



# Brain's Distributed Cognitive System - with Sports Culture Cognition as an Example

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## ABSTRACT

Cognition is a process of information processing in the brain. Usually intelligence refers to the ability to reconstruct information. In the cognitive system research field, the traditional artificial intelligence which uses symbolic representation for cognitive simulation has encountered challenges. With the development of brain neuroscience, psychology, cognitive science and related computer technologies, the research on cognitive system is progressing toward contextualization and personification. This paper systematically introduces the cognitive system and several cognitive pathways and analyses their differences and relations. It also describes the elements and characteristics of the distributed cognitive system in detail, including representations and calculations, culture cognition and interactions, etc., and takes the sports culture as an example to further elaborate them. The greatest advantage of the distributed cognition system over the traditional cognitive approach is that it emphasizes the importance of the environment to cognitive activities or processes. As a way to look at cognitive activities, it believes that cognitive processes are distributed to some extent and all cognitive activities should be included in them. This is of great significance to the researches on the cognitive system as well as artificial intelligence.

**Key Words:** Cognitive System, Distributed Cognition, Sports Culture

**DOI Number:** 10.14704/nq.2018.16.6.1554

**NeuroQuantology 2018; 16(6):275-281**

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## Introduction

Cognition (Garnham, 1990) is a process by which the brain acquires knowledge; cognitive science (Van, 1998) is a cross-disciplinary field that studies how information is formed and transcribed in the brain. Its research areas include philosophy, psychology (Repovs and Baddeley, 2006), artificial intelligence, linguistics (Cross, 2001), pedagogy and anthropology, etc. and the research content covers a wide range, from learning and decision-making mechanisms to logical thinking as well as the structure and conduction of brain nerves. The traditional understanding and definition of cognition mainly focused on the psychological level. It was believed that cognition (Markus and Kitayama, 1991) was only an activity occurring inside the brain, such as learning, memory or perception, and had nothing to do with the external environment. However,

the artificial intelligence built on this view failed to well simulate the human brain (Johnson-Laird, 1980), telling us that it was an incomplete and one-sided way to restore cognition by internal symbolic representation. With the development of various disciplines and people's increasingly profound understanding of the cognition process, the research on cognitive system (Beer, 2000) is now progressing toward personification and contextualization.

The research on artificial intelligence (Genesereth and Nilsson, 1987; Sharma and Goyal, 2017) has promoted the study of cognitive systems. The symbolic system hypothesis was the earliest intelligence simulation approach in the field of artificial intelligence. It was believed that computers (Xiaolan *et al.*, 2014) could use symbolic (Pozna, 2007) logics to simulate the human brain in processing information, such as

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**Relevant conflicts of interest/financial disclosures:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Received:** 2 March 2018; **Accepted:** 3 May 2018



learning and reasoning, etc. (French and Thomas, 2001; Zou, 2016), but such logics are only a sufficient condition for simulation, so artificial intelligence has been developing slowly for a very long time. The reason is that, in the process of interacting with information, the human brain has no definite rule of operation, but this approach simulates the brain through a single logic, which is incomplete. Later, after reflection on and evolution of the symbolic system (Nisbett *et al.*, 2011), it is believed that cognition is a process of interaction with the environment (Heft, 2013). Based on this, a new research path for cognition has emerged. At present, the research on situated cognition is quite mature and often applied in the teaching field; the extended mind hypothesis, which is quite controversial in the world, has rarely been studied in China; and the distributed cognition (Cole, 1993), on the other hand, has become a new growing point for this discipline in the international community, which is of great significance for the study of how the cognitive system is generated and the complete meaning representation of the cognitive system.

With the cognition process and cognitive system as the research objects, this paper studies the distributed cognition system (Hollan, 2000), describes the elements and characteristics of the distributed cognitive system in detail, including representations and calculations, culture cognition and interactions, etc., and takes the sports culture as an example to further elaborate them.

## Cognitive system

### Definition of cognition

In our daily life, cognitive activities take place all the time. For example, when we learn a new skill, appreciate a painting or enjoy a piece of music, or watch a football match, there is always a process of cognition. At present, there is no consistent view on the definition of cognition. A more representative and narrow definition of cognition is that it is a combination of information processing and knowledge application; in a broader sense, cognition is the psychological activity of the brain that reflects the essential attributes of objective things and other internal connections. A deeper understanding is that cognition is a process in which the system receives and digests new knowledge based on the existing knowledge structure and then

reconstructs the structure. Cognitive science is a discipline that systematically studies the principles for information processing, and even includes research on the nature of human intelligence and machine intelligence. Therefore, the study of the cognitive system can be carried out in three levels, as shown in Fig.1 below.

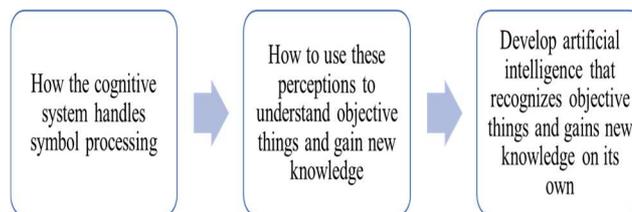


Figure 1. Three Levels of Study on the Cognitive System

### Structure of the cognitive system

A cognitive system is a complex system that contains many disciplines such as psychology, philosophy, neuroscience, and artificial intelligence. To study it, various methods and tools are required. Regarding the structure of the cognitive system, researchers from different disciplines have different views. The traditional psychology believes that the cognitive system has such a structure as shown in Fig. 2 below. It is merely a simplification of the human physiological mechanism, including the sensory organs, the afferent and efferent nerves, the central nervous system, and the locomotive organs. However, this does not reflect the process of information processing by the cognitive system.

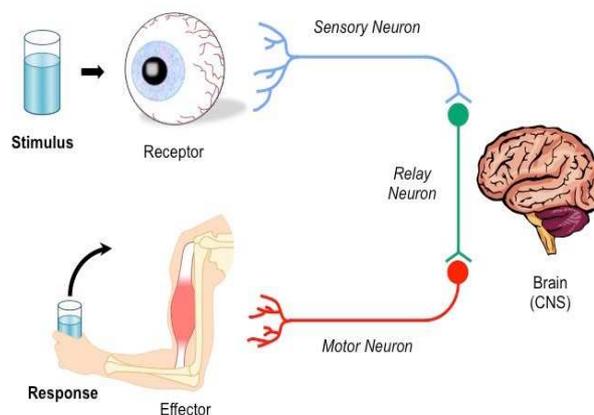
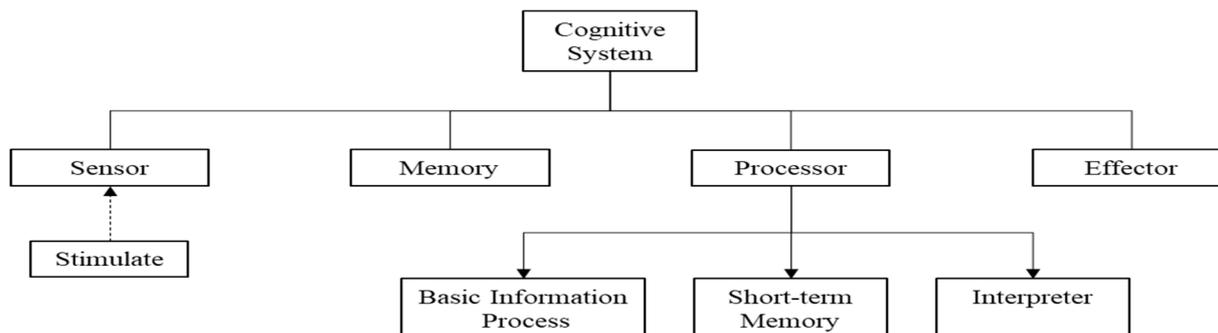
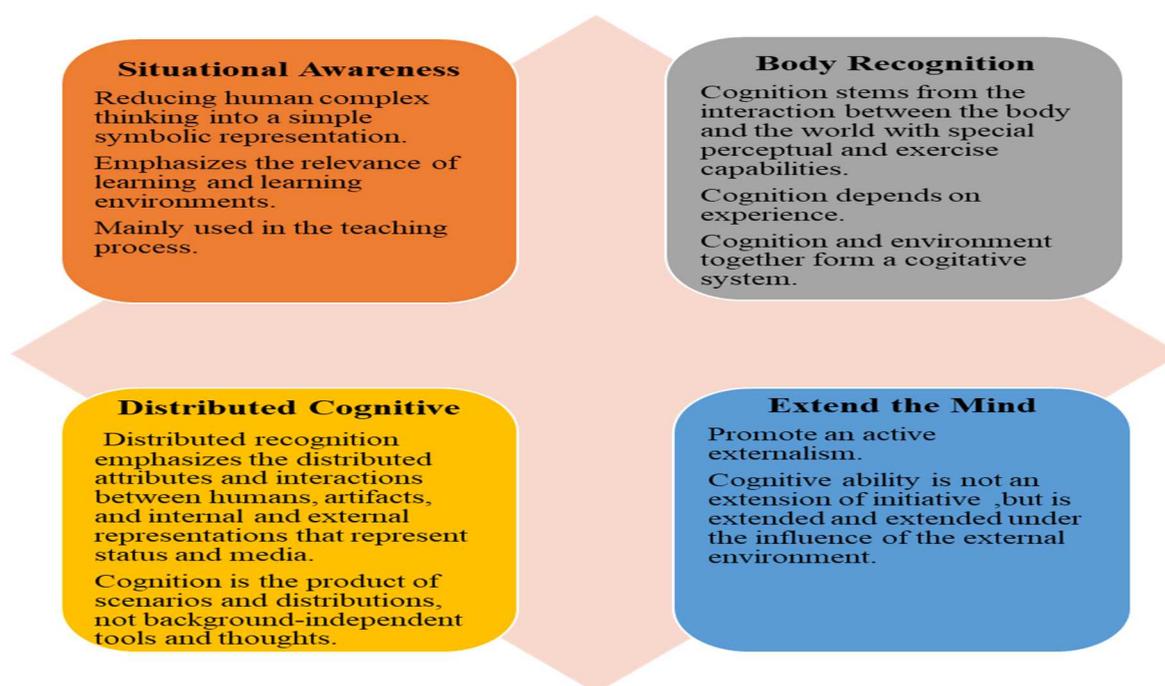


Figure 2. Components of Simple Reflex Arc



**Figure 3.** Components of Cognitive System



**Figure 4.** Research Methods for Cognitive System

In order to reflect the cognitive processing function of the cognitive system, other scholars have modified the structure of the cognitive system, as shown in Fig.3, which mainly consists of sensors, processors, memory, and effectors. This structure is proposed based on the psychological views, where the afferent nerves and sensory organs are combined, and the central nervous system is decomposed into processors and memory. Processors are where information is reconstructed.

**Research method for cognitive systems**

As an interdisciplinary subject, cognitive science covers various human-related intellectual activities, including perception, memory, movement, reasoning, awareness, and language, etc. In recent decades, the cognitive science research in artificial intelligence has been

hindered and challenged, for which the root cause may be that the human brain cannot be simulated as a completely internal symbolic system. Therefore, broader and more profound studies of cognitive science are required to help better understand the nature of cognition and give more possibilities for mind simulation. At present, there are mainly four research methods for cognitive systems: situated cognition, extended mind, distributed cognition and embodied cognition. The four methods are partially overlapping and progressive. The following Fig.4 briefly lists the views of these research methods and their respective application directions.

**Research on the brain's distributed cognitive system**  
*Distributed cognition*



Cognitive activities are always closely related to specific cultural and historical backgrounds, and external factors such as the environment and other people all influence the realization of cognition. Cognition is distributed over time. Longitudinally, it is distributed in the past, present, and future of a cognitive subject, and horizontally it is distributed in the time dimension. For example, we often educate the next generation based on our experience and understanding.

The distributed cognition advocates representation and calculation of spirit. It is a research method focusing on the cognitive process and was first proposed by an American scholar Edwin Hutchings. As shown in Fig.5, the following three aspects have promoted the research on distributed cognition.

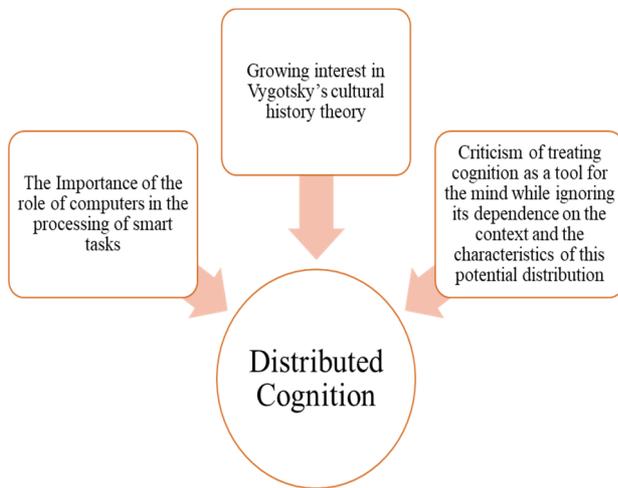


Figure 5. Distributed Cognition Development Reasons

The influence of culture on human spirit is the initial important source of distributed cognition. In the distributed cognitive system, all

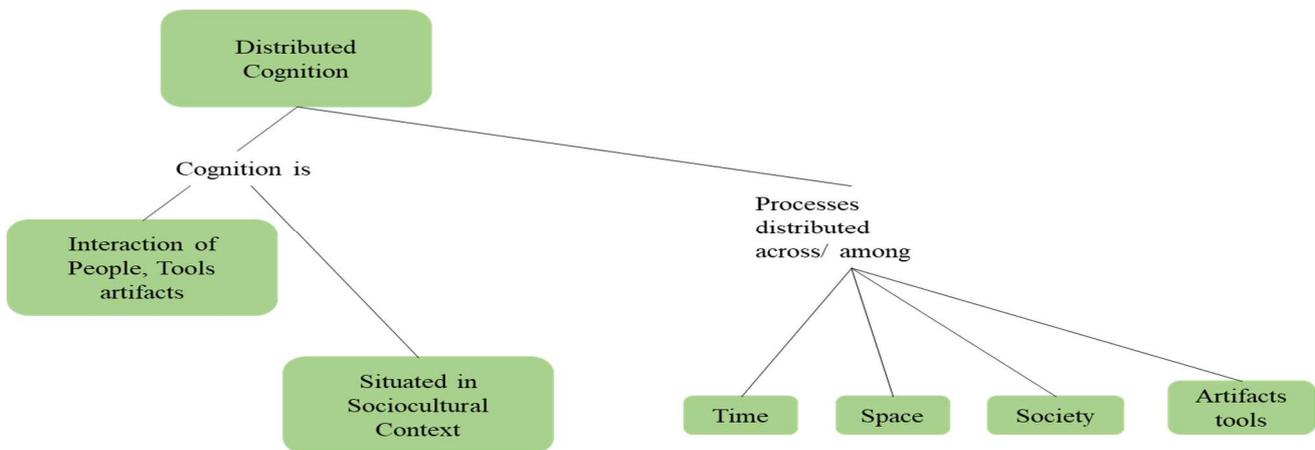


Figure 6. Overview of the Distributed Cognition Theory

elements are equal in status, without any centre, and the key condition is to have an organizational structure with a clear boundary, such as the sports circle, and another condition is that the organization or the group can produce the output with representative content, which is called collective judgment. The elements of the distributed cognitive system are shown in Fig.6 below.

*Representation and calculation of the distributed cognitive system*

In cognitive psychology, representation is seen as an existence form of information and also an object of information processing, and therefore it is an indispensable basic component of the cognitive process. Representation can be divided into two parts: internal and external representation. The former mainly refers to the forms in mind, while the latter refers to the rules and relations, etc. in the external world. Their common task is to represent the abstract task structure. Representation is a necessary condition for cognition. Only through representation, can we develop an independent imaginary world. However, representation cannot fully reflect our inner world. It is a relative concept.

The significance of calculation mostly lies in the propagation of the representational state and the flow of representational information. It includes both the traditional calculation process and the calculation of the phenomenon range. In the actual application process, such as competitive sports, calculation is not imagining, but a real activity that can take place only when people actually operate and must achieve a certain standard.



**Role of tools**

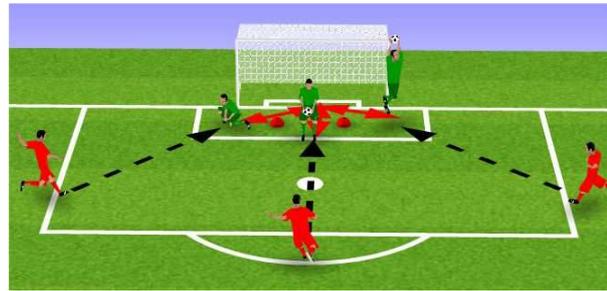
Unlike in other cognitive systems, in the distributed cognitive system, non-human technologies and tools are included as the elements of the system, rather than as add-ons, directly involved in the cognitive activities to shape and change the mind. In the cognitive system, tools are the important media to achieve representation and calculation. For example, in a football stadium, the lines on the field, footballs and woodwork, etc. can all be seen as cultural artifacts containing intelligence. Tools, on one hand, impose constraints on actions, and on the other hand, can be seen as the media for representation and calculation. Only through application can the tools play their roles and be understood. With the help of tools, people can have a deeper understanding of the world and the environment and also a more concrete understanding of the tools. It is what we call continuous interaction, showing the importance of the tools in the cognitive system.

**Power system – interaction effect**

(1) Interaction effect

The important relations in the cognitive system are the connections between cognitive agents. A set of well-established relations help form the coupling forces between agents. As all agents influence each other, another key element of the distributed cognitive system is the interactions between these agents. For example, in a football game, a football player and the environment and other players are mutually restrictive. The interaction between him and the referee or other players can change the player's judgment on the next behaviour. This decision-making behaviour affects the players on both sides. Fig.7 below is an example of the interactions between the

goalkeeper and the environment and the opposing players when he is making a decision.

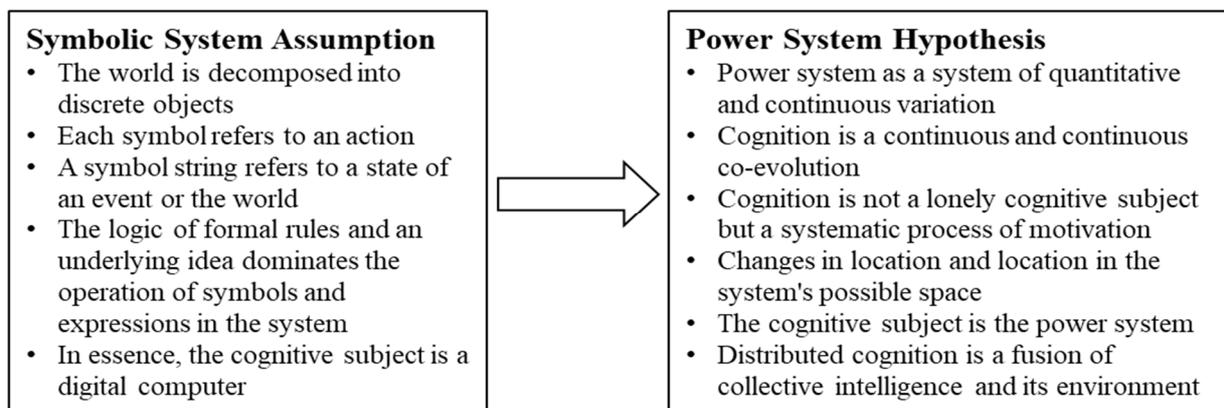


**Figure 7.** Example of Interaction in Football

In the real world, the interaction models are numerous and relatively complex, but they all have a common basic attribute, which can be interpreted as a certain social activity of a group in a shared environment. In the field of artificial intelligence, it is actually a series of exchanges of strings. In the cognitive system, each element and others are closely related and influence each other. However, the degree of coupling between these elements needs to be further explained using the concept of power system.

(2) Power system

With the development of various disciplines such as artificial neural network, neuroscience, and psychology, and the rapid development of computer hardware, people's new ideas or views about cognition can be input into the tools. The early symbolic system hypothesis has been upgraded to the power system hypothesis, which thinks that cognition is not a cycle-by-cycle structure but a continuous and sustainable evolution process with the time and the environment. The following Fig.8 is a comparison of the views under the two hypotheses.



**Figure 8.** Symbolic System Hypothesis and Power System Hypothesis



### *Comparison of several cognitive approaches*

Cognitive methods mainly include situated cognition, embodied cognition, distributed cognition, and extended mind. These four methods are overlapped in some parts and in progressive relations. They are no longer limited to individuals, but pay attention to the importance of the environment in the formation of cognition. In terms of views, both the extended mind hypothesis and the distributed cognition are skeptical that mind is confined to individual objects. In terms of cognitive structure, situated cognition agrees with distributed cognition that the situation is the fundamental factor that influences cognition. But the difference between the two lies in that the distributed cognition has a deeper and more profound understanding of the situation. It believes that situation is part of cognition and interacts with cognition. It can be said that the distributed cognition is an advancement and combination of the first three methods. It targets the whole cognitive process and the cognitive system, not just the individual's mind and the environment. Therefore, the research on distributed cognition is receiving more and more attention in this field. It is believed that this theory will also be applied in a wider range of cognitive contexts.

### **Research on the distributed sports culture cognition**

#### *Culture cognition*

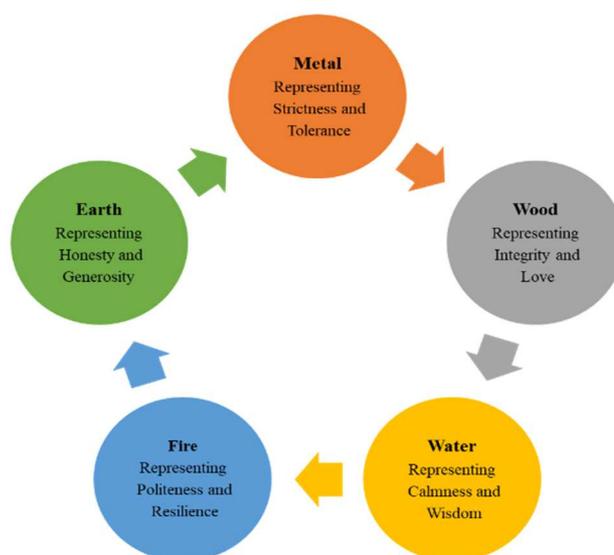
The core idea of the distributed cognitive system is that culture and cognition are closely related. Culture is the spiritual core of a society, a country, and even a nation. It is not a collection of abstract or concrete things, but a process by which people gradually understand the world and the environment, and cognition is precisely a process of how culture is developed. People are social animals living in specific cultural environments. Culture makes our world totally different from the societies of other species. Only culture gives us the ability to remember the past, plan the present and imagine the future. Culture is not patterned. It has profound interactions with specific historical periods, historical events, and specific environments in which human beings live. Culture is inevitably presented in a distributed fashion, as it is transmitted or obtained in people's everyday life.

As a cultural phenomenon, sports is an indispensable part of the entire cultural system. It has wide and profound influences on people's

lives and the social development. The so-called sports culture refers to all spiritual and material civilizations that humans create in sports activities, and in turn, these cultures are represented by players coaches engaged in the sports cause as well as various competitions and activities.

### *Connotation of sports culture in the contemporary era*

For thousands of years, sports have been popular among people all over the world and have kept them always enthusiastic and passionate about it. The deep reason is that sports itself has a profound cultural connotation - sportsmanship. This spirit is manifested externally, not just in the sports activities, but also in the players' unyielding and indomitable attitude and conviction in the competitive activities. These are what make sports so touching and attractive.



**Figure 9.** Five-element Theory of Sports Culture

The cognition of sports culture should be analyzed in combination with its external environment. In contemporary China, sports culture not only has the general cultural connotation, but more importantly, it is marked with two characteristics of the contemporary China: first, since its founding, China has been developing the culture that aims to "promote physical culture and build up the people's health"; second, with the overall strength of China increasing, the Chinese sports culture is also going global together with other cultures and becoming an important part of the world's sports culture. The sports culture in contemporary China contains the above characteristics and is



gradually influencing people's behaviours and values. The following Fig. 9 shows the connotations of the Chinese sports culture using the "five-element theory" in the traditional Chinese culture.

## Conclusions

Taking the cognition process and cognitive system as the research objects, this paper studies the distributed cognition system and obtains the following conclusions:

This paper briefly summarizes the cognitive systems and compares the current several research directions for cognitive systems, including distributed cognition, embodied cognition, situated cognition and extended mind. These four methods are partially overlapping and progressive. They reflect the systematic nature of cognition to different extents and in different aspects.

This paper systematically studies the distributed cognitive system and also describes its elements and characteristics in detail, including representations and calculations, culture cognition, interactions, tools and power system, etc., and takes the sports culture in China as an example to further elaborate them.

As a way of looking at cognitive activities, the distributed cognitive system emphasizes the interactions between cognitive individuals and the environment. Cognitive activities can occur anywhere, but they are all connected with the elements of the cognitive system.

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