**Security issues and countermeasures in cognitive domain extension**

Source: People's Forum Academic Frontier, June 2023

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2023-06-25

<https://www.rmlt.com.cn/2023/0625/676354.shtml>

【Abstract】“Cognitive domain” refers to the collection of content and places involved in cognitive activities. For a long time, the cognitive domain has been considered to be limited to the brain. However, more and more scholars believe that human cognition can be partially composed of factors outside the brain, so the human cognitive domain has extended beyond the brain and incorporated elements such as cognitive technology. In the process of continuous extension of the cognitive domain, people are worried that their own cognitive domain will be invaded by false information and manipulated by the will of others. In order to cope with the security challenges brought about by the extension of the cognitive domain, we should maintain a clear understanding of the "human-technology" relationship in the cognitive domain. At the same time, governments, experts and individuals should make efforts to protect the security of the cognitive domain from multiple aspects such as ethical laws, technical design and digital literacy.

【Key words】 cognitive domain extension, cognition, cognitive security, false information, human-computer collaboration

【Chinese Library Classification Number】G31 【Document Identification Code】A

【DOI】10.16619/j.cnki.rmltxsqy.2023.11.006

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In Phaedrus, Plato described Socrates' views on writing. Socrates believed that writing was a destruction of memory and that writing technology had a negative impact on human cognition. Nowadays, cognitive technology has entered people's lives in a more extensive and in-depth way. The development of high-tech technologies such as artificial intelligence, large language models, and brain-computer interfaces has profoundly affected people's cognitive methods, and even directly changed people's cognitive scope and reshaped people's cognitive activities. Therefore, it is necessary to re-examine the meaning of the "cognitive domain", understand the current changes and risks of the "cognitive domain", and judge the impact of the extension of the "cognitive domain" on the "human-technology" relationship, and prepare response strategies to adapt to the continuous extension of the "cognitive domain".

**Definition and extension of cognitive domain**

The so-called "cognitive domain" is simply the collection of content and places involved in human cognitive activities. The traditional view is that human cognitive activities all occur in the brain, and the brain is like a computer that performs representation and calculation. The impact of technical equipment on human cognitive content and cognitive processes is mainly achieved indirectly.

However, after entering the 21st century, this traditional view of cognition has been challenged. People have discovered that language symbols, paper and pen tools, and even some more complex technical devices, such as smartphones and the Internet, can not only be used as tools to assist cognition, but can also be used as an extension of human cognitive ability and become part of the cognitive domain. [1] These technologies continue to challenge people's views on cognitive internalism. As a result, the cognitive science research program represented by "extended cognition" has gradually been accepted by people.

Extended cognition focuses on the role of environmental factors in the cognitive process, and believes that environmental factors can constitute part of the cognitive process. To defend this view, Andy Clark and David Chalmers proposed the "parity principle", which states that "if a part of the world functions as a process when we are faced with a task, and if this process is completed in the mind, we will not hesitate to regard it as part of the cognitive process, then this part of the world is (as we claim) part of the cognitive process." [2] In other words, external factors that play the same cognitive function should enjoy the same status as internal factors.

Clark and Chalmers used the case of Inga and Otto to help us better understand how cognitive domains extend. Inga, who had normal cognitive abilities, wanted to go to the museum to see an exhibition, so she recalled the location of the museum and successfully arrived at the museum with this belief; while Otto, who had Alzheimer's disease, also wanted to see the exhibition, and his method was to retrieve the location of the museum by searching the notebook he carried with him, and finally successfully arrived at the museum. In both cases, the information in Otto's notebook played the same function as Inga's biological memory, and both constituted part of their respective cognitive processes. In this way, Otto's cognitive process extended to his notebook, and his cognitive domain thus included factors outside the brain.

In order to prevent the cognitive domain from expanding too much and even becoming all-encompassing, Clark and Chalmers listed several limiting conditions for external factors, namely, dependency, accessibility, reliability, and historical relevance. [3] Although there is still debate about these conditions, they at least provide a set of reference standards that can help us distinguish between two types of "external resources": one is used by us only as a tool, and the other is absorbed into the cognitive domain.

According to the view of extended cognition, people can regard some factors outside the brain as carriers of cognitive content. In this way, cognitive content is partially extended outside the brain. Similarly, supporters of extended cognition also agree that brain-computer interface devices are part of cognition and should be protected in the same way as the human brain. Even the cognitive activities completed by people through virtual reality technology have the same authenticity as the real world. [4] In this way, the cognitive domain is no longer a "black box" that belongs to an individual, but a domain that can be publicly revealed and even manipulated by others. For example, others can relatively easily view notebooks, mobile phones, etc. that have been included in the cognitive domain to understand the thoughts of the owner of the cognitive domain. In this way, with the extension of the cognitive domain, the risk of personal cognitive content being tampered with by others is also increasing. In the field of national defense, the "cognitive domain" has been regarded as the third largest combat space alongside the "physical domain" and the "information domain" [5]. In the game between major powers, "control of the brain" has become a key variable in whether or not the final victory can be achieved. In this case, how to correctly view, protect and make good use of the cognitive domain is not only a theoretical issue, but also a practical issue.

**Security issues facing the cognitive domain**

Nowadays, human-computer interaction is becoming more and more frequent, and most of human cognitive activities have been widely infiltrated by technological devices, making it difficult to distinguish purely internal cognitive activities. Even in cognitive activities such as meditation alone, people's concentration and depth of thinking are closely related to the surrounding environment. As the cognitive domain continues to expand, the security of an individual's cognitive domain is easily threatened by the outside world. In order to protect the security of the cognitive domain, people need to maintain a clear understanding of the possible infringements on the cognitive domain.

First, false information can easily blend into a person’s cognitive domain, thus affecting the cognitive basis for people to make judgments. Take the example of Inga and Otto above. Inga’s memories are stored in her brain, and others cannot directly read or destroy Inga’s mental content. In contrast, Otto’s notebook is more easily tampered with or destroyed, so the authenticity of the information in the notebook becomes difficult to judge. [6] Similarly, compared with people’s biological memories, schedules, photos, recordings and other information stored in mobile phones seem to be more easily modified by hackers. This means that the information people obtain with the help of technical equipment may not be reliable. Therefore, it is necessary to take additional screening measures for private information on external carriers to ensure the reliability of information.

However, "deepfake" or synthetic media technology has made public information that originally seemed authentic and trustworthy become precarious, which has also brought an impact on the human cognitive domain. At present, people can replace the faces of public figures into various film and television clips at a very low cost, and can also use artificial intelligence technology to imitate the voices of well-known singers to create music works. These fake videos and audios are often very realistic. If they are spread on various online platforms without being labeled, it is easy for tens of thousands of netizens to mistakenly believe that this is what really happened. It can be seen that in the cognitive domain, whether it is information stored on external carriers or information entering the brain, it is easy to be mixed with false information. Therefore, special attention needs to be paid to the authenticity of the information.

In addition to deliberately fabricated false information, the meaningless information output by cognitive technology will also affect people's cognition and make people's cognitive domain more chaotic. Large language models represented by ChatGPT can interact with users in real time and provide users with information, but they cannot guarantee the accuracy of the information. Compared with the above two examples of deliberate fraud, ChatGPT sometimes seems to be "talking nonsense", but this is not intentionally misleading users. The reason is that its working mode is to generate answers based on previous training data to calculate which vocabulary has the highest probability of appearing in the answer to the question, but it itself cannot understand the semantic content. Because it is difficult for cognitive subjects to distinguish whether they are stating facts or making up illusions based on the resources in their own cognitive domains, it may be more difficult for people to perceive the intrusion of such information on their respective cognitive domains. Such cognitive technologies are reshaping the cognitive process, cognitive habits and belief sets of cognitive subjects. Recently, ChatGPT has also launched a mobile app version. The more convenient it is for people to access such tools, the deeper their interaction with them will be, and the tighter the coupling between the human brain and technology will be, which will greatly increase the possibility that people will incorporate all kinds of meaningless information into their cognitive domain.

Secondly, with the rapid development of technologies such as brain-computer interfaces, one’s own cognitive domain is more susceptible to manipulation by the will of others. People are worried that after the large-scale promotion of neural technologies such as brain-computer interfaces, the devices implanted in the brain will invade their own thoughts, making their brains a database within the reach of technology companies, and even being manipulated by others. Some scholars have hypothesized four situations in which thoughts are manipulated through brain-computer interfaces: first, the brain-computer interface automatically updates information without people realizing it, such as synchronizing the latest holiday schedule; second, people voluntarily choose to join the automatic update protocol, but in fact they do not know what new information will be added to their cognitive domain; third, the brain-computer interface device automatically deletes the user’s long-term unused memories; fourth, the brain-computer interface works deeply with people to help humans make the best choice. [7] In the first three situations, people almost do not need to use their cognitive abilities, and the brain-computer interface device actually bypasses the cognitive subject to implant or delete information. The fourth situation is slightly more complicated. The brain-computer interface device may suppress the beliefs that the cognitive subject may have in order to achieve the optimal solution that the device believes, which actually hinders the creativity of the cognitive subject itself.

In fact, people have been potentially restricted by some technologies, and the autonomy of personal cognition has been affected accordingly. For example, some websites may set search association words, or arrange the order of search results, or directly push "Guess you like" to users. People's cognitive environment is potentially changed, and people's autonomy is affected by the designer's intentions. This is undoubtedly a way to limit people's choices. Some mobile phone software will deliberately add steps or warnings for users to turn off certain functions in order to influence users' autonomous choices. If people's continuous interaction with these websites and software is enough to allow them to be included in people's cognitive domain, then these guiding designs can even be understood as an attack that threatens cognitive autonomy.

In summary, cognitive domain security is vulnerable to the intrusion of false information and the threat of manipulation by others. These two types of problems can essentially be attributed to the trust issues of technology; in other words, the information content and auxiliary functions provided by cognitive technology lack clear authenticity and security judgment standards. People do not know how much trust they should give to cognitive technology, and what standards should be used to judge whether the information obtained through cognitive technology is reliable. To this end, we need to re-examine and deeply examine what dimensions the relationship between humans and technology in the extended cognitive domain presents, and on this basis, how we should respond to the challenges facing cognitive domain security.

**The “Human-Technology” Relationship in the Extension of Cognitive Domain**

Don Ihde, an American philosopher of technology, once distinguished four typical human-technology relations: the first is embodiment relations, that is, technology is a tool for people; the second is hermeneutic relations, that is, technology represents the world in which people live; the third is alterity relations, that is, people and technology interact with each other; and the fourth is background relations, that is, technology becomes the background of human activities. [8]

From the perspective of the extended cognitive process, the relationship between cognitive subjects and cognitive technology is not just a one-way embodied relationship. Especially in the extended cognitive domain, people's cognition is more easily manipulated by cognitive technology. For example, people browse information, record their lives, and share experiences on social media, and social media has become an extension of the human cognitive domain. However, some businesses will use the data of social media users to accurately portray user portraits and send relevant information in order to manipulate people's shopping intentions. Therefore, in the context of the extension of the cognitive domain, we should not simply understand cognitive technology as a passive tool. On the contrary, cognitive technology is profoundly reshaping the subject's cognitive process.

The continuous extension of the cognitive domain also means that the relationship between cognitive subjects and cognitive technology does not constitute a pure explanatory relationship. Today, the architecture and operating mechanism of cognitive technology are becoming increasingly complex. Even professionals cannot explain how the representation between cognitive technology and the world is achieved, which means that cognitive technology has a high degree of opacity. For example, the deep learning technology that is widely used today is actually a "statistical technology that uses multi-layer neural networks to classify patterns based on sample data" [9]. The neural network consists of input, output, and a large number of hidden layers in the middle. These hidden layers are not only numerous, but different variables are also given different weights. It is difficult to explain them clearly whether it is pre-deduction or post-retrospection. This also makes people doubt whether the information learned through cognitive technology really constitutes an accurate representation of the real world. In the context of the extension of the cognitive domain, the "opaque" cognitive technology in the cognitive domain makes the human cognitive process of the world also "opaque". Therefore, we cannot assume that cognitive subjects can successfully achieve the purpose of explaining the world by using cognitive technology.

However, it is not a wise choice to completely reject the use of cognitive technology due to concerns about transparency. First, at the tool level, cognitive technology is expected to provide low-cost and efficient services to ordinary people in the fields of education and medical care, and it is also a force that cannot be ignored in terms of national security. After the extension of the cognitive domain, the huge economic and strategic value contained in cognitive technology will only drive this field forward. Second, at the level of interpretation, it is difficult for people to reach a consensus on the transparency of cognitive technology. In other words, people are not clear about what level of transparency we need? What is the reference standard for transparency? Who will judge whether this standard has been met?

In fact, the extension of the cognitive domain has caused the relationship between the cognitive subject and cognitive technology to gradually transform into a "background relationship" and an "other relationship".

On the one hand, cognitive technology has become the background of cognitive subjects’ life experience, and humans are constantly under the influence of cognitive technology. First, human cognitive processes are not completely transparent. In particular, when humans make decisions involving intuition, hunch, and other factors, it is difficult for humans to understand the logical structure of the relevant behavior [10]. Therefore, it is unreasonable to require that the technology that serves as the cognitive background be absolutely transparent. Secondly, maintaining the transparency of technology should not be the primary requirement for people to maintain the security of the cognitive domain. Blindly pursuing the transparency of cognitive technology may reduce the complexity of cognitive technology and even sacrifice the accuracy of the output results. Sometimes people want to get an explanation that is not a lengthy reasoning process or detailed weight parameters, but an efficient and practical response. Instead of asking cognitive technology vendors to disclose their design parameters and training data, it is better to find other ways to make cognitive technology trustworthy so that cognitive subjects in the extended cognitive domain are more in line with their cognitive background.

On the other hand, more and more cognitive technologies are being incorporated into people's cognitive domains, which also means that the interaction between humans and cognitive technologies is becoming more and more in-depth; the continuous personalization of cognitive technologies makes cognitive subjects and cognitive technologies present an "other-other relationship". Although most cognitive technologies such as artificial intelligence can only deal with problems of specific types (such as text) and specific fields (such as chess), humans, as trainers of artificial intelligence, can convert non-text information into resources that can be absorbed by technology. Similarly, machines can also feed back the results obtained to humans, who can make meaningful interpretations of the results. Some scholars even proposed "Human-Extended Machine Cognition" [11] based on extended cognition, arguing that humans can also be regarded as a part of realizing machine-based intelligence. Recently, Neuralink, a company founded by Elon Musk, has obtained approval from the U.S. Food and Drug Administration (FDA) to conduct invasive brain-computer interface experiments on humans, which means that the relationship between cognitive subjects (cerebral cortex) and cognitive technology (brain-computer interface) is about to usher in closer interaction and integration. For example, blind people may be able to "see" images through brain-computer interfaces, and paralyzed patients can also use brain-computer interfaces to control machines. This "cyborg" technological revolution breaks the boundary between subjects and technology in the cognitive domain, which requires us to look at the new changes in the "human-technology" relationship in the process of extending the cognitive domain with a rational attitude.

Therefore, the subjects and technologies in the cognitive domain should maintain a close cooperative relationship. The ultimate goal of cognitive technology is not to become human, so cognitive technology should not be required by human standards or standards higher than human standards, or even restricted in its development. In the context of the extension of cognitive domains, technological updates go hand in hand with changes in human cognition. For example, reading and writing skills have improved people's communication level, and computers based on reading, writing and computing have raised people's cognitive ability to a higher level [12]. The birth of new technologies is bound to impact the existing rules and order, and people are worried about being replaced by technology, just as craftsmen during the Industrial Revolution were worried that machines would take away their job opportunities. However, the machines that seemed terrifying at the time have been integrated into people's lives, and the technologies that seemed novel at the time are also creating new jobs. After artificial intelligence enters the human cognitive domain, it will inevitably cause similar concerns. Instead of focusing only on the dark side of technology and choosing to stagnate, people might as well learn to coexist with cognitive technology, prepare countermeasures to maintain the security of the cognitive domain as early as possible, and allow cognitive subjects and cognitive technologies to fully interact to achieve the improvement of cognitive ability.

**How to deal with the security challenges brought by the extension of cognitive domain**

Given that the extension of the cognitive domain has led to the "human-technology" relationship showing the characteristics of "background relationship" and "other-other relationship", people need to adjust the ethical bottom line and legal norms for maintaining the safety of the cognitive domain in a timely manner according to the interactive development of cognitive subjects and cognitive technologies, and take non-biological factors in the cognitive domain into consideration. Humans cannot only focus on their biological bodies, but also pay attention to technical equipment in the cognitive domain, and even entities in the virtual world. To cope with the security challenges brought about by the extension of the cognitive domain, joint efforts are needed from governments, experts, individuals and other parties.

Government level. In the process of cognitive domain extension, the government needs to prevent the individual’s cognitive domain from being infringed by others through ethical and legal regulation. Incorporating external technical equipment into the cognitive domain means that they need to be given equal ethical and legal status in accordance with the “ethical parity principle”[13] and the “legal parity principle”[14]. Some scholars have directly suggested that the destruction of cognitive technology should be treated as a personal attack. [15]

Take Otto mentioned in the previous article as an example. Otto's notebook records what happened to him every day, his views on some events and his emotions at the time. If Otto's notebook is stolen by someone else, his cognitive ability will decline significantly. Therefore, this should not only be regarded as a case of personal property theft, but also as a personal attack. Similarly, in the homes of patients with Alzheimer's disease, the location and order of items may be important supports to ensure the patient's freedom of movement; if they are destroyed at will and the original placement order is disrupted, the patient's ability to move will be much worse than before. This is like being forced to consume excessive amounts of alcohol and disrupting the normal thinking of the brain, which also constitutes an immoral behavior.

At the same time, if people's cognitive domains enjoy such protection, then people should also bear the consequences of using technical equipment within their cognitive domains to infringe on others. Current technical equipment cannot act as a complete moral actor and cannot bear all moral responsibilities. By establishing strict ethical and legal norms and following the principle of consistency between power and responsibility, we can establish a clear responsibility allocation mechanism, which is conducive to warning people to pay attention to the cognitive environment and maintain the security of the cognitive domain.

Expert level. The new changes in the "human-technology" relationship in the extension of the cognitive domain require the coordinated development of humans and cognitive technology, which requires experts to take into account ethical issues related to cognitive domain safety at the beginning of technology design. As a whole, the various elements in the cognitive domain interact closely with each other, forming a complex system. It requires experts to consider the goals and value norms of cognitive technology in advance when designing cognitive products so that they can better integrate into people's cognitive domains. If the goals of the various parts in a cognitive domain are different, the cognitive level and action ability that this cognitive domain can exert will be limited. For example, a machine may ignore the potential harm it causes when completing work requirements. Disagreements between different parts will lead to a decline in overall cognitive and action capabilities. If experts take into account the concept of human-machine collaboration when designing cognitive technology equipment, the products launched will be more in line with the human cognitive process and easier to integrate with the human cognitive domain.

In addition, considering the huge power asymmetry between companies that provide cognitive technology and individual users, experts need to play a coordinating role between enterprises and the public. Most users, as laymen, sometimes find it difficult to clearly express their demands or choose the service plan that best suits their own interests. Even if users can explain their demands, it is difficult for them to influence the company's planning in terms of technical routes. In addition, the cognitive technology used by commercial companies cannot disclose relevant details due to commercial confidentiality, and relevant regulatory measures are difficult to reach the algorithm level. Therefore, experts should assume the role of coordinator, adjust the asymmetric relationship between companies and users, balance commercial interests and user interests, and continuously improve the interaction between cognitive technology products and users, improve the performance and safety level of cognitive technology equipment, and promote the interaction within the cognitive domain and the coupling of cognitive carriers.

At the individual level. With the extension of the cognitive domain, cognitive technology has become the background of human life. If humans want to take the initiative in the cognitive background of intelligence, automation, and informatization, they need to focus on improving their own "digital literacy" and understand and make good use of cognitive technology.

The so-called "digital literacy" refers to "the ability to understand and use information from multiple sources and in different forms presented by computers." [16] At present, "the average level of digital literacy of Chinese citizens is not high, and there is a large gap between the digital literacy and skills of certain regional groups and other regional groups." [17] This requires people to learn to use digital skills to meet their information needs, and also requires people to be able to distinguish information obtained using cognitive technology. Taking the cognitive threat caused by false information and meaningless information mentioned above as an example, on the one hand, companies can upgrade their technical means to objectively reduce the possibility of cognitive domain being invaded; on the other hand, they should educate the public to improve their cognitive discrimination ability as much as possible, such as identifying true and false handwriting, discovering strange expressions in face-changing videos, and unreasonable singing methods in artificial audio, so as to avoid false information from causing damage to the cognitive domain.

In addition, while using cognitive technology, people should also focus on understanding and evaluating intelligence itself. On the one hand, in addition to human intelligence, there are also animal intelligence and machine intelligence. By studying other intelligences, people can recognize other cognitive mechanisms, discover the advantages and disadvantages of human cognition, and thus clarify the direction in which cognitive ability can be improved. Moreover, the measurement methods of each intelligence are different. When people's cognitive domain is no longer a simple internal factor, people also need to change the way of measuring intelligence to evaluate their changes in cognitive level. This means that IQ tests designed for humans need to be replaced by a multi-dimensional evaluation system that can measure heterogeneous systems. The need to select measurement standards in turn requires people to understand the operating mechanisms of other intelligences. On the other hand, humans are inevitably biased, and so are cognitive technology devices designed by humans. Studies have found that in people's natural language, people are more inclined to pair typical female names with family words rather than professional words, to associate typical African American names with unpleasant words, and to associate typical male names with scientific and mathematical words. [18] Because of these potential biases in natural language, when people use natural language to train cognitive technology devices, these biases naturally permeate into the technology devices. Therefore, when people interact with these devices, they can recognize their own biases through the abnormal results output by the devices, and thus gain a deeper understanding of how different elements in the cognitive domain are interrelated and synergistic. At the same time, in order to improve the quality of cooperation in the cognitive domain, people should also think about how to input high-quality, less biased training data into the devices, so that the results of the entire cognitive domain become relatively fair.

**in conclusion**

The cognitive domain includes not only factors within the human brain, but also cognitive technology equipment used by people, and even more heterogeneous components such as social institutions. In the face of the extension of the cognitive domain, while people attach great importance to cognitive security issues, they should clearly recognize the new characteristics of the "human-technology" relationship that emerges in the process of cognitive domain extension. People need to build confidence in coexisting with cognitive technology and prepare response strategies. For the government, it is necessary to consider formulating rules to prevent others from infringing on personal cognitive domains and create a safe cognitive environment. For experts, it is necessary to incorporate more comprehensive ethical considerations in the design of cognitive technology equipment to promote smooth human-computer interaction within the cognitive domain. For the public, it is necessary to improve their digital literacy, learn to use cognitive technology well, enhance cognitive ability in the interaction with cognitive technology, and achieve the coordinated development of cognitive subjects and cognitive technology.

(This article is a phased result of the major project of the Key Research Base of Humanities and Social Sciences of the Ministry of Education, "Research on Basic Theoretical Issues in Contemporary Cognitive Philosophy", project number: 22JJD720007; doctoral students Liao Xinyuan and Yang Junjie from the Department of Philosophy of Peking University also made important contributions to this article)

**Notes**

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