Theorizing Technology and Its Role in Crime and Law Enforcement

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1. Introduction

Virtually any human practice or institution that exists in society has been seriously affected by the use of technology. However, the role of technology in society is little understood. Decision-making processes concerning technology are often driven by false and naïve images of technology and its interaction with society. A sound understanding of technology and its role in human practices and institutions requires specialist knowledge. Such knowledge is developed in several fields in the social sciences and humanities, including science and technology studies (STS), philosophy of technology, ergonomics, management of technology, and others. In this essay, I will review these fields, with particular reference to approaches and theories in STS and the philosophy of technology, and I will report on their main findings regarding the role of technology in society. This review will be carried out in section 2.

A second aim of this essay is to introduce a particular theory of technology and to apply it to an analysis of the role of technology in crime and law enforcement. The theory in question, *extension theory*, provides a powerful perspective for understanding the role of technology in society, in particular the powers that technological artifacts give to their users (individuals, groups and organizations) and how these powers help them further their aims. After introducing extension theory in section 3, I will use it in an analysis of the use of technology in crime and law enforcement in section 4. This analysis intends to show how new technologies have extended the powers of both criminals and law enforcement, and how these new powers play out against each other. The paper ends with a concluding section that reviews the essay's main findings.

2. Understanding Technology

Technology is a key driver of social change. The industrial revolution and the technologies it has yielded have radically transformed a great number of societies. Modern societies are shaped by modern technology, which has caused revolutionary changes in work, the economy, social organization and the way of life. The ever increasing pace of technological innovation promises more such changes for the future. Because of the profoundly influential role of technology in every sector and institution of society, whether it is healthcare, education, government, law, business, the arts, or any other, an adequate understanding of these sectors nowadays requires an understanding of the role and impact to them of technology.

Several academic fields have emerged to study technology and its role in society, including the nature of technology, its design and development, and historical evolution, its dependence on social and economic developments, its impact on individuals, society, and the environment, and the governance of technology. Most centrally, technology is studied in the interdisciplinary field of *science and technology studies* (STS), sometimes also called science, technology and innovation studies (STIS) (Hackett et al., 2007; Sismondo, 2009). This field aims to study the evolution of the institutions and practices of science and technology in society, their impacts on society, and their governance and regulation. STS emerged in the 1970s, and has established itself as a field with departments and programs around the world, as well as specialized conferences and journals.

STS is a loosely knit field, with a wide variety of contributing disciplines, such as sociology, history, cultural studies, anthropology, policy studies, urban studies and economics. It is fair to say, however, that it is dominated by sociological, historical and governance approaches. Sociological approaches are concerned with an understanding of institutions, modes of organization and practices of science and technology, and their interactions with other sectors of society. Historical approaches study the historical development of science and technology and the social context in which its institutions and actors operated.[1] Governance approaches, finally, investigate how science and technology and its impacts can be governed or managed in society, by government agencies as well as by the private sector and other relevant actors (Smits, Kuhlmann & Shapira, 2010).

Several other fields exist that study some aspect or dimension of technology and its role in society. They are either closely associated with STS, or have developed along a largely separate trajectory. They include, amongst others, economics of technology, ergonomics, material culture studies, internet psychology, design studies, technology management, innovation management, and the philosophy of technology. I will now further introduce one of these fields, the philosophy of technology. The philosophy of technology is a field that, next to STS, aims to develop theories of technology and society of a general nature. It is also the source of the theoretical perspective on technology that I will be developing in sections 3 and 4 of this essay.

The philosophy of technology emerged in the course of the 20th century, largely as a response to the major impacts of technology on society during that century, many of them

[1] In chapter 2 of this volume, Michael McGuire offers one of the few socio-legal/criminological accounts of the historical development of technology crime and control.

perceived to be negative by philosophers. These include the unprecedented destruction and carnage during the First and Second World Wars, the rationalization and automation of work which brings alienation, the rise of a consumer culture that promotes materialism and shallow consumption, and the destruction of the environment due to modern technology. Philosophers like Martin Heidegger, Jacques Ellul, Herbert Marcuse and Günther Anders developed extensive critiques of modern technology based on these perceived social consequences.

Since the 1990s, the broad critiques of these classical authors have made way for more pragmatic and empirically oriented philosophical studies that aim to better understand specific technologies their role in society. This new orientation has been called the empirical turn in the philosophy of technology (Kroes and Meijers, 2000; Brey, 2010a). Studies after the empirical turn tend to be more descriptive, more informed by empirical results from its own case studies and from empirical studies in other fields, more focused on concrete technologies and social problems, less pessimistic about technology, and less determinist about technological change and impacts of technology. In addition to this descriptivist empirical turn, the 1990s also saw the emergence of ethics of technology as a major field of study, including new specializations like computer ethics, nanoethics and ethics of design. Due to the empirical turn, the philosophy of technology has moved closer to STS, a field that it has incorporated methods and ideas from. In spite of this alignment, the philosophy of technology has largely retained a status separate from that of STS.

What is Technology?

Let us now turn to the insights into technology and society that can be gained from these fields. A proper understanding of these matters should begin with an adequate understanding of the concept of technology. Unfortunately, definitions of technology in dictionaries and professional textbooks differ widely in their meaning and scope. Technology is variably defined as a process of making things, a type of knowledge for making things, or the very things that are made (Reydon, 2012; Li-Hua, 2009). In addition, many definitions hold that technology involves the application of science to useful ends, but there are also definitions that make no reference to science and define technology as the application of knowledge for practical ends, where presumably this knowledge can be of any kind (Mitcham & Schatzberg, 2009). Moreover, some definitions hold that technology involves the manipulation of matter for practical ends, whereas others merely hold that it involves the creation of practical value, so that presumably applications of the social sciences would also qualify as technology ("social technology" or "soft technology") (Jin, 2011).

Most commonly, however, technology is related to engineering, and definitions incorporate three elements: technology is something that involves the manipulation of matter, that has an orientation towards practical ends, and that has a basis in the sciences. Technology can, according to this conception, be defined as the development, through the application of science and mathematics, of physically defined or implemented means (devices, systems, methods, procedures) that can serve practical ends. This assumes that technology is the mere application of science, whereas convincing arguments have been made that although science is applied in engineering, engineering also involves the application and creation of unique engineering knowledge, which is a highly formalized, evidence-based and systematic type of knowledge (Vincenti, 1990). So probably the definition should be amended to hold that technology is developed through the application of science, mathematics and engineering knowledge.[2]

This definition of technology characterizes it as a process that is carried out by engineers and applied scientists. However, in other contexts, "technology" appears to refer instead to the means created in this process, as when it is said that a store sells office technology, or to a form of knowledge, namely knowledge of the techniques for the production of artefacts and other useful means. Technology is hence defined as a process, a set of objects, or form of knowledge, depending on context (Mitcham, 1994).

Subclasses of technology are often defined in relation to engineering branches. The main branches of engineering are chemical engineering, civil engineering, electrical engineering and mechanical engineering, and they produce chemical, civil, electrical and mechanical technologies, respectively. More specialized branches, such as software engineering and biomedical engineering, also yield corresponding technologies. Note that engineering branches are sometimes defined in terms of technological features (e.g., mechanical engineering), and sometimes in terms of application areas (e.g., environmental engineering).

For a consideration of consequences of technology for society, the most relevant aspects of it are not technological knowledge or technology development processes carried out by engineers, but rather the technological products that result from engineering: devices, systems, procedures and methods that are used for practical purposes and that through this use impact society. The products of technology development are of two basic kinds: objects (tools, devices, systems) and instructions for carrying out processes (procedures, methods). The latter includes methods and procedures for processes like food irradiation, iron smelting and automated assembly of laser diodes. The focus of theorists has, however, mostly been on the objects produced by engineers: *technological artifacts*, which are the physical products of technology.

The notion of a "technological artifact" or "technological product" is usually associated with electronic and technologically complex devices, such as computers, mobile phones and automobiles. However, there are many human-made products that are the

[2] Another problem with the definition is that it does not allow for the creation of technological means that are not based in science, even though there seem to be cases of technological invention that are not science-based, such as James Watt's invention of the steam engine, which was hardly based on scientific principles. This example shows that it is difficult to arrive at a definition of technology that captures all of our intuitions. However, even if Watt's invention did not, 20th and 21st century technology invariably finds its basis in science, mathematics, and formalized engineering knowledge.

result of science-based technological production processes but that are not themselves machines or electronic devices. A nylon jacket is not generally seen as a piece of technology; it is not a device with mechanical parts and does not run on electricity. However, it is a technological artifact in the sense that it is a product of advanced technological processes of production of nylon polymers out of chemical compounds which are subsequently mechanically melted, spun and fused together into wearable items. Most products that people buy in stores are technological artifacts in this sense, including hammers, cups, tables and even many foods. It is often difficult to distinguish between technologically produced artifacts and craft-based artifacts; a wooden chair could be of either type. For this reason, theorists sometimes for convenience refer to any human-made artifact as a technological artifact, although in other contexts it may be appropriate to restrict the scope to engineering-based products, machines or electronic devices.

The most exemplary class of technological artifacts consists of (electronic) machines. A *machine* is a tool that consists of parts with different functions and that receives energy from a source and transforms it, through the interoperation of its parts, into useful actions. In the evolution of technology, one sees the evolution from simple tools and devices to mechanical machines (machines powered by natural forces like wind and water, or human and animal labor), followed by electrical machines (powered by electricity, or converting mechanical to electric energy), electronic machines (electric machines with active electrical components) and computing machines (electronic machines in which the store and flow of electrons is interpreted as information).

New technologies and fields of engineering emerge regularly, and new technological products and methods, often incorporating multiple technologies, are developed at an ever increasing rate. The constant emergence of new technologies means that technologies exist in society at different stages. A rough distinction can be made between entrenched and emerging technologies. *Entrenched technologies* are established technologies with long histories that have yielded many products that are broadly used in society. Automotive technology is an example. *Emerging technologies* are new technologies that have not yet yielded many concrete products and applications, if any, and that are still mostly defined in terms of fundamental research. Examples are nanotechnology (although it is yielding more applications every year) and synthetic biology. This distinction is important because in assessing future impacts of technology on society, it is important to not only consider innovations within entrenched technologies, but also to consider potential applications of emerging technologies.

The Mutual Shaping of Technology and Society

Majority support has emerged in STS and philosophy of technology for a number of positions concerning the way in which technology is developed and interacts with society, which I will now attempt to spell out. A first point of agreement is that technology does not evolve in a deterministic fashion, but rather evolves along a path that is strongly influenced by a wide variety of social factors. Technology is *socially shaped*, meaning that technological change is conditioned by social factors, and technological designs and functions are the outcome of social processes rather than of internal standards of scientific-technological rationality. (Mackenzie and Wajcman, 1999)

The social shaping thesis denies the technological determinist idea that technological change follows a fixed, linear path that can be explained by reference to some inner technological 'logic,' or perhaps through economic laws. Instead, technological change is radically underdetermined by such constraint, and involves technological controversies, disagreements and difficulties, that involve different actors or relevant social groups that engage in strategies to shape technology according to their own insights. The thesis implies that technologies will evolve differently in different societies (assuming that they are developed separately in them), and that society can exert strong influence over the way in which technologies develop.

Against a linear path model of technological change, proposals have been made for a *variation and selection model*, according to which technological change is multidirectional: there are always multiple varieties of particular design concepts, of which some die, and others, which have a good fit with social context, survive (e.g., Pinch and Bijker, 1987; Ziman, 2000; Brey, 2008). Many studies have been performed to show how users, regulators, civil society organizations and other actors affect the development and design of technology and the way in which technological artifacts are interpreted and used (Bijker, Hughes and Pinch, 1987; MacKenzie and Wajcman, 1999; Oudshoorn and Pinch, 2003).

Theorists also agree that the meaning and use of technologies is not pre-given, but that instead technology has *interpretive flexibility*, meaning that technological products can be interpreted and used in different ways (Pinch and Bijker, 1987). Different actors in society will attribute different meanings, functions and uses to technologies, and engage in processes of social negotiation. If such negotiations are successful, they come to a close and interpretive flexibility diminishes because the technology is said to stabilize, along with its co-evolved meanings and social relations. This implies the embedding of the technology in a stable network consisting of humans and other technologies, and the acceptance of a dominant framework on how to interpret and use the technology. It implies that the contents of the technology are 'black-boxed' and no longer a site for controversy, although black boxes can be opened at any time. The history of technology shows how artifacts like the telephone, the Internet and the automobile take on particular functions and societal roles that vary from time to time and from place to place.

A second major point of agreement between scholars of technology is that *society is shaped by technology*, meaning that technologies shape their social contexts. This is converse of the earlier claim that technology is socially shaped. The claim is not just that particular uses of technology have an influence of society, but also that technological innovations and products themselves shape their social contexts. This claim goes against a naïve conception of technology as a neutral means that does not itself affect society, and according to which it is the choices made by its users that determine its impacts on society (Feenberg, 2002). The technological shaping thesis holds that technological innovations and products engender a multiplicity of functions, meanings and effects that always, often quite subtly, accompany their use. Technologies become part of the fabric of society, of its social structure and culture, and have a deep and lasting impact on social structure and human behavior (Callon, 1987; Latour, 1992). Naturally, such an impact could also involve effects on criminality and responses to this.

The idea that society is technologically shaped means, according to many scholars, that technology seriously affects social roles and relations, political arrangements, organizational structures, and cultural beliefs and practices. Scholars have argued that technical artifacts sometimes have built-in political consequences (Winner 1980), that they may contain gender biases (Wajcman, 1991), that they may subtly guide the behavior of their users (Sclove, 1995; Latour, 1992), that they may support or hinder the realization and implementation of moral values and norms (Brey, 2010b), that they may presuppose certain types of users and may fail to accommodate non-standard users (Akrich, 1992) and that they may modify fundamental cultural categories used in human thought (Akrich, 1992; Turkle, 1984).

Let us consider some examples. Bruno Latour (1992) has aimed to show how mundane artifacts, like seat belts and hotel keys, induce their users towards certain behaviors. A hotel key, for example, has heavy weights attached them in an attempt to compel hotel guests to bring their key to the reception desk upon leaving their room. Langdon Winner (1980) has argued that nuclear power plants require centralized, hierarchical managerial control for their proper operation, unlike, for example, solar energy technology. In this way, nuclear plants shape society by requiring a particular mode of social organization for their operation.

Richard Sclove (1995) has pointed out that modern sofas with separate seat cushions define distinct personal spaces, and thus work to both respect and perpetuate modern Western culture's emphasis on individuality and privacy, in contrast to e.g. Japanese futon sofa-beds. Sherry Turkle (1984), finally, discusses how computers and computer toys affect conceptions of life, since due to their intelligent behavior, they lead children to reassess the traditional dividing lines between 'alive' and 'not alive' and hence to develop a different concept of 'alive'. Most authors would not want to claim that technological artifacts have inherent powers to affect such changes. Rather, it is technologies-in-use, technologies that are already embedded in a social context and have been assigned an interpretation, that generate such consequences.

To conclude, many scholars have proposed that the development of technologies, and therefore these technologies themselves, is shaped by society, and that technological innovations and products shape social and organizational structures and arrangements, and human practices and beliefs. Taken together, these claims can be summarized to say that society and technology co-shape or co-construct each other. Technological change is moreover held not to be linear but to proceed through a quasi-evolutionary process of variation and selection. In addition, technologies have interpretive flexibility, implying that their meanings, functions and capabilities are constantly open to renegotiation by users and other social actors.

3. The Extension View

Extension theories of technology provide a perspective on technology and its relation to human beings that has significant explanatory power and that can be usefully applied in the analysis of the role of technology in society. Extension theories are based on the idea that technological artifacts can be understood as means that build upon, and extend, capabilities of the human body and mind; they are extensions of the human organism. An analysis of technology and its function in society should take into account how technological artifacts extend, enhance, augment, supplement or replace human body parts and organs and their capabilities. Classical versions of extension theory have been put forward in the 19th and 20th century by thinkers like Marshall McLuhan, Arnold Gehlen, Henry Bergson and Ernst Kapp. In recent years, philosophers, including myself, have attempted to further systematize and improve extension theory (Brey, 2000, 2005; Lawson, 2010; Heersmink, 2012; Steinert, 2015).

The most influential classical version of extension theory has been put forward by Marshall McLuhan. In his famous *Understanding Media*, subtitled *The Extensions of Man*, McLuhan depicts technologies as extensions of human beings that extend beyond the skin various body parts and organs of humans (McLuhan, 1964). McLuhan made a basic distinction between two kinds of extensions: those of the body and those of cognitive functions, including the senses, the central nervous system, and the brain. Extensions of the body are technologies that augment or aid parts of the body that are used for acting on or protecting oneself from the environment, or regulating bodily functions. These include our limbs, teeth, skin, and bodily heat control systems. He theorized that during the mechanical age, technologies were developed that extended our bodies: bows, spears and knives extended our hands, nails and teeth; the wheel extended our feet; and clothing extended the function of bodily heat control and protection of the skin.

During the electrical age, McLuhan claimed, our senses and central nervous system were extended. He analyzed media as extensions of the senses, particularly those of sight and sound. The radio and telephone are long-distant ears, and visual media are extensions of vision. Electric media, in particular, are extensions of the information processing functions of the central nervous system in that they take over functions of information management, storage and retrieval normally performed by it. McLuhan foresaw another age of digital computer technology in which creative cognition and higher thought, or "consciousness" is also extended and taken over by technology. He envisioned that these cognitive functions would be automated and translated into information functions performed by digital computers.

McLuhan's account provides an interesting perspective on technologies as the externalization and partial replacement of human bodily and mental faculties. However, when considered as comprehensive theory of technology, there are problems with it. The main problem is that McLuhan holds that every technological artifact is functionally similar to some human organ and serves to augment or complement this organ's function. There are, however, many technological artifacts that appear to have functions that are not similar to any found in human organs. For example, electric lighting serves to emit light, but there is no human organ that has a similar function. Likewise, magnets, ionizers, roads and nuclear reactors do not seem to have functional analogues in the human body or mind.

If not all technological artifacts extend human organs, can extension theory still be maintained? I have proposed a version of it which categorizes all technological artifacts as extensions of the person, but not necessarily in a one-on-one relation with human faculties (Brey, 2000). In my account, persons come equipped with a set of means, or capabilities,that is provided to them by the unaided body and mind. Technological artifacts add to, or extend, this set of means. Some do this by replicating, strengthening or enhancing means that are already present in the human body and mind. Others do this by providing qualitatively new means to people, such as the means to illuminate one's environment, to fly, or to magnetize iron.

I have also emphasized, in my account, that by extending our means, technologies extend our ability to attain ends, that is, to realize our intentions. Linking technology to human intention is important because it helps explain the evolution and application of technology: technological artifacts are developed and used because they are believed to help unaided persons realize their intentions. My extension theory can therefore be summed up as follows: all technological artifacts extend the set of naturally given means (i.e., human bodily and mental faculties) by which human intentions are realized, either by replicating or augmenting human faculties, or by introducing qualitatively novel capabilities.

I have since come to believe that this account, though true, is not complete, because it ignores the fact that people are always situated in an environment, and in virtually any environment, people have more means available to them than just their bodily and mental faculties. Environments contain various elements that can also serve as means: natural objects such as rocks and plants, technological artifacts and infrastructures, and people and animals that could serve as means to one's ends. So in any given situation, the total set of means available to a person does not just consist of those means provided by her body and mind and any technological artifacts that she has in possession, but also includes the means that she has access to in her environment. Therefore, any technological artifact that is provided to a person does not merely extend the means provided to her by her faculties, but should rather be seen as extending the set of means that is defined by the human faculties and environmental elements that are available to her for use. The added value of a technological artifact for a person depends on its added functionality relative to the already available set of means, and relative to the intentions that the person wants to realize.

The fact that things in the environment other than technological artifacts can serve as means to realize our intentions also serves to broaden the notion of extension. Many things can serve to extend the abilities of the unaided body and mind, not just technological artifacts. Natural objects are frequently used as means to realize our intentions: a rock is used to crack a nut, a tree is used to provide us with wood for building a home. Other people can serve as a (temporary) means to ends, when we ask someone to pass the salt or when we hire someone to do work for us. In addition, we have devised modes of social organization and social expression that help us realize our intentions. A language, for example, is a shared system of symbols and conventions that helps us communicate. Social roles and relations confer means to people that help them reach ends. For example, someone's appointment as teacher or accountant gives him the ability to contribute to society with his skills and to earn an income. The establishment of a friendship between persons provides them both with means to have rewarding interactions and to get emotional and practical support.

Organizational and institutional structures, procedures, and regulations can also directly or indirectly provide people with means that they otherwise would not have, including means to reach joint ends, and to help direct one's actions and make them more effective. In addition, acquired knowledge and skills also serve to extend the means or abilities that are available to persons. Acquired physical or social skills, like maintaining good balance, typing, driving, speaking French, solving differential equations, or greeting people, can help people further one's intentions. The acquisition of (factual) knowledge has a similar role, as it can help people make decisions, guide actions, and function as a useful resource for others. It can be concluded that there are many things other than technological artifacts that can serve to extend the set of means available to people to realize their intentions: natural objects and structures, people and animals, social conventions and procedures, social and organizational structures, and acquired knowledge and skills. Any consideration of the function of a technological artifact for a person should consider how it adds to all of these means that are already available to him or her.

Extension theory also needs to take into account that although the primary role of technological artifacts is to serve as extensions for human users to further their intentions, technological artifacts are also found in different roles. Notably, sometimes technological artifacts are mere elements in the environment that are not used by persons to serve their ends. For a particular person, a car or computer system owned by someone else may merely be an encountered object that does not serve any ends for her, although it may indirectly benefit the realization of her ends or harm them. Technological artifacts can also serve as (part of) the target or goal of actions, rather than as a means by which goals are reached. They may be objects that someone seeks to observe, study, damage, dispose of, repair, develop or acquire. In such actions, the artifact does not serve as a means for realizing goals, but rather as an object at which one's means are directed.

Types of Technological Extensions

So far, I have only considered cases of technology use in which artifacts are used by one person in order to further his or her intentions. However, artifacts can also be used by collectives and organizations. For example, the roof, central heating system and sewer system of an apartment building do not serve as means for one particular person, but rather serve as means for a group of collective: the inhabitants of apartments in the building. Likewise, a computer network or website used by an organization is not in place to serve the needs of any particular person, but rather to serve the needs and objectives of the organization as a whole. The organization should be seen as an agent with its own intentions and objectives, and technologies are used by it to further these objectives.

A distinction therefore needs to be made between technological artifacts that serve as *individual extensions* and those that function as *collective* and *organization extensions*, of groups and organizations. Collective and organizational extensions are also used by individuals, and help further their intentions. For example, the sewer system in an apartment building is also used by its inhabitants considered as individuals, and employees of a firm make individual use of its computer network, even when their intention in doing so is to further the objectives of the firm. However, such individual uses derive from the collective or organizational function of the artifact or system.

Note, also, that artifacts may serve different functions for different persons, collectives or organizations at the same time, simultaneously extending them in different ways. For example, an organization's computer network may simultaneously serve the individual ends of employees when they use it for private messaging. Seat belts protect drivers from physical harm, but simultaneously also help protect insurers from financial loss. A pair of jeans extends the skin of the wearer, but the logo it displays also furthers the intentions of the manufacturer by serving as an advertisement of the brand. The latter two examples also show that an artifact can further an agent's intentions without the agent being an end-user of the artifact. Both the insurance company and the jeans manufacturer have however taken prior actions to ensure that these artifacts serve as means that further their ends, even if used by others.

Another useful distinction is between *physical* and *social extensions*, where physical extensions extend physical capabilities of agents and social extensions extend social capabilities. A physical capability is one that enables non-social physical actions such as cutting, transporting, repairing and cooking. A social capability enables social actions, which are actions that have as their primary intent to impact social phenomena, such as communicating, becoming friends, starting an organization, taking up a new profession, firing someone, and purchasing something. Social actions may centrally involve physical objects, as when someone purchases a dishwasher, but what makes such action social is that they are about altering the socially constituted status of such objects, which, in the case of the dishwasher, is its property relation to an owner.

Technological artifacts may either function as physical extensions, as social extensions, or as both. Mechanical tools and devices, such as drills, automobiles, heaters, and binoculars, generally serve as physical extensions. They extend physical capabilities of persons, including those of physical manipulation and alteration, movement, temperature regulation and perception. Technologies that function as social extensions depend on socially constructed meanings and statuses that have been granted to them. As philosopher

John Searle (1995) has argued, artifacts can acquire powers that do not (solely) derive from their physical properties but rather from collectively imposed *status functions*. Status functions are socially agreed meanings or statuses that are bestowed upon things, evens or persons in virtue of which they are able to perform certain social function or roles. Dollar bills, for example, are able to function as a medium of exchange not because they have inherent physical powers to perform this function, but because people have collectively assigned the function of being a medium of exchange to them. Without this assigned function, dollar bills could not function as such. Likewise, a text editor can only function as a text editor because people have agreed that the squiggles manipulated by them constitute words and sentences that have meanings. Otherwise, it would only be a device for manipulating meaningless squiggles.

Technological artifacts that constitute social extensions include information and communication technologies, as well as other artifacts that are used to serve social, cultural, organizational and institutional roles. A clock, for example, serves to display time, where time is itself a social convention. Technological artifacts can also serve multiple physical and social functions simultaneously. For example, an expensive car can both have a physical function of transportation, and a social function of signaling status and wealth.

Within the class of physical and technological extensions, further distinctions can be made between several subclasses. Within the class of physical extensions, artifacts can be distinguished that have a function for physical action (e.g., cutting, welding, refining, heating), for transportation (e.g., automobiles, airplanes), for perception (e.g., microscopes, telescopes), for regulation (e.g., thermostats, cooling systems), and for protection (e.g., clothing, walls, landmines) against others. Within the class of social extensions, some artifacts serve a communication function (e.g., telephone), others an information function (e.g., web browser), and yet others may serve functions of play, friendship, work collaboration, and creative expression, as well as various organizational and institutional functions.

A special class is constituted by so-called *cognitive artifacts* (Brey, 2005; Norman, 1991) that extend cognitive capabilities of persons and organizations. A cognitive artifact is an artifact capable of displaying, storing, retrieving or operating upon information, and having this as it primary function. Computers are, of course, cognitive artifacts, but so are thermometers, newspapers, clocks, and measuring rods. Cognitive artifacts mainly belong to the class of social extensions, because most of them depend on socially defined conventions to assign meanings to signs and symbols. Arguably, one could also include devices like telescopes and hearing aids that enhance perceptual information and that have been categorized as physical extensions. Cognitive artifacts extend human cognitive function by extending human cognitive abilities like memorization and information storage, interpretation, reasoning, calculating, and conceptual thought.

In Brey (2005), I argued that computers initially qualified as cognitive artifact, since their function in the 1960s and 1970s was to process and produce information within scientific research, education, administration, and defense, amongst other fields. Since the introduction of computers with graphical user interfaces and multimedia capabilities in the late 1970s and early 1980s, and the World Wide Web in the early 1990s, computers acquired functions that are noncognitive and non-informational, such as playing computer games, listening to and composing music, watching movies, and communicating with other users. I call these activities noncognitive and non-informational even though they involve cognition and information processing. I do so because their primary function is not to process or display of information, but rather to enable activities in which performance of these information functions is not the central purpose.

So what is extended by computers when they adopt these noncognitive functions? All kinds of abilities. Computers have become extremely versatile, multifunctional devices that can perform or support many very different actions and processes, such as drawing, playing music, banking, chatting, operating external devices like heating systems and refrigerators, and live streaming of camera images from remote places. Almost any social action can be performed with or mediated by a computer, like chatting, paying, becoming friends, and signing a contract, and some physical actions, like playing music, watching movies, and turning one's heater up, can also be performed with computers. Computers have therefore become very powerful technological extensions, that replicate in virtual, informational form the capabilities of ordinary technological artifacts and other extensions.

4. Crime and Technological Extensions

Extension theory can help illuminate the role of technology in crime and law enforcement. I will now perform a general analysis of this role from the point of view of extension theory. The analysis proceeds as follows. First, I will identify the main classes of actors in crime and law enforcement, their intentions, and the relation between these intentions. Next, I will survey and classify technologies used by these actors and their role in realizing the actor's intentions. Finally, I will provide a historical analysis of the role of technology in crime and law enforcement that aims to assess how technologies strengthen the powers of criminals and law enforcement.

For the first step in the analysis, we will consider the main classes of actors in crime and law enforcement, their intentions, and the relations between these intentions. The dialectic of crime and law enforcement involves three main classes of actors: criminals, human crime targets and law enforcement officers (cf. Cohen & Felson, 1979). Let us consider them in turn. Criminals are individuals that habitually or incidentally commit crimes. Crimes are acts committed in violation of law and punishable by the state. A criminal normally has two kinds of intentions relative to an impending criminal act. First, he normally has the intention to commit the act in question. I say "normally", because there are crimes in which the intent to commit the act in question was not there, for example in involuntary manslaughter. I will not consider such cases here. I will also restrict my discussion to cases in which the perpetrator knows that the act he intends to commit is unlawful, even though there are cases of criminal behavior in which the perpetrator is unaware that the act he commits is unlawful. In most cases, however, the perpetrator has an intention to commit an act that he knows to be unlawful. This intention is normally accompanied by a second intention, which is to escape punishment for committing this act.

The second class of actors, within which I will make no further differentiations, is that of law enforcement officers, by which I mean individuals sanctioned by the state to enforce the law, particularly criminal law. This includes anyone with a state-sanctioned duty to prevent, detect and investigate crimes and apprehend and persecute criminals. The intentions of law enforcement officers directly oppose those of criminals. They aim to prevent unlawful acts from being committed, and once such acts have been committed, they intend to ensure that the perpetrator does not escape punishment for committing the act.

A third and final class that should be considered is that of people and organizations that are targets of crime, and therefore its potential victims. Persons are potential target of so-called crimes against persons, such as murder, aggravated assault, rape and kidnapping. Both persons and organizations are potential targets of crimes against property, such as burglary, larceny, robbery, vandalism, arson and fraud. Crime targets have an interest and therefore normally an intent to prevent themselves from being a victim of crimes against persons and against property. In other words, they have an intent to prevent criminal acts from taking place with them or their property as the target. They may also have an interest in the punishment of the perpetrators once a criminal act has been committed against them, but this is not invariably the case.

In comparing the intents of criminals, law enforcement officers and human crime targets, we see, first of all, that they have opposing intentions regarding the perpetration of criminal acts: criminals have an intent to commit criminal acts, law enforcement officers have an intent to prevent criminal acts from being committed, and crime targets have an intent to prevent criminal acts from being committed to them and their property.[3] Second, criminals and law enforcement officers have opposing intents regarding punishment: criminals have an intent of escaping punishment for criminal acts committed by them, whereas law enforcement officers have an intent of ensuring that such punishment is meted out.[4]

These intentions by the three classes of actors induce them to acquire and use technological and non-technological extensions that are believed by them to make these intentions come true. These extensions may include technological artifacts, knowledge, skills, persons who provide assistance and support, social conventions and procedures, and social and organizational structures. For example, to ensure a successful robbery of a liquor store, a criminal may mobilize and use relevant technological artifacts (for example, a gun

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[3] McCord (2004) offers some good discussions of the role of intentions in offending.

[4] There are additional, less influential, intentions that shape the extensions of the three classes of actors. For example, it is an intention of society as a whole that law enforcement does not abuse its powers. The extensions of law enforcement are to some extent shape to prevent such abuse. For example, some jurisdictions nowadays require police to wear bodycams, motivated in large part for their ability to expose police abuses.

and a getaway car), knowledge (of the layout of the liquor store, its security features, and its contents), skills (in using a gun, or in breaking open a cash registry), accomplices (other persons who help in the holdup or drive the getaway car), and social conventions and procedures (for example, hand signals that can be made to accomplices, and agreed-on procedures for carrying out the robbery).

Technological extensions for and against crime

The technologies sought by criminals for their criminal pursuits come in two main types: technologies for committing crimes, and technologies for escaping punishment.[5] (Some technologies may fall into both categories.) What are relevant technologies in these categories depend on the type of crime. Let us first consider technologies for committing crimes. These are technological artifacts and processes that enable a criminal act to be committed at all or that enable it to be committed more reliably, effectively and safely. (Premeditated) Crimes against persons, such as murder, aggravated assault and rape, may include technological artifacts to help perpetrators get near the victim, to threaten or restrain them, to hide the crime from bystanders and observers so that it is not interrupted, and to commit the physical act that constitutes the crime. Crimes against property, such as burglary and robbery and, include technologies to get close to the crime target and get access to it, to avoid detection while doing so, to coerce or restrain persons on the premises, and to transport the property to a safe place. Crimes against society, finally, such as prostitution, narcotics violations, gambling and weapons law violations, constitute a diverse group that involves a variety of technologies for committing the crime.[6]

Artifacts for committing crimes include the following:[7]

- Artifacts for getting information about crime targets and for planning a crime: cameras, eavesdropping equipment, hacking software, etc.
- Artifacts for getting access to crime targets: burglary tools like crowbars, lock picks, bolt cutters, torches, and explosives
- Artifacts to disable or block security systems and cameras: wire cutters, signal jammers, hacking tools, etc.
- Artifacts for threatening, restraining or coercing persons: knives, guns, handcuffs, sedatives, artifacts such as nude photos that are used for blackmail, etc.
- Artifacts for maintaining communication between criminals: mobile telephones, computers, etc.

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[5] There is not an extensive literature on the technologies of crime and control, but natable works include Byrne & Rebovich (2007), McGuire (2012), and Marx (2016).
[6] The classification of crimes into crimes against persons, against property and against society is taken from the classification system used in the United States (National Incident Based Reporting System).
[7] The notion of artifact is conceived broadly, to include both technological and non-technological products.

- For cybercrime: software tools and services for breaking into computers, causing damage, and stealing data, such as exploit kits, botnets, fake fingerprint kits and Trojan horses.

Artifacts for escaping punishment include the following:

- Artifacts for preventing, altering, destroying, concealing or falsifying physical evidence (fingerprints, tire tracks, bodies, DNA, camera images, physical evidence of break-in, etc.): gloves, masks, cleaning products, disposable phones, data-erasing software, encryption software, web anonymizers, artifacts that are used to manufacture or constitute false evidence (e.g., fabricated DNA evidence, false Internet alibis, a murder weapon planted on a victim to suggest suicide), etc.
- Artifacts for a secure escape from a crime scene or from a police pursuit: fast cars, weapons, bullet-proof vests, mobile phones, door reinforcements (in hideouts), alarm systems, false digital trails, etc.

Criminals have increasingly powerful technologies at their disposal to effectively commit crimes and escape punishment for them. The technologies used in law enforcement have exactly the opposite aim: preventing crime and ensuring that criminals are punished for their crimes. Their first intent, that of preventing crime, is aided by artifacts that include the following:

- Databases with information on crime targets, (potential) criminals, and the possession and the distribution of (illegal) means for committing crimes, which help law enforcement determine where to mobilize its resources to prevent crime
- Artifacts that aid live surveillance and investigation of (potential) criminals, their preparatory activities, and crime targets: surveillance cameras, wiretaps, satellite feeds, live maps, helicopters, etc.
- Artifacts for hardening crime targets against crime (to the extent that this is seen as the responsibility of law enforcement): locks, fences, alarm system, firewalls, etc.

The intent of punishing crime is aided by artifacts such as the following:

- Artifacts to support the detection, processing and matching of physical evidence: fingerprint kits, cameras, databases (for convicts and their fingerprints and DNA data, licensed drivers, stolen and found property, vehicles, and so forth), etc.
- Artifacts for effectively locating and interrogating witnesses and suspects: GPS trackers, databases, lie detectors, etc.
- Artifacts for the pursuit and apprehension of suspects: fast police cars, weapons, bullet-proof armor, two-way radios, arrest cars, thermal imaging cameras, battering rams, handcuffs, etc.

Crime targets, finally, invest in artifacts and systems that prevent them from becoming the victim of crimes. They do not normally engage in surveillance of potential criminals and criminal activity, but focus on the immediate protection of themselves and their property. Artifacts used therein may include the following:

- Artifacts for physically protecting oneself and one's property and for deterrence: weapons, locks, fences, firewalls, reinforcements, safe rooms, etc.
- Artifacts for surveillance of crime targets and for signaling criminal activity: surveillance cameras, alarm systems, etc.

The employment of these technological artifacts by criminals, law enforcement and human crime targets should be understood as part of their strategies to optimize the set of means (extensions) that they have available to realize their intentions. Since these intentions are diametrically opposed between criminals on the one hand and law enforcement and human crime targets on the other, we see that an increase in one party's capability of realizing its intentions corresponds with a decrease in the opposing party's capability of realizing its intentions. This decrease is either achieved by employing means that can damage or destroy the opposing party's means (e.g., wire cutters that incapacitate an alarm), means that leave opposing means intact but that create conditions to render them less effective or irrelevant (e.g., a bullet-proof vest that partially neutralizes the advantage of a gun, a signal jamming device, gloves that make fingerprint collection irrelevant), and means that otherwise add new capabilities that cannot be effectively countered at the time (e.g., a Trojan horse that can pass through any firewall).

The process of adding better and better means that iteratively negate the advantage of the opposing parties or exploits their weaknesses makes the process of extension resemble an arms race (Ekblom, 1997). As criminals equip themselves with better, more powerful technological and other extensions to support their criminal intent, law enforcement and human crime targets respond in kind, and vice versa. This includes the iterative development and deployment of technologies to thwart the advantage of the opponent: criminals build Trojan horses to infect computers, which are then countered by firewalls, which are then in turn countered by Trojan horses that can disable or circumvent firewalls, etc. What one sees in countries in which crime is rampant is that criminals have won the arms race between criminals and law enforcement: they have the best technologies, modes of organization, information, training for skills, and other extensions. This, however, is not to say that systemic corruption, social deprivation, or high levels of inequality might not also contribute to high crime societies.

The Evolving Impact of Technology on Crime and Law Enforcement

To expand the above analysis, I will now briefly consider the evolution of technologies for crime and law enforcement in historical perspective, from the point of view of extension theory. Throughout history, technological advances have altered the targets of crime, the kinds of crimes that are committed to them, the ways in which they are committed, and the way in which law enforcement operates to prevent and respond to these crimes. Prior to the late 19th century, the means for protecting crime targets mostly consisted of physical devices and structures like locks, fences, and weapons, and surveillance was limited to observation by law enforcement officers walking the streets and limited keeping of physical records that were difficult to search and reproduce. There was no developed forensic science, and so persecution of crimes based on physical evidence was often difficult, which frequently made it difficult to persecute crimes at all. In this context, societies tended to choose harsh methods of punishment, often in public, as deterrent and used torture to extract confessions. In this way, the lack of other means for law enforcement to prevent crime and persecute criminals could be partially redressed.

Crime and law enforcement entered a new stage in the late 19th and 20th century, with the introduction of electric and electronic devices and the establishment in the early 20th century of forensic science. Electricity and electronics gave electronic communications, which benefited both criminals and law enforcement, and electronic surveillance, which mainly benefited the latter. Advances in forensics gave law enforcement powerful new tools for apprehending and persecuting criminals. On balance, the new technologies benefited law enforcement more than they did criminals. However, the increasing complexity of society, especially of cities, and the rise of organized crime (which constitutes a type of social extension of the individual criminal) partially offset this advantage. Many of the technological products of the 20th century also became targets of crime themselves, because of their value and expense. Products like cars, televisions and stereos became prime targets of theft.

With the introduction of computers in society in the 20th century, computer crime became an issue. Its real breakthrough came in the 1990s, with the emergence of the Internet as a mass medium. The emergence the Internet and computer networks made it possible for criminals to break into computers from a distance and therefore made computer crime much easier than it was before their emergence. Computer crime, or cybercrime, is crime in which the computer is used as a target or tool. The emergence of information technology has not only resulted in computer hardware becoming a target of crime (e.g., computers, smartphones, tablets) but also software and data have become a frequent crime target (e.g., digitally encoded credit card numbers, electronic money, downloadable digital content, personal information records and personal identities). When persons and organizations are the target of cybercrime, or when society is the target, the computer functions as a tool rather than the target (Wall, 2007; Brenner, 2010). Computers are nowadays used as tools for a wide variety of crimes, such as harassment, extortion, identity theft, drug trafficking, and child pornography.

As argued in section 3, computers reproduce in electronic form many social actions, objects, practices and institutions, from communicating to listening to music to banking. The Internet has become itself a kind of society, an electronic environment in which people work, play, form social relations, and engage in many of the practices that they also engage in in physical environments. It is for this reason that cybercrime should not be understood as just a new type of crime on top of all the others. Because the institutions and structures of society have moved for a significant part online, the Internet has become the new frontier for a broad range of previously existing criminal pursuits, including theft, fraud, extortion, harassment, vandalism, prostitution, child pornography, drug trafficking, and many more.

Cybercrime is more difficult to combat than ordinary crime. In cybercrime, criminals are able to maintain a large distance between themselves and the crime scene (McGuire, 2009; Yar, 2013). They have strong means for remaining undetected and erasing their tracks, such as anonymizers, strong encryption software, and darknets. Criminal law is usually running behind the latest technological developments and cybercrime often crosses international legal borders, which requires strong international cooperation between law enforcement. Internet service providers often do not want to cooperate to protect the privacy of their clients, and laws that protect civil liberties may limit the abilities of law enforcement to do surveillance. Law enforcement has in recent years made heavy investments in means to fight cybercrime, which include setting up monitoring systems and databases to track and investigate suspicious activity over digital networks, strong collaborations between jurisdictions and with the private sector, receiving access to national and global surveillance programs for espionage and combating terrorism and like ECHELON, and efforts to outlaw software tools and practices that aid cybercrime. Nevertheless, cybercriminals are still at an advantage.

Although law enforcement is still at a disadvantage in the playing field for cybercrime, information technology has given it powerful tools to combat ordinary (non-computer) crimes. The creation of large, searchable databases for individuals, past crimes, and forensic evidence, and the introduction of data mining techniques have provided law enforcement with powerful tools to track and sometimes even predict crime. Security cameras, sometimes equipped with facial recognition and other tracking software, have provided new sources of evidence and detection. Information technology has also made new forensic techniques possible, such as odor-detecting devices that can find buried human bodies and imaging technologies for examining hidden features in documents. On the whole, information technology may have given law enforcement the advantage in ordinary crime, but has opened up a new frontier of cybercrime where criminals have the advantage.

5. Conclusion

This essay had two objectives: to review the major theories and approaches for the analysis of the role of technology in society, and to introduce a particular theory within this category, extension theory, and apply it to an analysis of the role of technology in crime and law enforcement. The review was carried out in section 2. There, I introduced and reviewed the fields of science and technology studies (STS) and the philosophy of technology, which are arguably the two fields most concerned with providing general theories of technology and its relation to society. I reviewed discussions of the nature of technology and technological artifacts, and of the ways in which society impacts the development of technology, and technology impacts social practices and institutions. Some main findings were that technology development is not a linear, deterministic process but involves an evolutionary process of variation and selection that is shaped by social factors and interests, that technological artifacts have interpretive flexibility and have different meanings and uses for different actors, and that technologies are not neutral but shape their social context, including human behaviors and practices, social and political arrangements and institutions, and human culture.

In sections 2 and 3, I introduced the extension theory of technology, as a powerful account for the analysis of the role of technology in society, and I applied it to the analysis of crime and law enforcement. The extension theory holds that technological artifacts should be analyzed as means that extend the ability of persons, groups and organizations to carry out their intentions or goals, along with non-technological extensions such as skills, knowledge, human resources, and organizational structures. Analyses of the role of technological artifacts as extensions, or added means, for realizing intentions can provide for assessments of the added value of technology in certain practices and of assessments of the way in which technologies transform and improve these practices.

In the analysis of the role of technology in crime and law enforcement, it was found that criminals on the one hand and law enforcement and human crime targets on the other have diametrically opposed objectives. Technological artifacts used by these groups, such as guns, Trojan horses, surveillance databases and alarm systems, were analyzed as means that are added to an existing set of means and that, in relation to this set, may or may not enhance the ability of one group to reach its objectives and weaken the ability of the opposing group. I ended with a brief analysis of different stages in the evolution of the role of technology in crime and law enforcement, including the introduction of electric and electronic technology and the establishment of forensic science in the late 19th and 20th century, and the introduction of information technology and cybercrime in the late 20th century. I hope to have shown that extension theory provides a powerful tool for the analysis and assessment of the role of technology in crime and law enforcement that invites further studies within its framework.

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