

# Mental time of conversations with photos using speech, event and photographing time

Er Sin Khoo<sup>\*1</sup>Mihoko Otake<sup>\*1,2</sup><sup>\*1</sup>Graduate School of Engineering, Chiba University<sup>\*2</sup> Fonobono Research Institute

In this study, we propose the method to classify mental time into “Past”, “Present” and “Future” by using three temporal elements which are speech, event and photographing time. Speech time is the time of coimagination method was carried out or the talking time, while event time is the time related to the contents of utterances, and photographing time is the time of photo was taken. The relation of these three temporal information is connected with “before”, “after” and “at the same time”. By using the relation of three temporal elements, we classify the mental time of speakers and plot the graph of mental time travelling.

## 1. Introduction

The rapid growth of aging population has become a major social problem. In order to improve the health, quality of life, and physical and cognitional functions of older adults, many researchers have started to focus on studying aging-related problems. For instance, the large scale cognitive intervention studies among older adults have been carried out for many years to show the effects of long-term intervention [Ball 2002, Willis 2006, Rebok 2014].

There are also many studies on dementia but the cure for dementia have not been found. Hence, the prevention of dementia has become an important issue. In order to prevent the decline of cognitive function, coimagination method has been developed which assist participants to activate their episodic memory, divided attention and planning functions through group conversations. Based on the conversation data collected from coimagination method, we found that participants talk about past, present and future episodes during their conversations. Hereby, mental time is a time consciousness of human beings over past, present and future [Tulving 2002], while the language, is a communication tool for sharing episodes. Hence, the language is thought to have co-evolved with mental time travelling, which is a process allow human beings to travel to “non-present” times [Corballis 2009]. In order to visualize the mental time travelling of people during conversations, the conversation analysis was carried out. According to the designed rules, the conversation data are classified into “past”, “present”, and “future” and the graph of mental time travelling was plotted.

Besides, we found that some older adults talked about past episodes although they used the photos took recently [Khoo 2016]. Therefore, in this study, we propose the method to classify mental time into “Past”, “Present” and “Future” by using three temporal elements which are speech, event and photographing time. Speech time is the time of talking during coimagination method. Event time is the time related to the contents of utterances. Photographing time is the time of photo was taken. The relation of these three temporal information is connected with “before”, “after” and “at the same time”. By using the relation of three temporal elements, we classify the

mental time of speakers and plot the graph of mental time travelling.

## 2. Related studies

### 2.1 Speech time, Event time, Reference time

In 1947, Reichenbach has introduced the system to analyze tense in natural language [Reichenbach 1947]. Three temporal elements, speech time, event time and reference time were introduced. The relationship between these three temporal elements were used to distinguish the absolute tense and relative tense [Comrie 1985]. For instances, the “at” and “before” relation between E and R show the difference between simple past tense and past perfect tense.

### 2.2 Classification of mental time

In the prior research, Onoda et al. proposed the method to classify mental time of participants during conversations based on knowledge of philosophy [Onoda 2015] [Mellor 2002]. The mental time was classified into 9 classes using the tense of the utterances, (FF: Future in the future; FN: present in the future; FP: past in the future; NF: present future; NN: present at present; NP: present past; PF: the future in the past; PN: the present in the past; PP: the past past).

## 3. Method

In this study, based on the Reichenbach’s tense system, we propose a method to classify the mental time of people during conversations with photos. Hereby, we explain the definition of mental time for past, present and future using Figure 1. In Figure 1, the place of people standing indicates the time when speaker talking. The colour region indicates “Present” when the speaker talks about events happened recently, however the definition of recent varies from person to person. The event happened before is classified as “Past” and the event haven’t happened is classified as “Future”.

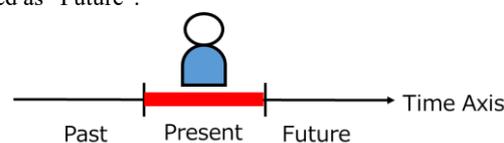


Figure 1 “Past”, “Present”, “Future” mental time

Three temporal elements which are speech time, event time and photographing time are used in this method. Speech time (S) is the absolute talking time, while event time (E) is the time related to the contents of utterances and photographing time (P) is the time of photo was taken. These three temporal elements are shown in the Figure 2.

The relation of these three-temporal information is connected with “before”, “after”, and “at the same time”. These relations will be written as “<”, “>”, and “=”.

This classification method is applied to three types of situations. The first situation is when the content of utterances is related to the photo, the second situation is when the content of utterances is related to the photo but the photo was taken long time ago, the third situation is when the person talks about events not related to the photo.

### 3.1 Utterances related to photos

In this situation, we assumed that the photos used by speaker are taken recently and before the conversation. Therefore, the photographing time, P is always before speech time, S. Table 1 shows the mental time axes classified as past, present and future according to the sequence of P < S.

In Table 1, the A1 is when speaker talk about event happened before the photo taken, which is considered as an old talk, and the mental time is classified as “Past”. A2, the speaker talks about events haven’t occur, so the mental time is “Future”. A3, A4, and A5 are classified as “Present”, but the conditions of each case is different. The A3 is when speaker talk about the event after taking pictures; the A4 is when speaker talk about the event being held during the photographing time; the A5 is when the photos are taken on-the-spot when speaker talks. These three cases representing “Present” are summarized as shown in Figure 3. According to Figure 3, the circle relates to the spoken event when the event happens for a certain time period. However, the condition for the duration is one day or less in order to ensure the photo was taken recently.

### 3.2 Utterances related to old photos

In this section, although the content of utterances is related to the photos, the photos were taken long time ago. Most of the order for E, P and S on the time axis is the same as Table 1, but the classifications of mental time are different. Table 2 shows the time axis for each classification of mental time. The main difference is the cases B2 and B3 are classified as “Present” when the photos are taken recently; but in Table 2, these cases are classified as “Past”. This is because when the spoken events related to the photos, the speaker thinks about past episodes and had mental time travelling backward.

The cases of B1, B2 and B3 representing “Past” mental time are summarized as shown in Figure 4. In Figure 4, the colour region represents the certain period of spoken events with the dotted line represents the border of the period. The time interval between boundary line and the speech time, S is within the time interval defined as “recent”.

In order to distinguish the photos are taken recently or long time ago, the suggested method is checking the printed date on the photos, the colors of the photos or asking the photo’s provider.

### 3.3 Utterances not related to photos

When speaker’s utterances are not related to photos, the proposed method is classifying mental time using E and S only, because the photographing time, P cannot be used as a reference in this case. Since there are only two temporal elements, it has only three cases of times axis as shown in Table 3.

Case C1 is classified as “Past” because the occurrence of the spoken event is before the speech time. Case C2, if the spoken event is happened within the time range assumed to be “Recent”, it is classified as “Present”. Case C3 is classified as “Future” because the events haven’t occurred during the speech time.

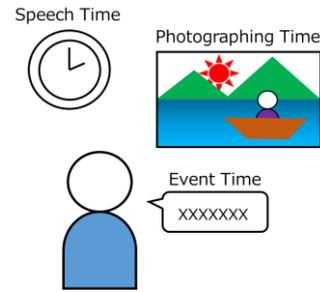


Figure 2 The three temporal elements during conversation  
Table 1 Mental time classification when the utterances are related to the photos

Cases	Situation	Classification
A1		Past
A2		Future
A3		Present
A4		Present
A5		Present



Figure 3 Summary of “Present” mental time  
Table 2 Mental time classification when the utterances are related to the old photos

Cases	Situation	Classification
B1		Past
B2		Past
B3		Past
B4		Present
B5		Future

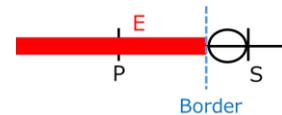
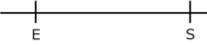


Figure 4 Summary of “Past” mental time

Table 3 Mental time classification when the utterances are not related to the photos

Cases	Situation	Classification
C1		Past
C2		Present
C3		Future

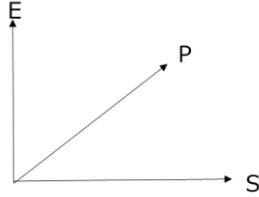


Figure 5 Three-dimensional mental time travelling graph

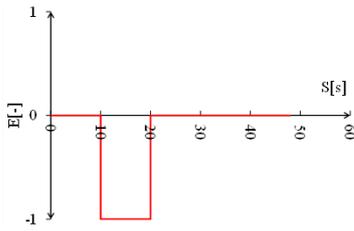


Figure 6 Two-dimensional mental time travelling graph

#### 4. Mental time travelling graph

In this section, we propose a method to show the mental time travelling during conversations. A three-dimensional mental time travelling graph is shown in Figure 5. The axis of the graph is as follows:

- (1) S Axis: Speech time.
- (2) P Axis: Time that varies with the photographing time.
- (3) E Axis: Event time representing the mental time travelling.

The three-dimensional graph can also be displayed in two dimensions as shown in Figure 6 according to the equation 1.

$$EP = ES + R \cdots (1)$$

Description of the symbol in equation 1:

ES: Mental time travelling regarding to the spoken contents without considering anything (speech event time)

EP: Mental time travelling considering about photographing time (photographing event time)

R: Coefficient which varies with the photographing time

Both ES and EP represent the mental time travelling, the former is the result of mental time simply classified by utterance, and the latter is the result of mental time considering the photographing time. Therefore, EP can estimate the real mental time of the speaker. The coefficient R, which varies with the photographing time and the cases where the coefficient of R changes are shown as below.

Here, in the mental time travelling graph, 0 represents “Present”, the negative direction represents “Past”, and the positive direction represents “Future”. For the “Past”, the recent past is represented by “-1”, the distant past is represented by “-2”. For the future, the recent future is represented by “1”, the distant future is represented by “2”. The blue dotted line shows ES and the red line shows EP.

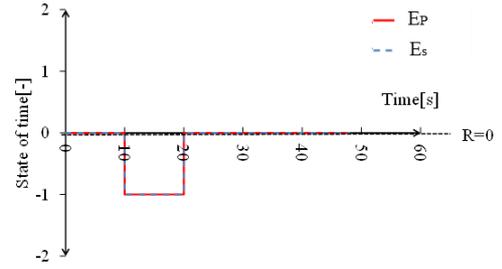


Figure 7  $R = 0, EP = ES$

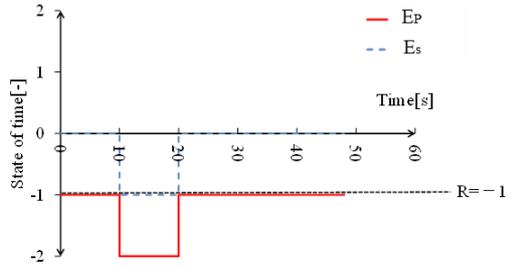


Figure 8  $R = -1, EP = ES - 1$

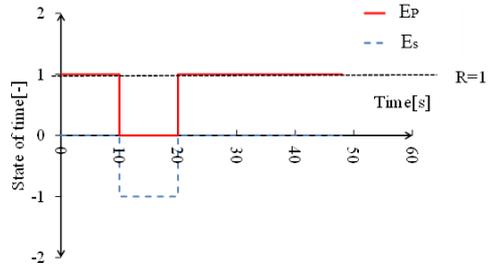


Figure 9  $R = 1, EP = ES + 1$

(1) When  $R = 0, EP = ES$  (Figure 7)

In this case, the utterance is related to the photo, and the photo is taken recently.

(2) When  $R = -1, EP = ES - 1$  (Figure 8)

In this case, the utterances are related to the old photo. For instance, based on the ES, although the mental time regarding to utterances is “Present”, actually speaker talks about old episodes related to old photos,  $R = -1$  and the actual mental time of the speaker is estimated from the EP.

(3) When  $R = 1, EP = ES + 1$  (Figure 9)

In this case, the spoken contents are about future episodes. Since the speaker cannot take a photo of future, they talk as if there is a photo of future which is different from the real photo, and talk with present tense. For instances, based on ES, the mental time regarding to the utterances is “Present”, but by the EP, it is actually the “Future”.

#### 5. Result and discussion

Based on the proposed mental time of conversation with photos using speech, event and photographing time, we analyzed speaker’s conversation data collected from coimagination method. In this method, participants are asked to provide photos and talk about it according to the theme of conversation within designated time. The mental time travelling graph of one speaker is shown in Figure 10. The utterances of speaker based on the theme “Small discovery” is shown in Table 4.

Figure 10 shows the mental time traveling of the speaker. The state of mental time of “Past”, “Present” and “Future” are represented by -1, 0, and 1. Here, regarding the spoken contents, the mental time of speaker ES is 0, classified as “Present”. The beginning of the utterances is not related to the photo, there is no coefficient R, while the rest of utterances is related to old photo, the coefficient R is equal to -1.

Table 4 shows the utterances of speaker about her discovery at Tokyo station one year ago. She was keen on talking about her memories and finished the conversation as the mental time still travelling in the "Past". The coefficient R is not constant because part of the utterances was not related to the photos, so there is no R and EP in part. When the speaker started to talk about the photo, although the contents of speech are “Present”, the mental time of the speaker is “Past”. Since the photo provided was taken one year ago, when speaker talked about the episodes of photo, she recalled her memories.

Based on the results above, it shows that the mental time of the speaker can be affected by the photo if the photos provided are old photos. In order to understand the real mental time of speakers during conversation with photos or conversation supported by coimagination method, it is important to consider the photographing time.

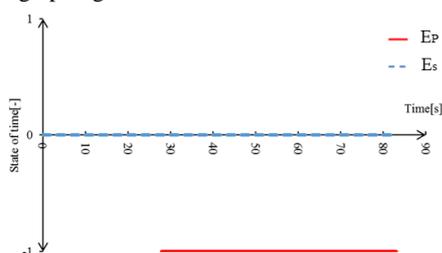


Figure 10 Mental time travelling of speaker

Table 4 Transcribed utterances of speaker

	<p>Um, it is a picture of the dome in Tokyo station. When I thought about the theme of small discovery for today, I could not find it easily. I thought that I could not find anything while walking in the garden with a camera. When I saw the pictures which I took until now, one by one, and then I said, “Oh, yes.” There was a small discovery.</p>	<p>No Ep, R</p>
	<p>It is a picture I took when I went to the Tokyo Station just about a year ago, with the relief of the zodiac at the dome of Tokyo station. It is very beautiful like cameo broach. It is a green white one floating. It is just like this. This is a sheep. Although it was said that there are 12 zodiac signs, actually there are no 12! Oh, this is the discovery of no 12 zodiac signs.</p>	<p>R = -1, Ep = ES - 1</p>

## 6. Conclusion

In order to know the mental time travelling of speakers during conversations with photos, we propose the method of classification of mental time using the speech, event, and photographing time. Based on the results of analysis, we also found that the effect and importance of considering photographing time when classifying mental time of speaker.

Future work of this research includes automating the classification process. Currently, the classifications were done using the transcribed conversation data, and by using the annotating tool to plot the time interval between each state of mental time. By combining classification and voice recognition technology, the mental time of speaker during conversation with photos can be classified in real-time.

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