Embodied Cognition View: The Return of Body As Subject in Cognitive Science Research

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Abstract

The view of embodied cognition believes that cognition is embodied in nature, only the dynamics involved in the interaction between cognitive activities and the nervous system, body and environment, only by closely linking the correct evaluation of time-dependent and relationship, then only can make a correct understanding of cognitive activities. The core concepts of body and environment involved in embodied cognition are different from the body and environment in the usual sense. In terms of research methods, dynamic research methods that are different from traditional computer simulations are also adopted. The article first integrates and analyzes the basic position and general propositions in the discipline, then the embodied cognition are explained based on author's understanding. In addition, the suitability of dynamic research methods , its advantages and disadvantages is analyzed, and finally, a brief summary of the current status of embodied cognition research.

Keywords

embodied cognition, position, opinion, body view, dynamic research method

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Introduction

The first generation of cognitive science was a direct product of the first "cognitive revolution" in the late 1950s. With the gradual deepening of research, the representational computing research paradigm itself exposes more and more problems. Especially because of the existence of problems such as the inability to fulfill the promise of advanced artificial intelligence and the inability to explain the origin and development of cognition, Representation-computationist have to gradually abandon their core point of view-- "cognition is to follow clear formal rules against abstract symbols, representation of manipulation (calculation), and a symbol is a viewpoint represented by any manipulable sequence of matter. In other words, the generation of the cognitive process is related to the specific rules of operating symbols, and has nothing to do with the material carrier that realizes this operating process." [1]. So, the connectionist paradigm that uses the brain as a metaphor and the ecological paradigm that advocates ecological validity began to appear in people's vision. However, these two also have to take a pluralistic route that merges with the representational computing paradigm because of their own limitations. Even if the current cognitive sciences show a trend of diversified fusion dominated by representation- computationalism, they still cannot save cognitive science from the dilemma. Because their integration does not fundamentally solve the problems encountered in cognitive science, in other words, this integration does not touch the most essential and core part of the problem-that is, the thinking of the cognitive subject's body.

Under the appeals and efforts of Heidegger, Merleau-Ponty, Dewey and Bartlett [2, 3]; Gibsons [4]; Vygotsky [5]; Beer, Brooks, Clark, Kelso, Thelen, Smith and Van Gelder [6] , A new paradigm transformation movement of cognitive science research is quietly going on, it has changed the old perspectives, positions, methods and even research tools of cognitive science research. In this way, the second generation of cognitive science [7], that is, embodied cognitive science came into being in this context.

Since the mid-1980s, in Western psychology, philosophy, neuroscience, cognitive anthropology, computer science, AI and other fields, "embodied cognition" and "embodied cognition" (embodied cognition) Concepts such as mind) and "embodiment" (embodiment) are increasingly being mentioned and paid attention to by the majority of researchers [8]. Although there are few

domestic scholars involved in embodied cognitive science, this field has begun to attract the attention of many researchers. Compared with the first-generation cognitive science, embodied cognitive science has the biggest difference in emphasizing the influence of the cognitive subject's body on cognitive activities. At the same time, it also pays more attention to the impact of the cognitive subject's real-time environment on cognitive activities, and regards the cognitive subject's environment as part of the cognitive system. The core concepts such as the body and real-time environment referred here are different from the body and environment that we usually understand. In addition, the understanding of embodied cognition cannot be completed through a simple definition. We must first understand the different propositions contained in different perspectives of embodied cognition. In terms of research methods, compared with traditional computer simulation methods of cognitive science, embodied cognitive science mainly focuses on dynamic research methods. Based on a large amount of literature, we have conducted a more in-depth analysis and detailed interpretation on these core concepts, key issues, and main research methods in embodied cognitive science.

2. The basic position and general propositions of embodied cognition

Since different scholars have different academic beliefs and viewpoints, different academic positions have emerged in the research camp of embodied cognitive science. But in these different academic positions, there are broad a recognitions and common tendencies, to re-examine the tradition cognitive science's research topics and research methods, and "change" them. In addition, in these different academic positions, there are also some generally agreed propositions, but there are still differences in the understanding of these propositions.

In order to compare the degree of fundamental changes in embodied cognition compared with traditional cognitive science, Clark divides embodied cognition into two positions based on the facts of embodiment and environmental embedding. Namely simple embodiment and radical embodiment [9]. Among them, Naive Embodiment mainly regards the body of the cognitive subject and the environment in which it is located as the limiting conditions for

the application of internal organization and processing theory. The radical embodiment goes one step further, believing that these facts will change the subject matter and theoretical structure of cognitive science. At the same time, the difference between the two positions of naive embodiment and radical embodiment is not absolute, and there is a neutral embodiment between them.

2.1 1 Simple embodiment

The simple embodied standpoint was first seen in some visual studies. When Ballard was exploring active vision (animate vision), he believed that the visual processing process is a dynamic process, and the corresponding behavior can only be performed as required when the visual environment is sufficiently stable [10]. Therefore, the active vision system that quickly changes its coupling with the environment promotes the fine representation of the environment. Even though the information to be characterized may not be needed, they can still be calculated quickly and more and more as required. When Ballard et al. studied the imagery coding of embodied cognition, they confirmed that human cognitive activities must involve interaction with the environment, which means that the specific form of the human body becomes an important constraint in defining many aspects of cognitive behavior [11]. In addition, they believe that deictic computation provides a mechanism to characterize the basic characteristics of external sensory data, internal cognitive processes, and motor behavior links. As a main feature of cognitive activity, working memory is closely related to the real-time physical feature configuration of eye movements and hand movements. Besides that, they also proposed the concept of deictic representation, which refers to the implicit reference system used by the body's orientation movement in the process of binding objects in the real-time environment to the cognitive process. Although the study of simple embodied began to focus on the role of the cognitive subject's body and environment in cognitive activities, it still showed the characteristics of relying heavily on internal character, computational transformations, and abstract data structures. Thus, under these conditions, the attention to the body, environment and behavior was used as a method tool to obtain internal data structure and operation authority.

2.1 2 Radical embodiment

The radical embodied position reputes that the the views of structural, symbolic, representational, and computational in cognitive science are all wrong. Brooks [12],Beer [13], Kelso [14], Gelder [15, 16] and Smith [17] believe that

cognitive science research does not require representations. Regarding the view that cognitive activities must involve representation, they believe that the reason is partly because researchers cannot imagine the existence of non-representational systems that can show the process of cognitive activities. In fact, dynamic research methods can completely avoid representation and provide a powerful theoretical framework for cognitive activity modeling. Gelder also believes that the embodied cognitive hypothesis consists of two parts: the nature hypothesis and the knowledge hypothesis [16]. The essential hypothesis holds that the cognitive subject is also a dynamic system, meanwhile, the knowledge hypothesis holds that dynamic methods must be used to study cognition. Therefore, we can only use non-computational and non-representational methods, as well as explanatory schema, and Dynamical Systems Theory, DST to further study cognitive activities [18]. But these radical embodied views are all after the opinions of a minority[9,18,19], and the debating point between simple embodied and radical embodied is the unresolved problem of the usefulness of representation [20]. In fact, the issue of the usefulness of representation is also a very core issue formed during the transition from traditional cognitive science to embodied cognitive science.

2.1 3 Neutral embodiment

Bechtel [21], Clark and Keijzer [20], and the others had opposed the idea which stated that radical embodiment completely abandons "representation". They have two main points:

(1) Representation critics see representation as a complete environmental model, and the use of representation in cognitive science is not limited to this specific type of representation,(2) Criticism on representation is mainly focused on cognitive processing involving lower levels of motor abilities such as superior sensory-motor coordination. When it comes to lower levels of cognitive processing, we may be able to abandon the use of representations. However, when it comes to real-time, higher-level cognitive processing such as thinking, language, and memory, representation is the basis of cognitive activity. Therefore, Clark [9], Markman and Dietrich [22] believe that there may be a middle ground between the naive embodiment that still relies heavily on representation and the radical embodiment that is completely negative. Keijzer further believes that the perception-behavior component deals with the "on-line" and the embodied aspects of cognition, while the representation-based cognitive

system deals with the aspect of "off-line" that requires representation processing [6]. It's worth to emphasizing that the "representation here" is different from the representation of the traditional cognitive science's content (deictic and action - oriented) and the essential attributes of the internal carrier (using transitional extensive process and complex dynamics rules as internal symbol).

In short, the debate between simple embodiment and radical embodiment has not stopped, but the author prefers a middle ground. In other words, the author agrees that cognitive activities require participation of representation, but do not believe that attention to the body, the world, and behavior is the only action in the formation of specific representations. Sometimes, people's cognitive activities do not involve representations, but use the most economical strategy to maintain an effective balance between coupling subjects and world adaptation. For example, most drivers programmatically keep their bodies in line with the direction they are changing when driving, especially those new drivers. This kind of procedural adjustment is often done unconsciously. The author also disagrees with the practice of radically embodied and extremely negative representations. From recent studies on embodied cognition, people have found more cognitive evidence of representation participation, and began to emphasize the impact of representation on cognitive activities. Carruthers strongly proved the existence of offline and online physical representations through the study of anosognosia for hemiplegia [23]. Goldman and Vignemont believe that the representation of different body forms and body codes has an important impact on cognitive activities [24]. Therefore, the authors think it may be more appropriate to take a middle ground.

2.2 The general proposition of embodied cognition

With the increasing attention to embodied cognition, the majority of researchers have reached a consensus on the view that "the study of the mind must be placed in the context of the interaction between the objective body and the environment." Received more and more widespread support. However, embodied cognitive itself has different positions and different propositions and this is vausing great controversy.

Therefore, Wilson believes that if we want to maintain a meaningful use of the term "embodied knowledge", we need to clarify these claims and re-examine the value of these claims [25]. He re-evaluated the six representative propositions in the study of embodied cognition: Cognition is situated. Willson

believes that our cognitive activities are not all situational cognition, there are also offline cognitive activities such as planning, memory and daydreaming. An important sign of human cognitive activity is its decoupling (decouple) in any interaction with the current environment. In addition, she proposed on the basis of Barsalou [26], Brooks and Waal [27] and other studies that the center of situational cognition is based on the needs of human survival in the wild is not very convincing. It will hinder us from figuring out the real situational aspects of cognition.

Cognition is time-pressured. When the situation requires the cognitive subject to quickly and continuously responses, the cognitive subject cannot form a complete mental model of the environment to obtain a plan of action. This induced phenomenon is called a "representation bottleneck". Wilson believes that not all cognitive activities are inherently involved in time pressure, and that the context in time pressure is inherently part of the task. However, we can discover more complex forms of situational cognition through the study of cognitive activities under time pressure. We off-load cognitive work onto the environment. Wilson emphasized that humans have limited information processing capabilities, so in actual cognitive activities we can use the environment to reduce cognitive load, that is, we can place cognitive work in symbolic off-loading representations. In the environment, this information is only extracted when need-to-know [10, 11, 28]. Especially when the purpose of cognitive activity no longer directly points to the context of the activity, it does not need to point directly to the spatial issue. Physical symbols, and even their own spatial relationships, can be used to represent the abstract and non-spatial realms of thinking.

The environment is part of the cognitive system. Wilson believes that the facts of causal control distributed in the situation cannot be fully proved the proposition "we must study distributed systems [13, 29]" is correct.

The ultimate goal of science is not to explain the causality of specific events, but to understand the basic principles of organization and function. Secondly, the definition of the system boundary depends to some extent on the specific purpose of the researcher's analysis, which is highly subjective. Third, distributed cognition has lost its signs of radicalism. This proposition does not require us to reform the research in the field of cognition, but simply adds to the phenomena that need to be studied.。 At last, from a long-term perspective,

whether this distributed approach can deeply reveal the nature of cognitive activities remains unclear. Cognition is for action and it is generally believed that the cognitive mechanism and behavior are connected in a very direct way, that is, the individual's perception, concept, and memory of a specific behavior pattern. And this view is exactly what Wilson wants to criticize. Research shows that cognition promotes behavior through a more indirect, flexible, and complex strategy. In this strategy, when the cognitive subject is not sure when the information about the nature of the external world will be used, it will all be saved for future use. Our psychological concepts usually retain rich information about the properties of objects, and we can use this information for different purposes, even completely different from the purpose for which we originally processed them.

Off-line cognition is body-based. Even if it is decoupled from the environment, the activity of the mind is still based on the sensory processing and motor control mechanisms which were produced through evolution during the interaction between the individual and the environment. Wilson believes that this proposition is very important and the most proven, but it has not received enough attention from researchers. She also believes that there will be more research on the way in which sensory and motor resources function in offline cognition activities. [7, 30-32]. Finally, he emphasized that we should not see this proposition as a theoretical advancement, but as a general and fundamental principle of cognition. Wilson emphasized that we should understand the specific claims that have been made based on the essence of them, rather than treating embodied knowledge as a single claim. Moreover, this also makes it easier for us to distinguish the online and offline aspects of embodied cognition. Her re-evaluation of these six propositions was affirmed by Ziemke [8], Anderson [33] and others. Anderson even reinterpreted the six propositions that Wilson had evaluated. It is worth mentioning that when explaining the proposition that "we build cognitive work in the environment", Anderson believes that the methods that organisms use the environment to simplify cognitive tasks can be divided into two categories: (1) The organisms use a stable environment features to simplify cognitive tasks; (2) The organism changes the environment to simplify cognitive tasks. He also believes that the proposition that "off-line cognition is based on the body" can also be divided into two different but related parts: (1) Perception, cognition and the nature and structure of their constituent

components (such as representations and concepts) are the same as the thinking process. Logical rules, like preferences, depend on the nature, structure and behavior of the body; (2) Even offline cognition, even if the thinking is not synchronized in time and there is no interaction between the body and the environment, it is still based on the body. In addition, On the basis of Wilson, Anderson also summarized some descriptive claims about embodied cognition that have emerged over the years into the following six points: (1) Like other human adaptive activities, the evolutionary history of cognition can help us to understand better of its function. (2) Cognitive evolution is because it is adaptive, that is, by coping with the environment more effectively, it can fundamentally increase the possibility of survival and reproductive success, (3) Cognition evolves in a specific environment, and it can use The physical structure and continuous characteristics of the environment to cope with the challenge of survival,; (4) Cognition has evolved in organisms with specific physical attributes and bodies with certain structural characteristics. Therefore, cognitive activities can make full use of these physical structural characteristics to achieve cognitive goals and shaping themselves in the process, (5) Cognition evolves in an organism with a set of prior behavioral possibilities, instincts, habits, needs, goals, and preferences. 6) The body organs that have evolved and are evolving together with other organs of the body, through joint evolution to solve the problems encountered by the body's functions. In addition, Anderson integrated the viewpoints of Wilson and Ziemke, and based on that, he proposed four propositions on the differences among embodied cognition, situational cognition and reduction biology. The four proposition are (1) Embodiment as structural coupling , (2) Historical embodiment. It mainly emphasizes that the characteristics of cognitive processing of the cognitive subject are not only formed in the history of germline evolution, and its shaped may also greatly due to continuous and repeated interaction with the environment, (3) Physical, organismoid, and organismic embodiment (Physical, organismoid, and organismic embodiment). These three aspects represent the three levels of increasing restrictiveness of the body example. (4) The social embodiment of society. This proposition mainly emphasizes that in addition to coupling with the objective environment, the organism is also coupled with the social environment. In short, it is very important to sort out and integrate the basic position of embodied cognition and its general propositions. It is also a prerequisite for our

correct understanding of embodied cognition. After discussing the basic position of embodied cognition and its general propositions, we will continue to explore another key topic that affects our correct understanding of embodied cognition-the view of the body.

3. The body view of embodied cognition

How to look at the role played by the body of the cognitive subject in the cognitive process is the core and most fundamental standard that distinguishes the first-generation cognitive science from the second-generation cognitive science. Therefore, the status of the body view in embodied cognition is can be seen. In the previous article, we also mentioned that the body in embodied cognition not exactly the body in the traditional anatomical sense, then what about the body in the view of embodied cognition? Also, how does it affect cognitive activity? Brooks and Dourish even believe that, like other embodied cognition researchers, they have limitations in explaining the problem of body outlook [34]. First of all, based on the question above, the author believes that, we can start with the question of "how does the body affect cognitive activities". Because only when we clearly know the role of the body in cognitive activities then we can better in answering the progressive question which is "What is the body in the embodied cognitive view?"In the process of explanation, we may need to understand some of the propositions listed in the previous article from the perspective of the body view. So, how does the body affect cognitive activity? Let's review the six propositions made by Anderson.。 Among them, the fourth point mentions that "cognition has evolved in organisms with specific physical attributes and bodies with certain structural characteristics..." In other words, physical characteristics and cognitive attributes are not static, and even joint evolution may exist between them. For example, the hand cannot directly take the food that is being grilled on the fire due to physiological limitations, but the hand can use some auxiliary tools to achieve its purpose.Hands will become more flexible in the process of using tools, and humans will continue to create new methods and tools in this process. At the same time, some physical characteristics that can be better applied to cognitive activities will be preserved, and correspondingly, cognitive attributes that can be applied to specific body organs will also be pre-

served. The sixth proposition clarifies the relationship between the body (organs) and cognition more directly, "The body organs that have evolved and those organs under evolving, can go through joint evolution together with other organs of the body, to solve the problems of body functions. We don't have to be surprised that cognitive organs are composed of functional units with limited variation, and we don't need to be surprised that cognitive organs involve repetitive and rich functional structures at a slightly higher level of structure, we also need not be surprised that the highest level of structure proves a high degree of specialization. It is not surprising that the cognitive organs do not require extensive central control (but this does not rule out central control in specific situations). "At the same time, Wilson also attaches great importance to the proposition that "off-line cognition is based on the body". The role of sensorimotor resources is realized by simulating certain aspects of the objective world as a means of characterizing information and reasoning. This kind of sensorimotor imitation of external situations affects human cognitive activities extensively. In addition, Gibson's "Affordances" concept is often mentioned in the research of embodied cognition, which is the core of the organizational structure of the ecological psychology paradigm [9, 35]. Behavior-giving is the possibility that the objective environment provides the subject to use, intervene and act. It depends on the degree of matching of the subject's body structure, abilities and skills with the behavior-related attributes provided by the environment itself. Gallagher gave a detailed argument on how body awareness affects our experience and how the body shapes experience through the construction of specific mechanisms [36]. He believes that, in order to correctly understand the role of the body in cognitive activities, it is also necessary to accurately distinguish the body schema and body image. The body scheme is a kind of sensory-motor ability system, which works below the level of consciousness and plays an important role in movement control, which means that the body scheme can unconsciously coordinate and control body movements. And body image refers to an artifact of body perception, which plays an important role in the individual's conscious experience.。 He separated the two through an empirical study. In experiments, patients suffering from lateral neglect usually only perform the above activities on one side of the body and ignore the other side of the body during the process of washing, grooming or even putting on clothes. However, the patient's hand tasks such as walking and tying knots were not affected. This indicates that the patient's body image is

destroyed, but the body scheme is still intact.

If the review we have done is piecemeal and cannot clearly clarify how the body affects cognitive activities, then Goldman and Vignemont's recent explanations on this issue can be described as systematic and comprehensive [24]. They believe that the body's influence on cognitive activities can be summarized in the following four aspects: (1) Explanation of body anatomy. Different parts of the body play an important causal role in cognitive activities with the help of different anatomical structures. Imagine that we replace human eyes with the bat's echo system, then humans will perceive the world in a different way, (2) the explanation of physical activity. Activities related to physical characteristics (such as gestures) play an important causal role in cognitive activities. Although Goldman and Vignemont think this explanation is slightly awkward in persuasiveness, recent research by Chandler and Schwarz proves that the movement of a hostile middle finger and an admiring thumb will affect the subject's impression of this person [37]. Blaesi and Wilson also confirmed through similar studies that the body movements of the cognitive subject affect their own perception and judgment [38]. (3) Interpretation of body content. The bodily representation with physical content plays an important causal role in cognitive activities. The division of the mental representation of the body content here is mainly based on the bodily format used in the representation encoding. Therefore, they think that the third explanation is just a transitional view of the fourth explanation, (4) the explanation of body form. The mental representations of different body forms or body codes play an important causal role in cognitive activities. Although there is still controversy over the specific criteria for the classification of body forms, they believe that the fourth explanation has the most potential especially in explaining how the body affects social cognitive activities.

In this way, we have completed the answer to the question of how the body affects cognitive activities. On this basis, let's clarify the question again, " What is the body in the embodied cognitive view". The body in the view of embodied cognition is not entirely an anatomical body, but it still means that the body in the view of embodied cognition includes an anatomical body. However, Goldman and Vignemont have made a unique interpretation of this anatomical body [24]. They believe that in order to highlight the importance of the body in explaining cognitive activities, embodied cognition researchers emphasize that

the body is a part of the body other than the brain. Because the brain itself is the place where mental activity occurs, and treating the brain as a part of the body weakens the claim that the body is essential to mental activity. In the author's view, the two people's original intention to emphasize the importance of the body in cognitive activities is understandable, but it is unacceptable to isolate the brain from the complete body. Their approach is superfluous. The discovery of mirror neurons as important evidence of embodied cognition (about mirror neurons, the author will state below), is enough to show that we cannot separate the brain from the complete body. Also,

Gelder [16] and Beer [13, 29] believe that in the study of dynamic methods of situational behavior, the cognitive subject's nervous system, body, and environment are all regarded as coupled dynamic systems.

Therefore, based on the discussion in this section and the related content in the previous article, we can think that the body in the embodied cognitive view, except to the body in the anatomical sense, it also refers to a body that has undergone "historical evolution" (evolved), a "situated" body in a specific situation, and "socialized" body and the body that forms the "body schema".

4. Dynamic methods of embodied cognition research

The wave of embodied cognition has swept across the entire field of cognitive science, and its impact on traditional cognitive science is self-evident. In terms of research methods, the first-generation cognitive science representation calculation methods are obviously out of date. This requires us to find new methods and tools for the study of embodied cognition. The view of embodied cognition believes that cognition is embodied in nature. It emphasizes the close connection between cognitive activities and sensorimotor levels, as well as the structured environment in which they are embedded. This is actually a disguised emphasizing that only by closely linking cognitive activities with the correct evaluation of the dynamics, time-dependent and relationship involved in the interaction between the nervous system, the body and the environment, can we understand the cognition. Activities to make a correct understanding. Then, from this perspective, the cognitive subject itself is a dynamic system. More precisely, cognitive function must be understood as a dynamic processing process. For these pro-

cesses, the tools provided by dynamics research method can be used to understand them well [13, 16, 29]. Then, why the traditional representational computing paradigm cannot explain cognitive activities well, but the dynamic method can? And why is it dynamics and not other methods?This seemingly simple problem is rarely involved in many documents that the author refers to. In fact, this is a very important question. First of all, this is because embodied cognitive science believes that the internal behavior of the cognitive system and the processing of the system itself are non-stationary, which is completely opposite to traditional cognitive science. In the activities of the objective world, the individual's cognitive system can not only react differently in different backgrounds, but it can also change as the result of its own activities. Cognitive activity is a unique event at a specific time and in a constantly changing situation. It itself is a product of the internal dynamics of an unstable system. However, this instability of the cognitive system is often overlooked in traditional cognitive science. Concepts, unchanging symbols, or representations that we advocate are all core theoretical structures in contemporary cognitive development research, and they are all considered To explain the basic elements of human cognitive stability [17]. Obviously, traditional cognitive science research methods separate unchanging concepts, symbols, and representations from the real-time and natural changes of cognitive activities and the category of dynamic systems, which is difficult to satisfy embodied cognitive research. Second, some studies have shown that the use of representations can be abandoned in cognitive processing involving lower levels of athletic ability. Kelso proved with convincing research conclusions that stable and continuous representations are not involved in the coordination of the movement of the index finger of the left and right hands [14].That is to say, traditional cognitive science representation calculation methods may be useless in low-level cognitive activities. Of course, we only emphasize this possibility here, without arbitrarily rejecting the use of representations by low-level cognitive processing.

In addition, the reason why embodied cognition adopts the dynamic research method is because of the suitability of the dynamic research method itself. Here, the author first introduce the concept of embodiment. In our broad sense, embodiment usually refers to structural coupling. This term was first introduced into cognitive science by Maturana and Varela, who regarded cognitive science as a biological phenomenon in their research [2]. This makes

Quick[39], DautenhAhn, Ogden, and Quick[40] deeply inspired when trying to precisely define the embodiment. In order to make up for the inadequacy of the previous definition of embodiedness, they tried to evaluate the relationship between the cognitive subject and its environment, in order to achieve the purpose of defining embodiedness from a quantitative perspective. They gave the roughest definition of embodiedness: if there is an interaction channel between system S and environment E, system S is embedded in environment E. The system S is embedded in the environment E at every time T when S and E exist. The subset of the possible states of the environment E related to the system S has the ability to disturb the state of the system S, and the possible states of the system S are related to The relevant subset of environment E has the ability to disturb the state of environment E. In fact, Quick et al.'s rough definition of embodiedness is the narrow embodied cognition DST we are discussing. In addition, Gelder [16] and Beer [29] believed that, broadly speaking, the dynamics system is a mathematical tool that can clearly describe the changes of the system over time. 而严格地讲,动 Strictly speaking, the power system is made up of three important elements which are the orderly time series T, the state space S and the evolution operand ○ t (○ t can be expressed by the relational expression: S→S turns into an initial state X0∈S at time T0∈T→→ state Xt∈S at time t∈T) consists of three elements. Among them, the state space S can be identified by a value or a symbol, and it can be continuous, discrete, or both. The number of variables required to describe the state of the system determines whether the system is finite-dimensional or infinite-dimensional. The evolution operand ○ t can be given directly or defined indirectly. It may be deterministic or stochastic. The tools provided by DST make the real-time behavior of the power system visible and analyzable. To this end, Beer [13, 29] also listed five dynamical modellings, which are intended to illustrate how dynamical method tools describe the evolution of the system.

It is worth noting that although kinetic modeling and DST are two aspects of kinetic methods, and there is no clear boundary between the two, however, the distinction between the two is very important [16]. Dynamic modeling is a branch of applied mathematics. It mainly provides abstract dynamical models to help us understand natural phenomena. Of course, this also includes the phenomena of human cognitive activity that we want to study. The latter is a branch of pure mathematics. More strictly speaking, DST is essentially a

geometric concept. It describes the behaviour of evolution of systems through systems of non-linear differential equations. Dynamicists try to understand the process and behavior of the cognitive system by using concepts such as state space, attractors, trajectory, stability, coupling, sensitivity to initial conditions, etc. Sheng Xiaoming[41], Li Qiwei[42], etc. believe that we also need to use coupled and interacting nonlinear differential equation systems to describe the variables that continuously influence, determine, shape, and dynamically evolve in the cognitive system. In addition, the system of nonlinear differential equations can be used to "express the cognitive trajectory of the cognitive subject in the state space, especially through the thought trajectory of the cognitive subject under a certain environment and a certain internal pressure to examine cognition in detail." . Due to the characteristics of embodied cognition and the suitability of dynamic research methods, dynamic research methods have become the main tool for embodied cognition research. Compared with other research methods in cognitive science, dynamic research methods have two major advantages: First, dynamic research methods focus on the continuous evolution of cognitive processes, which can explain the plasticity of cognition well. Second, this continuous process enables dynamic research methods to better explain the details of cognitive processing. Therefore, we can better explain individual differences in cognition through dynamic methods.This means that compared with the traditional cognitive science that focuses on the commonalities of behaviors between individuals, dynamic research methods may pay more attention to differences between individuals [22].

The dynamics research method has become the mainstream method of embodied cognition research. This method mainly makes use of the possibilities of current mathematical research. But the problem is that for multi-level open systems such as cognitive systems (wild systems), current mathematical research is powerless [43].

In other words, the general applicability of dynamic research methods in cognitive research is questionable. This is mainly manifested in the following five aspects. First, the complexity of the dynamics research method itself, especially its high threshold for mathematics and computer basic requirements, makes it not as widely understood and accepted by researchers as the method of representational calculation.。 Therefore, the complexity of the dynamics research method itself has become a stumbling block to its rapid popularization.

Second, the cognitive system is driven by random inputs that change its own unique time scale. In this way, basic concepts such as attractors and bifurcations in DST have no effect in the study of cognitive systems; third, the cognitive system is unstable. But the unsteady state here is different from the unsteady state in the kinetic method, and it should be understood as the result of the non-parametric change of the kinetic law itself. Fourth, the cognitive system is high-dimensional, and many of its variables evolve according to different laws of different subsystems. The current research on high-dimensional systems can only focus on specific types of overall parameters like synergetic systems and mean-field approaches. Fifth, the author believes that the dynamics research method easily deviates from our original research intentions. At first, we wanted to explore the phenomenon of human cognitive activity through dynamic research methods. However, dynamic research methods require us to pay more attention to how to model rationally, which is suspicion of putting the cart before the horse.

5. Conclusion

In the more than ten years since embodied cognition was first explicitly proposed, research on embodied cognition has penetrated more and more widely into various fields of cognitive science. Moreover, research results from various fields have gradually proved the correctness of the embodied cognition view. One of the most eye-catching is undoubtedly the research on Mirror neurons in the field of cognitive neuroscience and cognitive linguistics [2, 33, 42, 44-46]. Mirror neuron [47, 48] originally refers to a type of visual motor neuron that is activated by actively performing or passively observing actions related to objects. In short, the intersection of the motor neurons activated when an individual performs a certain action and the neurons activated when the individual observes other individuals performing the same or similar actions is not an empty set. Subsequent studies believe that mirror neurons are widely present in the human brain, and they can resemble the mirror in mapping the activities of other individuals. Therefore, the development of social cognitive activities such as individual action imitation learning [49], empathy [50], language and understanding the intentions of others [51] has extremely important significance. And just in

August 2009, the University of London Kilner, Neal, Weiskopf, etc. claimed to have found conclusive evidence for the existence of mirror neurons and their circuits in the IFG area of the human brain [52].。 The existence of mirror neurons in the human brain undoubtedly provides strong evidence for the important role of the human body in cognitive activities.

However, voices questioning embodied cognition also appeared. This is mainly manifested in: (1) embodied cognition lacks the support of convincing empirical research. Generally, there are four main types of data supporting the hypothesis of embodied cognition. a) In perception and conceptual processing, the motor system is activated directly, b) Behavioral evidence that the activation of the motor system spreads to the level of perception and conceptual processing; c) Evidence of the activation of the system is the sensation and movement induced by reading comprehension ; d) In the verbal decision-making experiment of subjects with impaired motor systems, the subjects' decision-making performance on nouns is better than that of verbs.However, the study of Mahon and Caramazza believes that these four kinds of evidence can also be explained by the non-embodimental viewpoint of cognition [53]. (2) Embodied Some important concepts in cognitive science are ambiguous. For example, embodiment. Although Dautenhahn, Ogden, and Quick have given a rough definition of embodiment, they also further pointed out that there is no clear explanation for the essence of embodied, and it is impossible to recognize it. A unified definition of embodiment is given in the discipline of knowledge science [2]. (3) Questions about embodied cognition research methods have been discussed in detail above, so we will not repeat them here.

Therefore, embodied cognitive science in the "adolescent" stage [54] is not mature enough, not stable enough, and has too many uncertain factors. The author believes that both the representational computing paradigm of the first generation of cognitive science and the dynamic research paradigm of embodied cognition that we now promoted are exploring by us via a small step in the research paradigm of psychology. Therefore, we still need to hold a critical views when we review the second generation of cognitive science research.

References

[1] Xu Xianjun. Embodied epistemology-the role of phenomenology in the transformation of cognitive science research paradigm. PhD thesis. Zhejiang University, 2007

[2] Lindblom J. Minding the body interacting socially through embodied action. Unpublished doctoral dissertation. Linkopings university, Sweden, 2007

[3] Osbeck L M. Transformations in cognitive science: Implications and issues posed. Journal of Theoretical and Philosophical Psychology, 2009, 29: 16-33

[4] Garbarini F, Adenzato M. At the root of embodied cognition: Cognitive science meets neurophysiology. Brain and Cognition, 2004, 56: 100-106

[5] Nooteboom B. Embodied cognition, organization and innovation. CentER Discussion Paper, 2006, 38: 1-30

[6] Keijzer F. Theoretical behaviorism meets embodied cognition: Two theoretical analyses of behavior. Philosophical Psychology, 2005, 18: 123-143

[7] Lakoff G, Johnson M. Philosophy in the flesh: The embodied mind and its challenge to Western thought. New York: Basic Books, 1999

[8] Ziemke T. What's that thing called embodiment. In L. Erlbaum (Eds.), Proceedings of the 25th Annual Meeting of the Cognitive Science Society, (pp. 1305– 1310). Boston, USA: Cognitive Science Society, 2003

[9] Clark A. An embodied cognitive science. Trends in Cognitive Science, 1999, 3: 345-351

[10] Ballard D H. Animate vision. Artificial Intelligence, 1991, 48: 57-86

[11] Ballard D H. Deictic codes for embodiment of cognition. Behavior and Brain Science, 1997, 20: 723-767

[12] Brooks R A. Intelligence without representation. Artificial Intelligence, 1991, 47: 139-159

[13] Beer R D. A dynamical systems perspective on agent—environment interaction. Artificial Intelligence, 1995, 72: 173—215

[14] Kelso J A S. Dynamic patterns: The self—organization of brain and behavior. Cambridge, MA: MIT Press, 1995

[15] Gelder T V. What might cognition be, if not computation? The Journal of Philosophy, 1995, 92: 345- 38
[16] Gelder T V. The dynamical hypothesis in cognitive science. Behavioral and Brain Sciences, 1998, 21: 615-628
[17] Smith L B. Cognition as a dynamic system: Principles from embodiment. Developmental Review, 2005, 25: 278-298
[18] Clark A. The dynamical challenge. Cognitive Science, 1997, 21: 461-481
[19] Clark A. Being there: Putting brain, body, and world together again. Cambridge, MA: MIT Press, 1997
[20] Keijzer F. Representation in dynamical and embodied cognition. Cognitive Systems Research, 2002, 3: 275-
288
[21] Bechtel W. Representations and cognitive explanations: Assessing the dynamicist's challenge in cognitive science. Cognitive Science, 1998, 22: 295-318
[22] Markman A B, Dietrich E. Extending the classical view of representation. Trends in Cognitive Sciences, 2000, 4: 470-475
[23] Carruthers G. Types of body representation and the sense of embodiment. Consciousness and Cognition,
2008, 17: 1302-1316
[24] Goldman A, Vignemont F de. Is social cognition embodied. Trends in Cognitive Sciences, 2009, 13 (6):
154-159
[25] Wilson M. Six views of embodied cognition. Psychonomic Bulletin & Review, 2002, 9: 625-636
[26] Barsalou L W. Language comprehension: Archival memory or preparation for situated action. Discourse Processes, 1999, 28: 61-80
[27] Waal F D. The ape and the sushi master: Cultural reflections by a primatologist. New York: Basic Books, 2001
[28] Kirsh D, Maglio P. On distinguishing epistemic from pragmatic action. Cognitive Science, 1994, 18: 513-549
[29] Beer R D. Dynamical approaches to cognitive science. Trends in Cognitive Sciences, 2000, 4: 91-99

[30] Talmy L. Toward a cognitive semantics: Vol. I. Conceptual structuring systems. Cambridge, MA: MIT Press, 2000

[31] Lakoff G, Johnsen M. Metaphors we live by. London: University of Chicago Press, 2003

[32] Wilson M. Perceiving imitatible stimuli: Consequences of isomorphism between input and output. Psychological Bulletin, 2001, 127: 543-553

[33] Anderson M L. How to study the mind: An introduction to embodied cognition. In Santoianni, F. & Sabatana, C.
Eds., Brain development in learning environments: Embodied and perceptual advancements. Cambridge, UK: Cambridge Scholars Press, 2007

[34] Dourish P. Where the action is: The foundations of embodied interaction. Cambridge, MA: MIT Press, 2004

[35] Clark A. Re—Inventing ourselves: The plasticity of embodiment, sensing, and mind. Journal of Medicine and Philosophy, 2007, 32: 263-282

[36] Gallagher S. How the body shapes the mind. New York, USA: Oxford University Press, 2005

[37] Chandler J, Schwarz N. How extending your middle finger affects your perception of others: Learned movements influence concept accessibility. Journal of Experimental Social Psychology, 2009, 45: 123-128

[38] Blaesi B, Wilson M. The mirror reflects both ways: Action influences perception of others. Brain and Cognition, 2010, 72(2): 306-309

[39] Quick T, Dautenhahn K, Nehaniv C, et al. On bots and bacteria: Ontology independent embodiment. In: D. Floreano et al. (eds.) Proceedings of the Fifth European Conference on Artificial Life. Heidelberg: Springer, 1999

[40] Dautenhahn K, Ogden B, Quick T. A framework for the study of socially embedded and interaction —aware robotic agents. Cognitive Systems Research, 2002, 3: 397-428

[41] Li Hengwei, Sheng Xiaoming. The embodiment of cognition. Research in Science of Science, 2006, 24(2): 4-9

[42] Li Qiwei. On "Cognitive Revolution" and "Second Generation Cognitive Science". Journal of Psychology, 2008, 40: 1306-1327

[43] Jaeger H. Today's dynamical systems are too simple. Behavioral and Brain Sciences, 1998, 21: 643-644

[44] Ding Jun, Chen Wei. The root of embodied cognition: from mirror neuron to embodied imitation theory. Journal of Central China Normal University (Humanities and Social Sciences Edition), 2009, 48(1): 132-136. 2008 45 Ding Jun. Evolution of Thinking. Beijing: China Social Sciences Press, 2008

[46] Tranel D，Manzel K，Asp E，et al． Naming dynamic and static actions：Neuropsychological evidence． Journal of Physiology– Parisc，2008，102：80-94

[47] Pellegrino G D，Fadiga L，Fogassi L，et al． Understanding motor events：A neurophysiological study． Experimental Brain Research，1992，91：176-180

[48] Gallese V，Fadiga L，Fogassi L，et al. Action recognition in the premotor cortex． Brain，1996，119：593-609

[49] Longo M R，Kosobud A, Bertenthal B I． Automatic imitation of biomechanically possible and impossible actions：Effects of priming movements versus goals． Journal of Experimental Psychology：Human perception and Performance，2008，34：489-501

[50] Sprengelmeyer R，Jentzsch I． Event related potentials and the perception of intensity in facial expressions． Neuropsychologia，2006，44：2899-2906

[51] Iacoboni M，Molnar -Szakacs I，Gallese V，et al． Grasping the intentions of others with one's own mirror neuron system． PLoSBiology，2005，5：529-535

[52] Kilner J M，Neal A，Weiskopf N，et al． Evidence of mirror neurons in human inferior frontal gyrus． The Journal of Neuroscience，2009，29：10153-10159

[53] Mahon B Z，Caramazza A． A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content． Journal of Physiology - Paris，2008，102：59-70

[54] Anderson M L． Embodied cognition：The teenage years． Philosophical Psychology，2006，20（1）：127- 131