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Go and Mental Referring: An Analysis of Cognitive Symbol Systems in the Chessboard

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Abstract

The game of Go can be regarded as a physical symbol system whose basic symbols consist of black and white pieces and a chessboard, and both have their own meanings. From the perspective of mental denotation theory, we discuss how to analyze the relationship between symbols and logical reasoning in Go according to Herbert Simon's hypothesis of "physical symbol system" in order to use Go symbols rationally. The essential properties of symbols indicate that a symbol is not only a representation of facts, but also contains information about other symbols and their relations in a particular way. Based on the formal analysis and decoding of this information, the mind is able to design strategies and engage in the process of reasoning and judgment by means of goals and expectations set by symbols. In the life sciences, this symbolic system is also manifested in the transfer of rules between symbols, similar to the concepts on a chessboard and the relationships between them.

Keywords: Physical symbol system; Intentionality; Mental reference

Introduction

A brief history of Go

Originating in China thousands of years ago, Go is one of the oldest board games in the world. Go is not only a form of entertainment, but also an important part of East Asian culture. With simple black and white pieces and a square board, the relatively simple rules contain profound philosophical and strategic thinking. In ancient times, Go was considered one of the four arts of a gentleman, alongside qin, chess, calligraphy and painting. "The character of Go has nine: one is said to enter the God, two is said to sit in the light, three is said to be specific, four is said to be through the ghost, five is said to use wisdom, six is said to be small, seven is said to fight the power, eight is said to be if the fool, nine is said to keep the awkwardness." Ancient Weiqi grade division not only symbolizes the high and low chess skills, but also reflects the level of the player's spiritual cultivation[1]. The status and connotation of Go varied in different dynasties in China, but its common philosophical meaning reflected people's profound thinking about wisdom, life, nature and society, as well as their pursuit of personal cultivation and spiritual realm.

The basic idea of Go as a semiotic system

Broadly speaking, all perceived things, and the complex things formed by their combination, as well as the mental activities that are realized, are symbols and some other forms to form the counterparts in consciousness, i.e., the basic materials that constitute consciousness,

1 [Wei] Handan Chun, The Art of Scripture, pp. unknown.

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which are always manifested in a certain form, and our thinking activities are accomplished through the organization of such materials[2]. Form is the structure and the way of expression of a thing or a symbol in a framework, and Go, as a semiotic system, has a non-formal level under the level of formalized symbols, which also corresponds to a certain kind of brain activity, although it is something outside of the consciousness that cannot be grasped by the subject directly. Or anything that enters consciousness with the help of some formalizing process. It can be suggested here with reference to Wittgenstein's claim that the limits of language are the limits of the world: the limits of formalization are the limits of thought[3].

Noting the similarities between information transfer and human cognitive processes, psychologists have borrowed concepts from communication technology and information theory to describe human cognitive systems. Claude Shannon and others viewed human cognition as an information-processing process, studying how organisms transmit information and their inherent limitations. Noam Chomsky proposed the "biographical grammar" of linguistics, and combined it with psychology to form psycholinguistics, which believes that language mastery not only depends on the accumulation of experience, but also involves the structure of innate internalized rules. These studies laid the foundation for the information processing theory[4]. The counterpart in consciousness is the mental representation, which is the projection of a mental representation onto a fact so that the fact implies the meaning of the fact represented by the mental representation, and so the fact projected onto it becomes the symbol of the fact being represented. Herbert Simon's "physical symbol system" hypothesis suggests that human cognitive processes can be viewed as symbolic operations, and that these symbols are embodied physical symbols. Thus, computers can simulate human mental representations by manipulating symbols[5]. This hypothesis allows symbols not only to express complex abstract concepts, but also to be manipulated, transformed, and used to externalize the intentional processes of the mind like physical objects. The black and white pieces and their layouts in Go, as a symbol system, convey both the strategic intentions of the players and act as a vehicle for information transfer and thought interaction. The basic rules of Go contain an extremely complex logical structure and symbolic interaction. Each position of a piece on the board can be regarded as a logical representation, conveying different information such as defense, attack or control. The fall of each piece makes the symbolic manipulation in the game a process of forward derivation. From a logical point of view, the positions and interrelationships of the pieces are not only one-to-one references, but also construct a complex reasoning system through the relationships between the symbols, and the multi-layered nature of the symbols as well as the connection with psychology will be gradually presented.

Semiotic Analysis of Go

Basic rules and symbol system of Go

The basic rules of Go are simple and easy to understand, but contain complex reasoning logic and symbolic interaction. In ancient times, Go was regarded as a tool for aristocrats to train in military strategy, and the link between the two and the complexity of the game is revealed in "Thirteen Essays on the Art of Chess" and "The Art of War" by Sun Tzu, which states that "Though chess is a small game, it is actually the same as war, with a thousand variations, and the game is not the same game[6]. The game of Go is played by two players, each holding black and white pieces. The board is usually a 19×19 grid, and each piece is immovable once it has been placed, which gives each move an irreversible logical and strategic significance, which is analogous to the general symbolic representation of a unitary function: $y=f(x)$[7]. Where x is the independent variable of the function and y is the dependent variable of the function, both of which constitute the function variable. f denotes a mapping from the domain of definition of the function to the domain of value. From the perspective of semiotics, the pieces in Go can be regarded as the basic symbolic units, and their positions and layouts on the board not only convey the intentions of the players, but also constitute the information exchange and reasoning process in the game. The rules of Go require that the pieces must be placed at the intersections of the board, not in the spaces[8]. Similar to the binary system of computers, each piece in Go expresses a different meaning in a particular position, and the role of 0 and 1 in such systems is equivalent to the opposing messages conveyed by the black and white pieces. Each move is a symbolic expression, with the positions of the pieces reflecting strategies such as defense, attack, land enclosure, or blockade. The board itself is the field of symbolic interaction, and the net-like structure of the board itself is the platform for information transmission. The essence of this symbolic interaction lies in the fact that the player transmits information and reasoning through the manipulation of symbols, and each move in the game can be seen as an interpretation of and response to the opponent's strategy. Thus, the pieces and the board together constitute the basic symbolic system of Go, and the progress of the game is the logical interaction and reasoning between the symbols. Each symbol is a fact and conveys information about other facts through certain rules. This semiotic feature makes Go an ideal model for the study of information transfer and cognitive reasoning processes: the black and white pieces represent the two opposing sides, and their distribution and movement on the board constitute the basic language of the game. The board acts as a field for the movement of the pieces, and its structure provides the rules and boundaries for the symbolic manipulation of the players.

2 [English] Margaret Boden, editor, Philosophy of Artificial Intelligence, Shanghai Translation 2001, p. 7.

3 [English] Margaret Boden, editor, Philosophy of Artificial Intelligence, Shanghai Translation 2001, pp. 8-10.

4 Herbert Simon, A Theory of Information Processing in Human Cognitive-Thinking, Science Publishers, 1986, i.

5 Herbert Simon, A Theory of Information Processing in Human Cognitive-Thinking, Science Press 1986, iii.

6 [Song] Zhang Shisheng, Thirteen Chess Scriptures, Chess Games, Part 1, 2010 edition, Zhonghua Shuju Bureaus.

7 Revised by Chen Zuyuan, Rules of Go for the 2008 World Mind Games, Chapter 1, General Administration of Sport of China, 2008 edition.

8 Revised by Chen Zuyuan, Rules of Go for the 2008 World Mind Games, Chapter 1, General Administration of Sport of China, 2008 edition.

The common real property of Go pieces and the board is a symbolic system that conveys a variety of abstract information paradigms through different piece configurations. For example, the "star-minor" layout represents an abstract paradigm of a balanced strategy, while the "three consecutive stars" layout may suggest an intention to control the center of the board. These layouts are not just simple combinations of physical symbols, but also reflect deeper ways of thinking and intentionality. Some players may prefer intense battles and direct confrontations, where quick calculations and precise reasoning lead to a kill shot in a short period of time, while others are more focused on solid long-term layouts, where they gradually build up an advantage to win. Younger players are more likely to be emotionally stimulated and tend to fight instantly, while more experienced players tend to be more focused on the overall balance of the situation and long-term strategy. Such intentional choices of style and strategy can be revealed by analyzing a player's history of games and positions. An understanding of the "set concept" of the game can be further revealed by identifying the common layouts and patterns used by players. Each piece and each move in Go can be regarded as a symbolic operation in a symbolic system, and by calculating and interpreting these symbols, a player's thought patterns can be externalized into objective symbolic representations for further analysis and reasoning. This semiotic approach can help us to understand the style and tendency of chess players, and can also be used to externalize the dynamic symbol system of a game into a concrete physical model through a computer program, so as to accurately decode the game and the thinking of the players.

Messaging and Cognition

Go as a model for information transfer

The board and pieces of Go form a dynamic symbolic system. The pieces are symbolic units, and the intersection points occupied by each piece in a particular position form an expression of information. In this system, the decision-making process of the players can be regarded as a process of logical reasoning, in which they deduce possible future positions based on the current state of the game, and the significance of each move is reflected in the possibility of its future development. The symbol system of Go is thus not only dynamic but also recursive, with each move laying the foundation for future symbol transformations and information transfer. This network of symbols is non-linear and complex, with each move not only changing the current position, but also influencing each subsequent move through a feedback mechanism. Thus, the progression of the game of Go is not just a one-time transfer of information, but a multi-layered, back-and-forth exchange of information. This recursion and feedback mechanism makes Go an ideal model for information processing in complex systems. In the study of complex systems, information transfer, feedback and self-organization features are important research objects[9]. The game of Go is similar to the process of information flow in complex systems. The player's choice of each move affects the development of the whole situation, and the change of the situation in turn affects the player's decision. Thus, the progress of a game of Go exhibits the typical non-linear characteristics of complex systems: each change in the situation may produce unforeseen chain reactions. Go provides a microscopic model for observing how information is transmitted and fed back in complex systems. For example, a "hijacking" or "dead-or-alive" problem that develops in one part of the board may affect the direction of the entire game. Each local state change may be extended to other parts of the board through strategic adjustments by the players. The study of such information processing and feedback mechanisms is not only crucial to the understanding of Go itself, but also provides a theoretical foundation for artificial intelligence and neural networks, both of which have considerable origins in the game.

Cognitive processes in machines and humans

Ever since Turing proposed "machines and intelligence", there have been two schools of thought on neural networks: those who believe that logic and symbolic systems are necessary to achieve artificial intelligence, and those who believe that artificial intelligence can be achieved by imitating the brain[10] [9]. The earliest chess-based AI paradigm was based on Shannon's information theory, in which Shannon defined the chessboard as a two-dimensional array, with each piece containing a corresponding subroutine that computes all the possible moves of the piece, and used the evaluation function as a technical tool. With the help of von Neumann's Game Theory and Wiener's Cybernetics, Shannon formed a game tree with the Minimax algorithm, and used α-β pruning to limit the uncontrollable growth of the tree's size, and the original static computation of the evaluation function was replaced by dynamic computation with a several-fold increase of the depth of the tree[11].

In the mid-1980s, Deep Blue, with its iterative computer architecture, ushered in a new era of machine learning in which human players began to rely on computers for training. Go is not popular in the West, and the more pieces and more complex combination paradigms make the alpha-beta algorithms of the game tree prohibitive. And the Monte Carlo method, which can flexibly quantify information when faced with different objects, led Google's AlphaGo to Reinforcement Learning (RL). Neural networks are composed of multiple layers of neurons, and deep learning uses a computer to simulate the neuronal structure of the human brain to form a neural network to achieve the function of machine learning. A layer of network is a function, then the multi-layer network is to be nested multivariate function, training complexity of the problem has been gradually solved, the "forbidden fruit" of the game of Go by the machine "to steal food" (Deep Blue and Alphago opened the chess and Go's "Pandora's Box" respectively). (Deep Blue and Alphago opened the "Pandora's Box" of chess and Go respectively).

The cognitive process embodied by the player is

9 Herbert Simon, A Theory of Information Processing in Human Cognitive-Thinking, Science Press 1986, p. 34.

10 Nick, A Brief History of Artificial Intelligence, People's Posts and Telecommunications Publishing House, 2017 edition, p. 100.

11 Nick, A Brief History of Artificial Intelligence, People's Posts and Telecommunications Publishing House, 2017 edition, p. 103.

analogous to that of a neural network. The cognitive process of human cognition of Go is different from that of machine problem solving, in that the requirement of intentional goals in Go is gradually satisfied, with some of the goals progressively reaching from the planning space to the detail space. A human being is usually able to come up with a consistent explanation for a small problem, but locally reasonable problems become contradictory and inconsistent after extension, just like losing a big one for a small one in the chessboard[12]. The computer's program paradigm abstracts a whole chessboard as an aggregate function and abstracts the Key (as in propositional logic, we perform truth operations such as extracting, analyzing, combining, etc.), and if a set of formal symbols is used to depict all possible layouts on the chessboard, then the characteristics of this set of formal symbols need to correspond to the characteristics of the layouts, and further actions can be taken if the characteristics are grasped. If these features are grasped, then further corresponding strategies can be adopted. A human player needs to analyze the board cognitively by means of mental references.

Information processing in Go

Information processing in Go is not only limited to the physical manipulation of symbols and the transfer of information, but also involves the cognitive processes of the players, especially mental reference. Mental reference is the ability to represent and interpret symbols in thought, which goes beyond language. Mental references are structurally similar to linguistic references, and even if they have no referent, they can be elements of true thought[13]. Mental referents precede linguistic referents, both in linguistic and non-linguistic beings, and perception provides non-conceptual and therefore non-linguistic content that contains referential elements[14]. Chess players need to "mentally represent" the pieces and the layout according to the current position[15]. This cognitive process does not depend on language, but on a non-verbalized perception and meaning, where the player refers to the current position and deduces possible future changes by means of an intentional analysis, which is immaterial. When the player sees a potential "eye" or "breakpoint", he mentally refers to the meaning of these local symbols and makes a judgment based on the overall situation. This "intentional" process does not rely on specific verbal descriptions, but rather on the player's intuitive understanding and experience with the Go symbol system. This type of information processing makes each move in Go not only a manipulation of physical symbols, but also a cognitive decoding and recoding. It is this repeated application that allows the multitude of unique and independent relationships to be generalized according to a unified pattern rather than vice versa, a unified pattern that defines each unique relationship.

Mental References and Perceptions

Allegations and mental allegations

In the history of Western philosophy, the problem of reference has always been a central topic in the philosophy of logic and language. The concept of reference explores how language refers to things, individuals, or concepts in reality through symbols, words, or expressions[16]. The central question for philosophers is: how does language relate to the real world? And how do we express ideas and knowledge through language. Among the traditional denotational theories, the direct denotation theory claims that the contribution of a proper name to language is constituted by its denotation, and Kripke, as a representative of the direct denotation theory, explicitly points out the defects of the facsimile theory and rejects it. As opposed to the traditional referential theory, Kripke proposed the causal referential theory, according to which the referent of a name is the result of coordination with the referent of that referent through coordination among language users. The descriptivist theory assumes that the meaning of a name is given by, or is equivalent to, a relevant body of information, and that the denotation of a name is the truth value of that information. To understand a name is to relate that body of information to the name. Mental reference (mental reference) is an extension of the theory of reference to the field of psychology and deals with how we express, communicate, and interpret subjective experiences such as thoughts, feelings, and desires through language and other symbolic systems. It is concerned with how people connect external symbols to their internal meanings on a psychological level. Psychological denotation theory suggests that individuals make sense of symbols through mental representations that can be visual, auditory, or abstract concepts[17].

Mental references in Go cognition

Symbolic theory further states that mental states have symbolic and syntactic characteristics, and that the contest in Go is based on these symbolic representations, which are manifested in the exchange of form and content of thoughts between players. Go pieces are not only physical symbols, but also have their unique mental representations in the minds of the players. Every move in Go can be regarded as a kind of "mental language", reflecting the psychological state of the players. In a game, facing a crisis of "broken point" in the upper right corner, player A does not defend immediately but chooses to drop a stone in the lower left corner to "attack the west from the east". With the help of psychological allegations, Player A assumed that his opponent B would be so eager to attack the upper-right corner that he would lose sight of the whole situation, and thus gain an advantage by using the layout of the lower-left corner. In professional games between top players, it is common for a player to "attack the mind" by using his

12 Herbert Simon, A Theory of Information Processing in Human Cognitive-Thinking, Science Press 1986, p. 147.

13 Mark Sainsbury, Reference Without Referent, [M] Oxford:Oxford University Press, 2005:p217.

14 Mark Sainsbury, Reference Without Referent, [M] Oxford:Oxford University Press, 2005:p218.

15 Song Rong, Philosophy of Mind Inquiry on the Content of Thinking, China Social Science Press, 2012, p. 15.

16 Liu Jingya. On Sainsbury's theory of reference [D]. Central China Normal University, 2022.DOI:10.27159/d.cnki.ghzsu.2022.003186.

17 Song Rong, Philosophy of Mind Inquiry on the Content of Thinking, China Social Science Press, 2012, p. 15.

mind to devise extremely complex situations or by using unusual strategies to interfere with his opponent's thinking. Through these symbolic behaviors, the player conveys his intentionality and demonstrates its meaning on the board. In pre-linguistic times, humans were able to process non-verbal symbols through perception and thought, and this ability helped them develop complex language and thought systems[18]. In Go, a player's cognitive processes demonstrate a highly evolved form of this ability. However, a player may become "emotional" during a game due to external pressures or the timeframe of the game, which is important in the case of self-referential emotions, since the subject himself also thinks about the external evaluation of his behavior and the outcome of the game.

The intended object of the "emotion" and the player experiencing the emotional state result in the development of more complex representations and emotional experiences, which complicate game-focused mental references and thus affect the player's decision-making and formal expression. The symbolic representation of players' mental references is useful for exploring how players adjust their mental states for information processing and on-board interactions in stressful or high-pressure situations. The behavior of chess players in a game depends on their ability to refer to and process complex information flows, while mental references and mental representations can be interpreted through the analysis of natural science perspectives.

Multimodal cognition and mental allegory

Multi-Modal Cognitive Computing (MCC), a new study of machine-simulated human synaesthesia for efficient perception and integrated understanding of multimodal inputs, can also be used to explore efficient perception and integrated understanding of chess players. Integrated understanding. In every real event that occurs on the chessboard, the player himself, as the subject of experience and evaluation, is always associated with the environment. In a chess game, the player's mental references are not limited to a single perceptual channel, but are accomplished together through a multimodal perceptual system, including the combined effects of visual, tactile, and auditory perceptual systems. Combined with machine computation[19], the exploration of the involvement of other senses in the process of mental referencing in Go can analyze the multimodality of the symbolic system and the influence of different perceptual systems on mental referencing, for example, how the role of vision and touch affects the player's mental representations (in a blind Go game, a player is unable to rely on visual symbols while his or her level of performance is still comparable to that of normal players, and the player perceives the layout of the pieces through tactile sensation instead of visual sensation, and the player's mental representations through memory and mental representations for "mental reference"). This enriches the multilevel nature of the Go symbolic system. Multi-Modal Cognitive Computing (MMC), as a tool for machine simulation of multi-sensory inputs for comprehensive understanding, also provides new possibilities for studying mental references in Go. Perhaps future intelligent Go systems can analyze the psychological state of the player more precisely by integrating the player's physiological data (e.g., heartbeat, respiration, etc.). This processing of multimodal information is not only limited to physical symbol manipulation, but also involves an in-depth understanding of the psychological intention, which will make the player's thinking process and psychological state more transparent.

V Natural Science Perspectives on Go Behavior

Natural science conceptual analysis of Go behavior

The natural science perspective of Go presents a physicalist philosophy of mind paradigm: the retina is imaged, and photoreceptors in the retina convert light signals into electrical signals before passing through the optic nerve, which transmits the signals to the brain. The brain's primary visual cortex (area V1) parses the image, and the secondary visual cortex (areas V2, V3, and V4) further processes the image to recognize more complex features. Finally, the visual information is transmitted to other areas of the brain for more advanced cognitive processing and ultimately to the prefrontal cortex for participation in decision-making and strategy analysis. Whereas signaling between neurons relies on neurotransmitters throughout the process, attentional focus enhances the processing of specific visual information. The involvement of memory helps in recognizing patterns in the game and predicting the opponent's next move. Based on the visual information and cognitive analysis, the brain sends commands through the motor cortex to control the hand muscles for the next move. The whole process involves the visual, neural, cognitive and biochemical systems and is a highly complex and dynamic physiological process.

By interpreting Go in a natural science perspective, the theory of biocomputers can be elaborated with the help of machine simulations of the Go playing process. The neural links of the human brain consist of one million trillion neurons, and technological advances in chips are accelerating the approach of artificial neural networks to the brain, while the concept of biocomputers is to utilize this possibility of DNA as a potential computational and storage medium, as well as its ability to carry out complex chemical reactions in living organisms, to build a new type of computational system. DNA (deoxyribonucleic acid) is the molecule that stores genetic information in living organisms. DNA (deoxyribonucleic acid) is the molecule that stores genetic information in organisms, and it consists of four nucleotides (adenine, thymine, cytosine, and guanine), which are arranged in different combinations to form the genetic blueprint of an organism. Theoretically, one gram of DNA can store about 215 petabytes (1 petabyte = 1024^{1024} gigabytes) of data, and this system with a much larger amount of information could mimic the intentional behavior of the human brain to solve problems that are difficult for conventional computers to handle.

18 Mark Sainsbury, Reference Without Referent, [M] Oxford:Oxford University Press, 2005:p217.

19 Shannon, C. E. "A Mathematical Theory of Communication." The Bell System Technical Journal, 1948, pp:56-65.

Mindstream

Psychologist Mihaly Csikszentmihalyi in "Mindstream: The Psychology of Optimal Experience" developed the concept of a highly focused state of mind that an individual achieves while concentrating on a particular activity[20]. When a chess player is in the state of "mindfulness" during a game of chess, he or she will fall into a state of "forgetfulness" and will reach the subject's highest mental representational performance (on the chessboard). When a chess player is in a state of mindfulness, neuronal activity in the prefrontal cortex is reduced, while neural networks related to vision, spatial perception, and logical reasoning are highly active. This state of "forgetfulness" can be illustrated with the help of physical symbol systems and neuroscience, by simulating the digital synaptic resonance of human nerves through machine computation, explaining how Go as a dynamic system realizes complex strategies and cognition through biofeedback mechanisms, as well as explaining a kind of "satisfaction" gained by a player from completing a game of Go under the influence of the neural system. "satisfaction" and how players use highly focused reasoning ability and symbolic manipulation to make real-time decisions to reach strategic goals when faced with complex situations. By simulating this symbolic manipulation and reasoning process, the computer's deep learning model can also reproduce a similar strategy deduction process, which may explain that the "mental flow" is the result of the player's in-depth understanding of the Go symbolic system and the accumulation of experience[21].

20 Csikszentmihalyi, M. Flow: The Psychology of Optimal Experience. Harper & Row, 1990, ii.

Reach a Verdict

This paper discusses the theoretical basis and practical application of Go as a cognitive symbol system. Applying the physical symbol system to Go with the help of computers can formalize the intentionality of the player's thinking, and computers "have" the cognitive ability of human beings at this time. The board and pieces also have cognitive referential functions, and the player can process information with the help of intentionality. Mental referentiality also provides an important explanation of the complex cognitive process of Go under the paradigm of natural sciences, as well as a framework for a deeper explanation of the symbol system. As the intersection of semiotics and cognitive science, Go provides a "third way" for information transfer and human-computer interaction. The artificial intelligence paradigm of computers is not entirely derived from physical symbol systems, but the combination of the two is undoubtedly helpful for artificial intelligence research and simulation of complex human cognitive processes.

21 Von Neumann, J., & Morgenstern, O. Theory of Games and Economic Behavior. Princeton University Press, 1944, pp:123-145.