Cognitive science-the frontier scientific field in new millennium

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Abstract

Cognitive science is a highly multidisciplinary and comprehensive subject in unraveling the mysteries of human mind. It investigates the most frontier scientific issues which able to influence the human destiny in future development, and has received widespread attention from the community. Based on a myriad of up-to-date information and data, this review introduces the status quo of cognitive science research around the globe, analyzes the future trends of its development, discusses the prospective application of cognitive science, and points out the challenge facing the future generation of cognition researchers.

Keywords

cognitive science, mind, brain, emotion, environment

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The establishment of cognitive science in the second half of the 20th century marked a new stage in the development of mental research. As a highly multidisciplinary comprehensive discipline that studies the mysteries of human minds, cognitive science covers many disciplines such as philosophy, psychology, computing science, neuroscience, and anthropology. Cognitive scientists cooperate and communicate with each other, through multidisciplinary theories and experimental collaborations work and integration have greatly promoted understanding of human in nature of the mind, and many researches with theoretical and applied value have been obtained. The results of the

research have affected all aspects related to the development of modern science and technology, such as [1], human cognitive bias and the research on risk perception models, the proposition of many theories in the field of artificial intelligence, the rise of the cognitive science school in modern linguistics, and the development of behavioral finance in economics.

Based on detailed information, this article first introduces the current status of cognitive science research in our country and overseas, then analyzes the research trends of cognitive science, then discusses the application prospects of cognitive science, and finally points out the challenges faced by future researchers.

1. Overview of the development of cognitive science

1.1 Introduction to Cognitive Science Research Institutions

Cognitive science, as an emerging discipline, has shown great vitality to the world. Since the establishment of the Cognitive Science Society in the United States in 1979, many prestigious academic institutions have organized their own cognitive science research teams. There are more than 60 universities in Europe and North America (such as Harvard, Cambridge, MIT, Stanford, etc.) have established special cognitive science projects, and many other colleges and universities have also opened courses related to cognitive science [2].。 For example, the University of California, San Diego established the world's first Department of Cognitive Science in 1986 [3]; Brain and Cognitive Science is one of MIT's fastest-growing majors, and it will be listed as an important research area developed in the next 10 to 20 years [4]; the British Medical Research Council established the Institute of Cognitive and Brain Sciences to study the basic mental processes of humans [5]; four out of the eight research groups under Department of Neuroscience, Pasteur Institute in France are engaged in research directly related to cognitive science [6].

Although our country's cognitive science research started relatively late, it still actively and effectively carried out the exploration of major frontier issues in cognitive science, and its development momentum is good. Major universities and relevant research institutes affiliated to the Chinese Academy of Sciences have listed cognitive science research as an important topic and have actively

provided policy and financial support. For example, Peking University established the Brain Science and Cognitive Science Center with key personnel from the Department of Psychology, the School of Life Sciences, the Information Science Center, and the Institute of Neuroscience [7]; Beijing Normal University established the Brain and Recognition Center and The Institute of Knowledge Science and the Key Laboratory of Cognitive Science and Learning of the Ministry of Education have recently integrated their forces to establish the State Key Laboratory of Cognitive Neuroscience and Learning [8];The newly established State Key Laboratory of Brain and Cognition Science integrates the scientific research teams, instruments and equipment of the three key laboratories of the Chinese Academy of Sciences, cognitive science, visual information processing, and mental health. Supporting facilities, gathers its unique advantages and resources, formed a high-level and strong brain and cognitive scientific research team [9].

1.2 Important Cognitive Science Research Programs in Developed Countries

Cognitive science discusses major frontier scientific issues that affect the future development of mankind, and it has broad application prospects. Therefore, it has received great attention from governments and enterprises in each countries. Developed countries have made key arrangements for cognitive science in their national science strategic plans, relatively. In 1997, the United States officially launched the "Human Brain Project" and supported more than 20 famous universities and research institutions to carry out research on neuroinformatics (a borderline subject combining neuroscience and informatics) [10].

In the strategic action program - "The Science and Technology Shaping 21st Century" is use for the development of science and technology in the 21st century, the government of United State has classified "cognition and neurobiology" and "brain disease biology" into two key areas which are fundamental research and human health services, respectively. In the early 21st century, the National Foundation of the United States, the United States Department of Commerce, and the National Science and Technology Commission Nano Science Engineering and Technology Subcommittee jointly proposed the concept of convergence technology that integrates the four major scientific and technological fields (NBIC, nano-bio-info-cogno). The "C" stands for cognitive science [11]. The Japanese Council for Science and Technology proposed a 20 years term programme- "The Age of Brain Science" in 1996 (with

a total budget of up to 20 billion U.S. dollars, which is 10 times more than the country's "Super Steel Material Development Program".), in which the cognitive function of the brain and its information processing are the most important [12]. The British government provides 15 million pounds to fund the "Brain Sciences-A Cross-Research Council Programme", and hopes that the programme which is led by the British Medical Research Council, and joint by the Biotechnology and Biological Research Council, the Engineering and Physical Science Research Council and Research Council Central Laboratory Council can promote human understanding on brain and its working functions in both healthy and diseased states [13].

The International Graduate School of Neuroscience at Ruhr University, Bochum was established in 2001 by the German government and its one of the major research is advanced cognitive function [14]. The Centre National de la Recherche Scientifique in France also invested in the establishment of the Institute for Cognitive Science, Lyon – France, whose main purpose is to develop multidisciplinary research on cognitive mechanisms[15].

1.3 International cooperation in cognitive science research

Cognitive science research has also embarked on the path of internationalization due to the acceleration of the process of globalization. Researchers working in the forefront of cognitive science have formed various coordinated organizations. On the one hand, they arouse the attention of the public and decision makers to cognitive science, and on the other hand, they promote the cooperation of scientists from various countries and clarify the direction of future research.

The "Human Brain Project" has now become an international cooperative research project on par with the Human Genome Project, and getting more countries and groups have joined this project [10].The Human Frontier Science Program (with a planned investment of 10 billion U. S. dollars), which is a multinational cooperation with the US Strategic Defense Plan and the European Eureka Plan, listed cognitive science as an important research topic at the beginning of its proposal [12, 16].In the latest round of research funding for the Sixth Framework Program for Research and Technological Development (2002-2006) of the European Union, the European Union invested 45 million euros in brain science research. In the 7th Development Framework that began in 2007, the European Parliament will further increase its investment in brain research [17]. Our country is also actively participating in important international

research cooperation. It formally became one of the member states of the "Human Brain Project" in 2001, and established the "Neural Information Center of the Chinese People's Liberation Army General Hospital", which marked the country's "Human Brain Project" and neuroinformatics work was officially launched, and plans to make contributions in the fields of traditional medicine with Chinese characteristics (such as acupuncture and moxibustion) and mandarin cognition and also neuroinformatics research on special perception [18-19].

2. Trends in cognitive science research

Traditional cognitive science research focuses on representation and calculation, and regards the human brain as an information processing system similar to a computer [2,12]. Many important research results in the field of cognitive science, especially problem solving, learning and language use, are based on the mind-computer analogy [2]. Contemporary cognitive scientific research actively absorbs new achievements in related disciplines, constantly adjusts research ideas, expands and develops on the original basis, and shows vigorous vitality.

2.1 Computation-unchanging theme

With the continuous emergence of new knowledge and new theories, the classical hypothesis of characterization-computation has been widely challenged and doubted due to its limitationsBut the best way to solve the problem is to continuously modify and improve this hypothesis, rather than completely abandon it [2]. In contemporary cognitive science exploration, the research on characterization-computation still has important value, and it is able to radiate new vitality through the integration of disciplines such as brain science, information science, artificial intelligence, mathematics, computer technology, and robotics science.

Among the four major researches focus in the research institute of Cognitive Science, University of Pennsylvania, computing accounted for half of them, namely, "economic strategic behavior and calculation" and "logic and calculation "[20].

The MIT Department of Brain and Cognitive Sciences lists the field of computing as the department's key research direction, focusing on motion

control, vision, neural network learning, knowledge-based perception and reasoning, and robotics [4]. The Department of Cognitive and Linguistic Sciences at Brown University is launching a National Science Foundation project called "Computational and Mathematics of the Mind", which explores issues including how humans are processing data under uncertain conditions, how mathematical models explain the process when human are processing data, and how to use computational models to implement these processes on machines [21]. Japan's "Brain Science Era Project" also lists the establishment of calculation principles for cognition, movement, behavior, and thought as a key research area [22]. It is the long-term goal of the Center for Brain Science and Cognitive Science of Peking University to explore the cognitive and neural mechanisms of brain information processing and establish an implementable computational model [7].

2.2 The brain-the material basis of cognition

The brain is the physiological substrate of cognitive function, and the scientific community has reached a consensus on it. Nobel Prize winner Francis Crick proposed in his book <Amazing Hypothesis-Scientific Exploration of the Soul> that "human mental activity is entirely determined by the behavior of nerve and glial cells, and affected by the nature of atom, ions and molecules"[23]. Japan's top cognitive science research institution-a direct product of the "Brain Science Era Project"-was named RIKEN Brain Science Institute (RIKEN Brain Science Institute) [22].Furthermore, the original intention of the Center for the Neural Basis of Cognition jointly established by Pittsburgh University and Carnegie Mellon University is to integrate brain science and mental science [24]. This showed that the study of the brain has become the core content of contemporary cognitive science. The emergence of brain imaging technologies such as ERP, EMG, PET and fMRI allows researchers to "directly" observe the areas and characteristics of brain activity [12]. Using brain imaging technology to study the structure and cognitive functions of the brain has become an indispensable and important part of cognitive science. The "Brain Science, Addiction and Drugs" project of the UK Foresight Programme pointed out that brain imaging technology will be an important driving force for the development of brain science in the future [25]. The Lyon Institute of Cognitive Sciences attaches great importance to the cooperation with our country's PET and fMRI center, we hope to jointly develop a new multi-modal method with brain positioning as the goal to understand the hu-

man mind and brain function [15]. The Institute of Cognitive and Brain Sciences of the Medical Research Council of the United Kingdom has been working on Neuro-imaging project with the University of Cambridge Wolfson's Brain Imaging Centre in the past 5 years, and this project become its priority development strategy [5]. The State Key Laboratory of Brain and Cognitive Science in our country also clearly proposed that brain function imaging will be used as a core research method [9].

It should be pointed out that brain imaging technology is not a panacea for solving mental problems. In addition to the fact that the spatial and temporal resolution has not yet reached the expectations of researchers, one of the inherent shortcomings of brain imaging research is that it can only provide information about brain structure or regional functions, but cannot reveal the deeper layers relationship of brain neurons and various advanced cognitive processes [24].

However, with the rapid development of life sciences, especially cell and molecular biology, and the successful completion of the Human Genome Project, it has become a reality to study the brain and cognitive mechanisms at the cellular and molecular level. Using the gene map as a clue, molecular cell biology technology was used and researchers have find out considerable number of physical substrates for abstract cognitive functions (such as genes that control memory). The neuroscience project of the Cold Spring Harbor Laboratory in the United States, known as the sacred place of molecular biology, has achieved world-renowned results in the study of molecular and cellular mechanisms of learning and memory [26]. The field of molecular and cellular nerves is one of the five key research areas of the Department of Brain and Cognitive Sciences at MIT. It is hoped that the brain can be understood at the most basic level by studying the basic components of the nervous system [4]. One of the expected goals of the second five-year plan of Japan's "Brain Science Era Plan" from 2003 to 2008 is to understand the molecular and cellular mechanisms of learning and memory [22]. The Brain and Scientific Research Center of the Institute of Biophysics of the Chinese Academy of Sciences has also taken the exploration of the cellular and molecular mechanisms of learning and memory as an important direction of attention [27]. In order to promote the development of cognitive neuroscience research in China, a number of excellent academic monographs and popular science readings compiled by Chinese scientists have been published in my country in recent years, providing readers with a large

amount of valuable information for reference. "Principles and Methods of Cognitive Neuroscience" edited by the Neuroscience Laboratory of Kunming Institute of Zoology is a reference book on experimental techniques and basic principles of cognitive neuroscience [28]. Wei Jinghan and Luo Yuejia from the Institute of Psychology of the Chinese Academy of Sciences successively co-authored two advanced courses, "Cognitive Event-Related Brain Potential Course" and "Attention Cognitive Neuroscience Research". The former discusses the principles, techniques and methods of ERP in a simple and simple way In cognitive neuroscience and clinical applications [29], the latter explores the brain mechanism of attention from the perspective of cognitive neuroscience [30].

Scholars from the Institute of Physics and the Institute of Psychology of the Chinese Academy of Sciences co-authored the popular science essay "Consciousness and the Brain-Multidisciplinary Research and Its Significance", which uses easy-to-understand language to show ordinary readers the richness of the field of brain and cognitive science Content [31].

2.3 The return of emotions

Emotions have been ignored by cognitive scientists for a long period of time. The identity of emotion as an important part of the cognitive process was universally recognized by the academic community in the end of the 20th century. The "Human Brain Project" compares the cognitive process of emotions with learning, memory, cognition, language and other classics cognitive science. [10]. The research on emotion itself and the interaction between emotion and other processes (such as learning and memory) has become a research hotspot in contemporary cognitive science. The European Dana Alliance for the Brain, grouped of dozens of top European brain scientists, proposed that the brain activity basis for understanding emotions will be to promote the development of children, help children realize their potential, enrich adult life, and it is also one of the necessary conditions for a healthy old age [32].The Institute of Cognitive and Brain Sciences of the Medical Research Council of the United Kingdom regards emotions as one of the four major research directions of the institution, and the subordinate Cognitive and Emotion Research Group studies the nature of the basic cognitive and neural processes of awakening and regulating emotions [5]. The Lyon Institute of Cognitive Sciences in France mainly focuses on emotional expression and how to use neuropsychological methods to study the neural distri-

bution of emotions [15]. The National Natural Science Foundation of our country approved the implementation of the key project "Theories and Methods of Affective Computing" in 2004, and handed it over to scholars from two domestic authoritative research institutions-the Department of Computer Science, Tsinghua University and the Cognitive Psychology Research Office of the Institute of Psychology, Chinese Academy of Sciences for joint research.

2.4 Environmental impact perception

With the deepening of research and the accumulation of knowledge, scientists have realized that the function of the brain and the development of cognitive structure depend on the influence of the environment, which means that cognitive ability is a kind of adaptation which is formed through natural selection under different environmental pressures [12].; Incorporating the influence of environmental and cultural factors on cognitive ability into mainstream research has become an inevitable trend in the development of cognitive science. The Department of Cognitive Science of the University of California, San Diego puts the research project titled "Studying Humans in their Natural Settings" as a featured research and puts it on the department's official homepage for publicity. This project aims to lay the foundation for the realization and development of Context Aware Environments [3]. The "Interagency Neurolab" which is organized by the National Science Foundation uses the manipulation of the environment-space flight-to observe the response of the human nervous system and the effects on human behavior, perception, and learning. In order to try to clarify the basic connection between neurodevelopment, signal processing and sensorimotor integration [33].It is a key research field of the State Key Laboratory of Brain and Cognitive Science to reveal the interaction between the complex brain system of cognition and culture and society [34]. The Population and Health Innovation Base of Shanghai Academy of Biological Sciences proposed in 2005 that behavior and cognition in complex environments will be one of the key development directions of the base in the field of cognitive science research in the future [35].

2.5 The mind is a dynamic system.

From birth to death, the human brain is in a dynamic process of continuous changing in both function and structure aspects. However, the traditional study of analogy of the mind to the computer ignores the mind, as an important feature. The plasticity of the central nervous system and the symptoms of various degenerative diseases of the nervous system are manifestations of mental dynam-

ics. Research on the development of cognitive functions and aging is not only important in the academic significance but it also directly relates to the improvement of the quality of human life in the future.

The European Dinah Brain Alliance lists the promotion of human understanding of the development process of the brain before and after birth as the primary goal that should be achieved in future brain science research [27]. The European Brain Commission also listed the development, plasticity and aging of healthy and diseased brains as a key research area in the draft of the "Consensus Document on Future European Brain Research" [17]. In 2003, Japan's "Brain Science Era Project" added a new topic called "Nurturing the Brain" to the original three research focus. It is a new focus dedicated to clarifying the principles and mechanisms of brain development and the maturation process of the human mind [22].

The Cognitive Development Laboratory and the Developmental Cognitive Neuroscience Laboratory are set up under the Department of Cognitive Science at the University of California, San Diego. These two important laboratories are dedicated to conduct research in the dynamic changes of cognition[3]. The development mechanism of learning and memory is also one of the important research areas of the State Key Laboratory of Brain and Cognitive Science. It is expected to reveal the neurobiological basis of learning and memory during development, and to clarify the underlying development process of learning and memory in the normal state at the two levels of cellular molecules and functional systems. [34].

2.6 Multi-level cognitive science research

When facing a complex and changeable object such as the human mind, a single level (such as neuron level or behavior level) research can only be a glimpse of the leopard.To truly understand the cognitive process and the mechanism behind it, the only way is to conduct multi-level systematic research that spans from the micro to the macro. The exploration involving the brain in the "Human Brain Project" covers organs, tissues, cells, molecules, genes, and other levels, the current ongoing research includes both the microscopic neuronal ion channel protein and the macroscopic brain anatomy atlas [10]. The British Biotechnology and Biological Research Council requires that all applications for the "Integrative Analysis of Brain and Behaviour" research project fund proposals must be integrated analysis at least two levels (can be genes, protein molecules,

cells, nervous system, cognitive process or neural network modeling)[36]. The MIT Department of Brain and Cognitive Sciences proposed to use the most advanced methods and measures to study the mechanisms and processes of the brain and mind at all levels from molecules to systems [4]. Peking University Brain Science and Cognitive Science Center also tried to carry out multi-level comprehensive research from molecules and cells, systems, to cognition and behavior from the human brain structure and function[7].

2.7 Multidisciplinary integration

The multidisciplinary of cognitive science is not a simple summation of philosophy, psychology, computational science, neuroscience, etc., but a deeper integration of experiments and theories [2]. \At present, researchers in various branches of cognitive science pay more and more attention to mutual dialogue and communication, and obtain inspiration from creative research. The scope of cognitive science is also expanding with this interdisciplinary integration, and even fields such as literature, art, and history are now making important contributions to the development of cognitive science.

The faculty members of the Department of Cognitive Sciences at the University of California, San Diego have backgrounds including the Department of Anthropology, Department of Biology, Department of Communication, Department of Computer Science and Engineering, Department of Linguistics, Department of Music, Department of Neuroscience, Department of Philosophy, Department of Psychology, Department of Psychiatry and Department of Sociology [3]. The MIT Institute departments that have established a good cooperative relationship with the MIT Department of Brain and Cognitive Sciences include the Picower Learning and Memory Center, McGovern Brain Institute, Biology and Computational Learning Center, Department of Linguistics, Department of Biology, Martinos Biomedical Imaging Center, MIT The Clinical Research Center, the Department of Mechanical Engineering, the Computer Science and Artificial Intelligence Laboratory, and the MIT Media Laboratory, known as the mecca of contemporary new media art [4].

As one of the first cognitive science projects established in Korea, the Seoul National University Cognitive Science Project not only has faculty members from cognitive psychology, linguistics, philosophy, computer science, neuroscience and other professional backgrounds, but also cooperates with the university. The Department of French, Department of Biology, Department of

Neurology, Nuclear Medicine, Pharmacology, History and Philosophy, and Institute of Molecular Biology and Genetics are engaged in effective dialogue and communication [37]. The population and health innovation base of the Shanghai Academy of Biological Sciences listed its expected partners for the research of brain function and cognition, including the Institute of Biophysics, the Institute of Psychology, the Shanghai Institute of Neuroscience, the Institute of Acoustics, the Kunming Institute of Zoology, the Institute of Automation, the Institute of Software, Institute of Computing Technology, Shanghai Institute of Biochemistry and Cell Biology, and Institute of Genetics and Development [35]. The Tsinghua University Cognitive Science Innovation Base has 6 supporting disciplines, namely philosophy, psychology, linguistics, anthropology, computer and information science, brain and nerve science.

2.8 The emergence of new disciplines

The integration of multiple disciplines has promoted the emergence of new sub-disciplines, among which neuroinformatics, neuro-information technology (Neuro-IT), and knowledge science have attracted much attention. The Institute of Medicine of the American Academy of Sciences in a 1991 report entitled "The Positioning of the Brain and Its Function: Integrating Enabling Technologies Into Neuroscience Research" (Mapping the Brain and Its Function: Integrating Enabling Technologies Into Neuroscience Research) recommended the establishment of a special fund for funding Those research plans that combine neuroscience and informatics [10].This marked the birth of neuroinformatics. Nowadays, neuroinformatics has become the most eye-catching branch of cognitive science research. The core content of the "Human Brain Project" is neuroinformatics [10]. The British Medical Research Council, the Biotechnology and Biological Research Council, and the Engineering and Physical Sciences Research Council jointly funded a strategic project named "UK Neuroinformatics Network" (UK Neuroinformatics Network). Informatics formulates a development charter with the theme of multi-level computational modeling of the nervous system [38]. The Neuroinformation Center of the Chinese People's Liberation Army General Hospital, established to cooperate with my country's entry into the international "Human Brain Project", is the first neuroinformation center in my country. Its main task is to establish a neuroinformation work platform to provide the necessary conditions for the development of neuroinformatics research [19].

The neuro-information technology proposed by the EU FET (Future and

Emerging Technologies) project is a new multidisciplinary research field based on the interface of neuroscience and information technology. The focus of neuro-information technology is how to make the IT industry nervous. Benefit from scientific research results to develop better IT products, and how to make neuroscience make better use of information technology to test models and hypotheses [39].

In the era of knowledge economy, the role of knowledge in the process of human civilization has become more and more obvious, and the object of knowledge science research is knowledge and its characteristics and laws [40]. Research on the acquisition, development and utilization of knowledge is an important driving force for the sustainable development of the knowledge economy. The Department of Informatics of the National Natural Science Foundation of China has organized meetings to discuss and analyze the latest research status of knowledge science and related fields (such as computing science) and the future prospects for development trends [40, 41].

3. Broad application prospects of cognitive science research

Carrying out cognitive science research is not only to satisfy human intellectual curiosity, but more importantly, it enhances humanity and improve the quality of human life. Any research result of knowledge science can truly realize its own value only when it is truly applied to the actual field of production and life. The broad application prospects of cognitive science research have been presented to the world.

3.1 The field of clinical medicine and drug control

When talking about central nervous system diseases such as Alzheimer's disease, Parkinson's syndrome, functional neurological disorders, and the devastating consequences of nervous system damage such as stroke and high paraplegia, people will shudder. Cognitive science, especially neuroscience research, will make it possible to overcome these diseases.

Japan's "Brain Science Era Project" clearly stated in the plan that the treatment and prevention of Alzheimer's disease should be found before 2007, seeking a comprehensive understanding of the pathological mechanisms of Parkinson's disease, epilepsy, and Down's syndrome and developed The final

treatment method, as well as exploring the technology to promote the recovery of brain function and the method of diagnosing and treating functional psychiatric disorders [22]. The European Dinah Brain Consortium put forward the goals of clinical application that can be achieved in future brain science research, including: developing new methods to promote the regeneration of the central nervous system; identifying genes that cause familial schizophrenia, manic depression and their pathogenic mechanisms ;develop methods to reduce the damage caused by stroke to the brain, design new rehabilitation and recovery treatment methods; develop new early diagnosis and treatment methods for multiple sclerosis, epilepsy, motor neuron diseases and Alzheimer's disease[32] . The State Key Laboratory of Brain and Cognitive Science will provide the theoretical basis and methods for the prevention and treatment of brain and cognitive dysfunction. The mid-term goals of the laboratory include elucidating the pathogenesis of neurodegenerative diseases and mood disorders, and providing new ideas and propose effective methods for their prevention and treatment, by targeting certain brain and cognitive function decline and obstacles [9]. In addition, research in the field of cognitive science will also promote human understanding of addiction, drug abuse and the underlying mechanism [25], so as to provide strong scientific support for the effective solution of drug problems. Other medical applications include pain and its control, new drug design and development, etc.

3.2 Smart machines and robots

Manufacturing smart machines and robots has always been a human dream, but the reality is that the robots and smart devices used in production are still in their infancy. After the initial rapid development of artificial intelligence, it seems that it has also fallen into a bottleneck.This gap between reality and ideals is largely due to the fact that cognitive science has long compared the brain to a standard computing machine for research. Recent studies have shown that the work of the brain cannot be described by simple computer principles [2]. However, contemporary cognitive science starts research from a new angle, making the emergence of intelligent machines no longer remote. The United States put forward a new concept of "artificial servants" in the Convergence Technology Report of the four major scientific and technological fields. Human needs, feelings, beliefs, attitudes and values will all permeate in this new type of intelligent machines[11]. The "simulated brain" theme of Japan's "Brain Science Era Proj-

ect" aims to reveal the mechanism of the brain from a theoretical and engineering perspective, thereby providing brain-style computers and computers capable of processing knowledge and emotions. The final development of the robot lays a solid foundation [22]. \The Computational Intelligence Laboratory of the Department of Computer Science at the University of British Columbia in Canada studies the calculation methods that make intelligent reasoning, action and perception possible, and applies the existing results to a new generation of high freedom called "Platonic Beasts" Degree robots are under development [42].

The State Key Laboratory of Brain and Cognitive Science included the establishment of a theoretical model of advanced cognitive functions and its application in the design of a new generation of machine intelligence systems as the laboratory's mid-term goal [9].

3.3 Learning and education

In the information age, how to extract information from massive amounts of data and absorb and understand it, and how to quickly and effectively disseminate rapidly accumulated knowledge is a major problem facing by mankind.。 Using cognitive science theories and laws to help people learn more effectively, and applying laboratory results to specific educational practices and knowledge transfer is the best solution to the challenges brought about by the information explosion [43]. The report on the integration of the four major science and technology fields in the United States proposed that the use of NBIC scientific knowledge to explore new educational methods to help people learn how to learn is one of the necessary prerequisites for "Expanding Human Cognition and Communication" [11].

The European Dinah Brain Alliance hopes to promote the application of scientific research knowledge of the brain to promote the development of children and help children realize their potential [32]. The State Key Laboratory of Cognitive Neuroscience and Learning of Beijing Normal University proposes to take the major needs of national talent training and education reform as its basic foothold, from the perspective of the integration of psychology, cognitive science, cognitive neuroscience, educational science and other disciplines, to carry out scientific research and to promote the scientific solution of educational practice problems [44]. The Population and Health Innovation Base of the Academy of Marine Sciences also takes as one of the research goals to enhance the learning and memory abilities of adolescents and improve the condition of

people with learning and memory impairments to provide new ideas and methods [35]. In addition to the three main application areas mentioned above, cognitive science research will play an incalculable role in many aspects such as corporate organization management, software engineering, mass media, policy making, consumer product design, living environment planning, and art and entertainment. [11]. For example, in the software development industry, one of the three ways to improve software productivity and reliability is a knowledge-based approach guided by cognitive science theories[45]; meanwhile, in the entertainment industry, an animation production software prototype called SWAN written by artificial intelligence technology can automate the traditional animation generation process, thereby greatly reducing the production cost of animation [46].

4. Challenges facing by researchers in the future

Cognitive science, while showing vigor and bright prospects, but also poses severe challenges to related researchers and research institutions. Perhaps there is no more scientific research field that is more suitable to be described by the term "interdisciplinary" than cognitive science [47].In the study of cognitive science, experts in the traditional sense are far from enough. Its multidisciplinary nature determines that having a broad range of knowledge is one of the necessary qualities for future researchers. Facing this situation, universities and research institutions in various countries have made corresponding adjustments. On the one hand, they have established a core team with an academic background covering the main research fields of liberal arts, science and engineering. Undergraduates and postgraduates in the field of cognitive science adopt a "wide-caliber" training.The current practice has not yet pointed out the best way to cultivate multidisciplinary cognitive talents, but all those who have worked or are preparing to work in the field of knowledge science should be aware of research What the mind needs is a "a merging mind" [47], to actively broaden one's knowledge and be able to integrate them. As said by Denise Manahan-Vaughan, Dean of the International Graduate School of Neuroscience at Ruhr University, "The brain is so complicated that we will never be able to fully understand it if we study it only from the perspective of a single subject. .[47]"