MECHANISMS UNDERLYING THE HERMENEUTIC CIRCLE BETWEEN CONNOTATION AND DENOTATION IN THE CONSTRUCTION OF SYMBOLIC COMMUNICATION SYSTEMS

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The expression "Can you pass the salt?" exchanged at the dining table can be interpreted as either requesting a salt shaker or literally enquiring if the person to whom the question is addressed to is able to pass the salt shaker. An expression has not only a literal meaning (denotation), but also an implied meaning (connotation), and they are interdependent. The process of determining the meaning of an expression involves a saying/implicating circle (Carston, 2002), which is thought to develop eventually into a structure of individual parts and whole, called a hermeneutic circle (Tsuda, 1984; Levinson, 2000). However, the mechanism that lead to the formation of this structure from its primitive stage is unclear. We therefore developed a coordination game with messages that simplifies the denotation and connotation based on the framework of experimental semiotics (Galantucci, 2009; Scott-Phillips & Kirby, 2010). Furthermore, while developing a computational model that is positioned as model-based reinforcement learning that performs as well as humans, we found several mechanisms underlying the primitive circle.

The proposed coordination game is as a terminal-based computer game (Galantucci, 2005) in which players and their partners randomly place pieces in separate 2×2 rooms and aim to move them to the same room. Before moving a piece, players can choose one of the four available shapes and exchange it with their partners only once at any given time. Players can move their own piece only once or keep it in the same position, but cannot move it diagonally between rooms. The result is then disclosed, and the two pieces are again randomly placed. In the process of repeating this series of operations in each game round, most players form symbol systems that map the shapes to their pieces to the room locations.

In this game, as the pieces cannot be moved diagonally, there is only a 50% chance of matching the partner's move if a piece is moved to a particular room without exchanging messages with the partner. However, if the first sender can tell the location of the present room and the second sender can reply with a destination where the two can meet, they can match their movements. Here, the relationship between game rooms and symbols corresponds to the denotation of a semantic element and the first location and destination of a piece correspond to its connotation of a pragmatic element. In an experiment with 20 pairs of human participants, 14 pairs (65%) constructed a symbol system that could consistently match the rooms to which the pieces were moved by the pair after 60 rounds of repetition. The designed computational model of the proposed game probabilistically determines the symbols, rooms, and when to send symbols. The probability changes through trial-and-error reinforcement learning, and the computational model has a parameter for interpreting symbols as indicating being/going to a room. This parameter is estimated from the partner's action history. In computer simulations using this parameter, the number of rounds required to achieve consistent matching of rooms to which the pieces were moved by both players was reduced to approximately 1/5 of that without using this parameter.

This reduction can be achieved by estimating the location of the partner's piece based on the received symbols and changing the probability of moving the piece to that estimated location. For example, when the location of the partner's piece is known, the probability of moving the piece to a position with no contact should become zero. This mechanism deviates from the framework of reinforcement learning, which changes the behavioral probability based on the rewards obtained from the results. However, this may be the mechanism by which symbols manipulate a partner's behavior. It was also necessary to coordinate the symbols when two players used the same symbol for different rooms or different symbols for the same room. We considered the implicit arrangement of role divisions, such as leader and follower, or the introduction of ambiguity into the denotation to solve this coordination. We adopted the latter mechanism owing to its lower computational cost. The computational model with the above mechanisms could consistently match the rooms to which the pieces were moved by both players for 9 pairs of participants (45%) out of the 20 pairs.

Computational models that deal with both literal and implied meanings can form symbol systems faster than computational models that only deal with literal meanings. In addition, a mechanism that changes the action probability before acting based on the literal and implied meanings inferred from the symbols is necessary for the realization and mutual action coordination at a low cost. These features improve the adaptive value of language acquisition in human evolutionary processes (Scott-Phillips, 2015).

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