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Ethical Research on Artificial Perception Technologies

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ABSTRACT
The development of artificial perception technologies has surpassed the limitations of human natural senses, expanding humanity's perspectives on the world and self-awareness. However, it has simultaneously introduced new ethical challenges. These emerging challenges necessitate a philosophical reexamination of concepts such as 'nature,' 'artificial,' and ' invasiveness ' to better address associated issues. The advancement of artificial perception technologies not only involves scientific and practical applications but also profoundly influences human values, social ethics, and the future trajectory of human civilization. Amidst the current transformation and transition in modes of cognition, reevaluating the relationship between technology and humanity becomes a crucial task.

KEYWORDS
Artificial sense; Artefact; Brain-computer interface; Invasive

Compared to natural perception, artificial perception is a process that simulates natural perception through technological means such as computers and sensors. Its technical methods are typically based on research into natural perception, especially the study of sensory organs. Both artificial and natural perception involve the ability to collect and process information from the external environment. However, the distinctive feature of artificial perception technology lies in overcoming some limitations of human natural perception, providing humans with additional sources of perception and sensory information, thereby expanding human cognition of self and the world. Nevertheless, artificial perception has also raised a series of new issues. These problems not only prompt a reexamination of the definitions of 'natural,' 'artificial,' and 'intrusive' in this new technology but also compel us to reconsider the impact and role of artificial perception on natural perception. Artificial perception provides crucial insights into understanding the essence of natural perception and cognition while simultaneously posing ethical challenges and philosophical reflections, profoundly influencing the development of human civilization. These questions have sparked discussions on technological and socio-ethical issues to ensure that the development and application of artificial perception technology align with moral and societal values.

1 Current Status of Artificial Perception

Utilizing technologies such as Brain-Computer Interfaces (BCIs), humans have crossed the boundaries of their natural senses, activating sensations and perceptions in the human brain through external signals. This new form of human perception, constructed through the synergy of technological means and the central nervous system, is referred to as 'artificial perception.'[1] Artificial perception systems, by mimicking natural sensory functions, have evolved to match or even surpass biological sensory systems. The significance of these systems lies in their provision of therapeutic perceptual restoration and offering new avenues for the extension and enhancement of natural perception. Emerging in the 1970s, this technology has rapidly advanced with in-depth research into the nervous system and computer technology. The first BCI international conference defined BCI as 'a communication system that does not depend on the normal output pathways composed of peripheral nerves and muscles.'[2] Compared to human natural perception, artificial perception possesses the capability for faster and more precise recording, analyzing biological responses to various stimuli, conduction, and identification processes. Consequently, it provides a novel perspective and tools for epistemological studies. Artificial perception technology successfully addresses some limitations inherent in natural perception in humans, further enhancing or altering human perceptual abilities. This newly constructed artificial perceptual capability, achieved through technological means, differs from traditional sensory augmentation and pure machine perception. Its implementation relies on technologies such as sensors, computer vision, speech recognition, and biometrics. It can be employed to assist individuals with sensory impairments, enhance the perceptual abilities of normal individuals, and even support those pursuing 'transhuman' capabilities beyond biological constraints, achieving 'superhuman' perceptual abilities. Currently, research on artificial perception spans multiple interdisciplinary fields, including human-computer interaction, machine learning, neuroscience, and cognitive psychology. This interdisciplinary research aims to explore how artificial perception technology changes people's interaction with the world, enhances perceptual abilities, and investigates its wide-ranging applications in healthcare, rehabilitation, scientific research, and other domains. This not only provides new tools and methods for cognitive research but also pioneers new research areas, leading the forefront of technology and science.

Based on whether the sensors used to detect brain signals are implanted in the brain, artificial perception technology can be categorized into invasive and non-invasive types. Additionally, based on their intended use, these technologies can be distinguished as therapeutic or augmentative. The working principle of these technologies is to convert perceived information into signals that the brain can interpret. Invasive techniques involve directly implanting devices into the brain, a process that may entail risks such as scar tissue formation or the body rejecting foreign objects. The surgical risks associated with invasive techniques are high, and the procedure is costly. On the other hand, non-invasive artificial perception technology detects signals externally to the skull and regulates the central nervous system using electrical stimulation signals. These artificial perception devices can be considered as new human senses, or artificial senses. They extend human perceptual abilities and are referred to as 'sensory prosthetics,' including devices such as cochlear implants and retinal implant devices. [3] Through this technology, individuals can not only regain basic information acquisition capabilities, such as the five senses, but also achieve unprecedented expansion of originally intact perceptual domains.

In recent years, a series of artificial perception devices designed to expand human senses have been progressively deployed. These devices can convert infrared and ultrasonic signals into electrical signals, allowing individuals to 'see' infrared waves or 'hear' ultrasonic waves. This enables the human brain to 'process a broader range of sensory signals beyond those acquired through evolution.' Artificial perception technology has not only successfully addressed some limitations inherent in human natural perception but also provided humans with additional sources of perception and sensory information, expanding cognition of self and the world. Furthermore, artificial perception has sparked a new form of the mind-body connection: artificial perception does not require involvement of the physical body or muscle movement. This 'non-embodiment' is distinct from traditional forms of mind-body connections based on the body and natural perception. Currently, internationally recognized companies such as MindMaze, Neurable, Neuralink, and Kernel Co have emerged, securing substantial funding for the development of artificial perception projects. The mainstream direction of commercial applications remains focused on the fields of healthcare and virtual reality, with these technologies poised to bring significant breakthroughs and advancements to these domains.

2 "Natural" and "Artificial"

The distinction between 'natural' and 'artificial' has long been a persistent topic in the history of scientific thought, involving crucial philosophical questions about essence and value. In terms of essence, 'natural' typically refers to the untouched or unaltered environment, including the organisms, materials, and energies within nature. These elements exist in nature independently and do not rely on human intervention. On the other hand, 'artificial' refers to things intentionally created or altered by humans, such as buildings, tools, and artworks—products that are autonomously created by humans and are the outcome of human culture and technology. From a perspective of value, 'nature' is often seen as a pure and primitive mode of existence with intrinsic value, while 'artificial' is considered as human intervention and modification of nature, with its value contingent upon human needs and purposes. In traditional Western philosophy, nature is viewed as the origin of the universe and the foundation of life, while the artificial is seen as the result of human creation and alteration of the natural world. Nature is often regarded as an order created or guided by a higher power, while the artificial is considered as an expression of human will and capability. This distinction has sparked extensive discussions and reflections in the fields of philosophy and ethics.

With the rapid development of science and technology, coupled with the rise of artificial intelligence, the traditional binary opposition between nature and the artificial is gradually becoming less clear. People are beginning to realize the permeable and interactive relationship between nature and the artificial. The contemporary Western philosophical delineation of 'nature' and 'artificial' has delved into complex ontological issues, covering distinctions between the essence of artificial entities and natural entities. This becomes especially crucial with the rapid advancements in fields such as artificial intelligence, synthetic biology, robotics, and the study of cognitive philosophy. The traditional philosophical dichotomy between nature and the artificial 'tends to evoke extreme psychological reactions toward artificial intelligence, either extreme desire or extreme fear, and this is manifested in various aspects of society, such as policy-making and legal and ethical issues arising from human-computer interaction. '[4]Scholars have proposed new concepts, suggesting that 'the artificial is a new concept derived from an engineering and synthetic perspective re-examining biology. The boundary between nature and the artificial becomes more ambiguous, a result of this reevaluation. '[5]For instance, Bianchini proposes defining 'artificial' as 'entities constructed by humans using nature as a model, built by manipulating natural systems and processes, and capable of maintaining existing behaviors or operations in an open background or environment without human control, regardless of the material or substance of its components. '[5]According to this definition, any entity whose causal chain is linked to human intervention can still be considered an artificial entity. However, this definition raises a significant question: technologies like artificial perception that directly intervene in nature or even control biological evolution may lead to a state where life and human society enter a non-natural condition, potentially resulting in unpredictable negative consequences. Therefore, rethinking the relationship between nature and the artificial in the context of new technologies and philosophy, and addressing the ethical and moral challenges therein, is a pressing challenge in today's context.

The conceptual delineation between "nature" and the "artificial" has become more complex in modern times, primarily due to the inherent difficulty in precisely defining the concepts of "nature" and "life." This complexity is also reflected in the value meanings associated with "nature" and the "artificial." People have come to recognize that "nature" is perceived as safer and more reliable compared to "artificial" components such as chemical synthesis and synthetic materials. Certain phrases, like "in harmony with nature," seem to carry the implication that "nature" possesses special value. This naturalistic tendency traces its roots back to ancient Greek philosophy, viewing the natural world as a domain with intrinsic order and integrity, portraying it as pure and moral. While this perspective reflects a core value of reverence and conservation for nature, it also has limitations.

Excessive emphasis on the superiority of nature and the negative impact of the artificial may overlook humanity's pursuit of technology and creativity, as well as the potential of artificial interventions in improving quality of life and addressing real-world problems. In reality, the development of artificial technology is often inspired and informed by the natural world, and conversely, the natural world itself may be influenced by artificial interventions. Therefore, it becomes necessary to adopt a perspective that transcends traditional binary oppositions, approaching the relationship and value judgments between "nature" and the "artificial" in a more comprehensive and balanced manner.

In the relationship between nature and artificiality, artificiality is considered a way of potentially intruding into human life. Although Rajesh Rao defines invasive devices as those involving surgical procedures, where a portion of the skull is removed to implant electrodes or other devices into the brain for recording or stimulating neurons, the categorization of artificiality into "invasive" and "non-invasive" is not as straightforward as the relationship between "natural" and "artificial." Bernard Williams distinguishes between thin and thick normative concepts, where thin concepts provide evaluative direction with little additional content, and thick concepts are both descriptive and evaluative, offering evaluative direction tied to rich descriptive content. [6] In this context, invasiveness is considered a thick normative concept, implying destruction and danger. However, the reality is that invasive and non-invasive technologies do not perfectly correspond to the concepts of invasiveness and non-invasiveness. While the concept of "invasiveness" has multiple meanings, neuroethicists primarily use it to describe physical interventions on physiological features, with less emphasis on psychological or social intrusions. Recent evidence indicates a broader understanding of invasiveness among primary users of artificial perception technologies. Current research underscores the importance of reexamining the concept of "invasiveness" in neuroethics and the necessity of better understanding its meanings and applications within the field. Considering neurotechnology as "invasive" in the context of neuroethics, within the background of neuroethics, might be reasonable, necessitating further research to delve into the relationship between the concept of invasiveness and ethical themes in neuroethics.

In the long history of humanity, perception has always referred to the process of understanding and interpreting the surrounding world through the innate sensory systems of humans. Using sensory systems such as vision, hearing, touch, taste, and smell, we convert external stimuli into neural signals, which are then transmitted through the nervous system to the brain for information processing and interpretation. These innate sensory systems have been considered the most effective 'algorithms' throughout the millions of years of human evolution. However, with the rise of new generations of cognition revolutions, such as machine learning, artificial neural networks, and artificial perception, we begin to see the widespread application of these technologies. Over the past few decades, highly intelligent and advanced consciousness has been closely related concepts because the presence of advanced consciousness allows individuals to perform complex intelligent tasks. Although humans surpass machine intelligence in aspects like adaptability, developmental capacity, and creativity, the development of the new generation of cognitive technologies triggers contemplation about the yet unrevealed domains in the human mind. This raises a crucial question:

Are there abilities existing in this unknown realm that machines cannot quantify and, even more so, cannot simulate? If a day comes when artificial creations surpass the abilities naturally endowed in both physical and cognitive aspects, the value meanings of nature and artificiality might be redefined. Such a redefinition could profoundly impact other human values, triggering new considerations and adjustments in areas like ethics, society, law, and beyond.

3 Interference of Artificial Perception with Natural Perception

The importance of artificial perception for enhancing cognition is evident, and natural perception, as a cognitive input, is also subject to its influence. Artificial perception provides new outputs to the central nervous system, differing from traditional neural-muscular or hormonal outputs. The output of artificial perception is in the form of neural electrical signals and given that the physiological representation of the symbol system behind information processing in the brain is largely unknown, two key points cannot be overlooked. Firstly, there is a substantial lack of foundational knowledge about the functionality of the human brain. In this complex environment, the interpretation of signals through signal analysis and machine learning still faces significant challenges. Secondly, individuals operate in the natural environment and social context within the complexity of the real world. It is necessary to integrate background information into the process of analyzing and classifying neurophysiological signals. This implies that neurophysiological signals cannot be interpreted in isolation but must be considered within specific application contexts.

The perceptions themselves coordinate and complement each other, encompassing various non-traditional senses in addition to the five traditional senses. Traditional senses are physiological mechanisms by which living organisms gather data from the external world. These data result from the interaction of observable physical phenomena with sensory organs. These sensory organs have the ability to perceive changes in different aspects of the physical world and generate physiological signals, which are decoded in the cognitive processes of higher vertebrates. Moreover, each sense has specific physiological and cognitive mechanisms behind it, determining not only the aspects of reality each sense can perceive but also their natural limitations. These limitations pose challenges to overcome and define frontiers for further research. Non-traditional senses include pain, balance, temperature, among others. All these non-classical senses play an indispensable role in our process of perceiving reality. While traditional senses are primarily used to perceive the external world, non-traditional senses involve the ways we perceive the internal aspects of ourselves. Compared to the five traditional senses, the limitations of non-traditional senses are more complex, especially for those senses whose perceiving entities and mechanisms are located within our bodies. They often exist in a distributed manner, presenting unique challenges.

Modern neuroscience has found that the division of different perceptual neural areas is not very clear-cut: even in the adult brain, different sensory systems can cross recognized anatomical boundaries. For instance, when blind individuals read Braille with their fingers, their visual cortex can be activated by touch.[7] In such cases, if artificial perception substitutes for or enhances natural perception in a singular manner, it can lead to a sudden change in a sensory input, which could be a variation or an amplification. However, perception is a balanced whole, and different natural senses are input into the brain in a state of balance. They don't surpass the limits borne by the physiological parts of the brain. The input of artificial perception can substitute for and enhance the input of natural perception, but it acts like a force outside the natural balanced state. Blindly substituting and adding sensory input might disrupt the original balanced state of perception.

In the neuroscience research of natural perception, the visual process is the most dominant process in the brain, constituting about thirty percent of the brain, while touch and hearing, in contrast, constitute only about eight percent and three percent of the brain, respectively.[8] This has led to the 'visual paradigm' (VPA), emphasizing that our sensory experience is acquired by imitating visual experiences. This interpretation might favor the substitution of artificial perception for natural perception, assuming that understanding the workings of vision captures the essence of natural perception. In reality, there is no assurance that the operation of vision can be extended to non-visual domains. Moreover, many judgments we make in daily life are cross-modal. Thus, no sensory channel can work independently, and human cognition is achieved through the collaboration of multiple channels. This multisensory collaboration is more conducive to enhancing human perceptual and cognitive capabilities than a single sensory channel.[9]

Furthermore, if a certain sensory function is lost, other senses are enhanced. Neuroscientist Helen Neville has demonstrated that in deaf individuals, the auditory brain regions are used to process visual and tactile information, leading to enhanced vision. [10] Correspondingly, individuals with visual impairments excel in tasks related to speech perception and sound recognition.[11] From this, Casey O'Callaghan suggests that human perceptual experience has an irreducible multichannel structure. Within this, two fixed implications arise: multichannelity and irreducibility.

The first aspect is the multichannel nature, where specific sensory channels depend on others, and different sensory processing regions can interconvert. Cross-modal information processing has been identified as a fundamental feature of brain function. Normal humans use visual information input to the brain to construct a spatial representation of the world, understanding relationships between things. However, blind individuals gather information through touch and hearing, yet they process information and construct a spatial representation of the world similarly to sighted individuals. [12]This indicates the existence of a multisensory, cross-modal information processing process, where perceptual signals from touch, hearing, or vision are interrelated and ultimately form an 'information package.' This information package is not solely caused by natural perception; artificial perception aiming to replace natural perception must start from different sensory channels. Single-channel artificial perception can only input isolated sensory signals, potentially disrupting the reshaping of experiences in other channels.

The second aspect, irreducibility, implies that perception is a whole, not a simple addition of sensations, but an integration of multiple sensory channels. This indicates interconnections between different sensory channels and the existence of cross-modal information integration. The resulting perception is something that individual sensory experiences do not possess. Foreign researchers have compared brain activity when seeing lip movements synchronized and desynchronized with hearing sounds: the results show that when they are synchronized, there is an additive effect in parts of the visual and auditory cortex; when desynchronized, these areas exhibit subtractive effects.[13] Damasio also states, 'To perceive an object through sight or other senses, an organism needs both specialized sensory signals and signals from bodily regulation. '[14]This integrative approach beyond simple addition poses challenges for the study of artificial perception. At the current stage, we might have a considerable understanding of the neuronal signals of various senses, but multichannel perception could lead to the emergence of new types of perceptual experiences. For example, the smell of an orange is something that single-channel artificial perception cannot capture.

In addition, natural evolution has shaped the adaptability of perception. Artificial perception seeks to enhance existing human senses and expand the perceptual domain, allowing humans to perceive a more authentic and comprehensive world. However, 'authenticity' has never been the primary pursuit of the human brain; 'adaptability' is. The existing human perceptual functions are adaptive products of millions of years of natural evolution. The world is objective, but what kind of world is perceived depends on the survival and reproductive needs of the organism. How we subjectively experience ourselves is only a small part of the field of neuroscience.

Henri Bergson believed that perceptual adaptation is the process by which we acquire sensory information, pair it with previous memories to perceive the world around us. Data is obtained through disturbances in the perceptual environment, information processes data, knowledge processes information, and wisdom processes knowledge. Since the processing involved is the utility of information reserves at that level, each level has a higher value than the level below it. This bottom-up processing can play a role in collecting information in areas unfamiliar to humans. Top-down processing occurs when we use memory to understand and fill in the gaps in what we see in front of us. To understand bottom-up artificial perceptual information, we rely on the memories formed by previous natural perceptions. Now, artificial perception replaces natural perceptual input, equivalent to suddenly facing a world with a huge amount of information, which is bound to impact our previous information storage and thought patterns. Our cognition may also be overturned or disrupted.

4 Traditional and New Ethical Issues of Artificial Perception Technology

Traditional technological ethics has always focused on the impact of emerging technologies on fair distribution and individual dignity. Seeking a balance between technological progress and social development has been a key issue in the philosophy of technology and ethics. The advent of artificial perception technology not only increases the quantity of perceptual experiences but may also lead to qualitative changes. However, this upgrade may result in inequality, with some individuals unable to adapt being excluded from society or even marginalized. In the process of upgrading, privileged individuals may form an elite class, using their abilities beyond ordinary people to dominate decision-making in the entire social civilization process. Current research indicates that artificial perception technologies, represented by brain-machine interface technology, are not applicable to everyone. Some people are referred to as "brain-machine interface illiterates" because they cannot focus their attention on brain-machine interfaces and therefore cannot effectively use this technology. Relevant statistics show that this group accounts for 15% to 30% of the current trial population.[15] Looking back at human history, although societies have always had varying degrees of social advantages, from a biological perspective, there has never been a true biological difference between people. While in the past and present, some religious or aristocratic groups have claimed that certain human groups have greater wisdom or uniqueness, these claims have never been scientifically proven. Liberal principles have been widely applied in some societies. Despite issues of inequality such as wealth disparity, it emphasizes the equal value of different human experiences because the natural perceptions of each individual are inherently similar. However, the emergence of artificial perception technology may lead to significant differences between human bodies and cognition. The use of such technology may also shift from the original intention of helping individuals with impaired sensory functions to regain perceptual abilities to the direction of enabling healthy individuals to undergo further "upgrades." This shift raises ethical concerns about potential social inequality and discrimination arising from differential access to these technologies.

In addition to traditional ethical issues related to technology, artificial perception technology also brings its own unique new ethical problems.

Firstly, will artificial components have a negative impact on natural senses, or even weaken the functionality of natural senses? This question involves a redefinition of the concept of 'human.' Currently, we anticipate increasingly intelligent artificial perception technology devices with expanding applications. These technologies not only address physical disabilities but also enable self-enhancement, providing rapid access to abilities acquired over the long course of human evolution. However, on the other hand, this also implies that the autonomy and subjectivity of artificial entities will gradually strengthen. Viewing technologies like BCI as mere tools is superficial. Such a perspective overlooks the unique role these technologies play, circumventing the muscular system and the body, a role that holds special significance in the sequence of actions. Broadly speaking, technological inventions throughout human history possess a characteristic of artificial perception: telescopes and microscopes extend our visual range, microphones and telephones expand the transmission range of our voice, books and electronic storage devices increase our memory and cognitive capabilities. Therefore, the development of human technology is essentially an extension of humanity itself. According to the concept of 'Extended Cognition' in the 4E cognition theory, cognitive processes can be extended through tools and technologies, involving the use of external tools to enhance the cognitive abilities of the subject, transcending the limits of the body in the cognitive process. However, current technologies still rely on human sensory perception to generate awareness; thus, they cannot completely replace natural senses, at most being termed as 'extended perception' rather than strict artificial perception. For artificial perception technology, its perceptual mode formed through brain-computer interfaces no longer relies on traditional bodily senses. How might this new mode of perception affect the human body? For instance, artificial cochlear implants produce artificial hearing that bypasses the biological cochlea, altering the natural auditory perceptual pathway. This process involves the artificial cochlear acting as a brain-computer interface, converting sound vibrations, such as speech, into electrical signals, stimulating the auditory nerve, and ultimately forming auditory sensations in the brain, enabling individuals to receive auditory information. Do the natural and artificial perceptual pathways produce the same neural sensations when exposed to the same external stimuli? Is perceptivity to visual information received through the auditory system a new form of unknown perception? What if the cognitive experiences of 'superhumans' are entirely different from those of ordinary humans? Will they regard ordinary humans in the same way humans view their ancestors, like chimpanzees? When existing human ethics and values no longer hold significance for upgraded superhumans, what will happen to the world and society that all humans depend on for survival?

Secondly, regarding the invasiveness of artificial perception devices, physical invasiveness is not the sole form of invasion. Robyn Bluhm suggests that the concept of invasiveness can also have other meanings, such as 'emotional or psychological' or 'lifestyle' invasiveness. Through emotional/psychological invasiveness, they propose that as long as a device has an invasive impact on a person's mental life, it can be considered invasive.[16] In addition to physical intrusion, an increasing number of biomedical devices can stimulate and alter brain function in a psychological sense, reading neural activities or their correlates in the brain, sometimes even a combination of both. These types of devices enable us to access information about mental life that was previously unattainable. When such access is unauthorized, these devices are considered to have psychological invasiveness. For example, brain-machine interface devices used to detect and infer subconscious processes, such as inferring personal identification numbers (PINs) at banks,[17] fall into the category of psychological invasion. Artificial perception devices may also have social invasiveness. Non-medical devices, such as mobile communication or recording devices, when used in public, may intrude on social privacy. Medical devices may also have social invasiveness. During airport security checks, individuals carrying hearing aids not only experience the physical intrusion of the device but also undergo social invasion during inspection because they cannot separate the device from themselves and place it in carry-on luggage. The fact of having a medical device may attract unnecessary attention and could potentially be a source of embarrassment.[18] Medical devices may also have social invasiveness on a more intimate level.

Finally, how will artificial perception technology impact human cognitive abilities? Where are the limits of artificial perception technology? All technologies 'in some sense make us smarter than we imagine, while also confusing us, subjecting us to control and domination.'[19] The formation of perceptual experience involves complex interactions, including those between the subject, the external environment, and the nervous system. Human perceptual experience can be understood as a process where the subject continually interacts with the external environment, receives information, and reacts. The human cognitive process is not merely a simple summation of inputs from multiple senses but an interaction among these inputs, collectively forming a more comprehensive, complete, and unified cognitive experience. When individuals no longer rely on their original sensory organs but rather on artificially created novel sensory stimuli, these artificial perception devices, by altering the composition and source of perceptual experiences, can be seen as a 'new organ' integrated into the human cognitive process. These devices can exhibit a certain degree of flexibility and, possibly, a degree of 'autonomy' in handling cognitive tasks. Does this mean they have a degree of subjectivity? If only a small number of low-intelligence devices are implanted or replaced, it may not have a significant impact on human cognitive thought processes in the short term. However, what if the implanted devices become increasingly intelligent, and the proportion of replaced sensory functions continues to rise?

Currently, the academic community in China has recognized the lag in the development of technoethics and neuroscientific medical ethics standards. Efforts are being intensified to formulate and improve technoethics standards, guidelines, etc., especially in key areas such as medicine, to strengthen technoethics review and supervision.[20] However, for the future of artificial perception technology, there is no need to be overly pessimistic. The relationship between technology and the development of human society has always been a core issue in human civilization. Throughout the course of history, we have experienced multiple revolutions in civilization and cognition. Many scientific and medical breakthroughs initially benefited only a few, but eventually, they became widespread among humanity. Moreover, many technologies faced strong criticism in their initial stages but ultimately proved their value, bringing significant benefits to humanity. From a broader perspective, humans have always relied on the extension and modification of artificial technology. The tools we create not only extend and modify our bodies but also our cognitive abilities. These extensions and modifications have become so ubiquitous that they are now part of our lives, even indispensable. Perhaps humanity will continue to embrace the cognitive revolution brought about by artificial perception technology in a similar way.

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