Proceedings of the 6th International Conference of Cognitive Science,
The Korean Society for Cognitive Science (Eds.), 115-118, 2008

Constructive Study on Dynamics of Communication: The Role of Ambiguity and Context

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Abstract

In this study, we investigate how dynamic features of communication are realized in simulated processes. We hypothesize that ambiguity and context play important roles for maintaining the dynamics of success and failure in communication. We propose a game model of communication by adding ambiguity and context to Steels' Language-Game. As a result of simulation experiments of two types of the game model, it was shown that ambiguous words are disambiguated at the situation of communication by utilizing contextual information. We claim that the disaccord of interpretation arose by the ambiguity is one of the integrant parts bringing the dynamics of communication, such as superficial communicative success, failure and re-establishment of communication.

Introduction

Communication is a dynamic process. Symbol used in communication are composed of three terms: forms, references and interpretations (Peirce, 1935). While both forms and references are often physically knowable, interpretations are physically unknowable definitely by other people. Since this unknowability, inconsistency of interpretation often occurs on the way of communication. People usually try to guess others' interpretations and retry communication through modification of interpretation. Even if a way of interpretation once leads to a success in mutual understanding, it is not guaranteed that the same way of interpretation makes the following communication successful. Due to this indefiniteness and the guessing effort, communication has the dynamics of success and failure in mutual understandings. These features of communication are summarized as follows;

- ✧ Inconsistency of interpretation occurs on the way of communication and we retry communication through modification of interpretation.
- ✧ Even if a way of interpretation once leads to successful communication, the success with the same way of interpretation in following communication is not guaranteed.
- ✧ Success and failure of mutual understanding continues forever.

In this study, we aim at understanding this essential dynamics of communication. To this end, we take constructive approach (Hashimoto, 2008), that is, we try to understand the dynamics features of communication through constructing an agent model of communication, observing the processes of communication in computer simulation, and operating the model. We hypothesize that ambiguity and context play important roles for maintaining the dynamics of success and failure in communication. We adopt Steels' Language Game (Steels, 1996; Steels & Kaplan, 2002) as a base of our model, then, we develop in order to take ambiguity and context into consideration.

Language Game

Language Game is a model of language evolution in which an establishing process of the common vocabulary is represented. In the game, a speaker and a hearer communicate about some objects through naming and guessing. The speaker names each object, and the hearer learns the names of the objects. The basic procedure of the Language Game is the following:

1. Some of objects, having IDs, are decided (randomly) as an object-set.

2. A speaker selects one topical object from the object-set and makes an utterance about the topical object according to its own lexicon.
3. A hearer answers an object according to its own lexicon.
4. If the answer is collect, the communication is success. If not collect, the speaker teaches the selected object and the hearer updates its lexicon by recording the correspondence between the utterance and the object.

A cycle from the stage 2 to 4 is called one step.

Repeating this procedure, the agents who initially cannot communicate with each other at all come to be mutual understanding finally. That represents a process from failure to success of communication. But after a while they succeed always, if there is no change in the objects or in the communicating members. Namely, the dynamics of communication fades away.

Modeling

In attempting to keep communication dynamic, we introduce two features concerning our assumption into the Language Game. One is a mechanism to maintain ambiguity of symbols, the other is a disambiguating mechanism of the polysemous symbols by utilizing contextual information.

We construct two new games. In one game, called game A, hereafter, the following two settings are added:

- ✧ Each object has multiple features in addition to the ID. The speaker gives particular names to all the features and ID. The hearer accepts all utterances as names of the Objects' IDs. This device is for ambiguity.
- ✧ The hearer reconfigures its lexicon sometimes. In the reconfiguration process, the hearer seeks a feature that is common to all objects having the same name and makes the name and the common feature correspond. This process represents a kind of induction to disambiguate polysemous names.

The other one, game B, has the following setup:

- ✧ All objects are discriminated only by IDs (no features).
- ✧ The number of symbols is restricted. This promotes ambiguity.
- ✧ Each object-set has particular objects that appear with high probability. This setting is called "situation". The speaker names each object associated to the situations. The situation changes sometimes but the hearer cannot notice the change of situation. Note that the object-set is fixed during one situation.

Simulation Results

Game A: With Features of Object and Reconfiguration of Lexicon

We conducted computer simulation of the game A with the following parameter settings:

- ✧ The number of objects: 50
- ✧ Features: 3 features and 3 values for each feature; Form {circle, triangle, square}, Color {red, green, blue}, Size {large, middle, small}
- ✧ The number of names: 60
- ✧ Lexicon reconfiguration: Every 100 steps or 200 steps (different simulation runs)
- ✧ Initial lexicon: Both the speaker and hearer do not have any name.

Table 1 shows a part of hearer's lexicon at the 199th steps in the game A with 100 step interval of reconfiguration. This timing is just before second reconfiguration. There are some ambiguous symbols, shaded in the table, i.e., the names in the shaded part correspond to plural objects (IDs).

Table 1: A Part of the hearer's lexicon before several times of the reconfigurations in the game A with 100 step interval of reconfiguration.

Name	ID	Form	Color	Size
34	23	Square	Blue	Large
34	41	Square	Green	Small
34	11	Square	Green	Middle
15	50	Circle	Blue	Middle
33	50	Circle	Blue	Middle
1	32	Circle	Green	Small
1	2	Triangle	Red	Small
1	8	Triangle	Red	Small

This ambiguity was lost through reconfigurations. Table 2 depicts a part of the hearer's lexicon at the 900th steps in the same game. Each name makes one-to-one correspondence to an ID or a feature. The

communication became full success as shown in Figure 1 with the lost of ambiguity, the same as Steels's Language Game (Steels, 1996; Steels & Kaplan, 2002). The reconfiguration by induction is so strong in this small lexicon that all ambiguity resolved. No dynamics of communication was found in this game.

Table 2: A part of the hearer's lexicon after several times of the reconfigurations in the game A with 100 step interval of reconfiguration.

Name	ID or Feature
34	Square
1	Small
9	34
13	Circle
24	24
5	Red
39	14
32	1
17	7

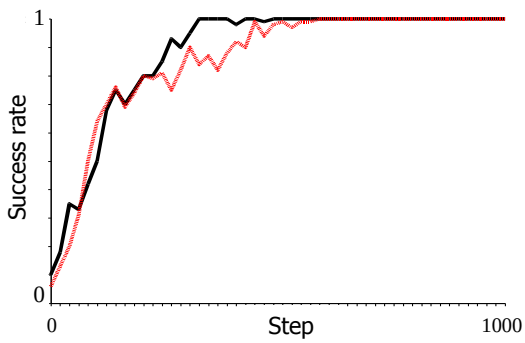

Figure 1: The change of the success rate of communication in game A with 100 step intervals of reconfiguration (solid) and 200 step intervals (broken).

Game B: With Restricted Number of Names and Change of Situations

Next, we describe the simulation results of the game B, in which we incorporate situations and exclude features. The setting of game B is as follows:

- ✧ The number of objects: 30
- ✧ The number of symbols (names): 10
- ✧ Four of five objects are peculiar to a situation.
- ✧ The number of situations: 5
- ✧ The situation changes every 5 steps. New situation is randomly selected from 5 situations.

Table 3 is parts of the speaker's and the hearer's lexicons at the 200th step. All names in these tables are ambiguous, i.e., one name corresponds to plural objects. The success rate of communication per situation changes with situations as shown by the solid line in Figure 2. It grows roughly until around 100 step (25th situation), but stays around 0.5 with fluctuations after the 100th step. Even after acquiring all names, communication between the agents may fail since the hearer does not know when situation changes. We have confirmed that this dynamics does not disappear how long the communication continues.

Table 3: Parts of the lexicons of the speaker (left) and the hearer (right) at the 200th steps.

Speaker

Name	Obj.	Sit.
2	3	1
	2	3
	3	3
4	5	3
	7	5
7	6	2
	6	5
	14	4
9	2	2
	11	2

Hearer

Name	Obj.	Sit.
2	3	1
	2	3
	18	4
4	5	3
	7	5
5	1	2
	4	3
	23	1
9	27	3
	2	2
	11	2

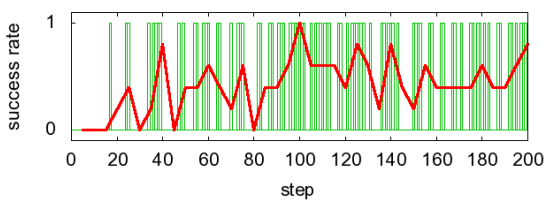

Figure 2: The ratio of successful communication per situation (5 steps) (line) and the success/failure of communication at each step (bars). 1 and 0 mean success and failure, respectively

We compare the success/failure between at the beginning and the end of each situation (Figure 3). The bottom graph is apparently denser than the top one. Namely, the speaker and the hearer are more