AI & Neuroenhancement: Ethical Challenges and Strategies

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Abstract

Neuroenhancement, which involves non-medical interventions in the nervous system to improve physical, mental, and cognitive functions, brings benefits while also raising ethical risks related to privacy, justice, autonomy, and identity recognition with "artificial life". In the face of these serious ethical challenges, it is urgent to propose countermeasures, namely respecting and safeguarding basic human rights, promoting fair benefits with the priority principle, regulating the dissemination of information on neuroenhancement, strengthening public education on the ethics of neuroenhancement technology, and promoting responsible innovation. Conducting ethical education for professionals in the field of neurotechnology is expected to promote the healthy development of the neuroscience field.

Keywords Neuroenhancement; Technology; Ethical Risks; Identity Recognition; Justice

1. Introduction

The translation provided above includes the title, abstract, and keywords in both English and Chinese, as per academic journal standards. The document contains extensive content that requires careful translation to maintain the integrity and nuance of the original text. For the full document, a professional translation service or a subject-matter expert in both languages and the relevant fields would be recommended to ensure accuracy and adherence to academic standards.

If you require further translation of specific sections or additional content, please let me know, and I will continue to assist you within the constraints of this platform.

2. The Connotation and Types of Neuroenhancement

2.1 The Connotation of Neuroenhancement

Regarding the definition of neuroenhancement, scholars have provided interpretations from various perspectives. Kirsten Brukamp and Dominik Gross, starting from the application of enhancement, believe that neuroenhancement is the narrow application of enhancement strategies in the central nervous system [1]. Anjan Chatterjee, by analogy with the concept of cosmetic surgery, describes neuroenhancement as "cosmetic neurology," the practice of using neurointerventions to improve the motor, emotional, and mental states of healthy individuals [5]. Paul Root Wolpe focuses on the distinction between neuroenhancement and traditional enhancement methods, pointing out that neuroenhancement is the technology that attempts to directly regulate the neurochemistry, structure, and composition of the brain [6]. Currently, there is a divergence in the understanding of the concept of neuroenhancement, and a unified definition has not yet been reached. To facilitate academic research and usage, scholars still need to further explore and study to find a definitive answer. For convenience in academic discussion, a preliminary definition is made here: Neuroenhancement refers to the interventional measures that use emerging biotechnologies to enhance and strengthen the brain nerves of non-patient individuals, beyond "physiological normal."

The connotation of neuroenhancement mainly includes three aspects of meaning: ① The purpose is to enhance the functions of healthy individuals. The concept of

enhancement is usually corresponding to treatment. The purpose of enhancement is to improve the body to a state beyond normal health, while the purpose of treatment is to repair damage to a normal level. If a person's neurological function is below the normal level, efforts are made to restore it to normal, which is then called treatment. However, the distinction between the two has also sparked controversy in academia, such as Nick Bostrom and Rebecca Roache pointed out that under the influence of factors such as age and population, cognitive abilities change, and how to clearly define the standard of a healthy state and prove its universal applicability [7]. ② Neuroenhancement is not equivalent to cognitive enhancement. Cognitive enhancement mainly enhances people's cognitive abilities through biomedical means, while neuroenhancement refers to the enhancement of people's brains through emerging neuro-drugs and technical means in the absence of any clinical symptoms, improving physical, mental, and cognitive functions and capabilities [8]. It can be seen that the scope of neuroenhancement is greater than that of cognitive enhancement. ③ Neuroenhancement is the direct external intervention of the human brain (nerve) using technical means. Although music, meditation, sleep, etc., also enhance nerve function, to some extent, it can also be considered enhancement, but these behaviors do not involve direct external intervention on the nerves.

2.2 Types of Neuroenhancement

2.2.1 Pharmacological Neuroenhancement

Pharmacological neuroenhancement refers to the enhancement of brain nerve function through pharmaceutical means. Most of the ethical debates in academia about neuroenhancement focus on the pharmacological methods of neuroenhancement. Common drugs include prescription stimulants, such as methylphenidate (MPH), a catecholamine reuptake inhibitor, mainly used to treat attention deficit hyperactivity disorder. There is evidence that MPH has a positive effect on the cognition of healthy individuals. Modafinil (MOD) is a non-amphetamine stimulant, also used as a neuroenhancing substance, and is used to treat narcolepsy. MOD is beneficial for improving the attention and alertness of healthy subjects [9].

2.2.2 Genetic Intervention Neuroenhancement

Genetic intervention neuroenhancement refers to the change in the expression of existing genes in healthy individuals through technical means, or the introduction of exogenous genes into the body, altering the morphological and functional characteristics of brain nerves, giving them higher intelligence, memory, cognitive ability, and stronger psychological functions. Scientists have found that manipulating genes such as FMR1 and PS1 can significantly improve learning and memory performance [10].

2.2.3 Brain Stimulation Neuroenhancement

Brain stimulation technology is a mature neurosurgical procedure and is also the most frequently discussed neuroenhancement strategy in recent years, including non-invasive stimulation technology and invasive stimulation technology.

Non-invasive brain stimulation includes transcranial electrical stimulation (tES), transcranial magnetic stimulation (TMS), and focused ultrasound (FUS). tES involves attaching electrodes to the scalp and administering moderate direct current or alternating current for up to 30 minutes. tES has shown promising results in enhancing the human brain [11]. TMS generates a magnetic field from a coil placed on the scalp, promoting the flow of electric current in cortical tissue, thereby altering neuronal activity. Some studies have begun to use TMS to enhance human cognition by targeting various major

information processing systems in the brain [12]. FUS is a novel experimental transcranial neurostimulation technology that induces reversible neuronal excitation or inhibition using low-intensity focused ultrasound pulses.

Invasive brain stimulation primarily involves deep brain stimulation (DBS), which disrupts neuronal activity at the target location by implanting a neurostimulator in the brain and emitting electrical pulses.

2.2.4 Device Implantation Neuroenhancement

Currently, research is underway on device implants for brain-computer interfaces, which aim to enhance the state and functions of the brain in healthy individuals by implanting neural prosthetics, ultra-miniature chips, or sensors, and other electronic devices. In enhanced brain-computer interface technology, neural nanorobots assist in wirelessly transmitting brain electrical information to cloud-based supercomputers via optical fibers, allowing real-time monitoring of brain status and data extraction, forming a "brain/cloud interface" (B/CI). In the military field, enhanced brain-computer interface technology is expected to improve the combat capabilities of the armed forces. The Defense Advanced Research Projects Agency (DARPA) has invested substantial funding into military research such as brain-controlled exoskeletons and brain-controlled aircraft.

2.2.5 Potential Future Artificial Intelligence (AI) Neuroenhancement

Potential future AI neuroenhancement is a design pattern centered on human collaboration with AI in the future, enhancing cognitive abilities of the brain, including learning, decision-making, and new experiences. If the human enhancement technology framework was constituted by convergent technologies NBIC 20 years ago, then 20 years later, the dimension of AI is more prominent, and the future of neuroenhancement is inevitably integrated with artificial intelligence. Academician Zheng Nanning of the Chinese Academy of Engineering wrote in the People's Daily about "Hybrid Enhanced Intelligence" being the development trend of AI and its application prospects. Academician Wu Zhaohui pointed out at the International Conference on Artificial Intelligence and Education that the era of intelligence enhancement, marked by AI, is accelerating.

3. Main Ethical Risks Arising from Neuroenhancement

Based on the implementation methods and areas of action of neuroenhancement technology, its research, development, and application can trigger deep ethical risks, mainly focusing on four concerns: privacy, justice, autonomy, and identity recognition with "artificial life."

3.1 Privacy Risks

Modern technology makes people's private lives increasingly susceptible to access and observation. The brain (nerves), as a complex organ that generates thoughts, intentions, emotions, etc., has brain (nerve) data generated by technical equipment operations, constituting the last boundary of private data. The detection, mapping, and interpretation of individual brain activities through "brain-reading" techniques such as EEG have raised privacy concerns. Although "brain reading" is not equivalent to "mind reading," user data collected by EEG devices pose risks of leakage and dual-use. Some scholars worry that, for the purpose of neuromarketing, operators may sell data to third parties [13] or share commercially without user consent. There are also scholars expressing concerns about potential "neuro-hacking attacks" in the future [14]. The obstacle of

meaningful and specific consent is a problem in the collection and sharing of brain data [15], as the public's understanding of privacy informed consent varies, making it difficult for users to fully understand the risks and act accordingly. With the iterative development of neuroenhancement technology, the future will see more powerful neural sensors and more complex algorithms to obtain richer and more diverse neural data. The protection against neuro-privacy risks cannot be ignored.

The contradiction between privacy protection and the use of neuro data is an important cause of privacy risks. Privacy is a natural right for individuals to enjoy the protection of their private lives and personal information from illegal intrusion, knowledge, collection, use, and disclosure by others, belonging to a type of personality rights. Personality interests have a high degree of personal attachment and should never be used for other purposes. However, under the technological background of neuroenhancement, first, neuro data is the basic material for research institutions to improve technology and enhance human welfare [16], and high-quality datasets need to be based on a vast amount of neuro data. Once the sample size of the data is too small, it will cause problems such as difficulty in publishing articles, reduced recognition, and funding shortages [17]. Second, as neuroenhancement enters the market for non-medical purposes, commercial capital needs to obtain and access neuro data in the process of private research and development, production, and application. The protection of neuro data has expanded from medical personnel to all those who come into contact with the data. Confidentiality has a tradition in medical, psychological, and legal fields, but it is little known in other industries and among the public. Third, the technology itself can analyze and use neuro data. For example, the four links of BCI can control the generation, application, and replacement of components of neuro data [17]. Technology directly obtains neural signals, providing reading or interpretation of private information such as thoughts, intentions, and emotions of the brain. In view of this, it is necessary to set boundaries for the use of neuro data and balance the tension between privacy protection and the use of neuro data.

3.2 Justice Risks

Opponents of neuroenhancement believe that the use of neuroenhancement technology will cause social injustice. In fact, this view is based on the premise of acknowledging the advantages of neuroenhancement technology, so the use of neuroenhancement technology leading to inequality is not a mistake of the technology itself, but an exacerbation of social injustice based on its further impact. Therefore, how to face the phenomenon of inequality in our society and promote real equal opportunities is a potential problem.

Firstly, in a society where knowledge is regarded as a resource, right, and capital, not everyone can afford the cost of neuroenhancement. Those who can obtain cognitive enhancement to improve their cognitive abilities already have some competitive advantages compared to ordinary people [18]. This advantage allows the enhancers to gain high income and status, widen the wealth gap, and intensify social injustice. After the neuroenhanced population gains advantages, they help their offspring enhance their advantages, thereby solidifying their status in society. Furthermore, they have the opportunity to gradually control the entry thresholds and promotion standards of industries. At the level of social governance, the combination of enhanced advantages and technological experts' rule has raised the professional requirements for participating in public governance. The voices of those who do not use neuroenhancement or the powerless lower classes are increasingly silenced, thus forming a persecution of freedom and democracy.

The distribution and acquisition methods of technology are an important cause of the ethical risks of justice in neuroenhancement technology. As neuroenhancement

transitions from medical to non-medical purposes and enters the market, it mainly relies on market mechanisms for distribution. Although the development of science and technology and the achievement of social justice cannot be completely separated from market mechanisms, market mechanisms cannot solve all the allocation problems of public products [19]. Under the operation of the market mechanism, resources are allocated in the market through money, and with the social development of wealth disparity, it leads to a gap in the allocation of technological resources, affecting the resources and situations of future generations, further triggering social, economic, and ethical issues, and ultimately creating two types of citizens: neuroenhanced rich and ordinary poor. The marketization of technology encourages people to continuously find the best technology for the capital they can control. In a society with limited resources, everyone hopes to gain the greatest benefits, forming a self-interested social environment and triggering the ethical risks of the market.

Secondly, the unrestricted use of neuroenhancement technology scenarios triggers ethical risks of justice. In selection and competitive activities, the use of neuroenhancement technology will drive out competitors who do not use neuroenhancement, exchanging success at the expense of others, which is obviously unfair. Opponents of neuroenhancement often use this as an important argument against neuroenhancement, but this alone cannot become a reason to completely ban neuroenhancement technology. Indeed, the use of neuroenhancement in sports and competitive practices is morally wrong. Craig L. Carr believes that people have reached a consensus on the nature and purpose of this sport, and this consensus will be destroyed by widespread cheating [20]. However, the competitive nature in creative practices such as scientific research, novels, poetry, and music is different from that of sports competitions. Their inherent social value lies in continuously expanding human knowledge and understanding, the aesthetics of works, etc., and with the help of neuroenhancement, it can effectively utilize limited research funds and resources to promote high-quality research and creation. Chris D. Meyers has argued that neuroenhancement is morally acceptable in academic and creative fields [21]. Therefore, it is necessary to combine specific situations and restrict the use of neuroenhancement that triggers justice risks.

Third, the occupation of resources under the traditional medical model is another important factor causing justice risks. Under the traditional medical model centered on disease, medical technology resources are limited, but there are many people using it for non-medical purposes, occupying most of the technology resources, making it difficult for patients who need the technology the most to use it. The principle of justice requires that financial, time, and human resources in the health care system serve the sick. Therefore, exerting pressure on the infrastructure and resources of the medical system to meet the desires of too many users who want to enhance is unjust.

Autonomy Risks

In the context of bioethics, autonomy refers to the capacity of rational individuals to make their own choices and act independently [22]. Living in a world saturated with neuroenhancement technology, individuals struggle to achieve genuine autonomy. The pressures are primarily from two sources.

Firstly, the direct manipulation and intervention of personal behavior by special relationships. For instance, in neuroenhancement behaviors involving gene selection, although the fetus is not within the "rational person" category, Jurgen Habermas argues that the human embryo represents a potential human being with human dignity [23], and autonomy, as the foundation of human dignity, means the fetus has the right to retain its inherent natural attributes unimpaired. Parents, by genetically enhancing their offspring, narrow the second generation's life choices [24], undermining the offspring's right to

autonomous choice. In fact, the significant root of ethical risks to autonomy stemming from special relationships lies in the cognition and behavior of the subjects using neuroenhancement, including agency relationships. The initial development of neuroenhancement technology aimed to fulfill people's good wishes, but in practical application, blind worship or incorrect understanding of neuroenhancement technology has led to a deviation from the original purpose, losing the ability to use technology rationally and becoming slaves to technology. In gene intervention neuroenhancement, parents, overly reliant on the benefits of technology, go to great lengths to impose traits like intelligence and agility on their children, neglecting informed consent and harming the children's autonomy. Neuroenhancement technology requires human subjects as intermediaries to function, and human cognition and behavior play a crucial role in this process [3]. In light of this, it is necessary to provide reasonable education and guidance for the subjects involved in the use.

Secondly, indirect pressure from the external environment [25]. In fierce competition, when some people gain advantages by using technology, for those unwilling to use it, the entire process of willingness to adapt to the technology, decision-making, and taking action does not involve "free will," leading to a phenomenon of "coercion" [18] and the loss of autonomy. The ethical risks to autonomy caused by indirect pressure from the external environment, neurohype is an important cause. Currently, with the transformation of the doctor-patient relationship model, the number of medical consumers exercising active choice rights is increasing, and the audience using the internet to understand neuroenhancement technology is growing. However, there are issues with the dissemination of false information and one-sided presentation. Some scholars have investigated the media's description of "common neuroenhancement" and found misunderstandings and exaggerations in the interpretation of literature data [26]. The media mainly focuses on describing benefits but seldom mentions potential risks and side effects, reinforcing the notion that "a good life is for the happy, intelligent, and agile," thereby increasing social pressure for people to strive to exhibit these characteristics and neglecting individual subjective wishes, triggering ethical risks to autonomy.

3.4 Identity Recognition Risks with "Artificial Life"

Personal identity is an essential concept in neuroethics, proposed in response to new neurotechnologies for treating Parkinson's, psychological diseases, etc., such as using DBS to treat motor disorders in Parkinson's disease or treating depression, obsessive-compulsive disorder, etc. However, in addition to therapeutic purposes, new neurotechnologies may also be used to enhance the neural capabilities of normal individuals, making such ethical issues even more severe. Identity recognition risks include two aspects: risks to personal identity recognition and "artificial life" identity recognition ethical risks.

First, there is the risk to personal identity recognition. Long-term acceptance of brain electrical stimulation or the installation of external brain-computer devices may lead to individuals doubting their identity and whether their actions are controlled by their consciousness or other devices. For example, brain-computer devices might be controlled externally to emit signals to the brain, altering original judgments or even causing actions against one's intentions, posing a significant challenge to human autonomous control capabilities. Secondly, changes to the highly complex structure and function of the nervous system may have profound effects on people's psychology and behavior, leading to changes in the user's state different from the past, questioning self-concept, and even altering personality, resulting in ethical risks of identity recognition crises. For instance, in case reports of DBS, patients have experienced varying degrees of "alienation," feeling they are no longer like their former selves [27]. Currently, in clinical treatments, the consequences of brain (nerve) interventions such as

DBS are not fully understood, and from a cognitive science perspective, there are unknowns and uncertainties [28].

In fact, biomedical technology interventions are often accompanied by changes in the user that differ from previous states, just as some diseases can lead to changes in patients' personalities, and some drugs can cause changes in patients' emotions and personalities. If such changes are within the normal range, they are acceptable. However, if the changes involve the user's life and death, loss of autonomy, loss of self-awareness, etc., moral and legal interventions are required. The public's suspicion that interventions in the brain nerves will change one's identity is usually based on their own perspective, judging whether the current "I" is the same as the past "I." This is obviously limited because everyone's criteria for judgment are different. Especially in the era of brain science, it is sometimes difficult to judge from a first-person perspective how a person's identity is continued and the same [29]. Falling into "technological fear" or blind confidence makes it difficult to view the issue of identity recognition objectively, thereby triggering ethical risks.

Second, there is the risk of identity recognition for "artificial life." With the continuous development and integration of brain-like chips, artificial intelligence, and human brains, upgrading and transforming the human body, and creating "artificial life" is eventually possible, which raises the issue of the boundary between humans and machines, as well as the ontological level of the concept of "human" that needs further consideration. For example, brain-machine devices may "liberate" the brain from the limitations of the body, extending to another body-brain, and then extending to the external world, forming a new "body schema," continuously expanding perception, cognitive abilities, etc. When the brain (nerves) surpass the boundaries of the "body," how should we view the relationship between the brain (nerves) and the body? Will this lead to the dissolution of human subjectivity? Does the brain-machine device as an extension of the body change human natural attributes, and does it deviate from the category of "human"? These will be key research directions for the ethics of neuroscience in the future.

In the discussion of the prospects of neuroenhancement technology, although there are various worried voices, on the other hand, it is also worth looking forward to. Neurophysiologist Miguel Nicolelis believes that compared with worries about intelligent machines simulating, surpassing, and dominating the human brain, any of the

risks of environmental destruction, nuclear war, climate change, infectious diseases, etc., are greater than the technical risks of brain-machine interface out of control [30]. For the time being, due to the high complexity of the human nervous system, there are still many unknown areas in its research and development. Breaking through human "class nature" through neuroenhancement technology is still just a distant idea, but its future direction still needs to be approached with caution.

4. Strategies for Addressing Ethical Risks of Neuroenhancement

The healthy development of neuroenhancement technology is inseparable from the governance of ethical risks. Therefore, it is necessary to clearly analyze and judge the ethical risks caused by neuroenhancement technology and to propose feasible countermeasures to promote the development of neuroenhancement technology towards the direction of benefit Continuing the translation of the document:

4.1 Respect and Protect Basic Human Rights

In the global context, the deep integration of emerging frontiers in neurotechnology and intelligent technology, along with their extensive applications for the general public in the future, will to some extent impact fundamental human rights, such as the right to privacy, personality rights, and the right to health. In response, academic circles both domestically and internationally have called for ethical guidelines, regulatory measures, and legislative actions. Firstly, the establishment of ethical guidelines is fundamental. An article in Nature magazine pointed out the ethical challenges brought about by the integration of emerging neurotechnologies and artificial intelligence, and strongly recommended the formulation of guidelines at the international and national levels to restrict the context of use of enhancement neurotechnology (similar to the measures taken for gene editing) [31]. Our country's team of experts has also stated that ethical guidelines should be proposed in accordance with the cultural background and environment specific to our country, under the premise of complying with international ethical guidelines [32]. Currently, there is no consensus internationally on the ethical guidelines for neuroscientific research, and the scope varies; domestically, there are strict regulations on general ethical standards for research involving human subjects or animals, but there is a lack of specific ethical standards for neuroscientific research involving human nervous systems and anthropomorphic artificial intelligence. Therefore, at the international level, it is necessary to actively establish dialogue with international neuroethics, based on the principles of mutual understanding, openness, and inclusiveness, to host and participate in international neuroethics conferences, to engage in discussions on the formulation of international ethical standards, and to invite outstanding neuroscientists and ethicists from around the world to visit domestic universities and research institutions to exchange experiences in the ethical governance of neurotechnology; at the national level, relevant departments should accelerate the assessment and establishment of ethical guidelines applicable to enhancement neurotechnology. Neuro-enhancement partially transcends the medical field, and its ethical framework requires further evaluation and construction. Collect empirical research data from multiple stakeholders, create a space for negotiation between what is morally "ought to be done" in ethics and what is actually "capable of being done" within the existing socio-economic framework, assess the values that are most morally significant to the public, and ensure that ethical norms are practical and feasible.

Second, guided by the "precautionary principle," consider from a legal perspective how to improve laws and regulations related to neuroenhancement technology. The most discussed in this context is "neurorights." Neurorights emerge from the practical application of neurotechnology and are proposed by the neurotechnology, bioethics, and legal communities, with core concepts including cognitive freedom, mental privacy, and personality integrity. Foreign scholars are committed to incorporating "neurorights" into

the legal framework. For example, Rafael Yuste, the chief scientist of the U.S. BRAIN Initiative and a neuroscientist, organized a research team to propose the "Neurorights Initiative," attempting to persuade governments around the world to add "neurorights" to their legal systems. Domestically, there is insufficient attention from the legal community to the infringement of individual rights by neurotechnology research and application; therefore, relevant departments must expedite the establishment and formulation of relevant laws, clarify red lines and bottom lines, and continuously improve laws and regulations based on development.

Third, strengthen ethical review and technological regulation. Currently, the focus of China's ethical review committees is mainly on ethical reviews in the early stages of experiments, neglecting follow-up reviews in the middle and later stages [33]. The key to a sound follow-up review and investigation mechanism is to improve the regulatory mechanism of ethical review committees. It is necessary to strengthen the emphasis on ethical committees, clarify the content and scope of ethical reviews, form unified operational standards, and require researchers to report to the ethical committee in a timely manner when adverse situations occur. Institutions should regularly conduct systematic training and assessment of ethical committees, incorporating assessment results into annual evaluations. In addition, a robust technological regulatory framework is crucial for protecting human privacy, justice, authenticity, and autonomy. Currently, countries in Europe and America are strategically planning the development of human enhancement technologies based on convergent technologies at the national level [24]. As an important application field of human enhancement, the technological regulation of neuroenhancement is an essential safeguard for enhancing human well-being. Relevant regulatory agencies must continuously improve the regulatory framework, adopt strict accountability and responsibility systems, and strengthen compliance with research institutions and related facility rules to ensure that, in the future highly interactive and invasive digital world, the misuse of technology and the resulting risks are minimized.

4.2 Promote Fair Benefiting with the Priority Principle

Ensuring that the public can universally access technological interventions, reasonably allocating and effectively applying limited neuroenhancement technology resources, can follow the priority principle to promote fair benefiting. First, public policies and laws and regulations can reduce injustice by supporting widespread development, competition, and providing subsidies for vulnerable groups. Second, for neuroenhancement technologies that are costly, consume significant human and material resources, and are limited and difficult to universally access but effective for both sick and healthy individuals, resources can be allocated through the priority principle [34]. For example, between medical and non-medical purpose resource allocation, prioritize medical purposes; in certain special professions, neuroenhancement can be used preferentially, such as pilots and astronauts, whose job nature requires improved attention and reaction capabilities. Using neuroenhancement technology can enhance work capabilities and reduce errors, bringing significant benefits to society. Lastly, for the use of neuroenhancement technology, specific situations should be analyzed specifically, strictly limiting the context, purpose, population, and nature of work of technology use. For selective examinations and sports competitions, the use of neuroenhancement technology is strictly prohibited. For those who are prioritized to use, timely ethical reviews and restrictions should be applied.

4.3 Regulate the Dissemination of Neuroenhancement Information, Strengthen Public Education and Training on the Ethics of Neuroenhancement Technology

Media should consciously improve their ethical literacy in science and technology, reporting on neuroenhancement technology and its ethical issues according to principles

of science, objectivity, and accuracy. Relevant departments and institutions should formulate regulations specifically to promote responsible media reporting on neuroenhancement, referring to ethical standards such as the "Chinese Journalists' Professional Ethics Code," establishing corresponding ethical guidelines and regulatory mechanisms, and creating an education and training system covering all communication platforms and practitioners engaged in news information services with media attributes and public opinion functions. Media should leverage platforms like mobile internet to promote facts and basic knowledge about neuroenhancement technology to the public, recommending joint efforts with neuroscientists and ethicists to strictly control media content, accurately reporting on the applicable population, purpose, dosage, methods, side effects, limitations, and potential life, ethical, legal, and other risks of neuroenhancement, enhancing public understanding of the current state of neuroenhancement technology development, and preventing false propaganda. Media public opinion should also truthfully publicize user feedback, guide the recognition of diverse value judgments, encourage people to make diverse choices [18]. In addition, for some neuroenhancement technologies that do not conform to ethical and moral standards, promote social public opinion to criticize and restrict them, guide the public to rationally apply the scope and methods of this technology, provide people with the correct cognitive concepts, and maintain the ethical and moral standards of the community.

Strengthening public education and training on the ethics of neuroenhancement technology aims to guide the public to rationally and autonomously choose and internalize in thoughts and actions, enhancing public moral self-discipline. The "Opinions on Strengthening the Governance of Ethics in Science and Technology" was issued in China in 2022, which pointed out the need to carry out science and technology ethics propaganda to the public, and to promote the public to enhance their awareness of science and technology ethics. Encouraging various associations, societies, and research associations related to neuroscience and ethics at all levels to build online and offline communication platforms, and strive to disseminate knowledge of the ethics of neuroscience and technology. First, at the ideological level, through lectures, training and other means, objectively and comprehensively publicize the pros and cons of neural enhancement technology, and as far as possible use easy-to-understand wording to promote public understanding; second, at the action level, advocate getting rid of excessive dependence on neural enhancement technology in action. Refusing technology dependence is not refusing technology, guiding the public to use technology reasonably, and the effectiveness and rationality of technology should be carefully considered; again, the teaching content should also emphasize other healthy methods of enhancing nerves, including sleep, exercise, psychological training, and meditation; finally, fully protect the user's informed consent, allowing individuals to weigh the pros and cons between risks and benefits, determine their own preferences, and require users who are willing to use neural enhancement technology to prove that they fully understand the risks and have the ability to handle risks responsibly. For the ethical risks of autonomy infringement from special relationships, supervision can be adopted to ensure protection.

4.4 Promote responsible innovation and carry out ethics education for practitioners in the field of neural technology

In view of the fact that most neural enhancement technologies are still in the research stage, the governance of ethics in the research and experimental stage is extremely important. Responsible innovation emphasizes the joint participation and collective negotiation of stakeholders in the innovation stage. Facing the ethical risks brought by emerging technologies, China has established the National Science and Technology Ethics Committee. In this case, clarify the general principles of science and technology ethics, and strive to incorporate these principles into the research field of emerging neural technology, and formulate specific guidelines. This requires the participation of

multiple parties to create an inclusive, open, and informed dialogue across society, experts in science and technology, ethics, law, medical care, enterprises, caregivers, users, and the public, etc., from their respective fields, to consider the potential ethical, social, and legal impacts in a forward-looking manner, express value demands, and integrate them into the innovation and research and development stage, to complete the professional, rational, and legal argumentation process, and truly implement ethical norms. In addition, ethics education should be carried out for practitioners in the field of neural technology. When neural enhancement technology flows to the market for healthy people, Rafael Yuste and others pointed out that in the business community, the pursuit of profit will often surpass social responsibility. Ethics education should be included as part of the entry training and assessment for technology developers, engineers, and other practitioners in the field of neural technology research and development, guiding them to view the achievements of neural technology from the perspective of long-term social development.

5. Conclusion

Neural enhancement technology is relatively new, and most of it is currently in the experimental stage or only used by neurological patients. With the huge market demand and increased experience of society for emerging neural technology, it may be included in the general use category in the future. However, the "ability" of neural enhancement technology cannot be equal to the "should" in ethics. Its further development and application will trigger ethical risks such as privacy, fairness, autonomy, and identity recognition, and compared with other types of enhancement, the nervous system has high plasticity, can respond to different endogenous and exogenous changes, and its enhancement involves mediating part of human identity. Once the brain nerves are reshaped, it directly changes the cognitive functions such as consciousness, self-awareness, free will, and personal identity contained in the concept of human beings, which goes beyond the bottom line of human life, and the "essence of human nature" becomes a technical tool, turning into a means to satisfy human desires rather than an end, demeaning the value of human dignity. Therefore, while having the good wishes of neural enhancement, it should be treated with caution. The governance of ethical risks in neural enhancement technology should revolve around "people", set the bottom line of principles, and seek benefits while avoiding harm. On the one hand, to protect "people", to protect the nature and value of people from being eroded by the tools of neural enhancement technology from multiple angles is the external condition, and to improve people's ability to rationally and freely choose neural enhancement technology is the internal basis; on the other hand, to develop "people", from the perspective of human social development, the potential research goals of neural enhancement need to be fully defined, truly worthwhile and effective research goals should be separated from short-term benefits and temptations, and be compatible with long-term, cooperative goals in human life, and then be realized through high-quality research and development, and ultimately benefit people. Due to space limitations, the direction of efforts in the governance of ethical risks in neural enhancement technology should also include: first, to propose solutions to the ethical issues in the research and development of neural science and technology from the perspective of Chinese traditional culture and national characteristics. Chinese expert teams pointed out that China's cultural value of emphasizing the power of the masses may lead to neglecting the personality of individuals in extreme cases, resulting in underestimating privacy and autonomy issues. Cultural values restrict the formulation and recognition of ethical norms, looking for ways to eliminate the cultural challenges of stigmatizing emerging neural technology and promoting effective measures for the public's non-professional understanding. Second, strengthen interdisciplinary cooperation research. The study of ethical risks in neural enhancement involves the integration of knowledge from multiple disciplines such as humanities and engineering, and the technology involves the most special part of the human body - the nerves, requiring experts from different disciplines such as neuroscience, psychology, philosophy, sociology, political science, mathematics,

etc., to discuss and research, and construct a multidisciplinary knowledge system for the governance of ethical risks in neural enhancement.

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