Symbolic language

《Fodor, J. A. (1975). *The language of thought* (Vol. 5). Harvard University Press.》

The Language of Thought Hypothesis: Thought occurs via structured relationships between symbols in a mental language

– Mental language ≠ specific spoken language

■ Mental language → common language across all humans

■ Symbols in specific spoken languages are mapped to symbols in the mental language

《1Harnad, S. (1990). The symbol grounding problem. Physica D: Nonlinear Phenomena, 42(1-3), 335-346. © 2019 Natalie Parde》

Symbol Grounding Problem：Symbols do not represent anything on their own. Symbols cannot be defined only in terms of other symbols 1Harnad,

Humans understand language by mapping symbols to real-world experiences

MARL

《Emergence of Grounded Compositional Language in Multi-Agent Populations》

文章做的事情：让agent边说边做，不给agent分配role，也不显式给语言的用途，最后产生了basic compositional language。

the agents form concepts relevant to the task and environment and assign arbitrary symbols to communicate them. There are similarly no explicit language usage goals, such as making correct utterances, and no explicit roles agents are assigned, such as speaker or listener, or explicit turn taking dialogue structure as in traditional language games.

一些概念定义：compositional language ：by compositionality we mean the combination of multiple words to create meaning, as opposed to holistic languages that have a unique word for every possible meaning(Kirby 2001).

一些观点：

1. 对语言的使用 才 代表了对语言的理解，强调functional aspects of communication。A view of (Gauthier and Mordatch 2016) that an agent possesses an understanding of language when it can use language

2、Compositional的起源是vocabulary size小，但环境复杂。Our work offers insights into why such compositional structure emerges. In part, we find it to emerge when we explicitly encourage active vocabulary sizes to be small through a soft penalty. This is consistent with analysis in evolutionary linguistics (Nowak, Plotkin, and Jansen 2000) that finds composition to emerge only when number of concepts to be expressed becomes greater than a factor of agent’s symbol vocabulary capacity. Another important component leading to com position is training on a variety of tasks and environment configurations simultaneously. Training on cases where most information is clear from context (such as when there is only one landmark) leads to formation of atomic concepts that are reused compositionally in more complicated cases.

《On the Pitfalls of Measuring Emergent Communication》

文章做得事情：提出了一种 语言是否真的产生 的判别方法。：

一些概念定义：MARL和referential game 的联系。researchers define a multi-agent environment where agents possess a (usually discrete and costless) communication channel, and train the agents’ policies (represented by deep neural networks) to maximize the cumulative reward. In most cases, the multi-agent environment is a cooperative referential game, where one agent (the ‘speaker’) has some private information about a public observation, and must communicate it accurately to the other agent (the ‘listener’)

一些观点：评价语言是否产生要从 说（positive signaling） 和 听（positive listening） 两方面。很多工作只做前者忽略后者。we categorize emergent communication metrics into two broad classes: those that measure positive signaling, which indicates that an agent is sending messages that are related in some way with its observation or action; and those that measure positive listening, indicating that the messages are influencing the agents’behavior in some way.

Referential game

《learning to play guess who and inventing a grounded language as a consequence》

做的是事情 agents learn to encode physical concepts in their words.(grounding)

we propose the use of situated interactions between agents as a driving force for communication, and the framework of Deep Recurrent Q-Networks for evolving a shared language grounded in the provided environment

一些观点：

成功做好grounding 有赖于 环境给出正确的feedback。

Language arose as a way of transmitting knowledge about the state of the world between the people that live in it, and it evolves as the world changes over time. Severing this link, by analysing text as a static standalone artifact, leads to problems with grounding of concepts and effectively eliminates exploratory mapping of the language. In contrast, when humans communicate they generally do so in connection to the environment and interactively in both directions, which provides the necessary grounding of concepts but also an immediate feedback on every utterance. The importance of feedback for human language learners was shown by Sachs et al. in (Sachs et al., 1981). This paper describes the case of Jim, a hearing child that was brought up by two deaf parents and had to learn to speak from watching television without any supervision or feedback. These circumstances severely delayed his acquisition of language and he did not learn to speak properly until after intervention from the outside. This indicates that not even humans can learn to master human language without the help of guided exploration via synthesis and feedback, i.e. social interactions.

《Natural Language Does Not Emerge ‘Naturally’ in Multi-Agent Dialog》

一些概念定义：

grounding -mapping words to physical concepts

Compositionality-combining knowledge of simpler concepts to describe richer concepts

situated language learning- learning the communication protocols of agents situated in virtual environments in a completely end-to-end manner.

Das et al. (2017b), who proposed a cooperative reference game between two agents, where communication is necessary to accomplish the goal due to an information asymmetry.