Logical Semantics Theory and Relevance Theory for Models of Dialogue Understanding
A Case Study on the interrogative form of Japanese sentences

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1. Introduction

The purpose of our research is to give a model of understanding utterances in dialogical settings, with the help of the logical semantics theory, of the relevance theory and of the acoustic linguistics. We, in particular, intend to clarify the role of the acoustic information in the understanding model of the utterances. We are interested in the mechanism of understanding an ambiguous expression which has various different interpretations in various different contexts/situations of an utterance of the expression;

(1) there is a neutral meaning (or "conceptual meaning") for each expression which is independent of the context/situation of an utterance of the expression. This conceptual meaning of an expression is, in many cases, derived from the logical form of the expression. This "conceptual meaning" is considered as the core part of the meaning for an expression.

(2) different interpretations can be derived from one conceptual meaning with the helps of context informations, including eg. common sense knowledge on the subject, logical implications, acoustic information from the speaker's utterance, and other situational factors. The relevance theory claims that one interpretation is chosen, in each context of dialogue, among the many possible interpretations of an expression based on the "relevance principle" (cf. [2], [8], [9]).

According to the above framework, we consider the two-layer semantics theory for understanding dialogical utterances.

The first level is a denotational semantics theory such as Montague-semantics, and the second is a theory for situational interpretations based on the relevance theory. We have developped a Montague-style denotational semantics theory for Japanese, where speaker's mood-expressions or intensional expressions are represented by specially introduced modal operators. Those modal operators are interpreted in terms of possible world (Kripke) semantics. Here, a mood expression is interpreted as a set of possible worlds. Such a denotational interpretation is considered as the basic meaning of the expression, and is given independently of the utterance situation or utterance context or speaker's specific intention. A specific meaning of an utterance at a specific context or a specific intention is explained in the second level of meaning theory, where the meaning of a mood expression is understood as a procedure to choose or focus on some spesific possible worlds out of the basic denotational set of possible worlds (of the first semantics level). More specific interpretation depending on the utterance context and the conversational situation is chosen by a hearer based on the relevance principle. During the development of a conversation, a speaker and a hearer change their role and try to make an interpretation each other so that the communication goes smoothly.

The second level of semantics/interpretation theory, hence, gives a dynamic view of development of dialogical communication processes. Among the important information with which a speaker makes a hearer (and a hearer makes himself/herself) understand speaker's specific intention is the voice information at the speaker's utterance. As the speaker's voice information, among the most important are (1) intonation, (2) accent, (3) duration length of vowels. Our goal of research is to show how much those voice informations can characterize speaker's specific intentions (i.e., can distinguishes various different contextual interpretations); in other words, to show how much the voice information contributes to the mutual understanding of a conversation in the above-described communication process.

2. Case Study on the Interrogative Form of Japanese

The interrogative form of Japanese sentences is charaterized by the end-particle "ka", which is often called "interrogative particle". It is well-recognized that a same interrogative form of expression could be interpreted in various different ways, according to the different contextual settings of dialogue. So, the interrogative form of sentences seems to be a good material for a case study of the above framework.

2.1 Montague-Semantical Analysis on the "Ka"-Form Interrogative Sentences

We first consider the conceptual meaning of the interrogative end particle "ka", by means of the Montague semantics theory. The meaning of "ka" is defined based on the analysis of the logical form of the Japanese interrogative sentences. A conceptual meaning of an expression is represented by a formal expression of the higher order intensional logic language. The denotational meaning for each formal expression is given by the Kripke model semantics for the higher order intensional logic. (See [6], [7] for the technical details of Montague semantics.)

For example, the grammatical analysis and the semantical analysis (i.e., the translation into a formal expression) of the interrogative sentence (with end-particle "ka") " Hanako ga kuru ka" [Does Hanako come?] are as follows;

Hanako ga kuru ka.

- syntax
  1. Hanako : CN = T
  2. ga : T \ S / IV
  3. kuru : IV = T
  4. Hanako ga kuru : S
  5. ka : X \ X / X
  6. Hanako ga kuru ka : S / S
- translation
  1. Hanako = λx [hanako (x)]: e$\rightarrow$t
  2. ga= $\lambda PQ\exists y[P(y) \wedge Q(y)]$: $(e \rightarrow t) \rightarrow (e \rightarrow t) \rightarrow t$
  3. kuru = λy [kuru (y)]: e$\rightarrow$t

4. Hanako ga kuru = $\exists y[hanako(y) \wedge kuru(y)]$: t
5. ka = $\lambda AB.(\Diamond A \wedge \Diamond B) \wedge (A \vee B) : X \rightarrow (X \rightarrow X)$
6. hanako ga kuru ka (otherwise) =
   $(\Diamond \exists y[hanako(y) \wedge kuru(y)]) \wedge$
   $(\Diamond \neg(\exists y[hanako(y) \wedge kuru(y)])) : t$

Here, the conceptual meaning for "Hanako ga kuru ka" [Is Hanako coming] is formulated as "both 'Hanako is coming' and 'Hanako is not coming' are possible". In other words, the conceptual meaning of an interrogative sentence is formulated as the set of all possible answer-sentences. This formulation of the formal translation of "ka" works not only for Yes-No interrogative form but also Wh-interrogative form where a set of possible answer-sentences could be infinite.

2.2 Relevance Theoretical and Speach-Acts Theoretical Analysis on Interpretations of "ka"-Form of Sentences

From the point of view of the speach act theory, the interrogative form of sentence "... ka" has the illocutionary force of genuine question if and only if the following conditions are satisfied. (Here, we assume A as the speaker and B as the hearer)

1. (a) A does not know the answer.
2. (b) A believe that B can provide the answer.
3. (c) A wants to know the answer.
4. (d) A request B to provide the answer.

[A] Genuine question
(1) Sato-san wa gakusei desu ka. (Is Sato a student?)
(2) Sato-san wa doko ni ikimashita ka. (Where did Sato go?)
(3) Doko ni Sato-san wa Ikimashita ka. (Where did Sato go?)

The cases which do not have the illocutionary force of genuine question.

[B] Rhetorical questions I.
(4) A saw B smoking who had said that he would stop smoking.
A: Dare ga mou tabakowo suwanai to iimashita ka [Who said not to smoke anymore?] (a,b,c are not satisfied)

[B'] Rhetoric questions II.
(5) A: Taro ga party ni kuruyo.[Taro is coming to the party.]
B: Masaka Taro ga kuruka [Good Heaven, does Toro comes?](b,d are not satisfied)

[C] Expository questions
(6) (At the beginning of the Philosophy class, the teacher said;)
Ittai, tetsugaku te nandarouka. Sore wa chi wo aisuru kotoda. [What is "Philosophy"? It's to love the intelligence.] (a,b,c,d are not satisfied)

(7) B: Karera seijika ga hontou ni kouyaku wo mamoru darou ka. [Do those politicians keep their promises?]
A: Seijika ga imamade kouyaku wo mamotta koto ga arimasu ka? [Have they ever kept any promise?] (a,c are not satisfied)

[D] Exam questions
(8) (In a geography class, a teacher asks a question to a student in the class.)
Buragiru no shyuto wa doko desu ka. [What is the name of the capital in Brazil?](a, c are not satisfied。 b is what is tested with this speach act.)

[E] Guess-questions (Game-questions)
(9) (A hides an apple on his back.)
甲：Ringo wa dochira no te deshyou ka. [In which hand do I have an apple?](a,b,c are not satisfied. d is required, but only by guess.)

[F] Surprise-questions (Echo-address)
(10) B: Sakujitsu no jichin de 5000 nin ijou no shishya ga demashita.[More than 5000 people died with yesterday's earthquake.]
A: Ee, Nan desu te. 5000 nin ijou no shishya ga deta no desu ka. [What? More than 5000 people died?] (a,c are not satisfied.)

[G] Reminder (Confirm)
(11) (After a medical operation, between a medical doctor B and the son A of the patiant)
B：Zannen nagara, otousama wa tasukari masen deshita. [We regret, but your father died.]
A: Yahari dame deshita ka. [Did he.](a,c,d are not satisfied.)

(12) A: Kokokara Tokyo eki made donokurai kakarimasuka. [How far is the Tokyo station from here?]
B: Ichijikan kakari masu. [About one hour.]
A: Aa sou desu ka. [I see.](a,c,d are not satisfied)

[H] Self-addressed questions
(13) (Self-addressing;)
Naze Yoko ni annakoto wo itte shimatta no darouka. [Why did I tell Yoko such a silly words?](b,c,d are not satisfied)

(14) (Opening a window;)
Aa, kyou mo ame ka. [Oh, it's rainy today again.](a,b,c,d are not satisfied)

[I] Speculative questions
(15) A is watching an abstract painting with his small son at an art exhibition.
A: Kono e wa nani wo imi shite iru no darou. [What does this painting mean?](b,d are not satisfied)

[J] Request

(16) Mado wo akete kuremasen ka. [Could you open the window?](a,b,c,d are not satisfied.)

3. Acoustic Analysis of "ka"-Form Sentences

Among various contex information the acoustic informaton seems a certain role for interpreting an ambiguous expression such as a "ka"-form sentence. The goal of our acoustic research is to identify the role of the acoustic information on the process of selecting an interpretation among many possible interpretations, based on the relevance principle (cf. [2],[8]). For this purpose, we collected acoustic data on the above listed 16 dialogues, from ten persons who use the standard Japanese accents (the Tokyo dialect). The acoustic data were collected three times per person, hence 30 data were collected per dialogue above.

The main results: 1. The intonation curves of "ka" are "up" for the genuine questions, the rhetorical questions, and the exam questions、the surprise questions、the requests. The ratio of the high frequency (of sound wave cycle) and the low frequency for each of those is between 1.5 and 2.0. In particular, the ratio for (5) the rhetoric question II is lower than the others. On the other hand, the intonation curves for the following are "down"; the expository questions, the guess questions、the reminders、the self-addressed questions、the speculative questions.
2. The duration time of "ka" for the Wh-type questions is shorter than that for the Yes-No type questions. The mean value for former is 245msec while the mean value for the latter is 265msec.
3. The curve patterns of the genuine questions and of the exam questions are very similar.

The above features of the acoustic data are interpreted as follows:
1. In general, the condition (d) is related to the "up" of the intonation curve. The only exceptions are (5) and (9), where (9) is "down" although it has (d), while (5) is up although it does not (d). In fact, although (5) does not (d), (5) expects some reaction from the hearer. Hence, in order to characterize the "up"-curves in terms of a speach-act style condition, it is more natural to take the following (d)', instead of (d).
(d)' A expects B to provide a reaction.
On the other hand, (9) is considered a very special setting of doing a game and the usual relationship between (d)' and "up" is not preserved.
2. A wh-question has a specific mark (a wh-expression, which is normally an "interrogative pronoun" in Japanese) for the question, and the end-marker "ka" seems less important. This seems the reason why the end-marker "ka" is not stressed with the presence of a wh-expression.
3. Exam-questions are consciously pronounced by a teacher (in a class) as if those were real questions, i.e., genuine questions. This explains why the exam questions have the same intonation curve pattern as the genuine questions.

The above data and analysis suggest that acoustic features are used by hearers as indices of some illocutionary forces of speakers. It is expected that further research of this direction would lead us to clarify the relationship between acoustic information and identification of an interpretation, based on the relevance principles.

Publication List

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