

# Interviewer Agent for Cognitive Task Analysis

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**Abstract.** A chat-based interviewer agent (IA) for cognitive task analysis was developed. This agent automatically generates questions for and responses to the answers from the human interviewee. The automated response process is based on shallow intelligence incorporating an interview technique for cognitive task analysis. We also considered the knowledge awareness (KA) effect and designed the interview as a fake group interview, with one agent interviewer, one agent interviewee, and a human interviewee. We conducted test interviews with 14 subjects to evaluate the new functions of the IA. The results show that KA and the fake group interview were effective and that the performance was better than that of the previous version, which used a one-on-one interview without considering KA.

**Keywords:** interviewer agent, cognitive task analysis, knowledge awareness, group interview effect.

## 1 Introduction

An interview is an effective method to elicit knowledge and opinions from other people because of its interactivity and flexibility. It is, therefore, often used in many domains for various purposes. For example, in the human factors and ergonomics (HF/E) domain, interviews are often used as a major knowledge elicitation method in cognitive task analysis (CTA) (Crandall et al., 2006), in which the cognitive processes in areas such as problem solving and decision making are examined. This type of interview is also applicable to and is often used for the assessment of the usability and accessibility of human-computer interactions (Polson et al. 1992). The interview is, however, time consuming in terms of preparation, implementation, and data analysis. Also, the quality of the data obtained from an interview depends more or less on the techniques and skills of the interviewer. There is also a limitation in that it is difficult to conduct interviews many times with many people. To solve this problem, we have been developing a chat-based conversational agent that conducts CTA interviews by generating questions for and responses to the answers from a human interviewee, and by managing the entire interview process. In this paper, we introduce the basic mechanism and several new features of this interviewer agent, and show how the agent works by presenting some interview results obtained by the agent.

In the next section, a short review of the related studies on conversational agents is presented, and the common problems of the past approaches are discussed. In Section 3, the new approach adopted for the design of our interviewer agent, i.e. CTA and the

group interview, is introduced and its implementation is explained in Section 4. Some test interviews were carried out for verification and the results are presented in Section 5, which is followed by discussion and the conclusions in Section 6.

## 2 Related Studies on Conversational Agents

There is a long history behind the development of the dialogue system or conversational agent (CA) (Weizenbaum 1966), and many related studies have been conducted to date. One of the main categories of the CA is the chat-agent or chat-bot, whose purpose is simply to chat and have fun (Wallace, Mauldin et al. 1994, Augello et al. 2008). Another major category is the interactive information provision system or a navigation agent through dialogue. This kind of system or agent tries to search a database and provide appropriate information or to help achieve a task such as ticket purchase through a dialogue with a human user (Kiyota et al. 2003, Watabe et al. 1986, Misu et al. 2007). However, no comparable development effort has been made in another CA category: the CA that is used to elicit information from a human user, i.e. an interviewer agent (IA). Several trials of interviewer agents have been conducted (Torizawa 2007, Ito et al. 2007); however, none of these CAs work effectively, judging by the excerpts of the conversation logs shown in the articles.

One of the main reasons for this is that they did not consider the specific features of interview conversations sufficiently. For example, an interview is a goal-oriented conversation, and is usually semi-structured. The previous IAs, however, do not contain such well-designed interview models, and simply have some key questions to present according to normal conversational rules. Also, there are many special techniques that can be used to promote interview conversations, like laddering or showing sympathy. In most cases, however, they consider only the laddering technique while ignoring the others. It is better to consider these techniques as much as possible to enable the CAs to better imitate the natural flow of an interview conversation.

Another major problem, which is common to all kinds of CAs, is that because the CAs do not understand the meaning or intention of the sentence entered as an answer by a human user, they provide unsuitable responses. It is therefore necessary to implement new techniques to reduce unsuitable responses, i.e., to deceive the human interviewee.

## 3 Our Approaches

To overcome the above limitations of the previous IAs, the critical decision method (Klein et al., 1989), which is one of the major CTA methods used in HF/E study, is adopted as a framework to manage the interview process and to offer a well-designed semi-structured interview. We also designed our interviewer agent as fake group interview software, consisting of two CAs and one human interviewee. One CA plays the interviewer and the other performs as a fake interviewee. For the human interviewee, therefore, it seems like a group interview where there is another interviewee, which is actually one of the CAs.

### 3.1 Critical Decision Method

The critical decision method (CDM) is a semi-structured interview technique that uses specific questions as so-called CDM probes to investigate the decision processes invoked by people during major or significant incidents. The CDM probes are applied according to the timeline of the important events in such incidents. We use a set of CDM probes like those presented in Table 1 to automatically generate key questions for the interview.

**Table 1.** Examples of CDM Probes

Category	Example
Uncertainty	Was there any uncertainty about that?
Prediction	Did any unpredictable events occur?
Timing	What kind of information was required at that time?
Attention	In that situation, where was your attention required?
Purpose	What is the purpose of that?
Alternatives	Did you have any alternative?
Obstacles, Difficulties	What were the difficulties in that situation?

### 3.2 Group Interview and Knowledge Awareness

We adopted a group interview style for the IA conversation. One of the reasons for this approach is that it would be easier for a human interviewee to understand the intent of a question after reading the answer provided by the CA interviewee to the same question, particularly when the question is vague or difficult to understand. Another reason is to add depth to the question by using the effects of knowledge awareness. Knowledge awareness (KA) is a concept that was proposed from the results of a collaborative learning study (Ogata et al., 1996), which helps a person to be aware of his/her own knowledge by presentation of another person's knowledge or story. In our IA, we use questions like those listed in Table 2 as KA questions, with the intent of making a human interviewee aware of his/her own knowledge and opinions and to help elicit that knowledge.

**Table 2.** Examples of KA questions

Item	Example
Reason	Why do you think he/she took that kind of action?
Information	What do you think was the most important information that prompted him/her to take that action?
Alternatives	If you were in the same situation, what other options would there be for actions that you could take?
Comparison	Did you take the same action as he/she did?
Reason	Why didn't you take that action?

## 4 System Design and Implementations

The system architecture and the mechanism used to generate the series of questions are explained in this section. This IA was designed and implemented for the Japanese language only.

### 4.1 System Architecture

The architecture of the IA system is illustrated in Fig. 1. The IA has a chat-type user interface shown on the right. The interview conversations are presented in the main window and the human interviewee enters his/her answer through the text window at the bottom. The database stores an interview guide, a phrase dictionary, and the conversation log. The interview guide is referred to for management of the whole interview process and is used to control the context of the interview by selecting the next appropriate question. The phrase dictionary is used at the query generation stage and provides a suitable phrase and expression for the query. The conversation log is used to create fake answers from the CA interviewee.

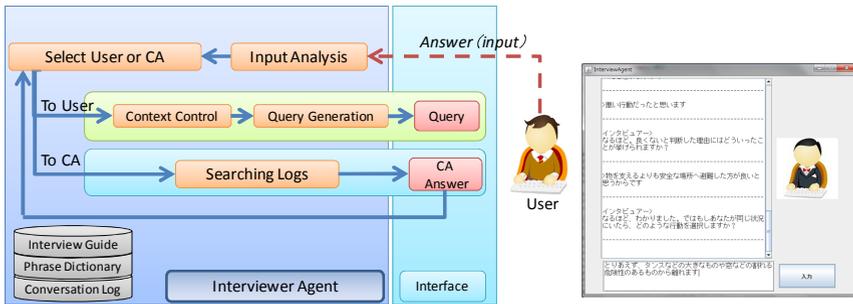


Fig. 1. System architecture

**Interview Guide.** The interview guide consists of a set of CDM probes and the conversational topics to be asked about with the probe questions. The topic can be defined hierarchically, which allows the structure of the interview to be determined. Fig. 3 shows an example of a question provided by the IA. In this example question, “To gather information” and “cellular phone” are the topics of the probe, where the former is placed in a higher category, and “are there any difficulties when you” is a phrase used for the probe question. The interview guide is editable for the purpose of an interview. An interview guide determines the overall flow of an interview shown in Fig.3.

情報収集の際に 携帯電話に関して、何か困ったことはありましたか？		
With regard to the <i>cellular phone</i> , are there any <i>difficulties</i> <u>when you gather information</u> ?		
(subtopic)	(CDM probe)	(topic)

Fig. 2. An example question (Upper: original Japanese, Lower: English translation)

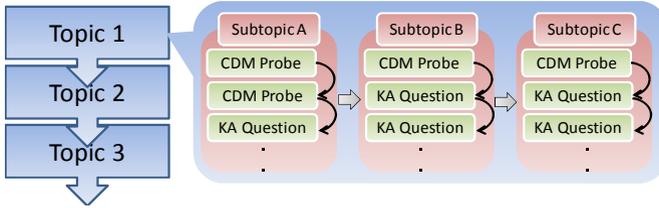


Fig. 3. Overall flow of an interview

**Phrase Dictionary.** Each questioning phrase in an interview conversation has a specific function, e.g., starting the conversation, exploring a subject in more depth, changing topics, or closing the conversation. The CDM probe and the KA question are also types of functions. We classified and implemented 40 different functions for the IA. We prepared several typical expressions and question templates, corresponding to each of the functions in the phrase dictionary. These expressions and the templates for the CDM probes and the KA are also stored in this dictionary. The IA selects an appropriate function based on the basic questioning graph, which is explained in section 4.2.1, in response to the previous input from the interviewee, and then picks up another expression or template at random and generates the next new question.

**Conversation Log.** Because this IA is a chat-type software, it is easy to record all the conversation data automatically. This record contains pairs of a question and its answer in relation to subject including its function, the target of the probe, and the input time and duration. This log is also used to generate fake responses from the CA interviewee by searching for the same function and target.

## 4.2 How to Form a Question

An interview starts with the IA introducing itself and asking the interviewee’s name. Then, IA generates the first question according to the interview guide and selects the first interviewee to be questioned. When the human interviewee is selected and the answer is entered, it is parsed and analyzed using natural language processing techniques to identify which cognitive process the answer refers to, from the four main cognitive processes: “information acquisition”, “situation awareness”, “decision-making”, and “action execution”. The IA then selects the next interviewee to be questioned; if the human interviewee is selected, the next question is generated according to the content of the previous answer and the basic flow of questioning. If, however, the CA interviewee is selected, the CA is provided with a similar question and then searches for an appropriate answer to the question from the database, and presents it as if the answer was given by another interviewee.

**The Questioning Sequence Graph.** While the overall flow of the interview is determined by the content of the interview guide, the local pattern is determined by a directed graph of the 40 questioning functions, which describe the possible sequences of questions. This graph is not a complete or a random graph, because each connection is

restricted by the meaning of the previous question, and it is sometimes conditional. We have carefully designed and implemented the graph with due consideration of such meanings and conditions, and with reference to actual human-human interviews.

## 5 Test Interview

We carried out an experiment to assess several functions of the IA, and compared the results with those obtained by a previous version of the IA, which has the same architecture and database, but lacks several functions that are present in the current IA. A sample interview log is presented in the Appendix. The entire interview has 102 turns; however, only 47 turns are listed because of space limitations.

### 5.1 Experiment

The test subjects were 14 people, 10 males and 4 females, with ages ranging from 18 to 30. The interview theme was about the experience of traveling home on March 11th 2011 during the Great East Japan Earthquake. The subjects were given an explanation of the interview with the IA and its theme. They were told to answer the questions posed by the IA with their experiences. They were also told that this was a group interview. It took about 5 min to give these instructions. Each interview lasted approximately 30 min. All interview conversations were automatically recorded and were analyzed in more depth after the interview. Subjects were asked to evaluate the quality of the IA dialogue from the 7 aspects listed in Table 3 with ratings on a 0-4 scale after the interview.

**Table 3.** Evaluation questions

No	Question
1	Is the overall flow of the interview natural?
2	Are the questions easy to understand?
3	Is the use of words natural?
4	Is there duplication of questions during the interview?
5	Is the conversation interactive?
6	Is the allocated time appropriate?
7	Do you want to use the IA again?

### 5.2 Results

**Subjective Evaluation.** Fig. 4 shows the results of the subjective evaluation and the differences between the current IA and the previous IA. The horizontal axis corresponds to the questions in Table 7, and the vertical axis represents the average scores of the subjective ratings. The previous IA adopted a one-on-one interview method and did not consider KA. The results for the previous IA were obtained with 9 different subjects under the same experimental conditions. The results showed that in all aspects other than No. 4, the current IA was superior to the previous IA; the most significant difference was found in the time allocation aspect (No. 6).

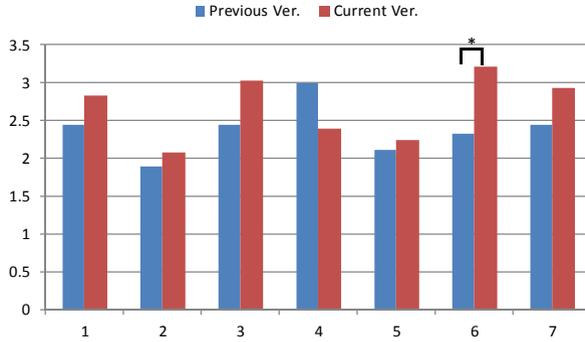


Fig. 4. Subjective evaluation of the quality of dialogue

**Efficiency of Knowledge Elicitation.** We analyzed the conversation logs by using a qualitative content analysis method and counted the new knowledge data and opinions that were obtained through the interview. Fig. 5 shows the results of this analysis. The bar graph on the right shows the knowledge elicitation ratio, which is the average number of new knowledge data and opinions obtained by one question. It shows that the current version was slightly better than the previous one, but was almost the same on average. We divided the logs of the test interviews into three segments and conducted the same analysis. The graph on the left shows this result; the first segment is the average ratio for the first one-third of the participants, while the second segment is the second one-third, and the third segment is the remainder. The results show that, while the efficiency decreased as we repeated interviews with the previous version, the current version maintained the efficiency over the final segments. This is not surprising because, as we repeat interviews, it will become increasingly difficult to obtain new knowledge and opinions because of the likelihood that the earlier interviewees provided them. However, the current version can provide more chances for the later interviewees to offer new information by using the KA questions with reference to the previous answers with their new knowledge and opinions. By detailed analysis, we found that it was actually this effect that improved the efficiency over the last one-third.

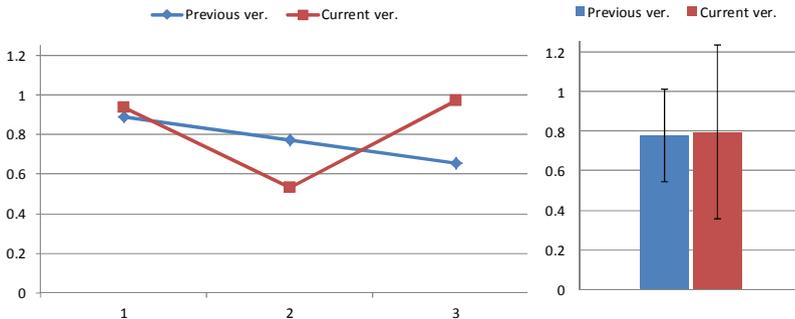


Fig. 5. Efficiency of knowledge elicitation

## 6 Conclusion

An IA incorporating the CDM, which is one of the major cognitive task analysis techniques, was developed. KA, which helps to elicit tacit knowledge with reference to other peoples' knowledge and opinions, was also implemented in this IA. In implementing the KA questions, we designed the interview as a fake group interview consisting of an interviewer agent, an interviewee agent, and a human interviewee. Test interviews with human subjects were conducted to assess the IA performance. The results show that the performance was slightly better in terms of both subjective evaluation and knowledge elicitation efficiency than that of the previous version, which used a one-on-one interview without considering KA. This suggests that a group interview with IA is possible and that the conversation quality does not deteriorate with the introduction of a fake interviewee agent, even though the group interview conversation became more complicated than the one-on-one interview. The results also show that KA was effective in maintaining high knowledge elicitation efficiency.

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## Appendix

1	IA	はじめにお名前を教えてください/Please tell me your name.
2	U	[被験者]/[User]
3	IA	初めまして[被験者]さん,[CA]さん.インタビューさせていただく[IA]と申します.本日はよろしくお祈りします/Nice to meet you [User] and [CA]. My name is [IA] and I am today's interviewer.
4	IA	[CA] さんに質問します.地震直後の安全の確保に関して,印象に残っていることを教えてください/I'd like to ask you [CA] about the most memorable thing when you secured your own safety after the earthquake.
5	CA	地震発生時は家にいたのですが,棚の上のものが落ちないように支えていました./I was at home at that time, and was holding a shelf so that the objects on it would not fall off.
6	IA	なるほど,わかりました.少し話は変わりますが,今までいろんな方が物の落下について話されたのですが,[CA]さんも印象に残っていますか/Hmmm, I understand. By the way, many people have mentioned falling objects. Did you also experience this [CA]?
7	CA	はい.全てのものは支えきれず,いくつか物が落下しました/Yes. I couldn't hold everything and some objects fell.
8	IA	なるほど.そのとき,利用した知識は正確なものだったと思いますか/Well, was your knowledge useful at the time?
9	CA	本当は物を支えるのではなく物の落下のないところに避難するべきだったと思います/Instead of holding the shelf, I think it would have been better to move to a safe place where things were not falling down.
10	IA	なるほど,わかりました.そのとき,優先的に収集した情報は何でしょうか/I understand. What kind of information did you preferentially gather at that time?
11	CA	地震の発生場所と規模です/The epicenter and its scale.
12	IA	参考になりました.ありがとうございます/That was very useful, thank you.
13	IA	[被験者] さんに質問です.[CA]さんが述べた物の落下に関する行動ですが,[被験者名]さんは「良い」行動だったと思いますか?それとも「悪い」行動だったと思いますか/Now I'd like to ask [User] some questions. With regard to [CA]'s reaction to the falling objects, do you think his reaction was good or bad?
14	U	悪い行動だったと思います/I think it was bad.
15	IA	なるほど.既に述べられていること以外で,どのようなことがこの行動を取る原因になったと思いますか/In that case, what else do you think was his reason for taking that action?
16	U	地震を甘く見てしまったことが原因だったと思います/I guess he underestimated the danger of the earthquake.
17	IA	わかりました.ではもしあなたが同じ状況にいたら,どのような行動を選択しますか/Well, if you were in the same situation, what other options would you take?
18	U	とにかく避難経路を確保して,机の下などにもぐります/ I would maintain an escape route in any case, and hide under the desk.
19	IA	なるほど.どういった理由でその行動を選択したのでしょうか/Hmmm. Why would you take those actions?
20	U	身の安全の確保を最優先すべきだと思うからです/Because I thought that securing my own safety was the first priority.
21	IA	わかりました.ありがとうございます/I understand. Thank you.
22	IA	地震直後の安全の確保に関して[CA]さんに質問したいのですが,そのことについて印象に残っていることを教えてくださいいただけますか?/I'd like to ask you [CA] about securing your own safety after the earthquake. Could you tell me what you remember about that?
23	CA	周りに倒れてくるものがないか確認しました/I confirmed whether or not there was anything falling down.
24	IA	わかりました.それはどうしてですか/Well, what was the reason for that?

25	CA	怪我をしたくないからです/Because I did not want to get hurt.
26	IA	怪我をしたくないからです/I understand.
27	IA	続いて[被験者]さんにお伺いします。地震直後の安全の確保に関して、他に印象に残っていることや苦労したことにはどんなことがありますか/Next, I will ask you [User]. With regard to securing your own safety after the earthquake, could you tell me what else was important or troublesome?
28	U	料理の途中だったので、すぐに火を消しました/I was cooking at that time, so I turned off the burner.
29	IA	なるほど、それでどうされたんでしょうか/Well then, what did you do next?
30	U	その他に火事の原因になるものが無いことを確認しました/I checked whether or not there were any other sources of fire.
31	IA	わかりました。ありがとうございます/I understand. Thank you.
32	IA	他に地震直後の安全の確保について[被験者]さんからお話しただけのことはありませんか/Do you [User] have anything else to tell us about securing your own safety after the earthquake?
33	U	ありません/No.
34	IA	このあたりで次の「安否や被災情報の収集」の話題に移らせていただきます/I would now like to move on to the next topic, which is gathering information about the disaster and the safety of other people.
35	IA	安否や被災情報の収集に関して[CA]さんに質問したいのですが、そのことについて印象に残っていることを教えていただけますか/I'd like to ask you [CA] about gathering information on the disaster and the safety of other people. Do you have something important to tell us about that?
36	CA	私は携帯からネットを使って調べました/I got information through the Internet by using my cellular phone.
37	IA	うーん、なるほど、どんなことがあったか、覚えてる範囲でかまいませんので教えて頂けますか/Oh. Please tell me what happened as you remember it.
38	CA	ダメもとでネットに接続してみたら使えたので地震速報のサイトで情報を集めたり、交通機関を調べたりしました/I thought it was worth a try and found that the service was available, so I collected information from a news website and searched for information about public transportation.
39	IA	わかりました。ありがとうございます/I understand, thank you.
40	IA	[被験者]さんに質問です。[被験者]さんは被災情報の収集に関して、[CA]さんと同じような行動を取りましたか/I will now ask you [User]. Did you take similar action to that of [CA] to get information about the disaster?
41	U	私はパソコンの電源を付けていたので、インターネットで情報収集しました/I was using a PC, so I gathered information from the Internet.
42	IA	そうだったんですか。[被験者]さんはどういった理由でその行動を選択しましたか/That is interesting. What was the reason for selecting that action?
43	U	パソコンの方が情報が見やすいし、携帯よりもつながりやすいと思ったからです/I thought it would be easier to see the information on the PC and would be easier to get connected.
44	IA	なるほど。同じ状況の時、選択する可能性がある行動にはどのようなものがありましたか/Yes. Did you have any other possible options in that situation?
45	U	“CA”さんと同様に携帯を使うことです/Using a cellular phone like “CA” did.
46	IA	わかりました。その行動はどういった理由で選択肢のひとつとして挙がったのでしょうか/I understand. Why do you think that this was one of the options?
47	U	情報収集として普段一番使っているツールだからです/Because we usually use cellular phones to search for information.