**Changes and prospects of cognitive technology**

Source: People's Forum Academic Frontier, June 2023

 Author: Jiang Minghu

2023-06-25

[Abstract] The human brain is the brain of language, and language is a tool for recording knowledge. It can be said that language enables human history to be preserved. Human cognition can be divided into three worlds: physical objects, subjective consciousness, and objective knowledge. The cognitive field, the physical field, and the information field are closely related and have certain differences. Computer Internet is the first revolution in the information age, and natural language processing is the core technology of artificial intelligence; artificial intelligence has promoted the development of cognitive science and technology. Cognitive technology is the second revolution in the Internet information age and will change our work and lifestyle.

【Key words】language, human brain, cognitive field, physics field, information field, artificial intelligence

【Chinese Library Classification Number】R318/TP18 【Document Identification Code】A

【DOI】10.16619/j.cnki.rmltxsqy.2023.11.003

[Author profile] Jiang Minghu is a professor at the Center for Psychology and Cognitive Science at Tsinghua University, a professor and doctoral supervisor of computational linguistics at the School of Humanities at Tsinghua University, and a former visiting professor at the Interdisciplinary Computing Center of Heidelberg University in Germany. His research interests are language cognition and computation. His major works include Language Information Processing, ERP EEG Cognition of Language (Editor-in-Chief), Language, Brain Evolution and Cognition (Editor-in-Chief), and Natural Language Processing (Editor-in-Chief).

**introduction**

The human brain and language have undergone a long evolution together. The human brain has evolved into a language brain. Animals do not have language, and therefore do not have history. Humans have language, which can describe and record the crystallization of wisdom accumulated by humans - knowledge. The accumulation of knowledge has brought about the evolution of logic, thinking and culture, and ultimately formed a civilized and intelligent human society. Artificial intelligence (AI) was also born and developed rapidly.

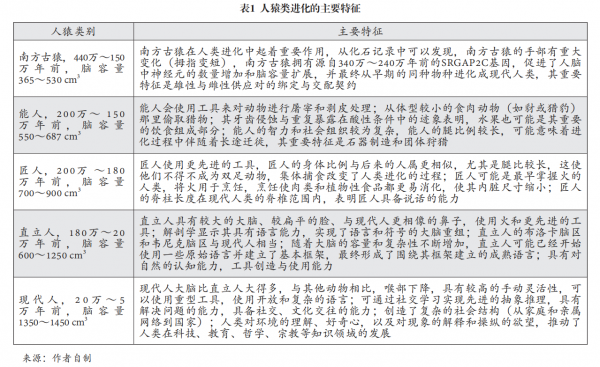
Language is a vocabulary and grammar system that combines form, sound, and meaning. It is a way for humans to communicate (Jiang Minghu, 2022). Although language is infinitely variable, its grammatical types are limited and can be classified, analyzed, counted, and learned. Therefore, it is possible to achieve automatic understanding and generation of language through computer training and learning. Cai Shushan pointed out that human mind and cognition are generated from the evolution and division of labor of the brain, based on language, developed in logic and thinking, accumulated into culture, and constructed society (Cai Shushan, 2021; Cai Shushan and Jiang Minghu, 2016).

There is a close relationship between cognitive science and AI. Cognition refers to the human thinking and perception process, including perception, memory, thinking and language. Although the human brain is born with several specific functional brain areas, in order to fully tap the huge potential contained in the human brain and develop more brain functions, acquired learning and thinking training are indispensable, among which language requires acquired training and learning. If you don’t understand the operation and cognitive mechanism of the brain, you can’t have a deep understanding of the laws of human language cognition (Jiang Minghu, 2016). Many concepts and algorithms in AI research draw on the research results of cognitive psychology. For example, brain-like computing models in natural language processing (NLP) and computer vision are simulating human language and visual systems. Conversely, AI has also had a positive impact on the development of cognitive science. For example, AI’s deep learning algorithm provides new ideas for the research of cognitive neuroscience.

**Language is a tool for recording knowledge. Language enables human history to be preserved.**

The human brain and language have evolved together over a long period of time. From the perspective of human evolution, the development of language is the most unique and significant feature of humans today. Wang Shiyuan pointed out that without the developed human brain, we would not have our ever-changing language; at the same time, without language to help us organize our thoughts and accumulate hundreds of years of scientific achievements, we would not be able to understand the brain, an extremely complex and sophisticated organ. Obviously, the brain and language are closely related and evolve with each other, and language and the brain evolve together (Wang Shiyuan, 2011; 2008). As far as the brain of mammals is concerned, the human brain has the largest proportion relative to the body and the most complex connections. The volume and complexity of the human brain have continued to increase during the evolution process, allowing some old functions to be improved and some new functions (such as language and tool creation) to emerge. This phenomenon has enriched human behavior and cognitive skills and determined their dominant position in species competition.

The brain organ is so complex that the evolution of human intelligence did not happen in an instant, and the use and development of language played a decisive role. Table 1 shows the relationship between the approximate time period of human ancestor evolution and brain capacity. About 500,000 years ago, spoken language appeared, and the functions of operating spoken language in the human brain, as well as speech and corresponding semantics began to evolve. The nervous system naturally became integrated, and the surface area of ​​the human brain began to increase (Jiang Minghu and Wang Lin, 2013; Jiang Minghu, 2019). Noam Chomsky believes that language appeared between 200,000 and 60,000 years ago, roughly 130,000 years ago, which means that it took about 5,000 to 6,000 generations of evolution (Chomsky, 2008; 2014). Human adaptation to language has made it so complex and so effective. Once symbolic communication became slightly complex in early primitive human societies, its unique representational function and open flexibility meant that it could be used for countless purposes and produce equally powerful reproductive results. The multi-layered structure of existing languages ​​and the languages ​​we use easily can only be explained as the result of secondary selection, which is generated by the social function of the first introduction of symbolic processes. Terrence Deacon believes that this may help explain why symbolic communication can only evolve in ecological species with large brains and long lifespans like apes (Deacon, 1997). Therefore, no matter how computing power improves, the absolute size of the brain may play an important role in language evolution. Dor Shilton et al. pointed out that the two overlapping stages of human evolution include: before the emergence of language, involving the initial development stage of primitive human lifestyle, namely hunting and foraging, tool making and allo-parenting; after the emergence of language, involving a stage of further improvement of emotional and cognitive plasticity, which is the result of guiding imagination through language (Shilton et al., 2020).



The human brain is the brain of language. Language is unique to humans and is characterized by the ability to generate and process hierarchical syntactic sequences, which is different from non-human primates. The complexity of language far exceeds the complexity of the communication system of any existing primate species. Its working mechanism is much more complicated than people imagine, and the development of language function is also based on basic physiological functions such as perception and movement. Its uniqueness lies not only in the complexity of its structure, but also in its inseparability from core cognitive abilities. Communication is an important driving force for the evolution of language, and cooperation is the basis for the evolution of language. The ancient source of language is the initial shared intention. With shared intention, there is cooperation. Human language is the result of a continuous and deep-rooted interdependence between our nature (i.e. biology and genes) and our nurture (learning experience and environment). Language relies on many mechanisms that we share with other species. Natural selection improves certain skills of humans, including the increase in brain capacity, the evolution of the vocal tract, the social needs of communication intentions, and the ability to learn complex sequences. All of these skills combined make human language possible. Therefore, the development of good language function needs to be based on rich perceptual and motor experience. At the same time, these brain areas involved in language processing do not work independently, but are organized with each other to form a neural network for processing language. The systematic nature of symbolization indicates that the representation of symbol associations in the brain should be distributed in different brain areas, while similar words share neural commonalities. Relevant brain areas are organized into different information processing networks to process different aspects of language information. A certain brain area not only receives neural signals from multiple other brain areas, but also sends signals to multiple brain areas. The transmission of signals is not completed at one time, nor is it one-way, but is a multiple round-trip and multi-directional interaction between different brain areas. Language is integrated with a wide range of human brain nerves, and they constantly interact and evolve together.

Martin A. Nowak pointed out that after hundreds of thousands of years of evolution, human language has enabled us to transmit unlimited non-genetic information between individuals and promoted the evolution of culture (Nowak et al., 2002). Language is associated with these core cognitive processes, and language signals will feedback and influence our understanding and representation of the world. Acquiring human language requires mastering a complex, multi-level symbol system, which is interwoven with several components such as phonetics, phonology, morphology, syntax, semantics, and pragmatics to achieve the inheritance of our thoughts and culture. This connection between language and cognition is a channel for learning and cultural transmission.

Language itself is based on symbols to represent concepts, and the concept symbol system is located in the "mental lexicon" of these brain regions. A defining feature of human language is its ability to flexibly represent and reorganize concepts. The human genome is deeply rooted in our biological makeup, and it provides a platform for language acquisition by building a neural system that can adapt and reorganize in response to input. The flexibility of human language means that we can use it to represent almost anything we can think of. Gestures, sounds, facial features, and related features have evolved together to form an increasingly complex, dynamic, and diverse human language and non-verbal communication system. When we are born, the neurobiological systems for speaking and listening are fully configured, allowing us to master spoken language relatively easily; reading and writing skills require formal instruction and can only be gradually developed and perfected after years of exposure and experience. Learning to read and write rewires our brains.

The co-evolutionary perspective holds that the evolution of language did not occur inside or outside the brain, but rather at the interface of cultural evolution influencing biological evolution (Deacon, 1997). Co-evolutionary processes have played an important role in shaping the human brain and mind. It is impossible to understand the human mind without recognizing that human anatomy, neurobiology, and human psychology are all shaped by something that can best be described as thought, namely, symbol-referenced thought. Although symbolic thinking can be entirely personal, symbolic reference itself is inherently social. That is, not only do we acquire this form of expression through interaction with other members of society, but the symbols themselves can also trace their social origins. In a specific sense, the unique human mind is the product of an unusual reproductive challenge that only symbolic reference can solve. Human language is complex, but easy to learn and use, which depends on effective symbolic communication. Long-term co-evolutionary accumulation has not only made symbolic communication easier and more effective, but also presented a trend of more efficient acquisition of symbolic information and more powerful use of symbolic communication.

The grammatical semantics and social attributes of language. Human language appears to be just a string of symbols, but it actually has a hierarchical tree-like syntactic structure. Human language is subject to formal analysis: all languages, whether written or spoken, are composed of small elements that are hierarchically and recursively combined into larger units. They have acoustic or artificial features and can be used in turn to form syllables, words, phrases and sentences, and then paragraphs and chapters. Such combination rules are not arbitrary, and each language has specific rules. The way words are combined in a sentence is determined by the hierarchical structure in the grammatical rule system, so human language has the ability to process hierarchical construction sequences and the ability to process recursive structures.

The biological process theory of language holds that humans are born with the ability to recognize grammatical structures, which enables them to develop and understand language (Jiang Minghu, 2022). According to this theory, this grammatical structure system is embedded in human genetics and supports the basic grammar of all languages. The language system is a complex system, and in natural science, complex phenomena and systems are usually decomposed into basic elements or operations for use. Once these basic elements are determined, they can be integrated to explain a complex system. The decomposition elements of complex language systems are morphemes and syntactic rules. For the field of syntax, this approach works well because there is a clear linguistic theory that defines the most basic rule, namely integration. Humans can create and understand completely new messages, and new messages are freely created by mixing, analogizing or transforming old information. A major feature of language is that a simple, finite set of phonemic items can produce an infinite vocabulary system, in which rules determine the form of each word, and meaning is inseparable from form, so that phonetic grammar is a simple combination of existing phonetic units. Another important feature of language is morphology and syntax, in which pre-existing units are merged to produce semantically novel or distinct lexical items (Jiang Minghu, 2022).

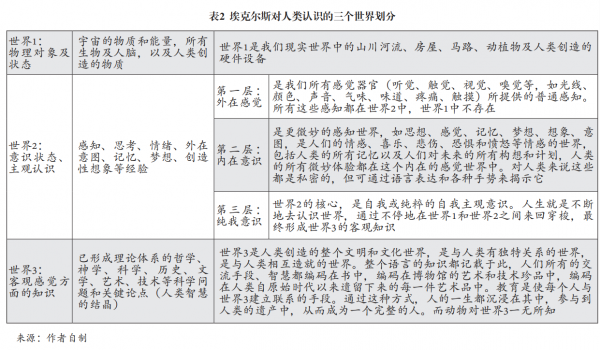
Language is changing and developing, and human creativity drives the change of grammar. Listeners must have rich imagination and creativity. Grammaticalization is essentially based on metaphor. Prohibiting the use of metaphors will prevent the development of grammar and also exclude all possibilities of expressing abstract ideas. Grammaticalization requires that a language system is frequently used among a group of speakers and passed from one group of speakers to another. The ability to ask questions is considered to be the ability to distinguish between language and non-human animal communication systems. Elissa L. Newport pointed out that the mechanism for humans to acquire their mother tongue requires both innate conditions and acquired cultivation, that is, the process includes both the language environment that learners are exposed to and the innate qualities that learners possess, and also requires learning the patterns of instantaneous organization of language in a special way (Newport and Aslin, 2004; Newport et al., 2004). Language is a way of communication, an important part of human behavior and a cultural carrier that defines our social identity. Human language also has a basic feature that makes it amenable to formal analysis: language structure consists of smaller units that are combined according to certain rules, and the combination order of small units that enter larger structures is produced at several different levels. Phonemes form syllables and words, and words form phrases and sentences. Such combination rules are not arbitrary. Each language has specific rules, which produce specific rules for effective or meaningful language structures. Humans are born to learn language. Chomsky pointed out that language is a free creative process. Its laws and principles are fixed, but the way in which the generative principles are used is free. Even the interpretation and use of words involves a free creative process. Chomsky believes that language is a "psychological organ", a set of finite computational mechanisms that can change infinitely, allowing us to produce infinite sentences (Friederici and Chomsky, 2017; Smith, 2004; Berwick and Chomsky, 2016).

Language is a fundamental human characteristic and a cultural universal. Unlike the limited communication systems of other non-human animals, human language is open and evolving, and an infinite number of meanings can be generated by combining a limited number of symbols. Almost every complex thing we say may have never been said before. The real mystery of language lies in how we use an extremely sophisticated and complex system of vocabulary and grammatical structures to freely express our consciousness and thoughts in real time. Externalized language is not only a cognitive problem, but also a social problem. The externalization of language symbols, whether it is paintings on walls or written words, is in a sense a social problem, and there should be some existing environment in the social and cultural field to support it. The generation of oracle bone inscriptions carved on tortoise shells and animal bones, as well as externalized symbols in the form of language, requires not only something in the brain, but also a complex social environment to support it and make it valuable. Language itself is a collective product, not an individual product, and has social attributes. Language has been systematic and social from the beginning. Language is determined by genes, the result of biological evolution, the result of social interaction and communication, and is essential for communication between humans and for the sense of identity of unified national, cultural and ethnic groups. The invention of writing systems at least 5,000 years ago allowed language to be preserved in physical form, which was a major technological advancement for mankind.

When exposed to linguistic data, the listener-speaker brain makes connections between sound and meaning. We usually learn words based on context, distinguishing their meanings through gradual acquisition, and learning their meanings by capturing their nuances, connotations, and how they fit with things. Thoughts are the product of cognitive activity, through which assumptions about our inner and outer worlds are made, conceptualized, structured, and strategized. Learning is a developmental or maturational process mediated by experience and neuronal reorganization, and the result of learning is the accumulation of knowledge and skills to better understand experiences and ideas and make sense of them. By conceptualizing ideas through language, we begin to understand something, that is, to establish a relationship between something (such as a word or concept) and the meaning of something when faced with new experiences through language-mediated interactions. The use of language through narratives and its close connection with culture are at the core of human cognition.

**Human cognition of the world and the development of cognitive science**

The three worlds of human cognition. Nobel Prize winner in medicine John Carew Eccles and philosopher Karl Popper divided mental problems into three worlds (domains) (Eccles and Poppe, 1984), arguing that everything in human experience can be classified into one of the categories of physical objects and states, consciousness states, and objective perceptual knowledge (as shown in Table 2). Cai Shushan divides human cognition into five levels (Cai Shushan, 2021), raising Eccles and Popper's division of human experience to a theoretical level, and believes that the "evolutionary miracle" of the human brain is that it is not only a flesh-and-blood cognitive computing organ, but also can produce five extraordinary phenomena: neural cognition, psychological cognition, language cognition, thinking cognition, and cultural cognition (the first two cognitions are low-level cognitions that animals also have, and the last three cognitions are high-level cognitions unique to humans). The emergence of this miracle is a direct result of language use.



World 1 is the world of physical objects and states, including the matter and energy of the entire universe, all living things, and all artifacts made by humans to encode information, such as tools, machines, books, and artworks. World 1 is the entire world of materialists; World 2 is the world of various states of consciousness and subjective cognition. All the content we perceive is in World 2, including the three levels of external sensation, internal consciousness, and pure self-consciousness; World 3 is objective knowledge, which is the crystallization of human knowledge accumulation. These three worlds are easy to define. In the classification of the three worlds of human cognition, there is nothing missing. It involves everything that exists and what we experience, that is, everything can be classified into three worlds (Eccles, 1973; 1970).

Humans have two kinds of memory (World 2): episodic memory (remembering specific events that have happened) and procedural memory (a type of memory related to skill learning). On the one hand, language uses procedural memory, and most of our pronunciation, grammatical processing, and sentence construction are skills that don't require much thought, just as easy as riding a bicycle or swimming; on the other hand, we can use a procedural storage system, which contains symbols that can automatically "access" the brain's semantic network and our rich life experiences. The human brain can use one kind of memory to associate and organize another kind of memory, which other species cannot use.

Language is a unique form of communication that only humans can achieve, and the brain has undergone many changes over the long process of evolution to make language communication possible. Objective knowledge (World 3) is recorded in language and is the precursor to experience (World 2). When we learn new information and modify our behavior by applying what we have learned, we create a new and richer experience. Because emotion is the end product of experience, the result of our intentional actions is a new experience with a new emotion. When we consciously understand how to create new experiences based on what we have learned and done, we have wisdom, which is the ability to consciously understand how we create experiences and eventually form objective knowledge of World 3 through continuous evolution. Therefore, the evolution of wisdom refers to the process of gaining wisdom by understanding the feelings we create based on the knowledge we have learned, demonstrated, and then experienced. Learning knowledge is thinking, and applying knowledge is practice and experience. Being able to repeat experiences with heart is human wisdom.

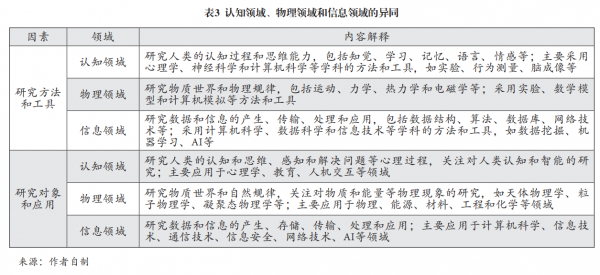
The transformation from subjective cognition (world 2) to objective knowledge (world 3) refers to the process of a person gradually understanding and accepting objective knowledge and facts from his or her own subjective cognition and experience. This transformation usually needs to be achieved through learning, practice and reflection. The transformation from subjective cognition to objective knowledge is a process of continuous learning, practice, reflection and adjustment. The formation process of objective knowledge is a process of combining experience (world 2) and rationality. It is necessary to discover the properties and laws of things through observation and experiment, collect data and information, analyze and deduce to discover the laws and connections, draw preliminary conclusions, and then verify and verify, and ensure its correctness and reliability through re-experimentation, comparison and repeated observation. The demonstrated objective knowledge can be disseminated through scientific and educational publishing or engineering applications. This process needs to be constantly updated and improved to adapt to the ever-changing world and knowledge needs.

Human intelligence is a unique cognitive ability and expression of wisdom, with the following characteristics: Human abstract thinking ability can abstract specific things into general concepts and laws, so as to better understand and grasp the essence of things; Human creative thinking ability can create new concepts, ideas, art and technology, and promote social development and progress; Human self-reflection ability can examine one's own thoughts, behaviors and values, and constantly improve and perfect oneself; Humans have group consciousness and cooperative spirit, and can cooperate to solve problems, share knowledge and experience; Human emotional cognition ability can perceive and understand the emotions and emotions of oneself and others, so as to better communicate and exchange; Human long-term thinking ability can foresee the possibilities of the future and make long-term plans, so as to better face complex problems and challenges. These characteristics together constitute the essential characteristics of human cognition and wisdom.

Human intelligence (World 2) and objective knowledge (World 3) are both used to solve problems, make decisions and reason. Objective knowledge is based on conclusions and facts drawn from scientific experiments and research, and is objective, repeatable and universally applicable; while human intelligence is more based on personal experience, observation, insight and intuition, and is subjective and uncertain. Human intelligence has the ability to perceive the multimodal sound, image, and text of all things in the world, the logical cognitive ability to connect different things, and the ability to learn and calibrate the feedback information from the social environment. The evolution and formation of human intelligence is a long and complex historical process, which is the result of the interaction and influence of many factors. It is influenced and affected by many factors such as brain structure, language communication, tool use, agricultural revolution, industrial revolution, social culture, learning and education. The interaction and influence of these factors drive the continuous evolution and development of human intelligence.

The connection and difference between cognitive science, physical science and information science. Cognitive science is a multidisciplinary field that studies human thinking, learning, memory, perception and decision-making. It involves disciplines such as neuroscience, linguistics, philosophy, psychology, AI and education. It studies how we think, perceive and make decisions. Cognitive technology combines these disciplines with engineering to develop technologies and applications for human cognition, intelligence, and simulation and enhancement of cognitive abilities, in order to enhance human capabilities and change the way we live and work.

Cognition is closely related to consciousness and is subjective in nature, shaped by personal experiences, beliefs, and emotions. Cognitive processes are more complex and flexible than physical or information processes. This process often requires the integration of multiple information and the use of logical reasoning and creative thinking. Cognitive technology relies on big data and advanced computing power to learn, reason, and interact with humans. It is similar to the human brain and can learn and adapt to new situations, create new solutions, and is flexible, intelligent, interactive, and autonomous. The cognitive field, the physical field, and the information field are closely related but different. As shown in Table 3, although all three are important areas of human activity and knowledge development, they each have their own research characteristics and application fields. There are also mutual connections and cross-applications between these application fields, such as the application of information technology in experiments and calculations in the physical field, and the application of AI in the cognitive field.



The cognitive field is also a rapidly developing field that involves complex multidisciplinary interactions. Through interdisciplinary collaboration, the cognitive field brings together skills and expertise from different disciplines to solve complex problems. From data science and engineering technology to cognitive psychology and neuroscience, from cognitive computing to virtual reality, from navigation, autonomous driving, smart cities, smart finance to big data healthcare, experts from different fields of theoretical and applied research can draw on a wide range of disciplinary insights and technologies, promote diversity and inclusiveness in the development process, work together to develop new technologies and applications, and promote innovative development in the cognitive field.

Two revolutions in the information age. The emergence of computer Internet is the first revolution in the information age, which has completely changed the way people obtain, disseminate and share information. Computer Internet has brought important changes to the information age. On the one hand, the Internet has greatly increased the speed of information dissemination. Through tools such as e-mail, instant messaging and social media, people can transmit information to any corner of the world in a few seconds, realizing real-time communication and global information sharing; on the other hand, it has become more convenient for people to obtain information. In the past, people may have to spend a lot of time in libraries or through traditional media to obtain information, but now it can be achieved through search engines and online databases. The rapid development of NLP and data mining technology has accelerated the efficiency of people obtaining the content and knowledge they need.

As the second revolution in the information age, cognitive technology emphasizes the importance of human intelligence and cognitive ability in information processing and application. On the one hand, based on AI, especially NLP technology, computers can better understand, process and analyze large amounts of information; on the other hand, the development of cognitive technology will change the way people interact with computers. Through technologies such as NLP and speech recognition, computers can better understand human intentions and needs and provide a more humane user experience. In addition, by analyzing and processing big data, computers can provide more comprehensive and accurate information support and assist decision-making, which makes cognitive technology have broad application prospects in fields such as medical diagnosis, financial investment and strategic planning.

AI technology has promoted the development of cognitive science and technology. The study of human cognition has a long history. Influential theoretical models such as cognitive psychology, cognitive linguistics and cognitive neuroscience provide a framework for understanding the nature of human intelligence and the cognitive processes behind it. Cognitive technology is a technology that uses AI technology to simulate human cognitive processes, enabling machines to perceive, understand, learn, reason and solve problems like humans. AI is an interdisciplinary study based on multidisciplinary integration, which has promoted our understanding and knowledge of linguistics and the development of linguistic theory itself. NLP is one of the core technologies of AI. Its goal is to enable machines to have the intelligence to understand language like humans and narrow the gap between human communication and machine understanding in different languages. Natural language research has evolved from the traditional mining of language facts with theoretical value and giving explanations to mining structured language big data knowledge that is easy for machines to access, realizing the statistical analysis of language wording and sentence formation rules from large-scale corpus.

Natural language is the most important communication tool for humans. By understanding and generating human language, computers can interact effectively with humans. Since a large amount of data is presented in the form of natural language, through NLP, computers can understand and generate human language by processing and analyzing these text big data, and mine valuable information and knowledge to support decision-making, public opinion monitoring and other tasks. Through NLP technology, large language models can be built and trained, language rules and probabilities can be modeled, text can be analyzed and understood, and applied to scenarios such as text classification, named entity recognition, automatic text summarization, machine translation, speech recognition and synthesis, question-answering systems, and human-computer dialogue systems. Search engines can understand user intentions and retrieve relevant information from massive data, and provide accurate search results, which provides a theoretical basis and technical support for many AI applications. ChatGPT, as a large language model of AI, is an application of cognitive technology, and its underlying logic is big data statistics. When a machine cannot accurately know the essence of things, it can gain experience through statistical training of big data, gradually approach unknown states through iterative operations, and thus judge the essential attributes of things. The premise for this process to be realized is that the probability of people using correct sentences is much greater than the probability of using incorrect sentences. On this basis, as long as the corpus is large enough, the computer can count the regular knowledge of language word formation and sentence formation for automatic language understanding and generation. It has a wide range of application scenarios and will provide people with more intelligent and convenient services and solutions.

With the rapid increase of larger data sets and more powerful computing resources, we can expect technology to further achieve more accurate and comprehensive semantic understanding capabilities, which will help improve the machine's deep understanding of text, including contextual reasoning, sentiment analysis, and logical reasoning. With the continuous advancement of globalization, cross-language communication and information processing are becoming more and more important. Future NLP systems will better handle the semantic differences, grammatical structures, and cultural backgrounds between different languages, and provide more accurate and natural cross-language communication support; at the same time, they will be committed to improving the processing capabilities of long texts and strengthening the modeling capabilities of dialogue systems, which will help achieve a smarter and more flexible dialogue experience, enabling machines to better understand and participate in complex human-computer dialogues. In terms of its application in related technical fields, NLP technology combined with computer vision can realize image description generation; combined with knowledge graphs and semantic networks, it can achieve deeper knowledge reasoning; combined with reinforcement learning, it can achieve smarter dialogue agents. The wider application of NLP technology will bring new opportunities for the development of artificial intelligence.

There are infinite sentences in natural language, but limited sentence patterns. Natural language has many ambiguities (its sentence structure and meaning can have multiple interpretations). Through a series of algorithms and models to parse grammatical structure, analyze word meanings, and through context inference, context recognition, and semantic role labeling, technology can eliminate the ambiguity of natural language. One method is to process language according to predefined grammar and rules; another method is to use statistical models, that is, to learn language rules and patterns by analyzing large-scale corpora. The deep learning technologies currently used, such as recurrent neural networks (RNN) and transformer models, learn the representation and generation of language through large-scale training, and combine grammatical, semantic, and contextual information to generate accurate and reasonable language expressions. Natural language is complex and changeable. To solve the ambiguity of language and process low-resource languages, we must continue to collect and annotate large-scale data sets, continuously improve and optimize algorithms, and continue to promote interdisciplinary cooperation and research.

The development level of AI is closely related to social progress and human well-being. The rapid development of AI will trigger tremendous changes in the fields of science, technology and culture, and have a significant impact on our work and life. Cognitive technology can help us process large amounts of information more accurately and efficiently, improve our decision-making ability and work efficiency, and better cope with challenges in daily life and work; smart homes, smart logistics and smart healthcare based on cognitive technology can help companies develop smarter products and more humane services, bringing us a more convenient and high-quality life and work experience; more importantly, the development of cognitive technology is conducive to accelerating innovation, which may not only lead to breakthroughs in many disciplines, but also improve productivity, thereby promoting the development of the entire society and economy.

**Cognitive technologies will change the way people work and live**

Cognitive technologies refer to technologies related to human cognitive abilities that change the way we work and live by imitating, enhancing or extending human cognitive processes. There is growing interest in the development of intelligent systems that can learn, reason and interact with humans in a natural way. This is due to breakthroughs in the field of AI and the increasing availability of big data and computing power, for example, predicting and preventing natural disasters, preventing and controlling group diseases, etc. As cognitive technologies develop, there is an increasing demand for edge computing capabilities, which can support real-time processing and analysis of data in distributed environments, and machine learning models and other intelligent systems are increasingly in need of the algorithmic interpretability and transparency it brings. The integration of cognitive technologies with the Internet of Things has created new opportunities for intelligent automation and data-driven decision-making in a range of industries. The integration of cognitive technologies with physical systems will lead to the development of new applications in areas such as robotics, self-driving cars and smart cities. These technologies are changing the way we interact with machines and each other, and have the potential to completely change the way we live and work. One of the key advantages of the cognitive field is its ability to evolve and adapt to changing environments and new discoveries, creating opportunities for innovative growth. Cognitive technologies may produce the following new breakthroughs and applications in the coming years.

Enterprise development. Cognitive technology can help the manufacturing industry design more efficient production processes by better understanding the thinking process of enterprise employees. Its theory can be applied to training and education to help enterprises better train and guide employees. By understanding the cognitive process and thinking habits of learners, cognitive technology can design more effective training courses and education programs to improve employees' learning effects and work performance; by understanding the cognitive process and habits of users, cognitive technology can design more user-friendly products, product interfaces and operation methods that are more in line with user cognitive habits, and improve product usability, user experience and product quality; by understanding human cognitive processes and decision-making principles, cognitive technology can design more intelligent, efficient, safe and flexible automated production systems, reduce production costs and better meet market demand; through automated production lines, smart assistants and machine learning algorithms, cognitive technology can gain insight into hidden patterns in big data, thereby helping enterprises improve production efficiency, reduce error rates and make more informed decisions.

Smart city construction. Cognitive technology can help design a more humane urban environment that better meets human needs and provides smarter urban management and public service systems, including transportation facilities, public spaces, and buildings, by understanding human cognitive processes and behavioral habits. This can improve the livability of cities and user experience, optimize community urban management, improve public services such as health care and education, and improve the quality of life and happiness of residents. By understanding the cognitive processes and behavioral habits of drivers and passengers, cognitive technology can design a smarter traffic management system, improve traffic efficiency and safety, help optimize urban traffic flow, and reduce traffic congestion and accidents. By understanding the cognitive processes and behavioral habits of criminals, cognitive technology can design a more targeted monitoring and crime prevention system to improve the safety and security of cities.

Intelligent finance research and development. Intelligent finance is the combination of AI technology and financial services to achieve intelligent financial services. AI technologies such as data mining, machine learning and NLP can analyze and predict financial big data, helping financial institutions to make investment decisions more accurately and intelligently; blockchain technology can improve the transparency and security of financial transactions, and realize the automation and intelligence of financial services through technologies such as smart contracts; cloud computing and big data technology can help financial institutions store and process financial big data, improve data utilization efficiency and system analysis capabilities, and reduce the operating costs and risks of financial institutions. The research and development of intelligent finance has brought more innovation and development opportunities to the financial industry. The combination of intelligent finance and financial technology can achieve innovation and upgrading of financial services in the fields of payment, lending, insurance, etc., and more comprehensively protect financial security and customer rights.

Big data medical development. With the rapid advancement of medical informatization, the amount and types of medical data are increasing rapidly. Big data medical plays an important role in promoting the development of the medical field and improving people's health. Machine (deep) learning, data mining and other algorithms can analyze and process medical big data to discover potential patterns and changing trends, predict the risks that may be caused by diseases, infer patients' reactions at various stages of the disease, and assist doctors in improving the accuracy of diagnosing diseases and making treatment decisions, improving treatment effects and reducing the waste of medical resources. Technologies such as intelligent diagnosis, intelligent monitoring and telemedicine can realize the intelligence of medical services. Big data such as electronic medical records, medical images and gene sequences can be used for the diagnosis, prediction, treatment and prevention of diseases. By collecting and analyzing a large amount of patient data, cognitive technology can optimize the allocation of medical resources and formulate different treatment plans for different patients, thereby improving the efficiency and quality of medical services. Personalized health management and monitoring systems will help people better manage their health and prevent diseases, effectively monitor and manage patients' health conditions, and provide personalized health advice. By mining clinical big data, cognitive technology can optimize experimental design and sample selection, accelerate the development and listing of new drugs, and through the collection and analysis of medical insurance big data, cognitive technology can realize the upgrade of medical insurance reimbursement models and improve the efficiency and quality of medical insurance services. By training data and updating models on local computing devices, cognitive technology can fully protect data privacy and promote platform cooperation and collaborative development of data users.

Advances in navigation and driverless technology. Navigation is the process of using various devices and technologies to help people determine their current location and find their target location. It not only needs to provide accurate location and route information, but also requires good human-computer interaction with users, making navigation more intelligent, humane and convenient. The fusion technology of multi-source data such as sensor data, map data and historical data can improve the accuracy, real-time and reliability of navigation; multi-modal navigation integrates multiple modes of transportation, such as public transportation, taxis and shared bicycles, to provide users with more convenient, more comprehensive and more time-saving travel services, realize information exchange among multiple modes of transportation, and realize intelligent road networks that exchange information, share information and monitor road conditions in real time between vehicles, provide more accurate and real-time road condition information and route planning for navigation, and improve the efficiency and safety of navigation.

Unmanned driving technology is the application of cognitive science and AI technology in the field of transportation. It uses sensors and control systems to achieve autonomous driving of cars, greatly improving traffic safety and traffic relief efficiency, and helping vehicles better perceive and adapt to the traffic environment, improve traffic flow management, and reduce traffic accidents and traffic jams. The intelligence and adaptability of unmanned vehicles can make autonomous decisions based on road, traffic, weather and other conditions, improving the driving safety and stability of cars. Human-computer interaction technology allows passengers to interact with cars more intelligently and naturally, achieving a more time-saving and convenient travel experience. Unmanned vehicles combined with intelligent road networks can achieve autonomous scheduling and optimization of traffic, thereby changing people's travel and lifestyles and improving the efficiency and safety of transportation.

**Conclusion**

The competition in cognitive technology is actually a competition for talent, and the Chinese government has always attached great importance to the introduction and training of talent. Tsinghua University has established the Ministry of Education's Cognitive Science Innovation Base since 2005. Peking University and Guizhou University for Nationalities have established first-level disciplines in cognitive science, which can cultivate cognitive science theory and technology talents at different levels of undergraduate, master and doctoral degrees. In recent years, technology companies such as Tencent, Baidu, and Alibaba have invested a lot of manpower and material resources in organizing research and development, and promoted the research and development of cognitive technology through a series of strategic key deployments and practices, seeking new breakthroughs in cognitive technology. From the government level, through a series of national key research and development plans, the National Natural Science Foundation and the National Social Science Foundation, the country has continuously increased its support for heavy-foundation and wide-application research such as brain-computer interfaces, cognitive science, AI (especially NLP), brain-like computing and social computing, actively simulated human intelligence, conducted brain-like computing, built artificial brains, and mined human knowledge in large-scale data, which promoted researchers from different fields and backgrounds to form a cohesive research team, laying a solid foundation for obtaining more influential research results.

Cognitive technologies have potential economic, social, educational and strategic benefits. As cognitive technologies become more complex, data from a wide range of sources has surged, providing new opportunities for further research and development of cognitive technologies. AI is a key driver of cognitive technologies. Research in areas such as deep learning, reinforcement learning and NLP has expanded the boundaries of AI research and provided support for new breakthroughs in cognitive technologies. Cognitive technologies will improve the way humans and computers interact, allowing computers to better understand and respond to human needs and provide smarter, more efficient and personalized solutions, which will trigger changes in many industries.

It is worth noting that while developing cognitive technologies, we should also focus on developing corresponding technical regulatory frameworks and standards to address issues related to privacy, bias, fairness, security, morality and ethics. For example, malicious actors abuse cognitive computing models to generate a large amount of spam or to generate a large amount of false and bad information for economic gain or other purposes, which will cause a series of adverse effects. Governments and scientific research organizations should develop corresponding ethical frameworks and guidelines for the development and deployment of these technologies, and promote international cooperation on related issues to ensure the responsible use of technology and benefit society.

(This article is a phased result of the National Natural Science Foundation of China key project "Research on cognitive mechanism and computer model of language comprehension" and the National Social Science Foundation of China major project "Research on high-order cognition at the level of language, thinking and culture", project numbers are: 62036001, 15ZDB017 respectively)

**References**

Cai Shushan and Jiang Minghu. 2016. Human Mind and Cognition. Beijing: People’s Publishing House.

Cai Shushan, 2021, Introduction to Cognitive Science, Beijing: People's Publishing House.

Jiang Minghu and Wang Lin. (2013). Brain and Language Cognition. Beijing: Tsinghua University Press.

Jiang Minghu, 2016, Language Information Processing, Beijing: People's Publishing House.

Jiang Minghu. 2019. ERP EEG Cognition of Language. Beijing: Tsinghua University Press.

Jiang Minghu, 2022, Language, Brain Evolution and Cognition, Beijing: Tsinghua University Press.

Wang, Shi-yuan. (2008). Language Emergence: Development and Evolution. Taipei, China: Institute of Linguistics, Academia Sinica.

Wang Shiyuan. 2011. Language, Evolution and Brain. Beijing: The Commercial Press.

RC Berwick and N. Chomsky, 2016, Why Only Us Language and Evolution, MA: The MIT Press.

N. Chomsky, 2008, Language and Mind, Third Edition, Cambridge: Cambridge University Press.

N. Chomsky, 2014, The Minimalist Program, Cambridge: The MIT Press.

CR Darwin, 1871, The Descent of Man, and Selection in Relation to Sex, London: Jone Murray, Albemarle Street.

T. Deacon, 1997, The Symbolic Species: The Co-evolution of Language and the Brain, New York: WW Norton & Company, Inc.

JC Eccles, 1970, Facing Reality, London: Longman Publishers.

JC Eccles, 1973, The Understanding of the Brain, New York: McGraw-Hill.

JC Eccles and KR Poppe, 1984, The Self and Its Brain, Berlin, Heidelberg: Springer.

AD Friederici and N. Chomsky, 2017, Language in Our Brain, MA: The MIT Press.

MA Nowak et al., 2002, "Computational and Evolutionary Aspects of Language," Nature, 417(6889).

E. Newport and R. Aslin, 2004, "Learning at a Distance I. Statistical learning of Non-adjacent Dependencies," Cognitive Psychology, 48(2).

E. Newport et al., 2004, "Learning at a Distance II. Statistical Learning of Non-adjacent Dependencies in a Non-human Primate," Cognitive Psychology, 49(2).

D. Shilton et al., 2020, "Human Social Evolution: Self-Domestication or Self-Control?" Frontiers in Psychology, (11).

N. Smith, 2004, Chomsky: Ideas and Ideals, 2nd Edition, Cambridge: Cambridge University Press.