

## INVITED ARTICLE

## Complicated Emotion Allocating Method Based on Emotional Eliciting Condition Theory

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**Abstract:** In this paper, we explain a method to obtain the user's emotions in an event. Simple emotions (pleasure/displeasure) extracted by Emotion Generating Calculations (EGC) are divided into 20 various emotions based on the Emotion Eliciting Condition Theory. The theory requires the discriminate criterion to judge which an event corresponds to "Feeling for another," "Prospect and confirmation," or "Approval/disapproval." "Feeling for another" means someone's emotion (not mine) in the event. It is determined by analysis result of EGC under the condition of another's taste information. "Prospect and confirmation" is determined by extracting some aspects and adverbs about the tense to judge. "Approval/disapproval" is determined according to the utterance's case frame structure with transitive verb.

**Keywords** Emotion, Emotion Generating Calculations, Complicated Emotion, Favorite Value, Facial Expression, Emotion Eliciting Condition Theory.

### 1. Introduction

Although we have recently been able to access various media by computer networks, some problems are noticeable about the interface tools to support communication between human and computer or human and human. In order to achieve natural communication, developing communication interactive tool considering the human mind is expected<sup>[1]</sup>.

Ekman classified body actions relating to communication as follows; verbal information, paralinguage and non-verbal information. Verbal information is expressed by strings obtained from sentences, utterances, and so on. Paralinguage is expressed by rhythm, intonation, and so on. Non-verbal information is expressed by facial expressions, gestures, blinks, and so on<sup>[2]</sup>. It is especially well known that the role of non-verbal information in communication and conversation is important. Mehrabian, a psychologist, reported "an affection reaches to the companion by verbal information (the weight is 7%), paralinguage (the weight is 38%) and non-verbal information (the weight is 55%) in a conversation<sup>[3]</sup>."

Various methods are proposed for perceiving the emotions from non-verbal information. Harashima proposed a method whereby a machine extracts and encodes the variation factors of facial expression from the user's facial image and another machine receives and decodes the factors and reconstructs the facial expression by Computer Graphics<sup>[4,5]</sup>.

However, people sometimes express facial expressions which differ from their real emotions. For example, a person smiles even if he/she is displeased. In this situation, if the former systems recognize the users' emotions as happy from the smile, the system never obtains their confidence. Therefore, a method to analyze the users' emotions based on not only non-verbal information but also verbal information, is required.

Generally, the utterances in the dialogue are represented in sentence forms, and they mainly express the events and the attributions. Then, we proposed a method to analyze the user's emotions from the event in his/her utterances. We employed 11 event types and 6 attribution types, and defined a calculation for each type. This calculation method extracts pleasure and displeasure from the synthetic vector among the values that means degree of like/dislike for three-dimensional case elements. We call the values "Favorite Values (FV)"<sup>[6,7]</sup>.

However, the classified pleasure/displeasure is too ambiguous to apply the pleasure/displeasure into the process considering the user's emotions. There are many kinds of emotions in human society like "relief," "expectation," "envy," and so on. Many psychologists have proposed the criteria of emotion evaluations to distinguish such various emotions from the simple emotions like pleasure/displeasure. For example, Wundt proposed three dimensions, namely "pleasure vs. displeasure," "calmness vs. tension," and "relaxation vs. excitement"<sup>[8]</sup>. Schlosberg proposed three other dimensions, "pleasure vs. displeasure," "attention vs. rejection," and "strong vs. weak for the activation"<sup>[9]</sup>. Plutchik proposed eight kinds of primary emotions (anger, disgust, sadness, surprise, fear, joy, acceptance

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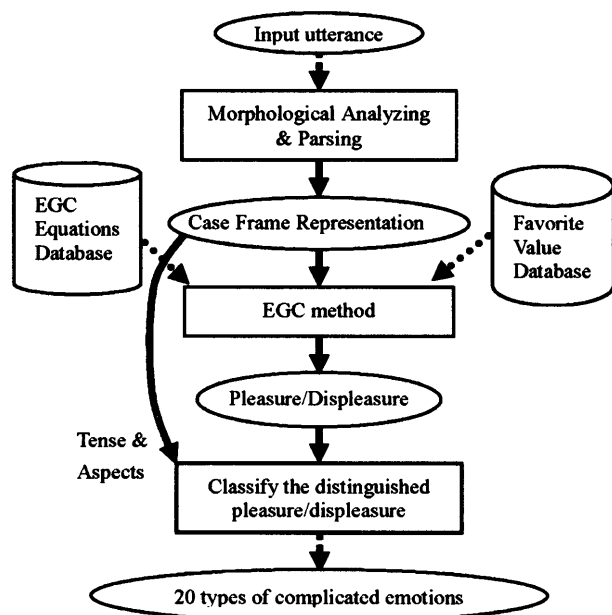


Figure 1. Process for generating emotions

and anticipation) and the degree of each emotion<sup>[10]</sup>. Although these studies are effective to classify emotions from the viewpoint of the person who arouses the emotions, they are not effective to guess the other person's emotions because their methods require the degree of the other's perceptions such as excitement and attention.

In this paper, we propose a method to distinguish complicated emotions from extracted pleasure/displeasure by the EGC method. We employ "emotion eliciting condition theory" proposed by Elliott<sup>[11, 12]</sup>. This method checks the emotion eliciting conditions based on the grammatical features like adverbs, aspects and content of the case frame like subject, verb type and so on.

Section 2 contains a quick review of the EGC method. Section 3 introduces a method to distinguish the complicated emotions from pleasure/displeasure, and experimental results are described in Section 4. Conclusion and future work are presented in Section 5.

## 2. Emotion Generating Calculations

### 2.1. Process for Generating Emotions

Figure 1 shows the process for generating emotions.

At first, the user's utterance is transcribed into the case frame representation based on the result of morphing and parsing.

Next, the agent extracts pleasure/displeasure from the event in case frame representation. In the psychological field, "unpleasure" is often used as the opposite of "pleasure." However, we use "displeasure," because an explicit intention about "unhappy" should be pointed out. The method uses the FVs. The equations consist of 2 or 3 terms and each term mainly means subject, object and predicate.

Then, the agent divides this simple emotion (pleasure/displeasure) into 20 various emotions based

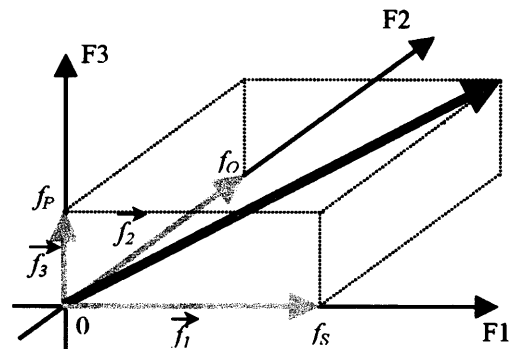


Figure 2. Emotion Space for EGC method

on the Elliott's "Emotion Eliciting Condition Theory." Elliott's theory requires judging such conditions as follows; "feeling for another," "prospect and confirmation," "approval/disapproval." The detail of this classification method is described in Chapter 3.

### 2.2. Case Frame Representation

The case frame structure bases the predicate phrase and the other case elements which connect to the predicate phrase.

In order to transcribe the user's utterances into the case frame representation, we implement morphological analysis and parsing to the input sentence. We use JUMAN as a morphological analyzer and KNP as a parser. Both of JUMAN and KNP are used only for Japanese and are developed in Kyoto University<sup>[13]</sup>.

The sentence is transcribed into the "deep case frame structure" as follows:

Predicate: <i>break</i>	Subject: <i>he</i>
	Object: <i>my car</i>
	Tense: <i>past</i>
	Aspect: <i>nothing</i>

### 2.3. Favorite Value Database

We calculate pleasure/displeasure about an event by FV. We give positive numbers to some objects when the user likes them, and give negative numbers to the other objects which the user dislikes. The FV is predefined a real number in the range  $[-1.0, 1.0]$ .

There are two types of FVs, personal FV and default FV. Personal FV is stored in a personal database for each person who the agent knows well, and it shows the degree of like/dislike to an object from the person's viewpoint. On the other hand, default FV shows the common degree of like/dislike to an object that the agent feels. Generally, it is generated based on the agent's own taste information according to the result of some questionnaires. Both personal and default FVs are stored in each user's Favorite Value database.

Default FVs are predefined based on corpus in the field that the system is applied.

The FVs of the objects were gained from a questionnaire. However, there are countless objects in the world. In this paper, we limit the objects that have default FV into the frequently appeared words in the dialogue.

**Table 1. Correspondence between the event types and the axis**

Event type	$f_1$	$f_2$	$F_3$
V (S)	$f_S$	—	$f_P$
A (S, C)			
A (S, OF, C)			
A (S, OT, C)			
A (S, OM, C)			
A (S, OS, C)			
N (S)			
V (S, OF)	$f_S$	$f_{OT} - f_{OF}$	$f_P$
V (S, OT)			
V (S, OM)	$f_S$	$f_{OM}$	$f_P$
V (S, OS)	$f_S - f_{OS}$	—	$f_P$
V (S, O)	$f_S$	$f_O$	$f_P$
	$f_O$	—	$f_P$
V (S, O, OF)	$f_O$	$f_{OT} - f_{OF}$	$f_P$
V (S, O, OT)			
V (S, O, OM)	$f_O$	$f_{OM}$	$f_P$
V (S, O, I)	$f_O$	$f_I$	$f_P$
V (S, O, OC)	$f_O$	—	$f_{OC}$
A (S, O, C)	$f_O$	—	$f_P$

**Table 2. Distinguish pleasure/displeasure using the sign of each axis**

Area	$f_1$	$f_2$	$f_3$	Emotion
I	+	+	+	Pleasure
II	—	+	+	Displeasure
III	—	—	+	Pleasure
IV	+	—	+	Displeasure
V	+	+	—	Displeasure
VI	—	+	—	Pleasure
VII	—	—	—	Displeasure
VIII	+	—	—	Pleasure

#### 2.4. Equation of Emotion Generating Calculations

In this paper, we assume an emotional space as three-dimensional space. Therefore, we present a method to distinguish pleasure/displeasure from an event by judging where area the synthetic vector exists.

Table 1 shows the correspondence between the case elements in the EGC equations and the axis in the three-dimensional model. In this table, each variable is expressed as follows.

- $f_S$  : FV of Subject
- $f_O$  : FV of Object
- $f_{OF}$  : FV of Object-From
- $f_{OT}$  : FV of Object-To
- $f_{OM}$  : FV of Object-Mutual
- $f_{OS}$  : FV of Object-Source
- $f_{OC}$  : FV of Object-Content
- $f_P$  : FV of Predicate

Table 2 is a list between the sign of each axis and the generated pleasure/displeasure. When the vector is on

the axis, the event does not raise any emotion.

When we calculate the synthetic vectors of the events which do not have  $f_2$  elements, we supply a dummy FV;  $\beta$  as  $f_2$  element. We tentatively defined  $\beta$  as +0.5 as it does not affect our method.

Figure 2 is an example of emotion space of event type V(S, O). There are three elements; Subject, Object, and Predicate, in the event type, and the orthogonal vectors by the elements construct a rectangular solid.

### 3. Complicated Emotion Allocating Method on Emotion Eliciting Condition Theory

#### 3.1. Emotion Eliciting Condition Theory

Elliott proposed emotion eliciting condition rules for the strong-theory reasoning component of the Affective Reasoner as shown in Table 3<sup>[11, 12]</sup>. This “Emotion Eliciting Condition Theory” classifies 24 emotions and its conditions are checked based on the following point;

1. pleasure/displeasure for the event
2. viewpoint from the other person
3. prospect/confirm the event
4. approve/disapprove the event
5. attraction for the event

We propose the methods to appraise pleasure/displeasure by the EGC result and extract situation information from the tense and aspect, content of the case frame and so on.

However, detecting the concept for likes/dislikes needs the personal taste information, one’s own experiences, perceptions, and so on. Then, in this paper, we deal 20 types of emotions except “liking,” “disliking,” “love,” and “hate.”

#### 3.1.1. Fortunes of the others

The emotions that belong to a group of “Fortunes-of-Others” are elicited from the emotion that the other affects. There are “happy-for,” “gloating,” “resentment,” and “sorry-for” in this group.

The EGC method calculates pleasure/displeasure concerning the event from the user’s viewpoint using FVs. The FVs which have been defined are based on the user’s preference. However, some emotions like “sorry-for” and “happy-for” are aroused based on the other’s emotions. We give the conditions for the emotions “pleased/displeased about an event desirable/undesirable for another.”

In order to appraise whether an event is desirable/undesirable for a person in the conditions, we assumed the condition as “the event pleases/displeases the person.” However, different reactions (pleased/displeased) can be aroused against the same situations (desirable/undesirable for another). Therefore, we translated these conditions as follows; 1) when the user likes the individual that is pleased about an event, the user feels happy-for him/her, and 2) when the user dislikes the individual that is pleased about an event, the user gloats over his/her misfortune. In order to confirm

Table 3. Emotion Eliciting Condition Theory by Elliott

Group	Specification	Types (name)
Well-being	Appraisal of a situation as an event	Pleased about an event (joy)
		Displeased about an event (distress)
Fortunes-of-others	Presumed value of a situation as an event affecting another	Pleased about an event desirable for another (happy-for)
		Pleased about an event undesirable for another (gloating)
		Displeased about an event desirable for another (resentment)
		Displeased about an event undesirable for another (sorry-for)
Prospect-based	Appraisal of a situation as a prospective event	Pleased about a prospective desirable event (hope)
		Displeased about a prospective undesirable event (fear)
Confirmation	Appraisal of a situation as confirming or unconfirming an expectation	Pleased about an unconfirmed undesirable event (relief)
		Pleased about a confirmed desirable event (satisfaction)
		Displeased about a confirmed undesirable event (fears-confirmed)
		Displeased about an unconfirmed desirable event (disappointment)
Attribution	Appraisal of a situation as an accountable act of some agent	Approving of one's own action (pride)
		Approving of another's action (admiration)
		Disapproving of one's own action (shame)
		Disapproving of another's action (reproach)
Attraction	Appraisal of a situation as containing an attractive or unattractive object	Finding an appealing object (liking)
		Finding an unappealing object (disliking)
Well-being/Attribution	Compound emotions	Admiration + joy → gratitude
		Reproach + distress → anger
		Pride + joy → gratification
		Shame + distress → remorse
Attraction/Attribution	Compound emotion extensions	Admiration + liking → love
		Reproach + disliking → hate

the translation, the adequacies of the translated conditions for generating these emotions are investigated by questionnaire. As the result, it was found that the person's preference and the event's impression for the person are important factors for these emotions.

Therefore, the method has to judge that "the person is favorable/hateful for the user" and "the event is desirable/undesirable from the person's viewpoint." The EGC is used for appraising these conditions.

First, it is detected whether an individual is favorite or hateful from the user's viewpoint. The FV of the target person is used for checking it, because the user's preference is already clear by the FVs. When the FV is positive, the user likes the individual. On the other hand, when the FV is negative, the user dislikes the individual.

Next, it is detected that an event is pleasure/displeasure for the other person. The EGC method can calculate pleasure/displeasure for the user's viewpoint based on the user's FVs. Then, if we use not the user's FVs but the other person's FVs, obtained pleasure/displeasure indicates the emotion from the person's viewpoint. We define the pleasure/displeasure as Emotion Value (EV). Therefore, we use "FVs from the other's viewpoint" for the EGC, and we consider the output EV as the emotion of "the other" about the event. The person's database of FV is managed in the same way as that of the user's one. When the individual's Favorite Value database does not exist, default database is adopted.

Table 4 shows a relationship between the preference of an individual, emotion for the event from the individual's viewpoint, and generated emotion. In this table, 'A' means an individual without the user. We

Table 4. Generated emotions for the preference of an individual and his/her emotion in the event

		EV (A)		
		Pleasure	0	Displeasure
A (user)	Like	Happy-for 'A'		Sorry-for 'A'
	0		0	
	Dislike	Resentment		Gloating

describe the FV of 'A' from the user's viewpoint as "A (user)," and the FV of 'B' from C's viewpoint as "B (C)." The EV of the event is described in the same way, for example, "EV (A)" means the EV of the event from A's viewpoint.

```

begin
  Calculate the emotion value against the event using A's FVs
  if (EV(A) = "pleasure" and A(user) = "like")
    then "Happy-for A"
  elseif (EV(A) = "pleasure" and A(user) = "dislike")
    then "Resentment"
  elseif (EV(A) = "displeasure" and A(user) = "like")
    then "Sorry-for A"
  elseif (EV(A) = "displeasure" and A(user) = "dislike")
    then "Gloating"
end

```

### 3.1.2. Prospect-Based Emotions

There are "hope" and "fear" in a group of "Prospect-Based". The condition for the emotion is "pleased/displeased about a prospective desirable/undesirable event." We can already check that the event is desirable/undesirable by using the EGC method as described in Section 3.1.1. But, we have to give a method to check whether the event is prospective or not.

Although people generally use reasoning to predict the future event, our study has not utilized such reasoning process. However, they do not always make a complete reasoning. When they cannot reason for the event, they occasionally refer the grammatical features.

Therefore, we also extract the information about “prospects” from the aspect in the case frame representation. When there is an aspect of “inference (will)” or “intention (be going to),” the event means a prospective event.

When pleasure/displeasure is calculated from the prospective event, we consider the agent affects “hope/fear.” The event which will happen in the future is taken into account in the “prospective event list” in order to confirm that the prospective event has happened or not.

```

begin
  if aspect = "inference" or "intention"
    then begin
      Take this event into account in "prospective event list"
      Calculate the emotion value against the event
      if EV(user) = "pleasure"
        then "Hope"
      elseif EV(user) = "displeasure"
        then "Fear"
    end
  end
end

```

### 3.1.3. Confirmation

There are “satisfaction,” “relief,” “fears-confirmed,” and “disappointment” in a group of “Confirmation”. The condition for the emotions is “pleased/displeased about confirmed/unconfirmed desirable/undesirable event.”

We can already check that the event is desirable/undesirable using the EGC method. But, we have to give a method to check whether the event is confirmed one or not.

To recognize that an event is **confirmed**, the event has to be prospected in advance and it has to happen actually. To recognize that an event is **unconfirmed**, the event has to be prospected in advance and it has to be confirmed that the event will not happen any more. In order to check the conditions, we consider “whether the event is prospected or not” and “the event is confirmed/unconfirmed/unknown.” Prospected events have already been taken into account in the prospective event list as described in Section 3.1.2. Now, we propose a confirmation method for the prospected event as follows.

First, we inspect the event with the past aspect in order to confirm realization of the prospective events. When there is the same content event as the one that is shown before, we consider that “we had predicted the event and it happened.” The effect of the negative aspect is shown in Table 5. Next, we extract four emotions such as “satisfaction,” “relief,” “fears-confirmed,” and “disappointment” using the result of confirmation and EGC output based on the conditions for the emotions. Table 6 shows the

**Table 5. Negative aspect's effect for confirming event**

		Confirmed Event	
		Affirmative	Negative
Prospective Event	Affirmative	Happened	Not
	Negative	Not	Happened

**Table 6. Generated emotions for the result of confirmation and EGC output**

		Confirmation	
		Happened	Not Happened
EGC Result	Pleasure	Satisfaction	Disappointment
	0	0	
	Displeasure	Fears-confirmed	Relief

relationship between the result of confirmation, the EGC output and generated emotion.

There is another process to extract emotions about confirmation. If the adverb which suggests “predicted result” exists in the event, we consider the event was expected because we can guess the event had already been expected even through the user did not inform us about the prospect. On the other hand, we consider the event was not expected when there is an adverb which suggests an “unpredicted result” in the event.

Some adverbs suggest confirming that the prospective event is due to happen or not. The following adverbs mean that suggest confirmation in “Present-day adjective using dictionary [14].”

**Predicted Result:** *SASUGANI* (as may be expected), *TSUINI*, *YATTO*, *YOUYAKU* (at last, finally), *ANNOJOU*, *YAPPARI* (as one expected), *NANNAKU* (without difficulty), *NANTOKA* (somehow or other)

**Unpredicted Result:** *IKKOUNI* (no progress at all), *IGAINI*, *ANGAI* (unexpectedly), *KAETTE* (on the contrary), *KEKKOU* (quite, very well), *TSUI*, *TSUITSUI* (unintentionally, unconsciously), *DOUSITEMO* (at any cost), *NAKANAKA* (not easily)

```

begin
  if (the event is in the "predicate event list" and
    aspect = "past")
    then begin
      Calculate the emotion value against the event
      if (aspect = "affirmative" or
        an adverb that indicates "predict" is in the event)
        then begin
          if EV(user) = "pleasure"
            then "Satisfaction"
          elseif EV(user) = "displeasure"
            then "Fears-confirmed"
        end
      elseif (aspect = "negative" or
        an adverb that indicates "unpredict" is in the event)
        then begin
          if EV(user) = "pleasure"
            then "Disappointment"
          elseif EV(user) = "displeasure"
            then "Relief"
        end
    end
end
end

```

### 3.1.4. Well-being

The emotions in the "Well-being" group are aroused when the user feels pleasure or displeasure for the event. The "Emotion Eliciting Condition Theory" suggests that joy is elicited when he/she is pleased about an event. However, this condition can be confirmed by the other emotions such as **happy-for**, **gloating**, **hope**, **satisfaction**, and **relief**.

In these events, eliciting joy is judged by adopting the EGC output about the event. Furthermore, when the user elicits **happy-for**, **gloating**, **hope**, **satisfaction**, and **relief**, the user elicits joy, too, because the eliciting condition of these emotions also meets a demand of the condition of joy. The condition about distress is dealt with in the same way.

If an event elicits opposite emotions at the same time, the situation is called **conflict**. For example, an event such as "my son was jilted by a bimbo," the speaker is **sorry** for his son but feels **relief** at the same time. Any special processes are not supplied for the conflict, but just extract two opposite emotions.

```

begin
  Calculate the emotion value against the event
  if ((EV(user) = "pleasure") or
    "Happy-for," "Gloating," "Hope," "Satisfaction" or
    "Relief" are outputted
    then "Joy"
  elseif ((EV(user) = "displeasure") or
    "Resentment," "Sorry-for," "Fear," "Fears-confirmed"
    or "Disappointment" are outputted
    then "Distress"
end
  
```

### 3.1.5. Attribution

There are "**pride**," "**admiration**," "**shame**" and "**reproach**" in a group of "Attribution". The condition is "approving/disapproving of one's own/ another action." We propose the methods to judge whether the event is approving or not and who happened the event.

First, we propose a method to judge whether the event is approving or not. The event is approved/disapproved of by the one's own judgement. There are various criteria for the standard character based on many factors like the users' senses of values, experience, living environment, social environment, and so on. However, it is impossible to compare all the events with all the moral values whenever the agent recognizes the event, because there are countless different values in the world and we need a system of complex reasoning to confirm that the event is in keeping with the values for each case. Furthermore, there are not any rules which can deal with such complex reasoning.

Therefore, we deal with only one moral value "An event that gives me pleasure is a good thing," because it is the simplest and the most instinctive moral. "An event that gives me pleasure" is defined as "the event that the EGC result is pleasure."

Next, we propose a method to check who happened the event. The actor of the event is also needed for detecting attribution emotion in the "Emotion Eliciting Condition

Table 7. Generated emotions for the actor and EGC result

		Actor	
		One's own	Another
EGC Result	Pleasure	Pride	Admiration
	0	0	
	Displeasure	Shame	Reproach

Table 8. Emotion compound rules from "Well-being" emotions and "Attribution" emotions

		Emotion of Well-being	
		Joy	Distress
Emotion of Attribution	Admiration	Gratitude	Conflict
	Reproach	Conflict	Anger
	Pride	Gratification	Conflict
	Shame	Conflict	Remorse

Theory." We adopt this method only when we use the verb transitive, because the concept of the actor is expressed as the subject of such an event. The event types with the verb transitive are type VI to type XI.

Then we classify the emotions based on "the actor of the event is one's own or not" and "the event is pleasure for me" as shown in Table 7.

```

begin
  if the verb of the event is "verb-transitive"
  then begin
    Calculate the emotion value against the event
    if (EV(user) = "pleasure" and subject = myself)
      then "Pride"
    if (EV(user) = "pleasure" and subject = another)
      then "Admiration"
    if (EV(user) = "displeasure" and subject = myself)
      then "Shame"
    if (EV(user) = "displeasure" and subject = another)
      then "Reproach"
  end
end
  
```

### 3.1.6. Well-Being / Attribution

The emotions in the group of "Well-being/ Attribution" are elicited as compound emotions. There are four emotions, **gratitude**, **anger**, **gratification**, and **remorse** in "Well-being/Attribution" group. As shown in Table 8, these emotions are compounded from "Well-being" emotions and "Attribution" emotions based on the "Emotion Eliciting Condition Theory." Some conflicts are elicited in this table, however, Any special processes are not supplied for the conflict.

```

begin
  if "Joy" and "Administration" then "Gratitude"
  elseif "Joy" and "Pride" then "Gratification"
  elseif "Distress" and "Reproach" then "Anger"
  elseif "Distress" and "Shame" then "Remorse"
end
  
```

## 3.2. Dependency among Emotion Groups

We consider the dependency among emotion groups, as shown in Figure 3, based on the eliciting condition of each emotion.

At first, we calculate pleasure/displeasure of the user concerning the event using the EGC method from the user's viewpoint. When the event is prospective, the emotion in the "Prospect-based" group is extracted. When the prospective event is confirmed or unconfirmed, the emotion in "Confirmation" group is extracted. Furthermore, the EGC is applied to the event from the other's viewpoint, too, and when the other feels pleasure or displeasure, the emotion in the "Fortunes-of-others" group is extracted. The emotions in the "Prospect-based," "Confirmation," and "Fortunes-of-others" groups are aroused when the user is pleased about the event. Therefore, the emotion in the "Well-being" group is extracted when these emotions are extracted or the user feels pleasure or displeasure about the event. On the other hand, the output of EGC also shows the moral value. When a moral is approved/disapproved of by the event, we can extract the emotion in the "Attribution" group.

At last, the emotion in the "Well-being/Attribution" group is compounded from "Well-being" emotions and "Attribution" emotions as shown in Table 8.

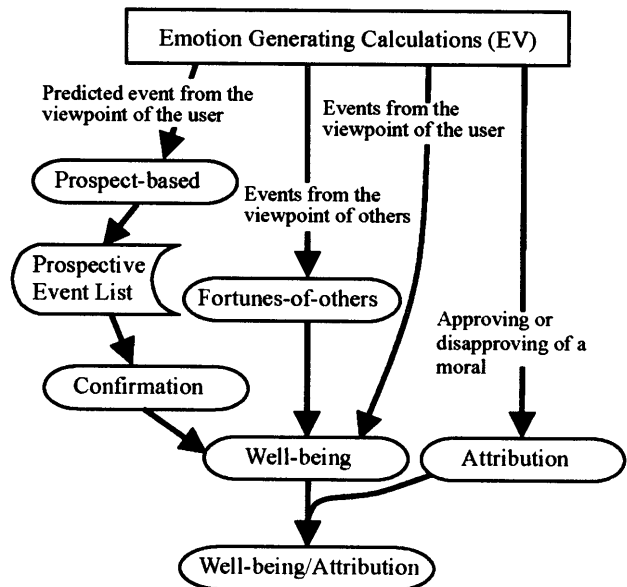


Figure 3. Dependency among emotion groups

### 3.3. Examples of our proposed method

Example 1: "Romeo dates with Juliet."

Emotion Generative Calculations method:

Predicate (P)	= "date with"	: +0.6
Subject (S)	= "Romeo"	: +1.0
Object-Mutual (OM)	= "Juliet"	: +0.9
Event Type: "date with"	→ V(S, OM)	
Emotion Space = $(f_S, f_{OM}, f_P)$		= (+1.0, +0.9, +0.6)
		= Area I (Pleasure)

Complicated Emotion Allocating Method:

(1) Fortunes-of-others (Section 3.3.1)

(a) Fortunes-of-"Juliet"

Predicate (P)	= "date with"	: +0.7
Subject (S)	= "Romeo"	: +0.9
Object-Mutual (OM)	= "Juliet (myself)"	: +1.0
Emotion Space = $(f_S, f_{OM}, f_P)$		= (+0.9, +1.0, +0.7)
		= Area I (pleasure)

EV from "Juliet's" viewpoint = **Pleasure**  
 & Romeo likes the "Juliet"  
 (FV of "Juliet" from Romeo's viewpoint: +0.9)  
 (Table 4)  
 ↓  
**Happy for "Juliet"**

(b) Fortunes-of-"Lord Montague (Romeo's father)"

Predicate (P)	= "date with"	: +0.3
Subject (S)	= "Romeo"	: +0.8
Object-Mutual (OM)	= "Juliet"	: -0.5
Emotion Space = $(f_S, f_{OM}, f_P)$		= (+0.8, -0.5, +0.3)
		= Area IV (displeasure)

EV from "Lord Montague" viewpoint = **Displeasure**  
 & Romeo likes "Lord Montague"  
 (FV of "Lord Montague" from Romeo: +0.5)  
 (Table 4)  
 ↓  
**Sorry for "Lord Montague"**

(2) Well-being (Section 3.3.4)

(a) "Happy for Juliet" is generated	↓
<b>Joy about the event</b>	
(b) "Sorry for Lord Montague" is generated	↓
<b>Distress about the event</b>	

Generated emotions from "Romeo dates with Juliet" are "happy-for Juliet," "sorry-for Lord Montague," "joy" and "distress."

Example 2: "The mother scolded her noisy child."

Emotion Generative Calculations method

Predicate (P)	= "scold"	: -0.3
Subject (S)	= "a mother"	: 0.0
Object (O)	= "her noisy child"	: -0.5
Event Type: "scold"	→ V(S, O)	
Emotion Space = $(f_O, \beta, f_P)$		= (-0.5, +0.5, -0.3)
		= Area VI (Pleasure)

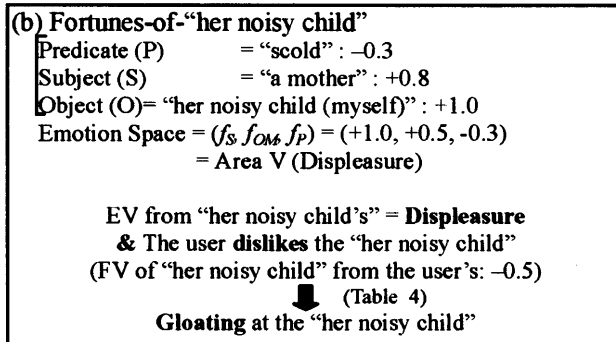
Complicated Emotion Allocating Method:

(1) Fortunes-of-others (Section 3.3.1)

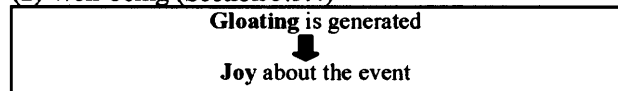
(a) Fortunes-of-"a mother"

Predicate (P)	= "scold"	: -0.4
Subject (S)	= "a mother (myself)"	: +1.0
Object (O)	= "her noisy child"	: +0.8
Emotion Space = $(f_O, \beta, f_P)$		= (+0.8, +0.5, -0.3)
		= Area V (Displeasure)

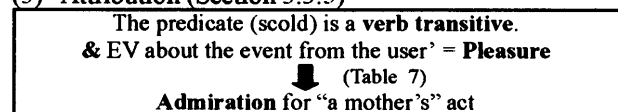
EV of the event from "a mother" = **Displeasure**  
 & The user does not have any impression for "a mother"  
 (FV of "a mother" from the user's viewpoint: 0.0)  
 (Table 4)  
 ↓  
**No emotion**



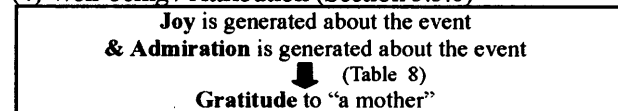
## (2) Well-being (Section 3.3.4)



## (3) Attribution (Section 3.3.5)



## (4) Well-being / Attribution (Section 3.3.6)



Generated emotions from “The mother scolded her noisy child” are “gloating at the child,” “joy,” “admiration for the mother” and “gratitude to her.”

## 4. Experimental Results

In this section, the adequacy of the generated emotion by our proposed method is reviewed through the analysis of compared the generated emotions of the system, with the result of the questionnaire. At first, we adopted our method to dialogue corpus and we extracted 30 sentences from the corpus. Then, we asked 15 university students which emotion was aroused by the content of the 30 sentences.

### 4.1. Experimentation 1

In this experimentation, we evaluated how the system generates emotions, similar to that aroused in the subjects. At first, we showed 30 sentences to 15 subjects, and they selected adequate emotions from the 20 emotions that our system can generate. Table 9 shows the comparative results between the system output and the subjects’ answers. The system extracted all the emotions that all subjects selected, and it extracted 75% of emotions that most of the subjects (80%) selected.

We consider two reasons that the system cannot extract common emotions. At first, there are rarely inadequate FVs of predicates. We define the FVs of predicate, based on whether the predicate means approach or avoidance. However, when the system analyzes an event “I don’t know the reason of my disease,” the subject is “I,” the object is “the reason of my disease,” the predicate is “not know,” and the event type is V (S, O). We give the predicate “know” the

Table 9. Reappearance Rate

Agreement rate (%)	100	90	80	70	60
Selected number	2	4	20	29	47
Reappearance number	2	3	15	20	31
Reappearance rate (%)	100.0	75.0	75.0	69.0	66.0

Table 10. Adequacy Rate

Adequacy Rate (over *)	0.8	0.6	0.5
Agreed emotions (%)	47.0	75.8	86.4

positive image because “know” means “gain some knowledge,” then the system generated “pleasure” about the event. However, the subjects aroused negative emotions like “fear (86.7%),” “distress (73.3%),” and so on. There is no doubt about “the reason of my disease is not preferable,” but we guess further disadvantages like “the disease won’t be cured” if the reason is unclear. We should define the FV of predicates considering such situations, too. We have to add the reasoning system to solve this problem completely.

### 4.2. Experimentation 2

In this experimentation, how the system generates adequate emotions is reviewed. We showed the generated emotions by the system to 15 subjects and they answered the adequacy of the emotions by the five grade evaluations such as “TOTEMO-DATOU (exactly),” “YAYA-DATOU (adequate),” “DOCHIRADEMONAI (so-so),” “YAYA-FUTEKISETSU (inadequate),” and “TOTEMO-FUTEKISETSU (wrong).” Then, we assigned the numbers 1.0, 0.75, 0.5, 0.25 and 0.0 to their answer patterns. We considered the adequacy rate as the average of the answer values.

$$\text{Adequacy Rate} = \frac{\sum (\text{subject's answer value})}{\text{The number of subjects}}$$

Table 10 shows the result. Half (47.0%) of the generated emotions by the system were evaluated that they were exactly correct because their adequacy rates were over 0.8. Furthermore, most (86.4%) of the generated emotions were evaluated that were relatively correct because their adequacy rates were over 0.5.

We consider two reasons that the system cannot extract common emotions.

The first problem is about the dependency of emotions. In our method, the system always generates “joy” when the EGC outputs “pleasure.” However, there are some exceptions in this experimentation.

For example, our method generates “gratitude,” “joy,” and so on about the event “My family manages my money instead of me.” The subjects agreed “gratitude (68.3%),” but they did not agree “joy (33.3%)” that was derived from “gratitude.” We are re-investigating the conditions of “well-being” by analyzing such paradoxical responses.

The next problem is the relationship among competing emotions. For the event “my friend was hurt,” the system generated not only “sorry-for” but also “reproach” and “anger.” The latter emotions are



caused by the displeasure about the situation "my friend's act upset me." Most of the subjects agreed "sorry-for (98.3%)," however, a few subjects agreed "reproach (26.7%)" and "anger (23.3%)." We have to consider the relationship "some people do not arouse aggressive emotions against a person that they are feeling sorry for," causes such situations. We investigate these relationships among competing emotions.

### 5. Conclusion

In this paper, we presented a method to classify generated simple emotion (pleasure/displeasure) by EGC method into 20 various emotions based on "Emotion Eliciting Condition Theory." The theory requires judging such conditions as follows; "feeling for another," "prospect and confirmation," approval/disapproval." We defined the rules to check the condition of "feeling for another" based on the EGC's result using another's FVs. And we judge "prospect and confirmation" by extracting some aspects and adverbs. "Approval/disapproval" is judged by the event's case frame structure with the transitive verb.

To verify the effectiveness of the proposed method, we compared generated emotions with human aroused emotions. As a result, 75% of the emotions that most (80%) of the subjects aroused reappeared by this method, and half (47.0%) of the generated emotions by the system were evaluated that they were exactly correct because their adequacy rates were over 0.8.

There are much more factors not only as we adopted, to connect events with emotions. We are investigating emotion-generating rules by clustering the relationship between emotions and events using tree structure. We have to compare the result with our proposed method and unite them.

Next, in this study, we do not supply any special processes for conflict, for example, "distress" and "admiration" are aroused for an event at the same time. Because there are various reactions against the conflict. We are going to investigate these reactions and its conditions based on psychology, and realize these processes.

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### References

- [1] Hasegawa,O.,Morishima,S.,Kancko,M.: Processing of Facial Information by Computer, IEICE Trans., Vol.J80-D-II,No.8,pp.2047-2065,1997. (in Japanese)
- [2] Ekman,P.,Friesen,W.V.: The repertoire of nonverbal behavior, Semiotica, Vol.1,pp.49-98,1969.
- [3] Mehrabian,A.: Nonverbal Communication, Aldine Atherton, 1972.
- [4] Harashima,H.: Intelligent image coding and intelligent communications, J.ITE, Vol.42,No.6, pp.519-525,1988. (in Japanese)
- [5] Harashima,H.,Aizawa,K.,Saito,T.: Model-based

analysis synthesis coding of videotelephone images-conception and basic study of intelligent image coding, IEICE Trans., Vol.E72,No.5, pp.452-459,1989.

- [6] Mera,K.,Ichimura,T.,Aizawa,T.,Yamashita,T.: Invoking Emotions in a Dialog System based on Word- Impressions, Journal of JSAI, Vol.17,No.3, pp.186-195,2002. (in Japanese)
- [7] Ichimura,T.,Mera,K.,Yamashita,T.: Construction of a Dialog System with Emotions for Elderly Persons by Neural Networks, Proc. of IEEE International Conference on IEEE SMC (SMC2000), pp.3594-3599,2000. (in Japanese)
- [8] Wundt,W.: Outlines of Psychology, Leipzig: Wilhelm Engelmann, 1897.
- [9] Schlosberg,H.: Three dimention of emotion, The Psychological Review, Vol.61,No.2,pp.81-88,1954.
- [10] Plutchik, R.: The emotions, New York: Random House, 1962.
- [11] Elliott,C.: The Affective Reasoner: A process model of emotions in a multi-agent system, Ph.D thesis, Northwestern University, The Institute for the Learning Sciences, Technical Report No.32,1992.
- [12] Elliott,C.: Components of two-way emotion communication between humans and computers using a broad, rudimentary, model of affect and personality, Bulletin of the Japanese Cognitive Science Society,1994. (in Japanese)
- [13] Nasukawa,T. et al.: Easy to Use Practical Freeware for Natural Language Processing, IPSJ magazine, Vol.41,No.11,pp.1201-1238,2000. (in Japanese)
- [14] Hida,Y., Asada,H.: Present-day adjective using dictionary, Tokyo Dou Publishers,1991. (in Japanese)



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