social environment that they are a part of. Tools can promote some values in society while hindering others (Baldini, G *et al.,* 2018). Tools are also embedded with certain values, and assumptions about how the world ought to function.

I explore these two frameworks in more detail later on in Chapter 2.

In Chapter 3, I explore the historical evolution of timekeeping with the use of different clocks. Usually, when clocks are mentioned, one often thinks of the modern mechanical clocks we wear on our wrists. However, the first clocks were large architectural monuments like Stonehenge. Timekeeping then evolved to using sundials and water clocks. With industrialisation, the mechanical clock and then atomic clocks became the preferred technology for timekeeping. The science of timekeeping is one of the oldest disciplines, which fuelled many scientific endeavors. However, through an exploration of its history, we find that it is not an objective science. While its advances have allowed human civilisation to flourish in groundbreaking ways, it is essentially a human construct. Evolution of timekeeping is by no means over, and we will continue to see breakthroughs in the way we understand and measure time. Each method of measuring time offers a window of perspective into the values and principles that its inventors held. Additionally, each timekeeping device clearly promoted certain values, while inhibiting others. To tie all of this together, I draw upon the work of a physicist and astronomer named Chad Orzel, who has extensively studied the various tools and mechanisms humans have used to measure time. I also draw upon the work of David Rooney, a horologist and astronomer, working at the Royal Observatory (the official organization that keeps the Greenwich Mean Time- GMT, or Coordinated Universal time - UTC). David Rooney looks at the history of time as the history of civilisation. He brings forth a unique perspective that timekeeping is a socio-political endeavor; one that has been used for many different goals. Religions and empires have all made attempts to control timekeeping, he argues; precisely because timekeeping brings order to our world, and thus the foundation of any cohesive society or civilisation is to share the same conception of time. Timekeeping is an important historical cognitive extension tool. I hope to draw novel insights by combining the work of these authors with the frameworks of cognitive extension and techno-social systems.

In Chapter 4, I bring my focus to the present and the future, through the lens of a more current technology (or set of technologies) which comprise the internet of things. This set of technologies shares some similarity with timekeeping technologies and also diverge significantly in many aspects. I explore the work of several authors that view these technologies as techno-social

systems. Technologies that are imbibed with assumptions about how human society ought to function. I draw analysis and comparisons between IoT and the historical evolution of timekeeping. IoT systems are modeled on large amounts of data. For a fully automated system to run well, it needs the environment it functions in to be predictable. If the algorithm is capable of making consistently accurate predictions about its environment, it will enable the system to function efficiently and desirably. However, there are attempts being made to deploy IoT systems in environments that humans inhabit. Thus human behavior needs to become more predictable for these systems to function well. Is the embrace of IoT technologies in our homes and workspaces making us more predictable? Is that a good or bad thing? I explore some of these themes in this chapter. Additionally, I explore the limitations of IoT systems that run on large amounts of data. These systems are being considered to run entire sectors or parts of the economy like transportation, power and so on. The potential for reducing human error and making systems more efficient are immense. Though we must also consider the increased fragility of such systems, where humans are increasingly dependent on algorithms, sensors and data to run their society.

A final discussion and conclusion chapter will follow, where I will attempt to tie the different arguments together and present my perspective on these subjects. I will also conclude by evaluating the presumption that new, better and cleaner technologies are the solution to the current challenges we face. I do this by taking into account both sides of the argument; the futurists who claim that advances in technology will solve most of the challenges our species faces today & also the claim that it is not changing technology that will solve issues but a change in human values and consciousness.

1.2 Research Questions

Through the course of this master's study, I aim to ask multiple, interrelated questions. The first is whether **tools & technologies are neutral**? My research aims to question the implicit belief that technologies are simply tools that are not inherently good or bad and so on. Instead I hope to argue effectively that technologies are almost never neutral but promote certain values over others. I expand on this formulation with my second question, **can the study of technologies be separated from social systems** that they are embedded in? Social systems are based on societal, cultural and political values. If we cannot study technologies without also looking at the social structures they are embedded in, technology cannot be thought of as a ‘neutral tool’. In situating my study firmly at the center of cognitive science I ask my next question: is there a **cognitive trade-off when using cognition extending technologies?** As we outsource certain aspects of cognition onto our techno-social environment, do we lose certain cognitive capacities? Cognitive evolution through mind extending tools is not linear I argue, there are gains but also losses in cognitive capability. Lastly, in light of human cognition, I try to investigate how different technologies affect us. My last question: **does the medium used for cognitive extension, matter as much as the goal achieved**? For instance processing emotions and stress might be one’s goal. Journaling with pen and paper versus interacting with an AI bot to process emotions, impact the individual and his/her cognitive processes in very different ways.

Chapter 2: Cognitive Extension through Technologies

❖

“Our technologies, our machines, are part of our humanity. We created them to extend ourselves, and that is what is unique about human beings.” - Ray Kurzweil

Many individuals subscribe to the belief that technology is applied science. Humans have always strived to develop and use various tools even during so called pre-scientific times. Some historians and anthropologists have gone as far as to say that our ability to make and use tools is the most significant factor distinguishing us from other living beings (Frischmann, B. & Selinger, E., 2018). The creation and use of various tools have enabled our species to accomplish things that would otherwise have been impossible. That being said, there are many other species that also use tools like chimpanzees, crows and so on. However, their usage of tools is still rudimentary as compared to human tool use, and would take many millennia to advance. While tools have dramatically increased our chances of survival and provided comfort, they have, and continue to shape our beliefs, worldview and capabilities.

Before continuing to define and explain cognitive extension through technology, I will first touch upon body extension. The most apparent example is that of clothes. Clothes not only protect us from the natural elements (cold, rain, wind, etc.), but also help us to signal who we are to others. We often wear our identity through our clothes, and there are countless ways we can use color,

shape, texture and symbols through clothing to indicate different things about ourselves. One's clothing is often the first impression we have about an individual's social status, worldview, and so on (Frischmann, B. & Selinger, E., 2018). Different cultures might ascribe different values and perceptions to the same piece of clothing. Thus, clothing is a tool embedded within a larger social context, whereby the individual extends his/her body based on societal values. The individual's extended body is embedded in a system that is composed of the person, plus the material clothes and societal ideas of fashion and so on. In a similar vein the possibility of extending our cognition is afforded by the tools we use and the societal culture we belong to.

The first example of a powerful cognitive extension tool is language itself. As historian Yuval Noah Harari claims, the human species went through a Cognitive revolution about 70,000 years ago, which involved new ways of thinking and communicating born out of language (Harari, Yuval N. 2015). He argues that while many animals are capable of communicating by uttering sound, only humans have developed the capacity for language embedded with imagined meanings. The ability to describe and create concepts that don't actually exist in nature were crucial to the coordination of ever larger groups of humans. Through the use of language, humans could construct shared myths that led to mutual trust and the possibility for large social institutions that could govern large communities of individuals. For instance, today people believe in laws, human rights, and money; none of which truly exist outside of the stories individuals invent and tell one another. These myths sustain empires, and empires allow large-scale cooperation required to create complex systems and technologies.

2.1. The Distributed Cognition Paradigm

The paradigm of extended or distributed cognition argues that cognition rarely ever occurs solely in the mind or brain of a single individual. For instance, when solving a mathematical equation, one extends his/her working memory through the use of material artifacts like pen and paper. Additionally, the mathematical rules and formula used to solve the equations have already been established and belong to one's social culture. According to the distributed cognition view the whole system is performing the cognitive task (Frischmann, B. & Selinger, E., 2018). The whole system, composed of the individual, the material artifacts (pen & paper), and the social artifacts (established rules of calculation, etc.). Many philosophers would disagree with this view, arguing that cognition occurs at the point of control. Cognition occurs at the one controlling when and how the inputs must be used. The individual in this case decides, judges and accomplishes the cognitive task, with the use of various tools. The limitation of this view is that we put a much greater weight on the achievement of a particular cognitive task, and discard what happens to the individual in the process of completing the task. An example to highlight this limitation is navigation. One individual might navigate through a hike in the forest relying on social artifacts - a hand drawn map of the hike with various landmarks to look out for. A second individual may use a GPS enabled smartphone map to navigate the same trail. While both may achieve the cognitive task of navigating through the forest successfully, are they both using their cognitive abilities similarly? The first individual exercises spatial awareness to a far greater degree, constantly trying to visualize where in space he/she might be. The second individual, using GPS navigation, has outsourced the cognitive task of visualizing where in space he currently is. He might completely lack spatial awareness and still successfully complete the task. Is the second individual the point of control in this setting? I.e. is it the individual doing the thinking or the GPS system? The extended or distributed cognition view is better at answering these questions. The system has accomplished the navigation task in both instances, but the individuals' role in the system's cognition could be said to be different in the first case, than in the second. Thus the type of tool used is important when considering how technologies shape our cognition.

In the late 1990s Clark and Chalmers provided a framework that tries to define the extended mind (Clark, A., & Chalmers, D., 1998). They posit that individuals view the whole cognitive process to be an integral part of their own mind when the following two criteria are fulfilled:

1. The technology should be easily available and routinely invoked.
2. Any information gained from the use of the technology should not be subject to scrutiny and should be considered as trustworthy as something simply recalled from biological memory.

One can see that timekeeping devices (clocks) fall squarely within both criteria, and when making a time-bound plan, we see clocks as integral parts of our own cognition. We don't for a moment think that we are outsourcing certain cognitive activities to the clock (or the designers of the clock). Another example is GPS technologies for navigation. We usually never question the route chosen for us and take it for granted that we would have chosen the same route if we had all the related information available to us. However, in Clark and Chalmers' version of the 'extended mind' they believe that the individual retains full autonomy in these situations. Through this thesis, I hope to present that this may not always be the case.

2.2. Types of Affordances Cognitive Technologies Offer Humans

Technologies that extend our cognition can be spoken of as 'cognitive technologies'. Cognitive technologies can transform the nature of a task by altering the sequences of actions that the individuals are required to contribute (Frischmann, B. & Selinger, E., 2018). Some ways in which cognitive technologies transform the nature of a task are:

1. *By minimizing how much attention or awareness is required to complete a task*.
2. *By transforming intellectual problems into perceptual ones.*
3. *By changing our relationship to space, to enable us to deliberately practice a real world situation or skill.*

4. *By changing our relationship to time, to enable us to make complex decisions that would otherwise require long periods of observation*.
5. *By changing the environment to reduce the demands placed on biological memory.*
6. *By transforming the process by which knowledge is transferred.*
7. *By changing the environment to enhance the reliability, efficiency and speed of routine tasks.*

1. *By minimizing how much attention or awareness is required to complete a task*. Examples are using pen and paper to solve a multiplication problem; a calendar application to schedule our days and a calculator to solve complex mathematical problems. While the affordances that these tools provide us are extremely valuable, the type of tool used affects our cognition differently. For instance, when trying to plan our next week, we might use a web based application or simple pen & paper. Oftentimes, when using a web application, the locus of control is not entirely with us. Through data on how many tasks we have accomplished, how many hours spent on focussed work and so on, we are inadvertently nudged towards being more productive and filling up our calendars more. While this might be intentional for certain individuals, the tool nonetheless mediates how we perceive time and performance.
2. *By transforming intellectual problems into perceptual ones:* The slide rule used in solving mathematical problems, transforms them into relatively simpler tasks of perceptual recognition. Humans have evolved to interact with the environment through the use of five senses. In this sense our cognition works optimally, when it is embodied and interfacing with the environment through our senses. The idea is to transform intellectual problems from being processed primarily in the head to embedding the same problems in our external environments, so that we can engage with them through our senses.

   Visualizing complex data in graphs and charts, allows us to more easily draw conclusions and understand patterns. Data analytics and visualization attempts to make large amounts of information an opportunity instead of overloading us. Better access to information allows us to make more informed decisions, whether in work, financial planning, nutrition and

so on. However, data visualization usually reduces a multi-dimensional field of information/ data into two or three dimensions (A. V. Pandey, et, al. 2014). Additionally, three randomized controlled trials attempted to gauge the correlation between data visualization and persuasion (A. V. Pandey, et, al. 2014). The researchers found that exactly the same data presented in a graph or chart was more likely to elicit attitude change in (persuade) the individual as compared to the same data delivered in tables or text. Solely relying on data visualization to form meaningful patterns about the world, can also have an unintended side effect of accepting more easily perceptual patterns presented to us without questioning the source and biases inherent in the visualization. Lastly, using data visualization tends to make us think in averages or the most common denominator, which might not actually exist in reality.

3. *By changing our relationship to space, to enable us to deliberately practice a real world situation or skill:* A professional chess player using a real board and real pieces to devise particular strategies and movements. The use of flight simulators to train pilots for emergency landing situations. A virtual reality system used to overcome one's fear of heights. Using virtual reality to help overcome phobias, negative associations or even accustom us to a certain environment can have many upsides. As opposed to the last form of cognitive extension, we mentioned, these types of extensions benefit our cognition from taking us away from our embodied state to practice a skill or strategy. We do this because we have little control over our environments and it can be quite cumbersome and risky at times to recreate the desired situations. Being removed from the real world, also removes risk, where we can familiarize ourselves with an experience so that we are not paralysed by fear when it actually occurs. That said, these are useful only when we actually augment the virtual systems with the real world and actually accustom ourselves also to real world risks.
4. *By changing our relationship to time, to enable us to make complex decisions that would otherwise require long periods of observation*: The use of a virtual 3d topographical chart to assess the flow of water through the course of the year. This could be implemented on a large piece of land to plan effective water storage and irrigation channels. One could also use a virtual 3d topographical chart to evaluate the changing path of sunlight falling on a piece of land through the year to plan planting across the land.

These extensions are immensely valuable for agricultural and forest ecosystems. A government or other organization can create a thriving forest ecosystem, quickly, without having to spend years observing the land to do so. However the obvious trade-off in this case is the loss of opportunity to actually interact and understand the land through observation done over the years. Simulated forest designs still lack in insight when compared to an individual who has lived and grown a forest from scratch over a period of twenty years. That said, both methods have their merits for different scales of application. Additional examples are by simulating the current use of resources and how it will impact prices and access in the future and so on. Many climate scientists also use similar extensions to forecast global climate change and other patterns.

5. *By changing the environment to reduce the demands placed on biological memory:* Today nearly the entire gamut of information is available at our fingertips. Our environments are replete with smartphones and computers that we can effortlessly access to store and access information. For instance, just a couple of decades ago, it was commonplace to remember multiple close people's phone numbers with ease. Today, our smartphones do the work for us, and we are arguably better off for it. However, unless we train our memory in other ways, the cost of these new technologies over a longer timespan will be a decreased capacity to memorize things and recall them as and when needed. We are also less likely to remember exact details like our friend's birthdays or other important holidays because of the ease at which we can access calendars or set reminders. An obvious argument in favor of extending our biological memory through tools is that we can free up cognitive resources in our brain and not have to constantly worry that we are forgetting an important appointment or the way our grandmother made our favorite dish.
6. *By transforming the process by which knowledge is transferred.* The clock embedded in our smart phones allow us to access the knowledge of what time it is quickly and reliably, without us having to look to the skies to tell the time. In an earlier age we would have to rely on a sundial or water clock to acquire the same knowledge of what time it is. The continuous evolutionary process by which we transfer knowledge makes us more capable of processing a greater number of concepts. Prior to the development of the written word, knowledge was transferred orally through

certain stories and myths. The written word provided us the possibility of transferring and storing wisdom and knowledge across generations. Today we have other tools like social media, short form and long-form video content, audio content, animations and so on. Each process or medium that we use to transfer knowledge affects the cognitive process of the individual involved. The same information might be transmitted through a book or a TikTok video, but the cognitive interaction the individual has with this piece of information is radically different based on the medium/ tool used.

7. *By changing the environment to enhance the reliability, efficiency and speed of routine tasks:* These forms of cognitive extensions are routinely employed in workplaces and residences as well. A relevant example is smart sensors that help automate certain functions in a factory or the usage of certain home appliances. Another pertinent example is Taylorism, or the scientific management of humans and workspaces first proposed by Fred Taylor in the beginning of the nineteenth century (Frischmann, B. & Selinger, E., 2018). Henry Ford, inspired by the idea of Taylorism, established the first factory assembly line for his automobiles. By simply retro-fitting his factory and assigning one task per individual on the assembly line, he managed to bring down the time it took to build a car from 12 hours to just 90 mins. These tools or systems of cognitive extensions greatly increased productivity, but also dramatically changed the nature of work. Building a car went from being a craft- where an individual was more or less responsible for building the entire car, to being a mechanical chore where each individual only had to know how to attach their particular part of the car.

2.3. Technology as Techno-social systems

Cognition is not only embodied, but is embedded, extended and enacted in a particular social environment. Cognitive extending technologies cannot be evaluated through the prism of a technology as a tool but must necessarily be seen as a techno-social system. This is especially important when questions of autonomy come to the forefront. It is not enough to see GPS as a navigational tool. GPS is a techno-social system enabled by satellites using powerful atomic clocks to depict the exact longitude and latitude based on the difference in time. Satellites are only one component of this system, the corporations who use this information and design maps for our use are also part of the system. Certain individuals are involved in the cognitive process ‘behind the scenes’ through the algorithms they write. Their algorithms prioritize certain navigational objectives over others. For instance, the quickest route is often prioritized over the route with the most beautiful view. Additionally our location data is used by these companies to help provide better suggestions. Many GPS map applications routinely send their users down sub-optimal routes to gain data on traffic and so on (Frischmann, B. & Selinger, E., 2018). As governments increasingly move towards ‘smart traffic management systems’, the techno-social GPS system will perform the cognitive tasks of navigation, while humans will become mere spectators without autonomy in the process of getting from point A to B. This might be highly beneficial to the system as a whole. However, as with all techno-social systems there is a trade off when we use cognitive extending technologies. Spatial awareness as a cognitive process, will lose its importance, eventually leading to its decline. As spatial awareness becomes optional, those that wish to retain it must exercise it outside of their regular routines. An acute sense of spatial awareness was key to the survival of our ancestors. Their ability to find water, food, and other resources depended greatly on it. Can we be completely sure that our skills of spatial awareness will not be required to ensure our survival at some point in the future?

2.3.1. Language as a Techno-Social System

We hardly ever think of language as a technology, but it is a sophisticated social tool that has opened up an immense variety of cognitive capabilities. Language can be considered to be the foundational bedrock on which cultural evolution has emerged. It also is the basis for the emergence of self-consciousness (Geering, L., 2015). Through language, we have created worlds. Worlds that we share and give us meaning. To define what I mean by ‘worlds’, I will use Popper’s model on the mind-body problem. These are the physical universe (world 1), human subjective consciousness (world 2) and the products of the human mind (world 3) (Popper et al., 1977). He defined products of the human mind as names, concepts, theories, and myths. These products, though non-physical, are embodied into world1. The physical world is given meaning and purpose through the symbols of world 3. Additionally, world 3 shapes the capacity and expression of human subjective consciousness. The material on which we build our individual worlds, stories and myths is sourced from the collective world 3. How does this affect cognitive enhancement? I propose that language has provided two separate avenues for cognitive enhancement.

The first, is the creation of symbols and myths which has resulted in the possibility for a shared identity that is not bound by one’s geo-spatial location. This has created the opportunity for ever larger groups of humans to trust and cooperate with each other. Human societies have since evolved with ever greater complexity. This ability to have a shared identity that stores information, wisdom and insight across generations has enhanced our cognitive capabilities. Every few generations, the stories increase in sophistication allowing us to keep evolving culturally at a rapid pace. Complex and sophisticated social systems allow individuals to specialize. Specialized experts bring more value to our shared worlds. This in turn expands knowledge and thus cognitive capabilities across the board. Societies which allow for cultural evolution are a force multiplier for the individual's cognitive abilities. This is primarily because the material required to construct our individual cognitive capabilities is not left to chance. It is outsourced to the collective ‘mind’. Thus, through stories, humans could not only collaborate with larger and larger groups, but also with their ancestors. This has been greatly accelerated by the written word. An elder

(expert) can transfer his/ her life teachings on to future generations, who could benefit from this lifetime of knowledge, condensed in a book (or other medium).

To quote a saying that is inspired by Archimedes:

“Give me a lever long enough, and a place to stand; and I shall move the world (Earth).”

Language is precisely such a lever. Through language, we have leveraged the collection of humanity (past & present) to move/ change the ‘world’. The second avenue for cognitive enhancement that language has provided is linked to the neural pathways that are forged through language. Language makes it easier for us to neuronally store information. Through the development of words, many of our past incidents, stored as memories, could be linked together (McCrone, J., 1991). Words provide a way to access our memories through much faster routes. McCrone argues that many cognitive systems like memory retrieval, self consciousness, emotional processing, and identity creation are all aided by the use of language. For instance, language enabled efficient memory storage and retrieval, which in turn gave us a sense of time, and thus a sense of continuity. This sense of continuity is the bedrock of our personal identity and self-consciousness. The biological evolution of our brain, allowed for the creation of language, which in turn has drastically altered neuronal structures in the brain.

In a systematic review of the effects of multilingualism on neural architecture, it has been found that the structure of brain areas related to visual processing and speech production, are altered significantly after acquiring a new language (Hayakawa, S., et al. 2019). Additionally, multi-linguists are shown to have better top-down attentional control with every new language acquired. If second, third and fourth languages can fundamentally alter our neural architecture, one can only imagine what acquiring a first language has the capacity to do.

Every language offers us slightly different affordances. Languages offer different vocabularies and different ways of perceiving and interacting with the world around us. For instance, some languages are better at explaining internal states of mind, while others are better at describing complex social systems

(Hayakawa, S., et al. 2019). Language forms the cognitive framing which offers us on the one hand great potentials to extend and enhance our cognition, while on the other hand also setting limiting boundaries on our cognitive expression. Languages have different rules, grammar, and vocabulary that emphasize the importance of certain contexts and values over others. By learning a language we are not only adding a tool of communication, but we are also adopting a worldview, and a way of interacting with the world. Language is not neutral; it plays a role in shaping our beliefs, values, worldviews and cognitive architecture. Language structure is partially determined by the prevailing socio-cultural structures and institutions while it was being developed (Lupyan, G. & Dale, R., 2010). For instance, in Finnish there are over 30 words for snow, showcasing the nuances and exploration of the concept of snow that the language allows for. Many languages that appeared in tropical climates would usually only have 1 word for snow. Another example is the large number of words used to describe various states of consciousness in Sanskrit (Burrow, T., 2015). This showcases a socio-cultural setting that prioritized internal exploration through meditation and yoga, with the language itself offering a greater depth of vocabulary to speak about and communicate these states of consciousness. For 11 major Sanskrit words describing consciousness, there are no English alternatives. To describe these concepts in English is impossible in just a few words, and requires multiple sentences or paragraphs to do the concepts justice.

This framework of technologies as techno-social systems that constrain and potentiate human cognition can be applied to many other tools as well. In this paper, I touch upon only two sets of technologies: those of timekeeping and the Internet of Things, but I believe the framework does apply to many other technologies as well.

Chapter 3: Time, Clocks & Timekeeping

“Time and space are modes by which we think and not conditions in which we live.” - Albert Einstein

The modern concept of linear time; the ticking clock by which most of us order our lives nowadays is only a recent phenomena. However, the urge to understand and calculate the passing of time has been present in all human cultures for millenia. Time as we think of it today, is something that is composed of perfect and regular intervals. It is measurable, precise and repetitive. This sense of time is a human construct. Time itself might be objective, but the measurement of time is a human construction that has undergone and continues to undergo change.

In this chapter, I explain the historical evolution of timekeeping with the use of various clocks. I also draw upon how the measurement of time is a process of extending human cognition. Timekeeping offers us many affordances, and much of our modern global economy depends on it. Time being one of our primary modes of thinking, I explore how different definitions of time radically transform the way we perceive the world. I end this chapter by looking into the cognitive benefits and also trade-offs that we have experienced by the wholesale acceptance of ‘objective’ timekeeping.

3.1. Introduction: Time as a Worldview

The natural world our ancestors lived in was unforgiving and unpredictable. Humans like other animals were at the mercy of natural forces, and their ability to successfully navigate nature was a matter of life and death. To navigate the natural world, they had to define its qualities. This helped bring a sense of order, stability and predictability to the cycles in nature that they could perceive but not understand. They did this through ingenious ways. One of these ways was through making sense of observable natural cycles. This was the beginning of a long and continuing process of timekeeping. Time was initially measured in natural cycles. Thus, time itself was perceived as cyclical. The perception of time as cyclical is more than just a philosophical stance. It impacts our entire worldview and belief systems. All ancient cultures thought of time as cyclical, and many inherently saw time as having no beginning or end.

Each culture had a slightly different perspective on time. Some saw time as God, while others thought of time as an illusion. In Hinduism for instance, time is thought of as having no beginning or end. This was the basis for beliefs in reincarnation and enlightenment. In ancient Indian philosophy for instance; life, death and rebirth are visualized as being on a cyclical continuum called Samsara (Reddy, S., 2009). Moksha or enlightenment which is the pinnacle of self-realization, is then understood as the capacity to escape samsara (the cycle of death and rebirth). Similarly in Buddhism as well, time is perceived to be an illusion, and the Buddha often repeats this in his teachings, when he proclaims that all that really exists is a continuum; a continually changing Now moment; future and past are but an illusion (Miyamoto, S., 1959). These philosophies are remarkably similar to the findings that Einstein came across in his theory of relativity (Einstein, A., et al. 1952). Einstein goes as far as to say that “The distinction between the past, present and future is only a stubbornly persistent illusion”. Should we dare question the existence of time as something measurable or objective? Today we can do so with little consequence, but questioning time in many cultures/ civilisations just a thousand years ago was nothing short of heresy. I will explain later on in this chapter why this was so.

Much as we view language as a techno-social system that enables and

enhances human cognition, time and its measurement is also a techno-social system. The system of time is composed of timekeeping devices, socio-cultural assumptions about what time is, individual astronomers and horological institutions. Like languages, different conceptions of time provide us with different affordances. Our worldviews, and interactions with the environment are circumscribed in part by the way we view time. Timekeeping devices allowed us to measure natural cycles, but more importantly they also allowed us to measure many human activities. With the advent of precise timekeeping, the ascription of value to time also arose. Today we often hear people say that 'Time is Money'. Our modern economy often calculates human labor and output through time. Many individuals get paid for working a certain number of hours. Our efficiency and productivity is calculated based on how much work we can accomplish in a fixed period of time. Timekeeping is a cognitive extension that has allowed us to bring the world into order, but it has also had an effect on the ordering of humans. Not only do we use timekeeping devices to measure phenomena in the natural world, we also use it to measure ourselves, our technologies and our socio-political systems.

3.2. Methods of Counting and the Units of Time

The concept of "zero", on which much of modern science and computation rests upon, emerged independently in multiple civilisations. It prominently emerged in the ancient Babylonian, Indian and Chinese civilisations approximately 2000 years ago (Kaplan, R., 2000). At the time, these civilizations all subscribed to the notion that time is cyclical, and thus the concept of zero as a nothingness (or infinity- depending on the perspective) with no beginning or end was not controversial. As Kaplan mentions, the adoption of zero around the world took many centuries to occur. It was met with strong resistance, even in the face of its immense value. On the European continent, only the pre-Christian Greeks accepted the concept of zero without resistance. Many christian leaders saw the concept of zero as dangerous saracen magic (It was brought to Europe from India, by Arab merchants). In Florence, for instance the 'Indo-Arabic' numerals containing 0 were banned in 1299 CE, for use by merchants and moneylenders

(Venkateswaran, T. V., 2012). Authorities felt that it was easy to alter numbers by adding a 0 to the end of a number, and that the Roman numerals were superior for purposes of accounting. This led to traders and moneylenders keeping secret books in Indo-Arabic numerals (using 0 as a placeholder made it much easier to make mathematical calculations than by using Roman numerals), and simply converting their results to Roman numerals in their official books (Venkateswaran, T. V., 2012). A few years later the ecclestiastical order in Padua also banned the use of Indo-Arabic numerals in 1348. Some authors and historians claim that this resistance was because the concept of emptiness and nothingness was difficult to accept in medieval Europe (Kaplan, R., 2000). However, a more probable reason is that the Indo-Arabic numerals arrived to Europe amidst the bloody backdrop of the Islamic-christian conflict and accepting the numerical system (or any other part of arabic culture) was akin to siding with them. In the late 9th Century CE, when Pope Sylvester II made a statement that counting would be easier with the use of zero, he was accused of hobnobbing with evil spirits (Venkateswaran, T. V., 2012). Even though the concept of zero was eventually accepted, older methods of counting still prevail in our units of time.

Prior to the invention of zero, many civilisations would count using the three segments on the index, middle, ring and little fingers. This would add up to 12, which was the base method of counting, as opposed to the number 10 that came into use after the invention of zero. The number 12 was also significant for many civilisations because it denotes the number of lunar cycles as well as the number of constellations in the zodiac (Orzel, C., 2022). This formed the basis for why most civilisations independently came up with yearly calendars divided into 12 months. Additionally, many cultures also divided day and night into 12 parts; the origin of the 24hour day that we currently follow.

Each interval of 12 can be counted against the 5 fingers of the other hand, adding up to the sexagesimal base 60 (Orzel, C., 2022). Though dividing our hours and minutes into intervals of 60 only happened much later, it was based upon this age-old method of counting. Only with the advent of mechanical clocks were we able to track and measure the intervals in a minute. At the time, individual astronomers were busy measuring astronomical movements with their

new precision clocks. Much of astronomy still used the base 12 and 60 format of counting, due to the 12 zodiac constellations. Thus, instead of reevaluating the entire numerical system, it made sense to divide minutes and hours into 60 intervals instead of 10 or 100 intervals.

The seven day week that we have inherited today is another inheritance of ancient astronomy/ astrology. The seven largest celestial bodies visible with the naked eye: the Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn each have been given one day of the week. Many ancient civilisations believed that the planets were custodians of particular days of the week. Based on cultural and religious perceptions of the planets, different days of the week were considered holidays. In Christianity for example, Sunday - the day of the Sun, provider of life is the day that one must offer prayer and take time away from one's duties. In Islam it is Friday- the day of Venus, considered in astrology to be the planet of connection and joy which is taken to be the most important day for prayer. In Hinduism, Saturday - the day of Saturn is the day to meditate and go inwards. Saturn in Vedic astrology is associated with the concept of Karma, and is considered a good day to cleanse oneself from past actions.

Interestingly, the Soviet Union, in a bid to halt all kinds of religious gatherings, scrapped the 7 day week in favor of a 5 day week in 1929 (Bronson, D. W.,1968). They created a system whereby each individual would be assigned a random day as holiday within the week. They believed having asynchronous holidays would help stamp out religion and also make it harder for revolutionary groups to gather. Instead of the rise in productivity that was expected, the change actually caused productivity to dip (Bronson, D. W.,1968). Having 80% of the workforce at work all the time, made it difficult to carry out maintenance on machinery. Family members all had holidays on different days and nearly everyone was unhappy with the system. In just three years they switched to 6 days a week, and a few years later made a comeback to the standard 7 days a week. They understood that time was a tool to bring order to society. However, they didn’t quite realize that for a new unit of time to be accepted, it had to possess some meaning beyond simply productivity and work.

How the passing of time is ordered is intrinsically linked to those in power.

Their beliefs of how society should function are embedded in the way they order and display time. Time has always been a cognitive extension that helps the ruling powers establish particular ways of ordering their subjects/ citizens. I will touch on this concept again in other sections of this chapter.

3.3. The First Clocks: Solstice & Equinox Markers

We tend to think of time as something that only modern industrial societies are preoccupied with. Time and its measurement has been a preoccupation ever since agriculture and before. Keeping track of time was central to our ability to survive. We take for granted the knowledge embedded into our calendars; the change of the seasons, the time of the sunrise and sunset and so on. In this sense, measuring time using natural cycles as a reference point was a way in which human beings could make sense of the seemingly chaotic world they inhabited. It also formed the basis through which they situated the meaning of their lives within the natural world. In many cultures, the ability to decipher the natural cycles with accuracy, was believed to give the individual divinatory powers; the ability to predict the future. In this sense, astronomy, astrology, religion and the science of timekeeping were inseparable.

When we think of clocks, we usually think of the clocks we wear on our wrists today, which are divided into 12 sections or hours, with accuracy down to the minute and seconds. The first clocks, however, were not tracking seconds, minutes and hours. These clocks were tracking the cycle of the sun through the year. This was of primary importance, because it allowed us to predict the best times to plant and harvest various crops. Stonehenge is an example of just such a clock that calculates the exact day of the summer solstice (Orzel, C., 2022). The first clocks were actually massive architectural monuments. The first use of monuments as timekeepers are referred to as passage tombs or passage graves. These passage tombs were often constructed using megaliths (very large stones) along with smaller stones. The passage to the tomb or grave in a number of different examples, was constructed in a way that the light of the sun shone

through on particular days of the year - usually coinciding with the solstice's or equinoxes (Orzel, C., 2022). The sun's movement through the sky and shadows made on the structures could tell us when the seasons were about to change. Coming back to the example of Stonehenge, the megalithic rock structures were stacked in a north-east to south-west alignment, in such a way that the avenues would face sunrise on the summer solstice and sunset on the winter solstice (Orzel, C., 2022). The structure was said to have been built over a period of 1500 years, and was mostly completed around 5000 years ago. The Stonehenge clock was a way to predict with precision, the onset of the coldest and hottest months ensuing immediately after the winter and summer solstices. In a culture that was dependent on the seasonal cycles of plants and animals, the ability to mark the turning of the year was a matter of survival. These structures not only allowed exact measurements of the sun's appearance in the sky but also tracked the movement of the moon and other planets. The site is known to have been used by neolithic cultures for various ceremonies and gatherings (Orzel, C., 2022).

The measurement of time for these cultures was intrinsically linked to natural cycles. By successfully measuring time in this way, these cultures came into communion with natural divine forces. The order created through the measurement of natural cycles allowed them to negotiate with a chaotic nature, through rituals and ceremonies. As a cognitive extension, megaliths like Stonehenge allowed for reliably passing on valuable information from one generation to another. These structures were important tools embedded with information, at a time when written mediums didn't exist. Additionally, these structures reduced the strain on our attentional capacities. Individuals no longer had to keep tracking the change in angles of the sunrise and sunset to know when the change in seasons was approaching. Megaliths were ways in which knowledge about the sun's movement in the sky, gained over millennia, was stored in a physical structure for future generations to access with ease.

3.4. The Order of Sun & Moon

As the first agricultural societies began to emerge the need to precisely predict the shift in the seasons rose to paramount importance. A lot of architectural structures arrived at this time to aid in tracking the seasons. Initially most cultures had lunar calendars that were tied to the phases of the moon. The moon phases change quickly and makes it easier to track the passing weeks and months than by only tracking the sun's movement. Tracking the moon cycles is more manageable given a human's normal attention span. Initial timekeeping efforts in the first agricultural societies attempted a reconciliation between the solar and lunar cycles. Many great astronomers and mathematicians tried to create a calendar that would perfectly map the lunar calendar onto the solar year. However, till today we are unable to create the perfect luni-solar calendar. There exists a fundamental incompatibility between the duration of the lunar cycle and the length of year, meaning that a 'perfect calendar' in which the solstices and equinoxes will always fall on the exact dates, while also being synchronized with the phases of the moon is impossible to construct (Orzel, C., 2022). This didn't put off scores of astrologers, religious institutions and emperors from trying to mesh the two cycles together in a straightforward and exact way. However, these attempts have led to a massive amount of innovation that has spread to countless other domains.

Three different ways to address the luni-solar cycle incompatibility are present. The first type of calendrical system relies solely on the movement of the sun and for most parts ignores the movement of the moon like in the ancient Egyptian calendar. The second type does the opposite by relying solely on the cycles of the moon and ignoring the tropical solar year like in the modern Islamic calendar. This is why in the Islamic calendar today, their holy month of Ramadan keeps shifting with respect to the solar year (Orzel, C., 2022). This was not always the case as the Islamic calendar was also a luni-solar calendar The third type tries to merge the solar and lunar cycles, as is visible in the Hebrew or Hindu calendars. They essentially follow the cycles of the moon but keep adding an intercalary or leap month every once in a while to keep the calendar synced to the tropical solar year.

Lunar months are 29.5 days long, and when multiplied by 12 months we get 354 days; approximately 11 days shorter than it takes for the Earth to complete one revolution around the sun. Every three years the calendar would slip 33 days - more than a month from the tropical year, making the lunar calendar less useful to time agricultural cycles of planting and harvest. Additionally, annual pilgrimages or religious festivals would happen in different seasons, complicating logistics and supplies. For instance, in a place with cold winters it didn't make sense to have large gatherings or pilgrimages on foot during the winter. Similarly in hot desert like areas, one would want to avoid being outdoors during the summer. To account for this difference, religious leaders in different parts of the world would regularly add intercalary months. The Jewish calendar, for instance, would add 7 intercalary months over a period of 19 years. These months would ensure that the lunar calendar still matched the tropical solar cycles. Pre-Islamic Arabia followed the Jewish method of adding intercalary months. However, unlike the Jewish calendar, there were no set rules or consensus on when the intercalary months should be added. For instance, there were periods when a month or two was added to postpone the annual pilgrimage because supplies were inadequate (Orzel, C., 2022). Increasing manipulation of the calendar by political leaders, led to increasing conflict with religious leaders. Finally the addition of intercalary months was prohibited and is even stated in the Quran as:

> *The number of the months, with God, is twelve in the Book of God, the day that He created the heavens and the earth; Know that intercalation (nasi) is an addition to disbelief. The evil of their course appears pleasing to them. But God gives no guidance to those who disbelieve. Surah at-Tawbah (9), Ayahs 36–37*

The Prophet Mohammed outlawed the addition of intercalary months and made the Islamic calendar a lunar calendar. However, the impracticality of organizing agriculture and empires according to only the lunar calendar was quickly felt. This led to the operation of two different calendars simultaneously: the civil calendar linked to the solar year and the religious lunar calendar that marked important rituals and festivals (Orzel, C., 2022).

Notice how timekeeping as something divinely ordained was, and is of central importance to the legitimacy of Islam. Presenting timekeeping as a very precise and divinely ordained mechanism was central to many empires and civilisations. To question the sanctity of time was to question the legitimacy of the ruling elite. Time brought order to human societies, and the smooth functioning of empires and religions depended on its citizens accepting the time unconditionally. Religious ceremonies and rituals, essential for societal cohesion and cooperation, are essentially timebound. Having a festival or a ceremony fall on a certain date and a certain time, which is easily calculable and predictable according to a calendar is essential. If time is divinely ordained, and a religious ceremony is time bound, then the religious ceremony itself is divinely ordained. Far from creating the rituals themselves, religious and political leaders are only following a divinely ordained script. To question why a religious festival should fall at this particular time and not at another time, is to question the divine order. Time is a foundational mode in which we think and understand the world around us. Time is also considered to be universal. To link religion to time, is a way of thinking about certain religious beliefs as being universal and infallible.

3.5. Time in Ancient Egypt

Another example of monumental clocks were the ancient Egyptian minor-step pyramids. 5000 years ago, the heliacal rising of the brightest star in the sky: Sirius, usually occurred a short time before the annual flooding of the Nile river (Seyfzadeh, M., 2017). Sirius (Goddess Sopdet) would ‘disappear’ behind the sun in May, and then a couple of months later return to the night sky in July, by rising above the eastern horizon a few moments before dawn (sunrise). This is known as the heliacal rising and was revered for its ability to predict the soon-to-follow flooding of the Nile river. The flooding deposited precious silt, crucial to agriculture in ancient Egypt. The reappearance of Sirius (Sopdet) in the night sky in ancient Greece on the other hand was associated with heat and drought. The Greeks placed Sirius in the constellation Canis Major: the dog, which gives rise to the saying “dog days of summer” (Orzel, C., 2022). The rising of Sirius occurred in early July about 5000 years ago. Today, however, the precession of

the equinoxes has pushed the rising of Sirius to early August, no longer coinciding with the exact flooding time of the Nile (It is to be noted that the flooding of the Nile no longer occurs since the construction of the Aswan Dam).

The heliacal rising of Sirius marked the new year in ancient Egypt. The civil calendar established in ancient Egypt ignored the lunar cycles of the moon. The calendar had 12 months, corresponding with the 12 zodiac constellations that the moon travels through in the night sky (Orzel, C., 2022). Each month contained 30 days each, which accounts for 360 days. This was a bit more than 5 days short of the actual tropical solar year, and they accounted for this by an addition of five holidays that were not part of any month, celebrated as the birthdays of important gods. This was exceptionally accurate for an era without telescopes or other precision measurement devices. However, the unaccounted quarter of a day, meant that the rising of Sirius moved by one day with respect to their calendar every four years. Without telescopes the heliacal rising was often contested, and it was only after every decade or so that there would be consensus about its shift in relation to the calendar.

The civil calendar was established somewhere around 2700 BCE and as the years passed it slowly became more unreliable as a means to predict the flooding of the Nile (Seyfzadeh, M., 2017). The minor step pyramids then rose in importance as astronomical observation towers to track the change of the heliacal rising of Sirius in relation to the civil calendar.

The history of timekeeping is considered by some to also be a history of civilization and religion. The star Sirius in ancient Egypt was associated with the goddess Sopdet. Sopdet was worshiped for bringing the floods to the Nile river valley. In a region that receives scanty rainfall, the annual floods were a godsend that brought water as well as valuable silt to the plains. In ancient Egypt the rulers (pharaohs) were considered to be embodiments of the gods. Their rule was legitimized by the gods, who were legitimized by being clear predictors of natural cycles (Rooney, D., 2021).

As Sirius' heliacal rising slowly began to slip away from the exact time of Nile’s flooding, certain individuals slowly began to doubt the predictive powers of

the goddess Sopdet (Seyfzadeh, M., 2017). Others believed that the goddess Sopdet was ‘angry’ with the people of Egypt and its rulers. As this continued, it caused an erosion in the divinely ordained power of the pharaohs. Regional and local leaders started fighting for power which led to civil wars and strife. The old kingdom, the age of the pyramid builders, faced its death blow during a period of drought between 2200-2150 BCE (Jean-Daniel Stanley, et al., 2003). The drought stopped the flooding of the Nile for a few years and the order brought about by the goddess Sopdet and her ability to predict the life-saving floods began to lose hold. There were obviously numerous reasons as to the collapse of the ancient Egyptian civilisation, of which the myth linking the rising of Sirius to the floods was only one contributing factor.

The old kingdom was soon brought back into stability and peace - a period known as the middle kingdom. The reinstated order involved changing the religious myths surrounding Sopdet (Sirius). From being the goddess that caused the annual floods, she came to be seen as a mother or nurse associated with fertility (Wilkinson, Richard H., 2003). She was slowly merged into the goddess Isis over the succeeding years. The middle kingdom still used the civil calendar of the old kingdom and used other astronomical observations to predict the flooding of the Nile.

To be able to predict the change of the seasons, the occurrences of eclipses, the appearances of stars in the sky was a mysterious affair to the common people in ancient times. Those that were able to predict these movements (the emperors and astronomers) were looked upon with awe. It was often thought that they must possess some way to directly communicate with the natural elements (the gods) to predict such movements. However, this was a double edged sword; if emperors were unable to predict certain events (especially difficult ones like floods), it was often perceived that they had fallen from grace (Wilkinson, Richard H., 2003). To propose that time is a human construct, was a threat to the divinatory powers of rulers and their entourage. Predictions about events like eclipses played a big role in legitimizing the rule of the pharaohs.

3.6. The Julian and Gregorian Calendar

The current calendar system we use - the Gregorian calendar is based on the Julian calendar with some slight variations (Orzel, C., 2022). The Julian calendar was created by the Roman emperor Julius Caesar in the first century BCE, when the civil calendar used by the Roman empire was badly in need of reform. The Roman empire before Caesar used to use a calendar based on meshing the luni-solar cycles (Orzel, C., 2022). To adjust the civil calendar with the seasonal cycles meant that emperors had to keep adding intercalary months from time to time. Many rulers misused this system to add extra months into the year when it suited them. At the time Julius Caesar rose to power, the calendar in use was about 80 days off the mark from the tropical year (Orzel, C., 2022). Julius Caesar, having spent considerable time in Egypt, borrowed their solar based calendar of 365 days. Additionally, he introduced the leap year system once every 4 years, where every 4th year an extra day is added to February. To bring the calendar back into sync with the seasons, he extended the year to 46 BCE - making the year a long one of 445 days (Orzel, C., 2022).

His successor, Augustus made some minor changes to the calendar - like changing the names of the months Sextillius and Qunitillius to July and August in honor of Julius and Augustus. July had 31 days and it seemed inappropriate that the month named after Augustus should have fewer days than that of Julius's month (Orzel, C., 2022). Thus, August too, received 31 days, and to compensate, an extra day was knocked off from February. The Julian calendar recorded 365.25 days a year on average. This is about 0.008 of a day longer than the actual tropical solar year. It didn't make much of a difference during the Roman empire and the centuries that followed. However, by the mid-1500s the calendar had slipped approximately 10 days when compared to the equinoxes. This gave way to the Gregorian calendrical system we currently use.

The Gregorian calendar reform was introduced by Pope Gregory XIII in 1582. The reason that is often cited to have driven the reform, was the exact day of Easter (Sellar, A.M. & Giles, J.A. 1907). The exact date of Easter is determined as the Sunday after the full moon that falls immediately after March 21st (spring equinox). In the 14th and 15th centuries multiple astronomers had made the

observation that the equinox in March was falling a few days before the calendrical date. This caused multiple individuals to begin questioning whether Easter was being celebrated on the right day. In 1582, October 4th was succeeded by October 15th in the Catholic countries of Europe (Orzel, C., 2022). The Protestant and Eastern Orthodox churches rebelled against this move and continued to use the Julian calendar to assess the dates of Easter. The Eastern Orthodox Church to date still uses the Julian calendar. The former Soviet Union was one of the last to follow through with the reform, only being able to do so in 1918, when the communist state managed to divorce itself from the Eastern Orthodox church (Rooney, D., 2021). They had to skip 13 days at the time to realign with the tropical year.

The current Gregorian calendar is still not perfectly in sync with the tropical solar year. There is a 26 second difference between the Gregorian year and the tropical solar year on average (Orzel, C., 2022). This means that it would take approximately 3323 years before the equinoxes or solstices slip by a whole day. The shift from the Julian to the Gregorian year is quite small and made little difference to things like agriculture. As is demonstrated by the ancient Egyptian civil calendar, civilisations have the capacity to last for long periods with even bigger calendrical mismatches. The political bickering was seen as necessary to push through with the change due to reasons of theology. To ensure that a particular religious festival (Easter in this case) would be celebrated at the exact right time. This exemplifies that the measurement of time is a social phenomenon. Time itself can be viewed as objective, but its measurement is replete with social, cultural and religious values.

The calendar is an example of a potent cognitive extending tool. It offers its users multiple affordances:

- ➔ It minimizes the need for focussed attention to know which day of the year it is in a precise manner. Though this precision is not really required for agriculture, it is nonetheless very important for the modern economy. The astronomical knowledge of the tropical year is embedded into the calendar, which we can pull up as required.
- ➔ It transforms a complex long-term observational skill into instantaneous perceptual understanding. We order a calendar year

into months, weeks and days, usually set up in rows and columns where it is easy to absorb knowledge quickly.

- ➔ It allows us to directly interact with future time. We can make schedules and plan what we will do on future days by using a simple calendar.
- ➔ By embedding calendars into our environment we reduce the demands placed on our biological memory. Instead of remembering important dates and appointments, our calendar stores the information and notifies us when necessary.
- ➔ Calendars also make it easier to create and follow routines increasing productivity and efficiency in time management. We can set up tasks to repeat once per week, or once per month and so on. The calendar reminds us of what we have to do in the coming days. This helps us set priorities about how we will spend our future time.

3.7. Using Time to Define Space

As empires grew, and trade routes began to span the entire globe from the late 1400s onwards, it became increasingly important to be able to navigate ships at sea. From the 14th to 17th centuries, many ships were lost at sea, due to errors in calculating their position. It is quite straightforward to calculate one's latitude (north-south orientation) from the sun at its highest point in the sky (noon) or the height of the North Star at night (Orzel, C., 2022). Additionally, a compass could give them their direction using the Earth's magnetism. Longitude (east-west orientation), to the contrary, was very difficult to ascertain. It took nearly four centuries; the tinkering of multiple individuals, and massive funding from various empires to finally solve the longitudinal problem (Rooney, D., 2021). The issue with ascertaining one's longitude at sea is that there is no fixed reference point in the skies. Due to the Earth's rotation, any point or celestial body spotted in the sky will continuously move from east to west. Thus

longitudinal measurement can only be solved by time measurement as a result of the Earth's rotation (Orzel, C., 2022).

To correctly measure longitude, one would have to know the exact time on board the ship as well as the exact time at a known location - usually a port. We divide the Earth's rotation into 360 degrees, which takes 24 hours to complete. Thus each hour of time difference would mean a 15 degree difference in longitude. The first part - measuring time on board a ship was relatively straightforward. When the sun reached its highest point in the sky, it was noon local time. To ascertain exactly when the sun was at its highest point, one could use cross staffs, back staffs and other angle measuring devices (Rooney, D., 2021). The issue was with reliably knowing the time at the closest port that the ship had just departed from. An obvious solution that was attempted as early as 1530, was to carry a clock set to port time on board the ship. Unfortunately, there was as yet no clock on Earth that could weather the elements at sea; temperature extremes, salty and moist air, and violent movements caused by storms. Additionally, no clock was accurate enough to keep time for months on end, during long intercontinental voyages.

The only other option was to use the lunar distance method, which basically used the angle of the moon from particular stars in the night sky to determine the time in Greenwich, England (Rooney, D., 2021). This method was extremely complicated, as the moon doesn't move at the same pace throughout its orbit around the Earth. This is because of the gravitational interaction between the sun, moon and earth - known in physics as the "three-body problem" (Orzel, C., 2022). This meant that only a very accomplished astronomer could use this method to determine longitude, and even then there were large possibilities of error. This was later solved by Tobias Mayer's lunar tables that predicted the motion of the moon. His work was later developed by Royal Observatory, Greenwich into the Nautical Almanac, a navigational tool based on the movement of the Moon in the skies that is still used today (Orzel, C., 2022).

Until the time the lunar tables were created by Mayer, the challenge for merchant and military seamen to navigate the oceans was still present. In the 1600s many ships were lost at sea, enough so that all the major colonial powers

began throwing money at the problem of determining longitude. The United Kingdom for instance passed the longitude act in 1714, offering £20,000 (£5 million in 2022) to anybody who could create a ‘practicable and useful’ solution to finding the longitude of a ship to within half a degree (Orzel, C., 2022). The problem was finally solved in the late 1750s by John Harrison who made a mechanical clock (today known as the chronometer) that could reliably tell the time for months, even with the tough conditions at sea. It took 20 years of his life and four different versions of the clock before it was finally a success. At the time the clock cost about £40 (£6500 in 2022) to assemble, which was still too costly for most ships. However, small iterations of Harrison's work in the following decades eventually drove the costs of the clock down.

3.7.1. Global Positioning System (GPS) & Time

The GPS system of navigation is powered by powerful atomic clocks, placed on separate satellites orbiting the Earth (Rooney, D., 2021). It is composed of a network of 32 satellites, each carrying multiple clocks on board. GPS receivers on land, embedded in our smartphones and other navigational devices search for time signals beamed by these satellites. Each receiver looks for time signals from at least 4 different satellites (Rooney, D., 2021). These satellites are all at different points in the sky, and their distance to the receiver differs. This means that the time signals from each of the 4 satellites takes different amounts of time to reach the receiver. These time differences between signals are then used by the receiver to figure out where on Earth it is located, through a mathematical process called trilateration (Rooney, D., 2021). The clocks in the GPS receivers don’t have to be extremely accurate as they get all their time information from satellites. The satellites, though, have to have extremely accurate clocks on board.

Our modern economy is heavily dependent on these satellites and their clocks. Our transportation, logistics and military systems all use the GPS network to get around. This has recently been seen as a vulnerability. The US military for instance has recently brought back navigation based on celestial bodies into their curriculum in 2016. The danger of attacks by jamming or spoofing are very

viable, with both Russia and China having the capability to block signals from the GPS satellites if they wished. Just last year on November 15th, 2021, Russia ran a military space test that demonstrated that it could bring down all 32 GPS satellites in the blink of an eye (NASA press release, 2021). The director of the National Security Council in the US is quoted to have said, “GPS is the single point of failure of the entire country”. Not only is the failure of GPS a military concern, it is also a financial concern. Today, the entire financial system is timed by using time signals from the GPS network. Algorithmic trading relies on making multiple trades within a fraction of a second, and there needs to be global consensus in financial markets about what exact time it is. The New York Stock Exchange has a ‘server farm’ in New Jersey with multiple GPS receivers on its roof to time its financial transactions (Rooney, D., 2021).

GPS satellites and their onboard atomic clocks are a form of cognitive extension. It not only allows us to navigate better in space but it also allows us to do things at speeds faster than is possible by human control. However, with the benefits it gives us there are also pitfalls. The global financial system needing to time trades right down to the nano second necessarily needs to use one universal time system for its trades. If one country uses another time system, as much as 1/ millionth of a second difference between the times will wreak havoc. Having such a high dependence on a single system for time, can make the entire financial system extremely vulnerable to attack. However, this issue has clearly been recognized by financial institutions in recent years and moves to create an alternate method of timekeeping are being thought of.

3.8. Timekeeping Divorces Natural Cycles

Up until 1960, a second of time was defined as 1/86400th of the time present in a mean day (Orzel, C., 2022). The mean day or rotation of the Earth on its axis is not always the same. The Earth’s rotation is slightly slowing down, causing the mean day to become longer by approximately 2 milliseconds every 100 years (Orzel, C., 2022). This slowing down is primarily due to the slight

decrease in gravitational pull of the moon. The moon is moving away from the Earth at a rate of approximately 3.8cm a year.

Apart from this long-term trend, other dramatic events like large earthquakes or volcanic eruptions also slightly change the speed of the Earth's rotation. With the advent of atomic clocks that could track changes in time down to the nanosecond, this variation in the Earth's rotation became apparent. The definition of the second, officially changed in 1960 to "the fraction 1/31,556,925.9747 of the tropical year or the revolution of the Earth around the Sun. Soon after, physicists pushed for the measurement of time to be de-linked from the motion of the Earth around the Sun. Time and specifically, a second, was redefined as the duration of 9,192,631,770 energy transitions of the cesium atom (Orzel, C., 2022). Cesium became the gold standard of atomic time measurement and was subsequently used to set the time, globally. Being able to track time to the nanosecond was important in its ability to track the speed of light. This allows the GPS satellites in orbit today to tell us our exact location on Earth.

3.8.1. Time Standardization

By the end of the 1700s transport and communications infrastructure had spread vastly, and synchronizing various local times had become a nuisance. At the time all cities followed the local solar time, and so cities just 300kms apart, would have a time difference of approximately 10 mins. This made it difficult to coordinate long distance transportation and communication. This was acutely felt by railway companies in the US, UK and Europe. Having to keep setting the clocks in a moving train to each subsequent station was quite complicated. The early days of the railways saw many accidents and crashes, due to mistakes made in converting various local times (Rooney, D., 2021). By the early 1800s, most railways began to synchronize their time to the closest big city. In the USA for instance, multiple railroad companies were existent, with 90% of them setting the time across their entire railway network to one of 7 big US cities (Orzel, C., 2022). Though this worked quite well for the railroad companies, it was a

nightmare for its passengers. They now had to keep a track of local time as well as railway time. Additionally, if they were traveling long distances in the country, having to switch trains, they had to keep track of the time difference on each subsequent train.

By the late 1870s, the American Meteorological society created a committee to lobby for standardized time zones across the US. Synchronizing meteorological observations made in local time, across the country, was prone to error. By 1880 the railroad companies heard about this and decided that it was in the best interest of the railroads to preempt government legislation (Orzel, C., 2022). Quoting William Allen, the then treasurer of the American Railway Association: “the matter of time standardization must not be left to the infinite wisdom of the state legislature”. Allen went on to propose that for railway transport purposes, the country should be divided into 4 time zones (with minor changes these are the time zones still in use today). All except 2 small railroads had accepted this time scheme by 1883 (Orzel, C., 2022). Soon after, many city and state governments started to align their time to that of the railroads. It was far more convenient to follow one time than to keep converting between local and railway time. Soon after federal legislation followed to standardize time across the US. The move to decouple clock time from solar time, goes to show how the measurement of time is a human convention.

As time standardization began to be adopted by various countries, the question of a global standard for a prime meridian (the 0 degree longitude) rose in importance. Three world class observatories that were contenders for keeping global time were the Royal Observatory in Greenwich, UK, the Paris Observatory and the US Naval Observatory in Washington DC. The late 1800s was the peak of the British empire, which controlled nearly three quarters of global trade. Most ships, maps and navigation tables already used Greenwich as the prime meridian. Additionally, the standard time in the US was already linked to Greenwich time. The railroad companies didn’t manage to agree on which US city would be set as the prime meridian and so found it easier to set their time according to Greenwich time (Orzel, C., 2022). Having an American city as the basis for the national time zones created rifts as issues of local pride were brought to the forefront. The eastern zone in the US is approximately 75 degrees

from Greenwich, which was set to GMT -5, and each subsequent zone to the west subtracted another hour from Greenwich time. During the International Meridian conference of 1884, the US backed the UK and agreed upon Greenwich as being the prime meridian. France abstained from the final vote and was upset that their rival got to keep the prime meridian, but finally came around to agree to Greenwich as prime meridian a few years later (Orzel, C., 2022).

3.9. The Social and Mythical Dimensions of Time

Time has a weird propensity to be associated with the concept or myth that society currently ascribes the highest meaning to. I would speculate that this is because the concept of time itself is highly subjective. Not many understand that time doesn't really exist outside our own relation to it. For each individual the passing of time is subjective and so is what we do with our time. Thus, from time to time, time itself absorbs the qualities of our modes of thinking. Time becomes that which gives us as individuals and societies the greatest meaning. I will now explore a few myths that time was and is closely associated with:

1. ***Time is Power***
2. ***Time is Discipline***
3. ***Time is Money***
4. ***Time is Temperance***
5. ***Time is God***
6. ***Time is an Illusion***
7. ***Time is an Equalizer***

1. ***Time is Power:*** David Rooney, a former curator for timekeeping at the Royal Observatory, Greenwich, asserts that timekeeping devices were and are symbols of power (Rooney, D., 2021). Large monuments used for timekeeping eventually morphed into public clocks in the last few centuries. These public clocks were not only used to tell the time, but also a display of power and authority. Every time an empire invaded or conquered a territory, the invasion was accompanied by changing or installing clocks that were mounted up on high towers. These clocks projected power and displayed the new order being established. For instance, the British empire built over 150 clock towers in India alone during the colonial period Rooney, D., 2021). These clocks had loud bells chiming every quarter of an hour. The clocks were not only erected to assert the British order, but they also hoped to assert time discipline.
2. ***Time is Discipline***: With the advent of public clocks, time became ever present. Prior to this the passing of hours was very subjective. Individuals (apart from royalty) did not have access to timekeeping devices and usually structured their day based on the positioning of the sun. Thus, the arrival of clock towers; clocks mounted on churches, town squares and important public locations changed our relationship to time. With clocks readily in view, societies slowly started to buy into the idea that time was something that could be wasted. This concept of time gained greater prominence in the 16th and 17th centuries. For instance, the theologian and puritan pastor Richard Baxter in an essay titled ‘The Redemption of Time’ claimed that wasting time was a heinous sin, with the sinner guilty of robbing time from God himself (Baxter, R., 1862). Well before Baxter laid down these ideas, there was a strong negative association with those seen as ‘wasting time’ or ‘relaxing’. Relaxing was seen at the time as idling away time. In this sense, not being constantly aware of the passing time, and not making full use of it, began to be seen as a sin. Thus, time-keeping was transformed into time-accounting.

Discipline exerted upon individuals through time keeping devices became even more ubiquitous with the rise of personal clocks. Individuals carried clocks in their pockets that were doing the job of the state and religion to keep its citizens productive. Time did not belong to the individual, time belonged to God, and the individual was borrowing it from God (Baxter, R., 1862). We still have remnants of this perspective of time as discipline today. We often unconsciously associate someone who is always on time as being a moral individual. Time is considered precious and those wasting it are undisciplined and immoral. However, as the concept of God began to lose importance, especially in Western societies a new more important concept had to be linked to time.

3. ***Time is Money:*** The American politician Benjamin Franklin popularized the usage of the term, time is money. He would often say that idling around (wasting time) is a sinful waste of money, because one could instead be busy making or working for money (Franklin, B. 1820). This conception of time is central to the modern economy. Many industries and companies pay workers for their time, instead of their output.
4. ***Time is Temperance:*** Temperance was often considered the highest of virtues in multiple religions. In Christianity as well as Buddhism and Hinduism you see many depictions of temperance. Right from the early 1300s temperance in Christianity began to be depicted with an hourglass (Rooney, D., 2021). The hourglass was at the cutting edge of timekeeping devices used to calculate the passing of an hour at the time. Time was running out and to be temperate was to be like passing time, neither too fast nor too slow. However, the concept of time as temperance was present more than 1000 years before Christianity began to depict it as such. In 44 BCE, a Roman philosopher likened temperate behavior and self restraint to time itself - it neither moved too slowly or too quickly (Cicero, M. T. 2018).
5. ***Time is God:*** Time has been likened to God in many civilisations. Time being that which orders nature, is often associated with the divine principle. Time, the thing which brings certainty to our world, is also often seen as that which brings change. Time has been worshiped in many cultures so that it may bring favorable instead of unfavorable change. The passing of time can be scary and unknown, likening it to the greatest symbol of meaning itself - God.

6. ***Time is an Illusion***: This conception of time is present in cultures (or more precisely sub-cultures) that are ascetic. These renunciate sects see the world of space-time as an illusion. Examples are found within Buddhism, Hinduism and taoism. They see matter, and its ordering principle of time as illusions. For them the highest goal is to transcend the 'material plane of existence' which is ruled by time-space.
7. ***Time is an Equalizer***: Time and death are often quoted to have an equalizing effect on us. Many cultures associate death with time as well. Death is that which none of us have control over, and is thus often feared. At some point in time, death will arrive; there is no other way. Thus one will often find the presence of timekeeping devices in our depictions and myths about death. For instance, father time is often depicted as an old man with an hourglass and scythe (Rooney, D., 2021). Both are perceived to depict the one way flow of time that eventually will take us to whatever is waiting beyond.

Time is a powerful and metamorphosing myth. Timekeeping as a techno-social tool is also used to exert values upon its users. Time has the uncanny power to become anything one wants it to become. One can make it as one wishes. Thus society has defined time by what it perceives to be the most important virtues in humanity. Our conception of what time is will keep changing. Thus, timekeeping as a cognitive tool offers us a window to look back at ourselves. At the heart of time, lies our own values, and time can be seen as a mirror showing us what these values are.

3.9.1. Time Perspectives

As Einstein displayed in his General theory of relativity - the physical nature of time itself is relative (Einstein, A. et al., 1952). What is also interesting is that based on the ways in which we measure and interact with time- we also have the possibility of changing our perspective. The two obvious perspective shifts are the short-term and long-term perspectives. With timekeeping devices meant to calculate a nanosecond proliferating, it is no wonder that much of our perspective is pivoted around the short-term. Our political and economic institutions are designed for short term gain. The next election cycle and the annual rate of economic growth, are some examples. Often, what we do for positive short-term outcomes jeopardize long-term results. It is quite impossible to think short-term and expect to do well in the long-term. Few individuals still embrace a long-term perspective that encompasses hundreds or even thousands of years. To do that would necessarily invite us to go beyond our own self interests, i.e. our perspectives would outlive our lives. Is it possible to instill in a timekeeping device this kind of long-term perspective? A perspective beyond the daily, weekly, monthly, and annual cycles? Can a timekeeping device change our perspective of time itself? A non-profit organization called the Long Now Foundation is attempting to do just this. Their mission statement reads, “Long Now is a nonprofit established in 01996 to foster long-term thinking. Our work encourages imagination at the timescale of civilization — the next and last 10,000 years — a timespan we call the long now”.

3.9.2. Time, Nature & Health

Human health is intrinsically tied to natural cycles. The latest in scientific research is now learning that our health is partially tied to our circadian rhythms, or our internal biological clock. For instance, we are learning that our internal rhythms are modulated by sunlight or more precisely the wavelength of light entering our retina (Tähkämö, L. et al., 2019). These internal rhythms include the functioning of our organs, the timely production of hormones and more. Prior to

the invention of electricity, a majority of individuals rose with or before the sunrise and slept soon after sunset. With daily timekeeping now divorced from the natural cycle of the sun, many of us eat, drink and sleep according to the clock. The move towards standardized routines, has meant that many of us eat meals at the same time everyday. We hardly ever stop to check in with our bodies if we are hungry or not. If we glance at a time way past our lunchtime, we are instantaneously brought to think about lunch. Similarly we hardly sleep based on whether we actually feel sleepy or not. Our routines made possible by our personal timekeeping devices don't really allow us to tune into our own biological clocks. We don't slow down or speed up based on bodily signals. We like to have an objective measure of routine and progress, and our own bodies are way too subjective.

In temperate regions of the world, where differences between day and night are stark when comparing winter to summer, is there an internal biological system that also changes with the seasons? Research has found that this is indeed the case. In the study, subjects residing in temperate or arctic latitudes required slightly more sleep during the winter months as compared to summer months (Honma, K. et al., 1992). There were many other parameters of the circadian rhythms that changed with the seasons. One could argue that we have stored in our own bodies, an amazing timekeeping device that we no longer use or cultivate awareness about.

Chapter 4: A Smarter Tomorrow: The Internet of Things

“The world's most valuable resource is no longer oil, but data.”

In our networked world, algorithms, and big data play an increasingly important role in mediating our relationships with the environment. These ‘smart’ networks are augmenting our own cognition and creating increasingly complex systems. The pull towards implementing such systems is increasing, with the promise of better efficiency, performance and automation. The internet of things (IoT) is creating an ecosystem that is data driven, and seemingly transparent. Many businesses recognize that it is upgrading their systems and providing them robust data on inefficiencies within their supply chains and logistic operations. As a set of technologies IoT is often touted as improving customer experience, increasing savings, automating operations, increasing employee performance and much more. Apart from the excitement IoT is causing in the business world, it is also viewed as beneficial for household and personal uses. The advent of smart homes, is promising individuals the ability to automate routine chores, to increase one’s personal time. Many applications are also being used to track and aid us in various ways. The creators of these technologies claim that our health, productivity, mental acuity, social skills and much more can be greatly improved through these aids. All we need is more and better data, which will give us insight, which in turn can nudge us towards better outcomes and behavior. Through the use of networked technologies, we can extend our cognition like never before. The dominant narrative makes it seem like IoT is a major inflection point in the history of human systems and cognition. Things might never be the

same, and the benefits of hopping on the algorithmic network far outweigh the concerns.

In this chapter, I shall begin by explaining what encompasses the Internet of Things (IoT). I also share the important applications of the technologies currently and what are some future possibilities. I then will move on to tie these sets of technologies into the framework provided in Chapter 2. I shall look at the underlying values programmed into IoT systems. What affordances they provide and deny us. Seeing IoT as a techno-social system, I look at how these technologies shape us and our cognition. There are powerful ways in which we can extend our cognition through IoT, but this extension is not linear. Through this extension, we lose certain other cognitive qualities, which may also alter what it means to be a human. Is more data the best way to understand ourselves? As we interact with data driven systems, do we also become more predictable? These are some of the questions I hope to throw light on in the upcoming pages.

4.1. What is IoT?

The Internet of Things (IoT) is an interconnected ecosystem that is made up of computing devices, digital machines, animals and/or people with unique identifiers (UIDs) (Gubbi, J. et al., 2013). These are brought together through a network, where the ability to transfer data is not dependent on human-to-human or human-to-computer interaction. Instead sensors and actuators are embedded within the environment that allows a seamless, realtime relay of information across platforms. The wireless sensor network (WSN) is essentially powered by high-speed internet and cloud computing.

The term IoT was first coined by Kevin Ashton in 1999 in reference to supply chain management (Ashton, K., 2009). However, in the decades that followed it has come to mean much more than just that. Today, it covers applications like healthcare, utilities, transport, agriculture, etc. The goal of these systems is to gather information, analyze it, and initiate an appropriate action (or string of actions), without the need for human intervention (Lee, I., & Lee, K.,

2015). Objects in the environment can communicate with each other to create a smart environment.

4.1.1. Essential IoT Technologies

Five key technologies are used in the successful implementation of IoT systems. These are:

1. ***Radio Frequency Identification (RFID)***
2. ***Wireless Sensor Networks (WSN)***
3. ***Middleware***
4. ***Cloud Computing***
5. ***IoT Applications***

1. *Radio Frequency Identification (RFID):* This is a technology whereby data is captured in tags or smart labels. The data is then transferred via radio waves to the reader. The data from the tags or labels are captured by the reader device and inputted into a database (Lee, I., & Lee, K., 2015). The most conventional applications are in inventory and supply chain management. However, today most smartphones also come with an RFID chip in them.
2. *Wireless Sensor Networks (WSN):* This is a wireless network of devices (sensors) that can monitor physical and environmental conditions. These networks can cooperate with RFIDs, to track all kinds of information/ data. Based on the kinds of sensors, they can track location, movement, temperature, sound, humidity, pressure, etc.
3. *Middleware:* This is a software layer that lies between the operating system and the applications running on it (Lee, I., & Lee, K., 2015). It can be viewed as a communication layer that enables data translation and management between varied applications. Different types of sensor-based devices can be connected using middleware. Middleware makes it easier to connect applications that were not initially designed to work together.
4. *Cloud Computing:* Cloud computing can be seen as on-demand access to many different digital resources. These resources can range from servers, to data storage, networks, applications, software, data streaming and so

on. All the various sensor-based devices used in an IoT system, generate large amounts of data. This data needs to be stored somewhere, it needs to be processed quickly, and needs to be connected to high speed broadband internet services to stream the data. The cloud can be seen as a backend manager that stores, processes, and manages large amounts of data.

5. *IoT Applications:* These are industry-specific software applications. They enable device-to-device and human-to-device communication. Some applications may be built to manage appliances in a household, while others may be built to manage transportation and logistics. For instance, a delivery company might use applications that are constantly monitoring the temperature, location, and the state of its packaging - whether it has been opened, tampered with and so on.

4.2. Applications of IoT

There are numerous applications of IoT. Certain applications enable industries and businesses, while others are used for improving personal spaces and residences. Applications to improve individuals' lives through data are proliferating. IoT can also be used for smoother governance, like managing natural ecosystems, transport systems, power systems, traffic systems and so on. Some industries where IoT is already being applied are:

1. ***Smart Transportation***
2. ***Smart Homes & Residences***
3. ***Smart Power Grids***
4. ***Smart Agriculture***
5. ***Smart Ecological Management***
6. ***Industrial supply chains and logistics***
7. ***Medical Health-care***

1. *Smart Transportation:* An industry report published by Allied Market Research, has estimated that the global market size for IoT in transportation in 2020 was $83 billion and is expected to reach $500 billion by the year 2030 (Chhabra, M. et al., 2022). Currently most ticketing and toll systems are shifting from manpower to RFID tags, which is increasing efficiency and minimizing queues at tolls. It is expected that in the next decade most railway systems will switch to being completely managed by IoT. This is expected to increase safety through real-time monitoring of train speeds, parts of the train, wheels, and train tracks along with communication between trains, stations and so on. IoT is also expected to grow dramatically in road transport. Self driving cars communicating with each other through a network of sensors is a possibility in the future. This is often touted to reduce - road accidents, traffic congestion, and increase speed and efficiency in transportation.
2. *Smart Homes & Residences:* These IoT systems are often referred to as monitoring and control systems (Lee, I., & Lee, K., 2015). The primary benefits are marketed as property protection, energy savings, and time efficiency. IoT systems can allow us to remotely monitor our house, lock or unlock doors to let someone in, adjust the temperature, and use other appliances. If one has solar panels on the roof of the house, the panels can communicate with appliances (eg. dishwasher, washing machine, etc.) and turn them on when excess energy is being generated.
3. *Smart Power Grids*: These IoT systems are also based on monitoring and control systems. A network of individual appliances, different types of power plants, factories and smart meters can communicate with each other to optimize the grid. Potential issues and areas for improvement can easily be spotted. Additionally, power lines, transformers and other heavy equipment can be constantly monitored, allowing for pre-emptive maintenance before total breakdown.
4. *Smart Agriculture*: These IoT systems, deploy multiple sensors that track multiple parameters like the water content in the soil, temperature, nutrient composition and so on. In mass-scale breeding, IoT is especially useful as it allows to track and monitor the health of animals. Additionally, RFID tags provide a seamless way to recognise and know the past medical history of

each animal. Sensors are also used to track the quality of output. For instance, in the dairy industry, where milk from multiple cows is combined, spoilage or a disease in one cow can render the entire batch of milk as useless. Instead of checking each container of milk, it is far easier to simply assess the quality of milk using an IoT system.

5. *Smart Ecological Management*: There is increasing discussion nowadays to use IoT systems not only to manage agriculture but to also manage natural ecosystems like forests and grasslands. These systems could be used to detect fires in their nascent stage, to track the health of endangered species, to monitor water quality and so on.
6. *Industrial supply chains and logistics:* IoT can be used in the production line to monitor various components. An issue or problem in one part of the production line can easily be observed and rectified. Different parts of the system can communicate with each other, removing the need for human supervision. Automation through IoT drives down costs and increases efficiency.
7. *Medical Health-care:* IoT enables healthcare service providers to personalize healthcare solutions for their patients. The market share of healthcare based IoT products is larger than in the transportation industry and has already crossed $100 billion (Chhabra, M. et al., 2022). Using big data and business analytics, multiple healthcare products are being deployed to enhance individuals' health. Applications to track sleep quality, heart rate, breath rate and much more are easily accessible today. For instance Proctor & Gamble have launched an interactive electric toothbrush with built in sensors. Using a mobile application, the user has data about his/her brushing patterns, which side they need to brush more and many other tips. In a study they published, they claim that their users brush for a much longer time than on average due to the continued interaction.

As we have seen, using IoT has many beneficial aspects for the future of the economy, healthcare and environment. However, as a set of technologies, IoT is not neutral. It is programmed to cater to a set of goals, oftentimes at the expense of others. What do we lose out on or sacrifice as humans when we

embrace and use these systems? Can we choose what the trade-off will entail? Below I shall speak about the key ethical aspects of using smart IoT based systems.

4.3. Data Privacy and Surveillance

How companies should manage personal data of individuals is at the forefront of much regulation around the world. In Europe for instance, laws about how companies should handle personal data, outlined under the General Data Protection Regulation (GDPR) have been around since 2012 (Politou, E. et al., 2018). These pertain to how the collection, processing and sharing of personal data is undertaken. While regulations will continue to tighten, there is a mismatch in the goals of corporations and the freedoms of individuals. A fundamental trade-off exists between the market's need for data collection, processing and sharing on the one hand, and the protection of personal data of users on the other hand. In a data driven economy, where large amounts of data helps to support innovation and bolster current applications, any kind of data protectionism is unfathomable. Thus data protection regulations usually stress the need for 'informed consent'; the ability to revoke consent and the right to be forgotten (Politou, E. et al., 2018). These are good first steps, but don't really change much in terms of who really has control over the data. Different ways are emerging to monetize data and it will require re-working existing business models to actually be able to make data privacy a primary concern.

The electronic contracting environment has emerged as a result of the GDPR and other regulations. Electronic contracting has given users little agency and freedom over their own data and has, to the contrary, been used to manufacture consent (Frischmann, B. & Selinger, E., 2018). It makes no sense for users to read through multiple pages of legal jargon, simply to access the contents of a webpage or the services of an application. The legal contracts are made purposefully lengthy and verbose, making it impossible to really understand or know how one's data is being used. Not consenting to the terms of use, usually means that one cannot access the service. Thus, the logical option that saves the user time, and much effort is to simply click accept. Once our personal data has been shared with the platform and company, the next step is

how the company will use and share the data. Most regulations aim to allow the company to process the data anonymously to improve their product. Data sharing without consent is usually not allowed, and the latest GDPR amendments in theory make it possible for individuals to remove their personal data. This sounds good on paper, but almost impossible to do in practice. As is often said, once your data is on the web, there is no way to remove it. To exemplify what I mean by this, if you share something on facebook (or other social media sites) and later decide to delete, facebook will still keep an archive which you can later retrieve. What's worse, there are independent third party 'data brokers' that have armies of robots that scan and copy all new pages created on facebook each day. These are then stored in their archives and sold to individuals, corporations or governments for a price (Tsesis, A. 2014). These data archives are not limited to social media, but encompass pretty much all the data out on the internet.

The electronic contracting environment not only manufactures consent but also changes our behavior in the long run. Through the continued interaction with dozens of websites and services in a single day, we almost instinctively click on the 'i accept' button. As some authors argue, this creates a situation where we become programmed to consent to ever increasing levels of surveillance (Frischmann, B. & Selinger, E., 2018). Many call upon governments to regulate the industry and how data surveillance is undertaken. However, governments too, benefit from big data; it helps them increase public utility, manage shared resources and also maintain order within society. While private companies extend surveillance to maximize profits, governments do so to maintain order and improve public goods. Many times, the same companies (whose business models are tied to big data), are the ones that create and implement IoT systems for governments. A classic example is the Smart power grid system in the US. It is implemented as a public-private partnership and many estimates claim that the data available from the grid will soon be more valuable than the electricity running through it (Kalogridis, G., & Denic, S. Z., 2011). Power consumption patterns, give data analysts insights into one's routines and much more. While governments can use this data to better coordinate power supply and distribution, they can easily be tempted to monetize the data or use it to enforce social credit systems.

The Chinese communist party sees the huge potential offered by the massive scale of surveillance in governance and other systems. However, it also views the proliferation of data in the hands of individuals and corporations as a major issue and has made large moves to monopolize control over data within China. Today technology companies that handle large amounts of data must store their data in government servers and the government can decide what kind of data they can access and so on (Hoffman, S., 2022). Many see this as an authoritarian move that reduces individual autonomy and control over data. It is seen as a form of data centralization where data no longer belongs to individual companies but to the state itself. Others argue that whether data is in the hands of the state or individual corporations, doesn't dramatically alter individual agency (Aho, B., & Duffield, R., 2020). The authors argue that China's approach is proactive, ensuring that there is no regulatory lag with the introduction of newer technologies.

Today to obstruct the flow of information or data, is a direct assault on the economy itself and is often treated as a crime. Individuals who drive trucks or cars for transportation or logistics companies are often tracked using their GPS location. Employers keep track of their fleet using IoT systems enabled by GPS. However, this kind of surveillance doesn't sit too well with many truck drivers that install cheaply available GPS signal jammers into their vehicles. Most countries have banned GPS jammers, with the US even considering making it a criminal offense to carry one. A jammer can block all signals in a small or large circumference depending on its strength. This can render smart systems dependent on radio signals completely obsolete. This exposes a fundamental point of weakness for relying completely upon IoT systems for the functioning of society. I will speak more about this weakness in section 3.5.

4.4. Values Embedded in IoT Design

All IoT systems are programmed keeping in mind certain goals and desired outcomes. These desired outcomes change the way we as individuals are situated within these techno-social systems. The affordances we have for extending our cognitive capabilities are also framed and constructed by the goals of the system as a whole. There are some goals that are ubiquitous in the current deployment of most IoT systems. Some of these are:

1. ***Uniformity***
2. ***Efficiency***
3. ***Predictability***

1. ***Uniformity:*** IoT systems cannot be chaotic and random. They are programmed to achieve standardization and uniformity. This usually ties into the next value embedded in IoT systems - efficiency. There is usually one or a few paths that would lead towards the most efficient system. In designing the most efficient system, it needs to be predictable, standardized and easily replicable. These values are not only embedded in IoT systems, but have become the core premises for the organization of the modern economy. The scientific management of humans and workspaces has been a work in progress, but was first formalized under Fred Taylor in the early 19th century (Frischmann, B. & Selinger, E., 2018). Through the process of industrialisation, factories were constantly looking for methods to produce uniform products. Henry Ford, inspired by the idea of Taylorism, established the first factory assembly line for his automobiles. By simply retro-fitting his factory and assigning one task per individual on the assembly line, he managed to bring down the time it took to build a car from 12 hours to just 90 mins. These tools or systems of cognitive extensions greatly increased productivity, but also dramatically changed the nature of work. Building a car went from being a craft- where an individual was more or less responsible for building the entire car, to being a mechanical chore where each individual only had to know how to attach their particular part of the car.

While factories around the world were now capable of producing uniform products on a massive scale, the individual's involvement in the process dramatically reduced. Working to make a car was no longer an enjoyable process. Uniformity stripped away the skill required to make an entire car from scratch and also the unique craft that went into it. This has taken place across industries, whereby individuals involved in production no longer need to have expertise, skill or inventiveness in their work. Now that the individual worker has lost his expertise, skill and satisfaction, these kinds of jobs are seen as drudgery. Further uniformity can be brought about by introducing automation through IoT. This would ultimately free the individual workers from having to do menial and repetitive tasks on the assembly line. Some believe it will allow for more creativity, allowing individuals to pursue their passions and develop novel ideas. However, we must think about what core value or skill is lost in the process of becoming uniform? I believe it is creativity. The shoemaker lost his craft and creativity when he became just another cog on the shoemaking assembly line.

Creativity and innovation are the key drivers of our economy and civilisation. Creativity is not a genetic predisposition, but a skill (Dyer, J. et al., 2019). It is something developed over countless iterations and exploration. Creativity being a skill is primarily developed in the process of mastering a craft - becoming an expert at something that is continually challenging (Dyer, J. et al., 2019). For instance, one doesn't develop innovative capacities in public speaking by simply memorizing speeches and delivering them. The individual has to step out of their comfort zone and be challenged by the prospect of speaking publicly. This allows them to both master the skill and innovate new ways and techniques of speaking that will make them even better at their craft. Interacting with a skill in this way, over many years is a key component to becoming truly innovative. The inventiveness and creativity earned as a result of this process trains our cognitive capacities, and increases our appetite to take on greater challenges and overcome them. If all our systems are run in an optimally uniform manner, most humans might lose their creativity. On the other hand, it might free us from repetitive tasks to become more creative. I think both situations are possible, but it depends very much on the values we embed into our systems. The process of mastering something and

becoming creative involves failure, suboptimal outcomes and can be inefficient. We seem to have made efficiency and uniformity a goal unto itself. There might be a point where increasing uniformity even further, is not optimal to the system as whole, when keeping human needs in mind.

2. ***Efficiency:*** Once we optimize systems to be efficient, we drive down costs, increase production, and make a larger amount of products and services available for a cheaper price. Efficiency is often defined as the ability to complete a task with minimal inputs of resources, energy and time. Efficiency is intrinsically linked to uniformity. Uniformity enables efficiency. In the workplace, the assembly line increases efficiency by increasing uniformity. But an efficient system also requires humans to act in uniform and predictable ways. An individual working on machine #7 in an aircraft assembly line, holds up the entire process of production if he is late to work, or wants a few minutes break. Thus, break times, work times, and holidays have to be synchronized and made uniform for the entire workforce. The clock and the precise measurement of time are key enablers to establish this discipline of uniformity. In an ideal situation, efficiency should minimize our energy expenditure on work and free up more time to pursue our passions. This has remained a pipe dream up until now, with individuals working much longer hours than agricultural and hunter gatherer societies. IoT promises to take efficiency to its zenith, allowing us to have much more free time than was ever possible before. It will help us save time, while increasing productivity.

A widely shared belief is that IoT will increase efficiency in our personal lives, free up our time and allow us to focus only on value creation instead of the mundane. This is one of the major reasons IoT based systems are being rolled out in workspaces, residences and public spaces. It will make our lives easy and give us more time. Similar perspectives were shared by the late hunter gatherers; amongst many reasons to take up agriculture, efficiency and optimisation was a major reason (Winterhalder, B., & Kennett, D. J., 2006). While switching to agriculture was efficient in terms of supporting larger societies and using smaller pieces of land to feed populations, it didn't really save time. While

hunter gatherers needed to work for approximately 15 hours a week to support themselves, early farmers had to put in double the amount of hours for the same (Winterhalder, B., & Kennett, D. J., 2006). IoT dramatically increases our capacity to produce goods and operate our systems. However, we might find that it might not actually give us more free time. By being continually connected to and communicating with devices, we might become conditioned to do what the system wants us to. IoT applications are used widely in personal settings to nudge us towards better habits like drinking water regularly, exercising, completing a certain number of steps, etc. While these might be optimal ways to use our time, IoT is slowly creeping into the domain of telling us how we should use our time. As more individuals begin to rely on these systems to optimize their habits, do we still retain the freedom to use our time as we wish? While this might not be the case at the individual level, when IoT systems merge with larger systems, it can definitely become an issue.

What is free time? Free time is defined by the Cambridge dictionary as the ability to choose what we want to do with our time. To have full agency over how we spend time. We don't consider working hours as free time, because we are often constrained by the work environment. We have to arrive and leave at a certain time, while completing certain objectives set by the employer. In our homes we have considerably more free time, because nobody is overseeing what we do. Can IoT change this? For example, imagine that insurance companies begin to set our health insurance premiums based on scores obtained through an interactive IoT system. We will be nudged towards spending a certain amount of time exercising, making sure we get enough sleep, and taking our medications on time. While these systems are being deployed with our best interests in mind, it is questionable whether it will increase our free time. While we allow such systems to enter our private space, they also begin to mold the kinds of decisions we make. Our 'free' time might become not so free when devices snitch on our habits to our doctors and insurance companies. Our life coach may tell us to curtail our gaming addictions and we might allow them access to our lifestyle data so that they can keep us on track. Our IoT nutritionist will keep track of everything we eat and give us a score at the end of the week. Our therapist will make us write down our emotions in an

interactive diary. Are we the ones making the choices in this case? Or have we outsourced the choices of how to spend our time to others? Some might say that these good habits are the optimal way that one would like to live, but often bad choices are made in the moment, due to fatigue or forgetfulness of our larger goals. IoT systems can then help us live exactly how we would ideally like to, by nudging us whenever we go off track. We might lose the capacity to train our own discipline and willpower in this situation, but that's besides the point. It is probably an illusion to think that IoT systems will give us more free time. When efficiency becomes a goal unto itself, time becomes a resource. We must use all the time we have available, towards manifesting our goals. IoT will certainly enable us to judiciously use every spare second that we have towards becoming efficient human beings. This might be great for society, with human culture and capabilities reaching new highs. While agriculture took away free time, it enabled ever more complex social relations. IoT will definitely increase the complexity of human civilization, but it might not contribute to the free time that we envision.

3. ***Predictability***: A system of interconnected, communicative devices is programmed with clear goals and expected outcomes. The system seeks predictability. Increasing the uniformity of output, and the efficiency with which the output is created also necessitates predictability. The system cannot be uniform and efficient if it is chaotic. As a general principle, we create systems to eliminate uncertainty and undesirable outcomes born out of chaos. For instance, let's imagine a smart transportation system that manages public transport as well as the routes for self-driven private cars based on traffic. In the highest probability the system will be optimized for efficiency. The quickest routes possible will be chosen, taking into account traffic and congestion. Apart from efficiency, the system might also be uniform, in the sense that it will look for the shortest route possible for everyone. This will make transportation predictable; the system will attempt to make best use of the available road space to minimize travel time. Alternatively, if the system is programmed to be non-uniform, it can prioritize certain elements of the system over others. Clean energy vehicles might receive priority over other forms of transport. The system could also prioritize those traveling to work over those traveling for leisure.

A complex hierarchical system may also be implemented based on an individual's social credit or rating. This makes the system more complex, while adding an element of hierarchy and inequality into the system.

It is interesting to ponder on whether the smart transportation system should be completely uniform or have preferences inbuilt into it. However, what I am interested in is what such systems do to the humans that are a part of it. Regardless of which type of system is implemented (uniform or hierarchical), the affordances that human participants have is limited. For the system to function optimally in either case, requires humans to be predictable. If humans are to participate in any uniform, efficient and predictable system, they also need to prioritize these values for the system as a whole to function well. Many proponents for self-driving cars argue that, if all cars on the streets were self-driven, it would reduce accidents by taking away control from unpredictable humans. A smart home system connected to the smart grid manages our household chores and after-work entertainment. It recommends what we should watch on TV and what games we should play based on data collected on our past likes and dislikes. Nudged by technologies around us, we act in predictable ways; a predictable average of our past actions. The robustness of a system depends on its ability to make participatory human agents act predictability and in a deterministic way. Suddenly stopping on the side of the road because one remembers one needs something from the shop is a liability to the uniform and predictable system. A small congestion caused by this ruins the system's calculations as it has already sent many other cars down the same route assuming that it would not be congested. Variability and chaos are arch enemies of a social system conceptualized in the language of computation.

These types of uniform, efficient and predictable systems work amazingly 99% of the time. Those events that are chaotic, unexpected, and random are highly problematic for the system. The system attempts to standardize humans and nature so that these features of the system can fit neatly into the computed algorithm. This might be a core vulnerability of the system. Dramatic,

unpredictable events don’t happen often, but they do occur every once in a while. One could argue that the core premise of evolution is adaptability and flexibility. Conditions dramatically change and those species that are capable of adapting to those changes ensure survival. Will IoT systems make us less adaptable? Are the systems in themselves optimized for efficiency at the cost of resilience? For instance, in financial trading, algorithmic traders outperform human traders most of the time. However, in highly random and chaotic moments, like the onset of a pandemic or the beginning of a nuclear war, humans tend to outperform algorithms (Taleb, N. N., & Raju, P. V. L., 2011). As Nassim Taleb suggests, algorithmic systems are easily fooled by randomness. This makes them necessarily fragile. To be resilient according to him, a system should grow and become more robust with disorder or chaos (Taleb, N. N., & Raju, P. V. L., 2011). Whether it is due to our evolutionary capacities or what some refer to as instinct, humans tend to fare much better in random and chaotic events. The risk we run of being overly dependent on such systems is a complacency to preparing for infrequent and random events. Should we prepare and give increased importance to extremely random events, even if they have a chance of occurring only once every 500 years? When we employ big data and analytics, these chance events are usually ignored, like a small needle in an increasingly large haystack. Can we even program an algorithm for all these events that have an extremely low probability of occurring, but when they do occur, have the potential to dramatically change the environment? To avoid being fooled by randomness, we have to prepare by interacting with some amount of chaos and disorder regularly. Taking into account long time frames of millenia, maybe predictability and uniformity are undesirable. Maybe we can actually contain these random events within our algorithms; after all, once the events do happen they should be able to learn from them, and prepare better next time around.

4.5. Core Assumptions and Pitfalls of IoT

In addition to the goals present in IoT systems I touched upon, there are some core assumptions at the heart of most IoT technologies. These assumptions are :

1. ***Social problems can be understood and resolved in the language of computation.***
2. ***More data equals increased insight.***
3. ***Sufficiently massive systems, and big data can manage society better than humans can.***

1. ***Social problems can be understood and resolved in the language of computation:*** This assumption is especially present in IoT systems used to resolve social issues. There is much hype around IoT systems that can resolve issues like loneliness in elderly, access to education, participation in democracies and so on. Social problems are usually framed by the myths and worldviews that are present within society. For instance exploitation of certain groups of people was not considered a social problem until societies adopted humanistic values. The worldview that all humans are equal and must have access to equal opportunity and so on. When we try to solve social problems through the language of computation, we frame the problems based on our current set of worldviews. Additionally, we only address the surface level of these problems. For instance, loneliness amongst the elderly can be tackled by virtual interactive technologies that engage them in ‘meaningful’ interactions. Obesity can be tackled by nudging individuals to exercise more often, eat healthier foods and gamifying health by setting targets and implementing health scores. Higher crime rates can be addressed through a social credit system or by using IoT to identify possibilities of crime before they occur. All of these solutions try to solve social problems by changing the surface level symptoms of societal problems. This tends to put the blame on the individual. For instance the assumption is that reforming the individual's habits is what is required to solve obesity. Is obesity caused only by individuals' habits? It is probably more complex,

and an interplay between personal habits, dysfunctional food systems, and environments designed to minimize physical energy expenditure. However, framing the problem of obesity in this way is far more complex and cannot be computed. We run the risk of trivializing complex social issues and providing patchwork solutions that hardly address the root cause of the issue.

2. ***More data equals increased insight:*** The idea that more data is equal to more information is ubiquitous today. There is definitely a lot of information that one can gather from data. However, with increased amounts of data, we also have an increased amount of noise or illusory correlations. To find meaningful information is like finding a small needle in an infinitely expanding haystack. Today, we have increasing amounts of data on all our health parameters. Does this always lead to increased insight about our health? Most people are confused about what it means to be healthy with the proliferation of numerous dietary fads and exercise routines, with scientific data backing each of them. We no longer trust the wisdom of our own bodies, about what kinds of foods feel good for us and what doesn't. To the contrary we have blocked out our bodily signals and overwhelmed our senses with all kinds of information and data about what it means to be healthy. With a sufficiently large dataset, we assume we can understand the perfect solutions to all our issues. Just beyond our limited dataset there is a one-size-fits-all solution to human problems.

If we blindly follow the insights provided by data, will we become healthy? Here again, the element of randomness and variability plays havoc with our data based models. For instance, research into the gut microbiota has found that every human has a different bacterial ecosystem, based on genetic and environmental factors (Cryan, JF., and Dinan TG., 2012). Aggregating large sums of data cannot display this insight. We attempt to measure, control and understand all variables that affect our health. Yet, it seems to be that the more variables we understand, the more confused we become. I posit that ancestral health wisdom managed to do what data will never be able to; to capture complex phenomena in an extremely simplistic fashion. More insight is buried in

grandma's folk medicine health tips, than the terabytes of data in an IoT application.

3. ***Sufficiently massive systems, and big data can manage society better than humans can:*** When it comes to data, big is beautiful. With smart agricultural systems, the larger the piece of land in the system, the greater the potential to maximize efficiency, and reduce wastage. Today, we have massive IoT systems that manage a country's electricity grids, defense equipment, transportation networks, and natural ecosystems. Is this the best way to manage systems? Bigger systems lead to bigger security concerns. Large systems are inherently more fragile, and less resilient to disruptive changes. For instance, a system overly reliant on radio signals can easily be targeted. These systems have a single point of failure that can be exploited through signal jamming or spoofing devices (Khan, M. A., & Salah, K., 2018). To interrupt electricity supply in an entire country could be possible through malicious attacks on the software or middleware applications. As some authors point out, maybe we should focus on smaller IoT systems that are able to deal with security concerns more reliably (Khan, M. A., & Salah, K., 2018).

4.5.1 Techno-social Engineering

Much analysis about new technologies focus on how machines are becoming increasingly intelligent and will soon have the capacity to outperform humans. The classic Turing tests examine if a machine is capable of fooling an observer into believing that it is an intelligent human. What if we invert this analysis instead? To examine at what stage a human being becomes indistinguishable from a machine? Through the analysis I presented above, IoT technologies aim to make humans more predictable, by enshrining human nature in the language of computation. As we increasingly interact with these technologies, we risk becoming indistinguishable from machines. This is not only

because the capabilities of machines are catching up to us, but also because we are becoming more mechanical. This is not to say that IoT based systems are not incredibly useful to society. They provide great value, but it is important to examine at what point, these systems have a dehumanizing effect upon us. What it means to be human is continuously in flux, with every technological advancement extending our cognitive capabilities in novel ways. However, IoT and AI might change the locus of control of the distributed cognitive system, from the human to the algorithm. It might be beneficial to our species as a whole and create some kind of collective mind. Alternatively it might not serve us so well, and cause us to reinvent the system of values that currently guides us. Whatever it brings, we can't fully understand the implications without going headfirst into it. Ultimately like all technologies, IoT will serve to bring us one step closer to understanding what it means to be human.

Chapter 5: Discussion

“Whatever happened, happened for the good. Whatever is happening, is happening for the good. Whatever will happen, will also happen for the good. Only if we learn to bring the mind into the Present.” - Bhagavad Gita

In this thesis, I situated my analysis within the distributed cognition or extended cognition framework. Seeing technologies as techno-social systems allows us to appreciate how closely interrelated human cognition is to the systems it is embedded in. Our techno-social systems frame the contours of our cognition; they provide certain affordances, while denying others. While this framework helps us to situate cognition, and reflect on its qualities, many questions are still left unanswered. For instance, what is the point of cognition? Cognition is very useful for our survival, but beyond that we are seemingly free to use it for whatever goals we envision. Thus, it is cognition itself that broadens our possibilities of what is possible, thus also increasing the range of purposes and goals that individuals create for themselves. Within this perspective, new technologies create new affordances, which in turn leads to new goals, purposes, experiences and possibilities. When survival is no longer a goal, we can often be confronted with the question, ‘what is the meaning of life?’, unless we have created some purpose or meaning for ourselves. There comes a time when our created sense of meaning doesn’t make much sense to us, and we once again

return to this question. Our constructed sense of meaning or purpose is crucial to the entire system. It can be described as a core cognitive capability.

Much human effort has been expended to create techno-social systems that provide individuals with meaning. The myths, stories, and worldviews employed to generate meaning are highly subjective, but the process of creating meaning itself is universal. One would be hard put to find a tribe or society that didn't or don't regard meaning making as its most important focus, in its techno-social design. The construction of meaning is universal, but the constructed meaning is highly subjective. The subjectivity depends on the experiences that the tribe societies or communities go through. For instance, a hunter-gatherer society dependent on natural resources, regarded the river, forests, and other natural phenomena as that which provided the ultimate meaning. As our environment, and the experience of it changes, so does the meaning we derive from it.

Let's assume for a moment that the larger meaning for our species as a whole and the planet is to experience as wide a variety of experiences as is possible. The process of evolution in some ways points to this. Evolution is random and chaotic, and many iterations are created, which don't always increase the adaptability of all species. The goal of evolution is certainly not uniformity or efficiency. I might be wrong, but I assume it is to extend the frontiers of what is possible to be experienced. We could also argue that human life is a never ending stream of experiences, that we tie together into a cohesive narrative, that we can make sense of. Every new set of experiences develops our cognitive capabilities in new ways. From this perspective, we are driven towards experiencing the world, and our life in novel ways. New technologies emerge out of this innate urge, which allows us to experience the world differently. However, not all new iterations to our cognition cater to our continued survival, in changing conditions. It is also nearly impossible to tell what exactly will be useful for our survival, when we cannot predict how the environment might change a few thousand or million years from now. I propose that exercising our ability to **de-link our internal cognition from our external techno-social cognitive extensions** (for brief periods of time) might be a good strategy. It will allow us to jump headlong into exploring different dimensions of experience through new

technologies, while also retaining aspects of experience that were a part of our evolutionary journey. In the next section, I detail what I mean by this ‘de-linking’ exactly, and how a ‘delinking’ strategy might look dramatically different for every cognitive extending technology that we use.

5.1. Layered Cognition - Peeling the Layers

Every tool or technology that we extend our cognition through, adds a layer to our existing cognitive capabilities. We can still use and develop our existing cognitive capabilities that were present before we began to use the technology. For instance, we are still able to approximate the time of day based on the angle of the sun even if we stop using a clock. Alternatively, we still have the capacity to hold many details in our biological memory, even though we use our smartphones and diaries to do so. We have the capacity to ponder over complex ideas and create detailed imaginary stories without the use of pen and paper, or computer. We can learn to navigate in a new area, and become spatially aware of its important features without the use of maps. We have the capability to experiment with and and listen to bodily cues to know the effects that different foods or herbs have upon us without ‘googling’ it. However, we are not born with all of these abilities, we must practice them to develop it, and continue to practice them to maintain it. Thus, cognition is very much a skill. It is something we practice to get better at. London taxi drivers in a pre-GPS era, had a very strong skill of spatial memory, and larger than average hippocampi to support their skill (Maguire, E. A., et al., 2000). Thus if we see our cognitive abilities as a skill, we must also realize that they atrophy if we don’t practice them, in much the same way our muscles atrophy if we don’t use them. This does not mean that we shun all new or existing cognitive extending technologies and learn to live like hermits. On the contrary, I propose a minimalist approach; without expending much time and effort, we can maintain our cognitive skills by peeling our cognitive layers from time to time. Before we look at ‘cognitive peeling’, let's first look at some of the core cognitive skills and how we extend them through technologies.

Cognitive Skill	Cognitive Extending Tool
Conscious Attention	Pen & Paper/ Note taking software
	Calculator
	Digital AI assistant
Spatial Awareness	Stories/ Songs to Orient Natural Spatial Features
	Physical Maps
	GPS
Memory	Stories, songs, myths
	Physical Calendars
	Smart phones, Computers, Search Engines
	Digital AI assistants
Social Cognition	Shared myths, stories, worldviews
	Traditions, festivals, family customs
	Social media, dating applications
Language	Oral medium: stories, folk tales, song, etc.
	Written medium: books, articles, blogs
	audio -visual medium: podcasts, videos
Emotional Processing	Meditation, Lucid dreaming
	Sharing, journalling
	AI Chat bots

Learning	Bodily signals, human to human interaction, observation
	Mimicking, practice
	Long form: books, documentaries, podcasts, journals
	Short form: videos, blogs, google

I have listed language as a cognitive skill above, but it is also a cognitive extending tool in and of itself. When practicing ‘cognitive peeling’, we would ideally want to spend some period of time (a few days) every few months or years without our cognitive aids. To get a feel of what it is like (to experience) our cognition without the use of the extension. For instance, using video games for entertainment is a way of extending our perceptual abilities to a virtual space, to experience excitement, stimulation and so on. We could use virtual environments for many other types of cognitive extensions as well. Taking time to remove this cognitive layer, say 10-20 days every year without being in any virtual or simulated environments, will allow us to recover our ability to feel entertained and stimulated without the need for the virtual environment. Alternatively we could do the same with our relation to time. Living for a few days every few months without access to any clocks. Gauging when to eat and sleep by only referencing the angle of sunlight and our internal biological clock. One could also take a holiday to a new location and attempt to navigate using physical maps or simply by asking directions instead of using GPS. One could also try to get a small glimpse of the nature of our cognition pre-language. We could attempt this by not using language outwardly; not speaking, writing, not reading and so on for a week or ten days. Though we predominantly think in language, it is quite difficult to actually imagine an experience not accompanied by language based thoughts.

Spending time in silence could actually peel multiple cognitive layers at once. We could take time away from all our extending technologies; pen and paper, clocks, smartphones, computers, digital assistants, smart home appliances and so on. At this stage, one might be thinking, what for? What is the point of peeling back these cognitive layers? What will it contribute towards my

goals, or me as a human? Today, with cognitive extension made possible by smart devices that run on complex algorithms, we run the risk of letting many of our cognitive abilities atrophy. While new abilities will be made possible through these technologies, we can't be sure that the changes will serve us for the long run. In distributed cognitive systems of IoT, humans are on the periphery of the cognitive process. The major cognizing is done by the algorithms and designers of the systems. While this might be fine to reach certain goals, it can be problematic if we cannot develop and maintain our cognition outside of these systems. Like anything in this world, if we become overly dependent on IoT to run our lives, we also need to take time to 'rehabilitate'. Dependencies and addictions rob us of our autonomy and free will.

5.2. Inextensible Aspects of Cognition

Are there aspects of our cognition that are inextensible? If there are, should they be considered core capabilities that must be prioritized? Intelligence is often seen as the cognitive capability that separates humans from many other animals. Intelligence is extendable through cognitive technologies, and can thus be continuously improved by using better and better devices. Intelligent artificial systems are expected to surpass human intelligence in the next few decades. Many see this as an ominous sign for the ability of humans to survive and thrive. The perceived threat that artificial systems and AI will take over is ubiquitous. However, is intelligence the epitome of human cognitive capability? Are there cognitive skills beyond intelligence?

5.2.1. Happiness is a Skill, not an Outcome

The belief that technologies will enable us to become happy and fulfilled is highly questionable. Happiness in eastern traditions like hinduism and buddhism is seen as an internal skill (Prabhupada, S. et al., 1972). It must be cultivated internally; and is not linked to external circumstances. Alternatively, many

biologists and neuroscientists claim that happiness is reducible to internal neural and chemical processes. Thus, we see the proliferation of treatments for depression or unhappiness in the form of hormones and chemicals. Some believe that we will soon know how to create bliss in the brain. At this stage all one needs to do is take the pill or enter the virtual space to be in bliss forever. However, happiness is relative. Those that resort to drugs to be continuously happy, are often the most unhappy people in the long run. I propose that fulfillment and happiness isn't a result of bliss, or the hormones and neural activations that cause it. To the contrary, it is more about learning to embrace challenges and difficulties in life. We all have our fair share, and though the promise of technology is that it will take away our challenges, I don't see it happening anytime soon. Happiness as a skill, is cultivated by the approach we take towards life and not by changing the circumstances of our life. We change our circumstances to make life more comfortable, and reduce effort. This won't make us fulfilled or happy.

Depending on external circumstances to provide us with happiness, is a problematic strategy. External circumstances keep changing. They are uncontrollable. However much we try to control our circumstances, there is always something waiting to upset our perfectly curated lives. This is not to say that we should embrace inaction. We can still do our best to create, manifest and change our environments to suit us. However, we shouldn't become dependent on the created environment to give us everything we need. When we become dependent on our environment, we become averse to changes, or challenges. Aversion to certain outcomes or circumstances, makes us unhappy. We put our energy towards avoiding certain feelings or thoughts, rather than embracing the challenge. The ability to metabolize our pains and sufferings is the key to cultivating happiness as a skill. We can still be focussed on doing, and creating, while attempting to be nonchalant about the outcomes of our action. Extending our cognition into the environment through tools, doesn't mean that we must also extend our need for fulfilment into the environment.

5.2.2. Inextensible Presence

I propose that the most prized cognitive capability that humans have is awareness itself, or more precisely our ability to cultivate presence. Presence is the ability to stay focussed on the present moment, without cravings, goals and aversions. Artificial systems are created with certain goals, and thus do not have this capacity to cultivate presence. Cravings or the need to fulfill certain goals take us out of the present moment. We crave something in the future based on memories of its experience in the past. We wouldn't crave something that we don't know exists. Thus, cravings take us out of the present and into the future. Aversion on the other hand is the inability to handle or digest the present experience as it is. There is an urge to escape and get away from whatever one is experiencing in the present. Presence is the ability to overcome our cravings and aversions and maintain our conscious awareness of the present moment. It might not be optimum to cultivate presence all the time, but it is definitely a skill worth refining. Additionally, presence is impossible to extend. We cannot cultivate presence through the use of medicines and technologies. A virtual system might enable or create the right conditions for us to create presence, but it cannot do it for us. It is a skill like happiness that must be cultivated internally.

The skills of presence and happiness are not new findings. They stretch back to the beginnings of human civilisations, and might just be the secret sauce that enables us to continue extending our cognitive capabilities without losing our autonomy and free will. They are often neglected aspects of our cognition, but ultimately the aspects that most individuals are unconsciously seeking.

Chapter 6: Conclusion

Through the course of this thesis, I expanded on the framework of distributed or extended cognition. Cognition as we experience it nowadays is distributed over complex systems. Systems that involve human agents and technologies, which is embedded in particular societies. These systems, I term techno-social systems. I went on to look at two examples of key technologies that are radically different from one another, and situate them within this framework. The first, is a set of technologies used for timekeeping, and the second is a set of technologies that comprise the internet of things.

An analysis of both the technologies revealed that, they are both potent cognitive extensions. They allow us access, to aspects of cognition that might otherwise have been difficult, while at the same time they alter our pre-existing cognitive abilities. These extensions also radically change our relationship to the environment. Each technology has social values embedded within them; usually by the individuals who create these technologies, based on prevailing societal norms and values. Additionally, these technologies impact us by promoting certain values over others. They change the way we look at the world, the way we think of what it means to be human and our interaction with nature and other humans.

While we are continually being shaped by the technologies we create, we often forget that there are aspects of being human that remain the same. Some fundamental questions have plagued humans since the beginning of civilisation, and will continue to do so. Technologies can’t give us everything in life, especially happiness, fulfilment, and autonomy. My thesis does not cover all aspects of these arguments, but I do believe it opens up an important line of thought considering we are in a period where technologies are extending our cognition more than ever before. I think this thesis and the works of many other authors, presents us a chance to begin thinking about how we would like to teach our next generations to relate to technologies. While many differing approaches to technologies will be employed, I believe that it is important to be prepared. To prepare our cognitive abilities without technology as well as with it. The more

dependent on technologies we become, the more at risk we put everything at, including our survival. Like the turkey that is fed all its life, begins to believe that humans are friendly. With every passing day of being fed, and treated well, it reinforces its belief that it is safe. Until it is surprised, a day before thanksgiving, to learn that its knowledge about the world is not complete.

To conclude this thesis, I believe that we can never know what is in store for us in the future. Nor can we know what is the approach that will lead to the best possible outcome. However, a healthy discussion and additional research offers valuable perspective that will hopefully help us to navigate what it means to be human.

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