I castelli di Yale online. ANNALI DI FILOSOFIA
Vol. XII, n. 2, 2024, pp. 29-42 – ISSN 2282-5460

Augmented Imagination
Thinking Technology Beyond Extension[1]

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Abstract. *This article seeks to unravel the relationship between technicity and imagination, asking whether the latter can be extended by technologies or whether it risks being desensitised by its contact with technical prostheses. Augmented Reality (AR) will provide an emblematic case study to showing how the activity of imagination is not merely extended through technological devices, but is rather a material process that occurs when we are actively engaged in the manipulation and exploration of the world. The analysis of AR will then allow us to put to the test the theoretical model of extension that has dominated reflection within the philosophy of technology over the last two centuries. Maintaining that technical behaviour does not precede the manipulation of objects, but rather emerges from our encounter with sensible matter, the article will argue that imagination is always already externalized, always "outside" of us, as it is constantly reconfigured in the relationship with the environment and especially with technologies and media.*

Keywords. augmented reality (AR), imagination, technology, extension, incorporation.

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[1] This article was written in the framework of the research project "AN-ICON. An-Iconology: History, Theory, and Practices of Environmental Images". The project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 834033 AN-ICON) and is hosted by the Department of Philosophy "Piero Martinetti" at the University of Milan (Project "Departments of Excellence 2023-2027" awarded by the Italian Ministry of University and Research).
While the article is the result of a joint effort between both authors, authorship responsibilities were designed as follows: § 1, 2, 6 written by Anna Caterina Dalmasso and § 3, 4, 5 by Sofia Pirandello.

1. Shaped by things

The co-implication of technology and imagination was captured by the most famous scene of the film *2001: A Space Odyssey* by Stanley Kubrick (1968), in the critical prologue sequence *Dawn of Man*, in which, following the apparition of the monolith, a humanoid ape, representing a distant ancestor of our species, discovers that they can make a weapon from the bone of an animal carcass. One of the most iconic moments in film history encapsulating the birth of technology and culture, this sequence is often interpreted as an emblem of a – historically unlocalizable – turning point in the development of human evolution. Re-enacting the mythical moment of humanity's first use of a technical tool, Kubrick's film seems to suggest that the roots of civilization are entangled with the shadow of violence, but, at the same time, that technicity is something that inherently belongs to human life, that the possibility of being extended or augmented through technology should be deemed an intrinsic feature or even the specific trait *par excellence* of humanity. Humans are thus to be defined by their ability to manipulate their environment, to turn things into an amplification of their body and will, developing the idea that, to put it in the words of Bernard Stiegler, a «prosthesis is not a mere extension of the human body; it is the constitution of this body *qua* "human"» (Stiegler 1998, 152).

However, it is rarely emphasized how this famous sequence also underscores the fact that the transformation of a mere thing – the bone as the inert remains of a living creature – into a technical object with a purpose-oriented function is driven by an imaginative interplay. When the humanoid ape first wields the bone as a tool, they do not direct their newfound competence immediately against the herbivores that populate their environment, or, as they will later do, against one of the members of a rival tribe. Instead, the femur taken from the skeleton crashes down on the inanimate carcass that lies in front of them: an action that should by no means be taken as a consequence of their bestial nature, since no animal would attack a corpse – for what would be the purpose of beating inert matter? You cannot kill what is already dead. Hence, the first use of what is presented as the primordial appearance of a technical tool is introduced not through the *direct* application of its functions, but, we might say, through a fictive enactment. Technical behaviour does not precede the manipulation of the bone-as-object, it is rather the encounter with the object, and the gestures that activate it, which allows the emergence of technicity as a possibility offered by matter itself. In other words, it is the object itself, used as a *prop* in a make-believe (Walton 1990), that provides cues and serves as a prompt for imagination, so that the humanoid ape can engage creatively with their surroundings and eventually turn the fictive performance into technical behaviour.

The activation of the affordances of the bone-as-tool happens through a mimetic, non-utilitarian, and explosive gesture of energy release. In the sequence this is emphasized visually by the use of slow motion, highlighting the decisive and sacral nature of this augural gesture, as much as its gratuitous character, the expenditure of force and the movement of *dépense*, that it entails. Thus, what happens is that a fragment is appropriated from physical and continuous space and comes to embed a virtual dimension, thereby operating a transmutation of the sensible into an operational-imaginative chain. To reframe this in Ellen Dissanayake's terms, we could see technicity as a form of «making special», a process of ritualisation that transforms ordinary experience, changing its symbolic meaning and redefining the materiality of things (Dissanayake 2001).

This primaeval scene of technicity is initiated with a figurative action, a mime, which is both an index of the work of imagination which is afoot and an invitation to such imagination. It is only in the space opened by mimicking the action of killing, that our ancestor discovers their capacity for manipulation, and, hence, their dominance over other beings and eventually over their own kind. Technicity stems from such imaginative

operationality: if the bone is no longer *just* a bone, but can be also seen as a tool, then by metonymy even the inert carcass of the animal can signify something other than itself – the living animal, the prey. It is the non-purpose-oriented doing, the process of the ape toying with the remains of the dead animal, which progressively transforms into an oriented action, precisely *by miming* the destructive technical action to come.

If the human body can endow itself with technical skills and tools capable of increasing the range of its action on the environment and mediating its relationship with other objects and beings, this capacity for technological augmentation relies on an ability to project itself virtually beyond its limits, that is to engage in virtual actions. «My body is wherever there is something to be done», wrote Maurice Merleau-Ponty in a famous passage of *Phenomenology of Perception* (Merleau-Ponty 2005, 291), to single out the distinctive feature that makes human beings able to «orient themselves towards the possible, the mediated» (Merleau-Ponty 1963, 176), and to project themselves into the future and the past, constantly transcending their goals.

We might also call imagination this capacity of the body to systematically overcome its possibilities (Montani 2014, 33) and its tendency to virtually project itself in time and space, which guides human behaviour. We could then argue that technicity, driven by this ability proper to the human body of relating virtually with the world, stems from imagination itself: it comes into being as an effect of an imaginative interaction, as a product of the play of imagination.

In this perspective, technicity and imagination converge and are mutually interconnected: as much as imagination "secretes" technical action, technicity activates imaginative potentials. Technicity in its primordial appearance can be radically reframed as the capacity to manipulate things by revealing in them unprecedented affordances, while imagination can be understood as the very foundation of our capability to "hijack" or "hack into" sensible matter so as to make it become something else. Thus, technology and imagination seem to be constitutively intertwined. Yet, describing their interaction is far from simple.

2. Questioning the extension theory of technology

Understanding technicity in its constitutive intertwining with imagination would allow us to partially put into question the theoretical model by means of which philosophers and theorists have traditionally framed the relationship between human beings and technology: the paradigm of extension (Brey 2000; Steinert 2016), namely the idea that technology is an externalization or prosthetic expansion of human capacities, enabling individuals to transcend their biological and physical limitations, thus enabling new ways of interacting with the world and having an impact on human embodied experience. In the philosophy of technology, the paradigm of extension has been articulated in accordance with a two-way movement: extension shall not simply be thought of as an amplification of human capacities, but as a more complex dynamic that is articulated as a dual complementary trajectory of both extension and incorporation.

On the one hand, we can observe that technical objects result from a process of externalization of bodily functions that are projected by the human being into the environment. This perspective was first introduced by Ernst Kapp at the end of the 19th century (Kapp 2018), suggesting that every tool could be understood as an exosomatic organ, namely as the «projection of an anatomic organ [*Organsprojektion*]». It is in the light of this projective movement that André Leroi-Gourhan described the development of technological behaviour in *homo sapiens*. However, for the French anthropologist and palaeontologist, no essential distinction could be drawn between the tool as a technical

"organ" and the bodily organ as a biological element: a technical instrument, such as a stone tool, emerges from sensible matter in the same way as the hand, insofar as they both are a «secretion of the body and the brain» (Leroi-Gourhan 1964, 132). In so doing, Leroi-Gourhan implicitly establishes a fundamental continuity between the organic and the inorganic, between our living body and its technical prostheses, inseparable from the development and historical evolution of the living body.

In their relationship with human sensibility, things cease to be mere objects and become instead «quasi-organs», contributing to our being open to the world and constituting an «extension of existence» (Merleau-Ponty 2005, 135). The paradigm of extension dominated reflection around technology during the 20th century, culminating in the work of Marshall McLuhan, who defined media as extensions of the human (McLuhan 1964). But, since every technical object affects and modifies the human sensorium and its cognitive capabilities, the media theorist also highlighted how the amplification deriving from the movement of extension in the environment always entails a form of mutilation, a self-amputation (McLuhan 1964, 42), since at the very moment in which the possibilities of individuals are extended, they are simultaneously affected by the specific dynamics imposed by the medium.

In fact, as long as it mediates our relationship with the world and others, any tool, device, or interface inevitably selects, amplifies, or reduces in various ways aspects of our experience (Ihde 1979, 1990) and also comes to filter our engagement with the world. By mediating our encounter with the world and with others, technologies alter the conditions of perception and thought, as they come to modify the prevailing structures of experience; hence, they can have an impact on our faculties. In the wake of McLuhan's work, Derrick de Kerckhove suggested that electronic media have come to extend not only our bodies and our nervous system, but also our psychology, acting as «psycho-technologies» (de Kerchkove 2014), in that they reproduce and amplify the powers of the human mind, an idea already anticipated by the psychologist Hugo Münsterberg with regard to the cinematic apparatus (Münsterberg 2013).

Conversely, on the other hand, if the human body extends itself into the environment through its instruments, it will also end up incorporating these mediations into its body schema and behaviour; such extensions and practices will become part and parcel of its way of engaging with the world and others. The movement of externalization then implies a parallel process of internalization or interiorization (Hall 1976), the two to be interpreted as complementary theoretical models on which hinges our interaction with the environment.

Through his account of corporeality, Merleau-Ponty provided an implicit phenomenology of instrumentation (Ihde 1990, 40), showing how the centrifugal movement of extension, that is the body's capacity of «dilating our being-in-the-world» and «changing our existence by appropriating instruments» (Merleau-Ponty 2005, 127), is always coupled with a centripetal movement of incorporation, since, through habit, our body has the power to include objects within its system of virtual action, and to embed its projections by incorporating elements of the environment. As in the classic example of the cane, which extends the range of action and perception of the blind person using it and, at the same time, is no longer perceived as a separate entity: it ceases to be an object and is incorporated as if it were an area of sensitivity (Merleau-Ponty 2005, 165).

Each new tool elicits a – more or less accelerated – process of adaptation of the body and its possibilities; that is, technologies come to reorganise our sensorium and reconfigure our cognitive and relational behaviour. In the terms of Vilém Flusser, we can say that every extension of the body resulting in a prosthesis also implies an *epithesis* (Flusser 2014, 165) as its reverse movement: that is, when the tool becomes an extension of my arm or the pen that of my finger, inversely my organs need to rearrange and modify themselves to adapt

to the new affordances that are ushered in. After having shaped an instrument, human beings will also have to reshape themselves around it, to adjust themselves to technology by supporting it with their gestures and attitudes, both from a bodily and cognitive, as well as a cultural and intellectual point of view.

Given this two-fold dynamic, we can now consider whether the paradigm of extension and incorporation could apply to the relationship between technology and imagination. First, we will explore to what extent imagination can be augmented or enhanced through technologies, understood in the broad sense as including the «techniques of the body» (Mauss 2006). This would eventually allow us to assess whether the extension theories of technology hold true, when questioned through an account of the co-implication of technicity and imagination. If imagination lies at the core of the development of technicity, driving the processes of virtual projection and introjection, could the capacities of imagination, in turn, be extended and externalized through technology? How do technologies produce an amplification of the powers of imagination?

If imagination can indeed be extended, would this imply the existence of something like an inner imaginative faculty – which can be externalized? We may wonder, is this the case? If, drawing from our analysis of Kubrick's famous sequence, technical behaviour seems to emerge as a by-product of the body's ability to interact virtually with the material world – picking up cues and engaging with the affordances embedded within it – how should we account for the imagination outside of us?

The coupling between bodies and technologies has never been as evident as in recent years, by virtue of the widespread diffusion of portable and wearable devices that act like as many forms of augmentation of our embodied engagement with the environment. Today virtual-, augmented- and mixed-reality technologies come to challenge once more this complex dynamic. How is imagination reconfigured in the relationship with these technologies? And what can these media practices teach us about the way imagination might be extended and reshaped by its interaction with technology? Through an analysis of the contemporary mediascape, we will then ultimately consider how the possibility of augmenting imagination through technologies can reveal something of the inherent structures of technicity itself. By investigating the possibility of augmenting and externalizing imaginative operationality, we will seek to argue that this account of technicity in its relationship with imagination could supersede or at least provide a deeper understanding of the movement of extension commonly used to describe technological augmentation.

3. The creation of an epistemic space

In an article published in 1994, David Kirsh and Paul Maglio introduced the concept of «epistemic action», namely an action performed for the purpose of more fluent reasoning. According to the two authors, such actions, which at least in theory can be distinguished from "pragmatic" and merely executive actions, are used to reveal information in the environment in order to improve the ease, speed and reliability of one's reasoning. For example, tying a knot in a handkerchief is not the ultimate goal of the action of tying a piece of cloth: it serves to make a note of something I want to remember. Epistemic actions can thus refine problem-solving tasks because they reduce the memory required for the computational task at hand (or space complexity) as well as the number of steps needed (or time complexity), thereby reducing the likelihood of making mistakes (Kirsh & Maglio 1994, 513-514). Kirsh and Maglio take the famous video game Tetris as an example, because it is easy to learn, even in a short time, and because it allows for a significantly reduced number of possible actions (rotation, translation, release). Specifically, the two

authors observe an improvement in speed and efficiency in the choices made by players who actually manoeuvre external objects, compared to those who only use cerebral resources. In short, trying out different possible rotations of the famous coloured polygons is not only useful for actually placing them, but also, and above all, for assessing where and how to position them before they are set down. Of course, this does not mean that epistemic actions cannot be unsuccessful: it may happen that I have absolutely no recollection of why I tied a knot in my handkerchief. Moreover, in most cases, actions cannot be strictly divided into those that have an exquisitely pragmatic purpose and others that are performed simply to improve one's computational performance: several everyday actions have both a pragmatic and an epistemic purpose.

Crucially, however, Kirsh and Maglio's contribution was the first to provide experimental evidence that involving the body and interacting with objects in a mental process can significantly improve reasoning outcomes.

For this to be possible, then, it must be admitted that some cognitive resources lie outside the boundaries of the human individual's body. In other words, human beings do not simply virtually project their cognitive activity outside their bodies: the body in action and the exchange with matter are genuine (and therefore active) mental resources for themselves. Recently, Maria Danae Koukouti and Lambros Malafouris have suggested that the study of imagination should also be reconsidered from this perspective, describing it as a material process resulting from the interaction between the brain, the body and the environment (Koukouti & Malafouris 2020). The two authors take the case of clay as an example: no artisan, however skilled, can simply impose a predetermined idea onto the material. Instead, the object that is actually produced is the consequence of the artisan's relationship with the clay in a specific event.

In a way, every technical manipulation re-enacts the circumstances of the primaeval technological gesture shown in *The Dawn of Man* sequence. As much as the material responds to every human stimulus, the matter in turn imposes impulses and opens up at least partially unforeseen directions of work. While there is certainly a *savoir faire* that is acquired through repetition and that allows a project to be worked out in advance, it is not reducible to the activation of a neural pattern, but is rather developed thanks to a physical habit built up through a series of movements performed at a specific rhythm and imprinted in muscle memory (Koukouti & Malafouris 2020, 42). Imagination cannot therefore be considered as an exclusively individual, internal and private faculty, nor as an activity carried out independently of things: rather, it is a phenomenon that occurs when all these components come together and whose course changes depending on the matter with which we come into contact. In this sense, according to Koukouti and Malafouris, imagining is a material process that manifests itself when we are involved in the manipulation and bodily exploration of the world, and they therefore describe it as the glue that holds together the various parts of the environment, mediating and modulating their collaboration. Indeed, there is not much we can imagine outside of the synergistic exchange between the brain, the body and the environment (Koukouti & Malafouris 2020, 42).

Since the 1960s cinema and other media have been an area of bitter contestation, amid fears of the autonomy of machines and the alienation of human beings from their capacities, now externalized in technical devices (Grespi 2019, 73). These fears take on the aforementioned McLuhan's idea that technology determines an empowerment of the human being by delegating some of their capacities to a technical tool. As a matter of fact, the so-called "new media" came to be seen as threatening, as having the potential to diminish the human imagination (Grespi 2019, 73).

However, in the light of theories such as those of Kirsh and Maglio or Koukouti and Malafouris, it does not seem possible to speak of a technical externalization of certain internal capacities, since creative thinking has always been, at least in part, outside us,

"naturally" predisposed to branch out into practices and objects. "Externalization" and "internalization", "extension" and "incorporation" are terms that prove inadequate for expressing the complexity of our relationship with material culture, since they propose a dynamic based on a rigid distinction between inert objects and a conscious human agent, who gives and loses, suffers additions or impairments, but ultimately directs and guides the exchange. On the contrary, internal and external resources are equally decisive in the constitution of the mind, and in particular of creative thought, the harmony of which is also made up of frictions, resistances and rigidities, but not of open conflict or total alienation.

In fact, we can affirm that becoming distributed among technical devices is the necessary condition for a living being to be able to imagine: objects serve as material cues for manipulation and ultimately orient the imaginative process as much as we do. In short, we needed the humanoid ape and the bone to engage in a reciprocal alignment of gestures for the technical imagination to emerge.

4. Innervated bodies

If we consider the contemporary mediascape, a phenomenon which is the contrary to externalization seems to be taking place. Thus, the attention of the largest technology companies is now converging on bodily movement and gesture.

In this respect, it is particularly pertinent to consider portable or wearable technologies, referred to as augmented reality (AR). From its origins, AR has been conceived as a way of integrating, modifying and enhancing the real environment, without replacing it, but adding electronic potentialities to the affordances already present in it (Wellner, Mackay & Gold 1993). The term first appeared to describe a prototype of a visor designed to speed up aircraft assembly workers by allowing them to see the instructions necessary to carry out a task in their field of vision, while still working: by reducing the time needed to retrieve information, AR was expected to improve productivity and enhance workers' performance (Caudell & Mizell 1992).

From that point onwards, smart glasses represented the ideal endpoint for AR technologies. Google developed Glass, a smart head-mounted monocle display, which was nevertheless withdrawn from the market in 2015, just one year after its launch (Eugeni 2021, 19-21). Similarly, Microsoft has recently announced that production of HoloLens, the most widely used smart glasses in the field to date, will cease in 2027 (Warren, 2024). Apple attempted to enter the market with the Vision Pro, a visor that was regarded as a prospective future leader in spatial computing. Nevertheless, the production of this device is also scheduled to end in 2025 (Barbera, 2024). Meanwhile Apple has already begun the development of models of wearable technology designed for general everyday use and home accessories capable of projecting responsive images (Verplaetse & Della Silva, 2023), and Meta has unveiled Orion, a prototype of smart glasses that it intends to launch on the market in the next few years (Meta 2024).

Due to technical limitations that are apparently slowing down the production of smart glasses, AR is currently mainly disseminated through portable devices such as smartphones or tablets and can therefore be defined more generally as a form of reality integration thanks to the addition of digital entities to the subject's perceptual environment. This then covers all technologies that involve the superimposition of digital elements on the field of vision, from mobile phones to visors to smart glasses.

On the other hand, why is it that, despite the obvious difficulties, smart glasses continue to attract the investments and energies of the major computer manufacturers? It is because, by literally grafting themselves onto the individual, they would allow most of the tools we use today to be integrated into humanity's earliest and most fundamental tool,

the body, turning it into the ideal computer. The goal with AR is therefore to realise devices for the so-called "naturalisation" of the technological experience: that is, they must provide an interface with which we can interact with sight, voice and gesture as we would with any concrete object in the world (Williams, Garcia & Ortega 2020). When engaging with them, the user manipulates responsive but intangible objects, for instance, documents, photos, videos, shared projects, works of art, and even distant individuals appearing in the form of avatars.

So, consciously or not, the creators of AR technologies, both portable and wearable, seem to have incorporated into their design the idea that a body in motion is a body that thinks, and that the mind is made up of objects, movements and space rather than solely of internal faculties. In fact, AR at least integrates rotation, oscillation and movement in different directions: when we use a tablet or a mobile phone to "reveal" objects and digital information in the environment, in addition to moving our hands, as we are used to doing with touch technologies, we also have to mobilize both the device and ourselves in space.

In some cases, organs such as the skin become full-fledged components of digital and networked technologies. The prismatic lens of Google Glass Enterprise Edition 2 used to redirect the light beam produced by the device directly onto the retina; to open the menu screen while wearing HoloLens 2, users must raise their left arm in front of their field of vision and click on the Microsoft icon that appears on the inner surface of the wrist. Apple Vision Pro is equipped with a machine learning system that scans the wearer's face to create an avatar that is as close to the wearer's appearance as possible, which promises to preserve the wearer's personality even in virtual interactions. The scanning process is also used in the pre-purchase phase to ensure that the wearer's fit is as comfortable as possible. Those parts of us that literally offer themselves as a support seem to constitute the solution to continuity between human and non-human, animate and inanimate, a border where the distinction fades and blurs, so that a momentary integration between living body and technological body occurs (Carbone & Lingua 2023, 145).

Eyes, hands, skin are thus incorporated as hardware elements of the device, together with the complex of bodily movements and behaviours that are fundamental to its functioning. The movement of the whole body, including the eyes and voice, assumes the character of taking grip. With HoloLens 2, for example, in addition to the voice commands now available on most devices, I can move screens by rotating my head, activate functions by staring at them, and select and modify the size and properties of the elements that appear with a pincer movement made by thumb and forefinger.

The basis of the operation of wearable AR, even when experienced by means of handheld devices, is first and foremost eye-hand coordination. More specifically, it allows the eye and hand to swap roles: the eye can finally touch as if it were meeting a surface; the hand alters things from a distance as if it were seeing them. The hand feels through space and time; it no longer compromises itself because it touches, without taking hold of, objects that have an ephemeral character. The renewed "augmented" coordination of vision and touch can thus count on the important advantage of operating at a distance, of "directly" manipulating an object that is only digitally present in its own space.

Certainly, we do not owe the importance of gesture in our evolutionary path to these devices. With the advent of digital technology, however, the cognitive bearing of gestures has acquired a further nuance of meaning: we think with our hands also because, over time, touching has become the operative gesture par excellence, holding together the material quality of direct manipulation and the abstract quality of reflection that does not imply to immediate practical purposes (Flusser 1985, 28-29). It is no coincidence that Apple began to speak of «spatial computing», rather than augmented reality: the aim of this type of tool is to innervate the subject's body (Benjamin 2008) in order to transform the surrounding

environment into a space for thinking, in which one can experiment with objects that offer the possibility of producing a large number of the aforementioned epistemic actions.

As we have seen, everyday experience already activates a "virtual sensibility". Contemporary cognitive science has very effectively proposed summarising the sense of interpretive and agentic potential that responds to environmental stimuli in the expression «I-can» (Di Paolo, Buhrmann & Barandiaran 2017, 230), reminiscent of the famous Husserlian formulation. Even in terms of the anatomy of the brain, it has been pointed out that, in addition to the more widely discussed "mirror" neurons, there are neurons, known as "canonical", that are specifically designed to gauge the extent to which it is possible to take hold of an inanimate object without the latter being involved in an action that we ourselves perform or that we see someone else performing (Rizzolatti, Fogassi & Gallese 2002, 151). In this respect, interactivity is not limited to digital material. For example, when I see a cup on the table, I am immediately led to feel the range of virtual actions that my body could perform in relation to the object, and only thanks to it (e.g., gripping, moving, bringing my face closer to drink).

What is specific to AR is that it works to make visible the "I-can" of the user's space, highlighting as much of the potential for modification and intervention available to the user as possible, and thus arguably expanding the range of information and connections that can be perceived without it. In this way, the augmented digital entities with which we interact are designed to increase the informational and operational scope of a context, particularly in specialised fields such as medicine, warfare, industry and advertising: it can instruct workers on the steps needed to build a particular model of an aircraft or a car; it can support the strategic operations of an army; it can show us how we would look with a new pair of glasses that we have not yet bought. And it asks us to physically interact with its additions, potentially incorporating every movement we make into a way of thinking.

5. What do we mean when we say "augmented imagination"

In order for AR tools to work when we put into focus a section of space with our mobile phone or smart glasses, and to respond exactly as we want, the software we employ requires an extenuating training process. This training is not only for the machine that learns from our movements, but also for the consumers who have to learn how to use it. There is a reciprocal power play between the two poles, in which it is by no means obvious that the user is in control: as Don Ihde and Lambros Malafouris would say, «we make things which in turn make us» (Ihde & Malafouris 2019, 196). On the one hand, AR technologies bring about the fusion of the individual with the other in a broad sense, namely environments, objects, other beings, implementing the layers of reality, in space and time, on the basis of which the mind is constituted and nourished, and thanks to which it transforms itself; on the other hand, they read reality through algorithmic systems, thus conveying a fragmented and regimented understanding of it in a limited set of instructions.

If it is true that, in order to provide assistance, AR technologies use their privileged position as portable and/or wearable to innervate the complex system of human gestures, it is also true that they require us to repeat certain specific gestures, effectively teaching us how to behave in a given setting involving their use. In other words, to imagine following their code.

One might then be tempted to view this as a discontinuity, arguing that the imposition of an "augmented" imagination, with its now fully post-human characteristics, has brought about a radical break with the all-too-human imagination of the past. In the transition to the 21st century, through the proliferation of a range of technologies capable of juxtaposing new parts of the world in the environment, it might be said, we have learned to imagine by

adding layers of digital information between which to juggle and make previously unknown connections (Wellner 2018, 47). In the age of wearable and algorithmic computing, imagination would thus be claimed to have become a purely mechanical and digital operation, this time truly externalized as being increasingly entrusted and even delegated to the smart devices we use (Liberati 2022, 407-408).

But what level of performance can imagination truly ensure if it is not fundamentally an operation of assemblage, through the fruitful connection of elements near and far, present and past, and so on? The result of an interactive collaboration that links different constituents, imagination is always *between* the human being and the other realities that make up an environment.

On the contrary, given its constant innervation in a space and a body, its interactive and operational dimension, AR presents itself today as the technology of (human) imagination *par excellence*. While the advent of the digital has certainly opened up areas of activity that were literally unimaginable before, this has been possible because the imagination, always active in the construction and use of tools, reconfigures itself from time to time according to its interplay with our material culture. An element added to the fabric of the world cannot but change its entire texture. Augmented objects have become part of the environment alongside physical objects, but they offer us different possibilities that redirect operationality in space, starting with how they elicit reactions in the body (Pirandello 2023). Moreover, the use of AR still needs to be anchored in a physical environment: in this sense, the imagination that emerges from the interaction of different materials cannot be considered as being purely digital, but rather as being of a mixed nature.

AR is a technology that is deliberately designed to re-educate imagination, whose characteristic is precisely that of being shaped by the human relationship with technology. Using headsets and goggles, as well as screen-based AR, we are asked, as bodies in motion, to collaborate with objects in space and with other users, even at a distance (Lukosch et al. 2015). Indeed, augmented imagination extends its reach to include algorithmic systems that connect us to other individuals in distant places and times (Finn 2017, 193). Imagining has always meant thinking together; in this case, we are increasingly imagining together with objects that relate us to other objects and other people. Hyper-linking is the specific enhancement of augmented imagining, an increasingly common mode of thinking, creating and remembering. Indeed, AR has a strongly relational vocation, to the point of mobilizing collective proprioception (Fedorova 2020, 236-239). Greater connection, even fusion with the other, is one of the main promises of augmentation that computer networks have been pushing towards for years. Thus, by wearing devices such as HoloLens 2, one can make others see what one sees, even in real time, to create a shared perception derived from a single collective body, which could lead to the hypothesis of the emergence in the future of collective individuals (Liberati 2020, 43).

So, why, if we have always used technologies, should AR be considered a tool specifically concerned with imagination? Because it was designed for the very purpose of being implanted in the body, mobilizing it in as many activities as possible. Much like the case of Tetris, cited above, the expectation is that it will speed up our cognitive processes, reveal more possibilities, and eventually reduce errors in every task it is applied to. Regardless of the more or less creative results achieved, the use of AR necessarily affects the performance of the imagination, as it changes the way we bodily interact with objects in space.

The term “augmented reality” tends to emphasize a quantitative aspect. It is certainly true that, on the one hand, AR implies the addition of things and information in a space. But over time, “more” also means “different”: images and artefacts of the world are not the seat of human creative thought projected outwards. This is especially true in the case of responsive digital objects, which engage all of our cognitive resources, inside and outside

us, and demand constant physical exploration and experimentation, even for activities that do not normally require them, in order to transform as many actions as possible into hyperlinked epistemic actions.

6. What is inside is outside and vice-versa

This exploration of the constitutive entanglement of human capabilities and sensible and virtual matter, allows us to call into question the theoretical model of extension, to complexify it through the action of imagination. We now need to consider: if we can apply the paradigm of extension to the imagination, must we conclude that, as imagination is indeed augmented by technology, then our imaginative capacities might risk being atrophied or de-sensibilized, just as human beings risk being de-skilled in their interaction with technologies? In his account of technicity in human evolution, Leroi-Gourhan expressed a similar concern with regards to the possible effects of further technologization of the body and its functions. On the one hand, he wondered whether in the future, with ever increasing technological exteriorization, the human being will end up feeling «encumbered by the archaic osteomuscular apparatus inherited from the Palaeolithic» (Leroi-Gourhan 1993, 249). But, more importantly for our present discussion about the powers of imagination, he also pointed out that our familiarity with audio-visual communication, media, and devices would eventually lead to a loss of the exercise of the imagination, with decisive consequences for human agency, considering that «a society with a weakened property of symbol-making would suffer a concomitant loss of the property of action» (Leroi-Gourhan 1993, 214).

In fact, underlying this legitimate concern is a somewhat fallacious argument. This would entail thinking of imagination as a stable transcendental faculty, whereas, as we suggested in the perspective of material culture, it is rather informed and constantly reshaped in the contact between human beings and the environment. In other words, while we still tend to conceive of imagination as an internal faculty, we need to acknowledge that imagination has always been primarily *outside of us*. We should think of it as a by-product of technologies as much as their source, in a relationship of reciprocal feedback or feed-forward. To put it in a nutshell, there exists no imagination separated from its extensions, from its technological prostheses: it is the technology that makes the faculty, as much as it results from the faculty (Koukouti & Malafouris 2020).

A trace of this inseparable co-implication can be found in the way we describe cognitive processes through figurative language that draws on our technical exchange with the world (and the way these metaphors change throughout history and the modifications of the coupling between humans and technologies): as we say that we try to “replay our memories” in our head, that we need to “put something into focus” to understand it better, and that we “are on the same wavelength” if we share attitudes and opinions or are capable of “tuning in” to others’ perspective, and so on. Technologies and media contribute to designing and informing our reality; they «classify the world for us, sequence it, frame it, enlarge it, or reduce it, argue a case for what it is like» (Postman 1993, 39). As much as they entail a reconfiguration and a structural transformation of our experience of the world (Ihde 1979, 66), technologies act like «metaphors through which we conceptualize reality in one way or another» (Postman 1993, 39). It is in this sense that we can affirm, without any hint of determinism, that technologies and media «determine our situation», as Friedrich Kittler asserted in the opening of his *Gramophone, Film, Typewriter* (Kittler 1999), insofar as they shape the *forma mentis* of a certain epoch, its perceptive, cognitive and imaginative possibilities. Technological *a priori* are the very form of our relationship with the world, they constitute the very dimension of experience.

Thus, imagination is a structural form of augmentation of the real. In the wake of recent studies in material culture and the extended mind, we have learnt that we should not conceive of it as a cognitive faculty in its own right, but as a capacity that is modelled and constantly informed in bodily and material contact with the environment and in particular with technologies and media. Augmented reality technologies make it more evident that the technical object, once it is invented, then comes to modify imaginative operationality with a reciprocal feedback effect: there is a feed-forward of the extensions on the faculty, so that, if imagination is what allows an extension of human capacities and therefore technicity itself, it is in turn augmented and constantly reshaped by it.

The relationship between technology and imagination thus needs not only to be reframed as a two-way movement – of externalization and incorporation – but also more radically historicized. Then not only is imagination not amputated by its technological extensions, but it must be thought of as constitutively augmented by technology, i.e., it is fundamentally historical and situated, inseparable from the technoculture of a certain epoch. Imagination does not go through a process of externalization; it has been *outside of us all along*. If we do not take into account this reciprocal feedback, we fail to think through the paradigm of "extension", always at the risk of reducing it to a one-way, merely unidirectional trajectory, going from inside to outside (in the movement of externalization) or from outside to inside (in the movement of incorporation). Whereas, to quote Goethe, we still need to consider that «nothing is inside, nothing is outside; For what is inside is outside» (Goethe 1957, 97).

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