Mathematical Kansei Analysis
Applying Fuzzy Reasoning

Michiko Yanai* Hiroaki Uesu*
Kimiaki Shinkai* Jiro Inaida**

*Waseda University, 15-1-704, Kujiraishinden, Kawagoe-shi, Saitama, 350-0809
JAPAN, yanai@wasedajg.ed.jp

**Nihon University, 1-10-8, Heiwadai, Nagareyama-shi, Chiba, 270-0157
JAPAN, ci4lang2@m5.dion.ne.jp

Abstract: It is interesting to investigate the educational subject with the color image and the semantic differential method (SD method). In this paper, we would like to analyze the Mathematical Kansei by applying the fuzzy reasoning regarding the color image and the SD method. As a first step, an opinion poll about the color image of a subject was conducted with a sixteen-color chart used for "a color test representative of character". We collected the results of the opinion poll among about twenty six hundred students ranging from junior high school to university. According to this poll, it is found that more than sixty percentages of students have chosen cold colors (blue, blue-green and blue-purple) on mathematics. As a next step, we conducted questionnaires with three standards based on the semantic differential method to the same students. In other words, we carried out questionnaires that adopted "beautiful-ugly" as an evaluation base, "cold-hot" as an activity base and "hard-soft" as an ability base. The result is that "beautiful-cold-hard" represents the sense image on mathematics. Then as a final step, we applied the fuzzy reasoning and carried out the analysis regarding the color image and the SD method. As a result, we could obtain an effective data about Mathematical Kansei from this analysis. It is very useful for educators to use this data when they offer the students their lecture on mathematics because they recognise what students feel and think about it.

Key words: *Mathematical Kansei, Semantic Differential Method (SD Method), Fuzzy Reasoning, Color Image*

1. Introduction

It is interesting to analyze the image on subject with the colors and the semantic differential method. In this paper, first, we would like to investigate the color image and the semantic profile on mathematics. And then, we try to analyze the Mathematical Kansei by applying the fuzzy reasoning regarding the color image and the semantic profile.

2. Method

2.1 Color Image

As a first step, an opinion poll about the color image of mathematics was conducted with a sixteen-color chart used for "a color test representative of character". We collected the results of that opinion poll among about twenty six hundred students ranging from junior high school to university. Accroding to this poll, it is found that more than sixty percentages of students have chosen cold colors (blue, blue-green and blue-purple) on mathematics.

In general, cold colors are said to represent calm and composed emotions. That is to say, we can judge that these results come from peculiarity of mathematics. Therefore, we call cold colors as basic colors on mathematics.

2.2 Semantic Profile

As a next step, we conducted questionnaires with three standards based on the semantic differential

method to the same students. In other words, we carried out questionnaires that adopted "beautiful-ugly" as an evaluation base, "cold-hot" as an activity base and "hard-soft" as an ability base as shown in Fig.1. From the questionnaires, we have obtained the response matrix K in Fig.2. The result is that "beautiful-cold-hard" is a semantic profile on mathematics. Then, integrated value e_{i1} of the evaluation, e_{i2} of the activity and e_{i3} of the ability are obtained by the fuzzy reasoning in Fig.3 ($1 \le i \le n$). In Fig.3, P shows a membership function regarding a positive response, and N shows a membership function regarding a negative response.

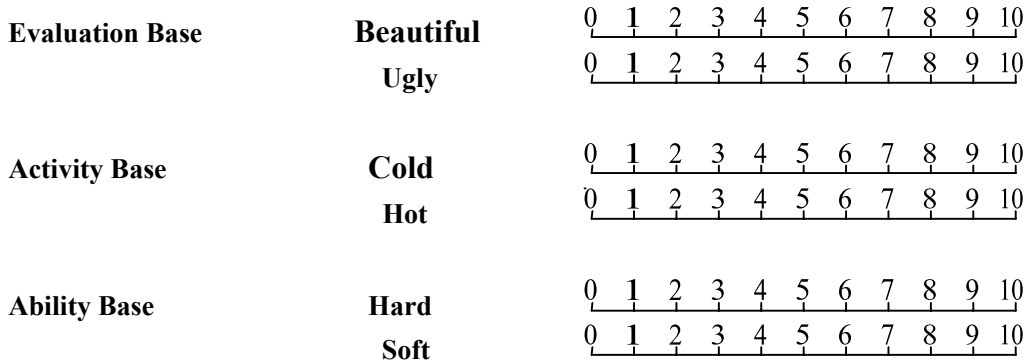

Fig.1 Questionnaires

	Evaluation		Activity		Ability	
	Beautiful	Ugly	Cold	Hot	Hard	Soft
S_1	r_{11}	r_{12}	r_{13}	r_{14}	r_{15}	r_{16}
S_2	r_{21}	r_{22}	r_{23}	r_{24}	r_{25}	r_{26}
:	:	:	:	:	:	:
:	:	:	:	:	:	:
S_n	r_{n1}	r_{n2}	r_{n3}	r_{n4}	r_{n5}	r_{n6}

Fig.2 Response Matrix K

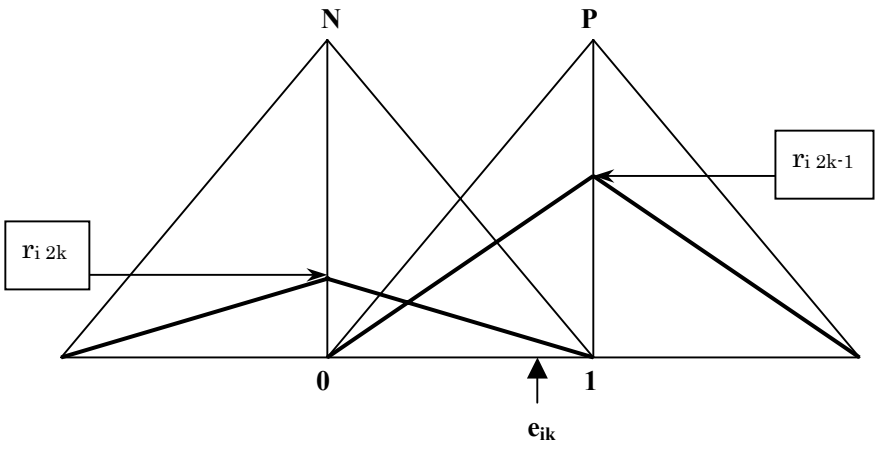

Fig.3 Fuzzy Reasoning ($1 \le k \le 3, 1 \le i \le n$)

2.3 Fuzzy Reasoning

As a final step, we would like to analyze the Mathematical Kansei by applying the fuzzy reasoning. The Mathematical Kansei ϕ is reasoned from the CI (color image)-value F_1 and the SD-value F_2 in Fig.4.

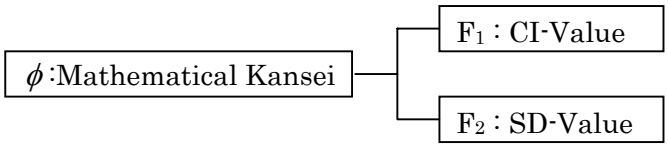

Fig.4 Reasoning Structure

The color image value is offered as the percentage of students who chose cold colors in the same class. The SD-value is given by an average of the mean value $\bar{e}_1$, $\bar{e}_2$ and $\bar{e}_3$. We present two standards of P (the reaction is usual) and N (the reaction is unusual) regarding F_1 and F_2. Next, for the evaluation of the Mathematical Kansei ϕ, we present three standards of A (good), B (medium) and C (poor). With these evaluation standards, ordinary triangular membership functions are used for fuzzy reasoning as shown in Fig.5, Fig.6 and Fig.7.

Finally, we worked on the fuzzy reasoning using gravity-sum-product method. The fuzzy reasoning-rule and its matrix are as follows:

Rule:
1. P, P → A
2. P, N → B
3. N, P → B
4. N, N → C

F_1 \ F_2	P	N
P	A	B
N	B	C

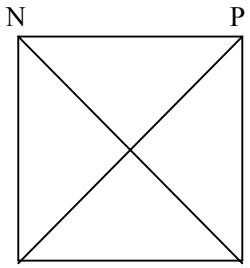

Fig.5 Membership Function F_1

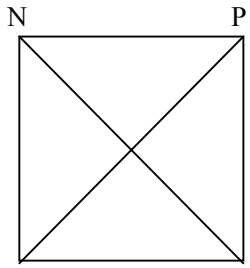

Fig.6 Membership Function F_2

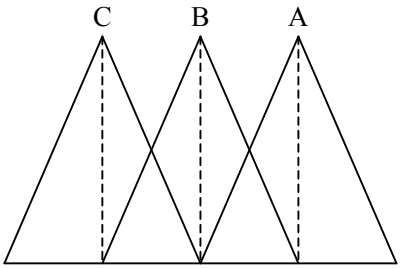

Fig.7 Membership Function ϕ

3. Practical Application

In this part, we would like to present a case study of the Mathematical Kansei analysis that has been experimented at university .We have executed the color image test and the questionnaires in Fig.1. From the color image test, the color image value F_1 is 0.67 in this case. From the questionnaires in Fig.1, we have obtained the matrix K as shown in Fig.8. From the matrix K, we have obtained the evaluation matrix R. From the matrix R, the mean values $\bar{e}_1$, $\bar{e}_2$, $\bar{e}_3$ of the class are 0.74, 0.77, 0.65. From the data, we could obtain SD-value F_2 as 0.72. Since F_1=0.67 and F_2=0.72, we carried out the fuzzy reasoning as shown in Fig.9, and gained $\phi = \phi(F_1,F_2) = 0.70$. The result is that students who answered the questionnaires above in this class seem to be fairly good.

	Evaluation		Activity		Ability	
	Beautiful	Ugly	Cold	Hot	Hard	Soft
S_1	4	6	3	7	4	6
S_2	6	4	7	3	7	3
S_3	5	5	7	3	6	4
S_4	7	3	8	2	7	3
S_5	8	0	6	10	2	7
S_6	8	4	9	3	8	3
:	:	:	:	:	:	:
:	:	:	:	:	:	:
S_{33}	10	0	6	4	7	3

Fig.8 Response Matrix K

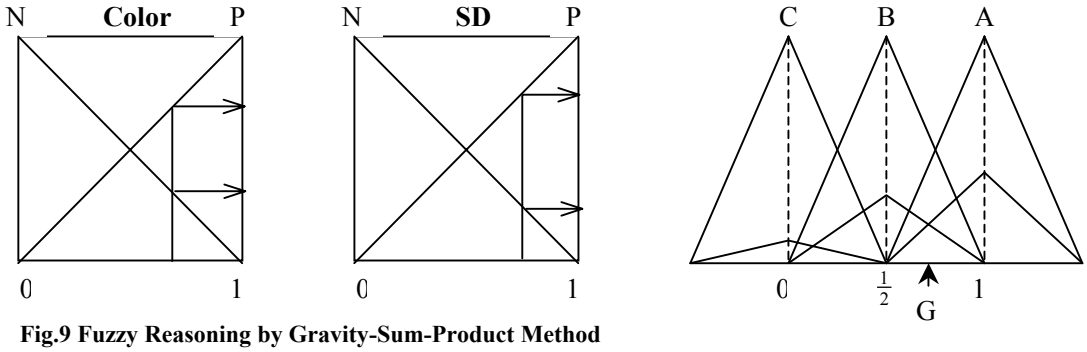

Fig.9 Fuzzy Reasoning by Gravity-Sum-Product Method

4. Conclusion

In this paper, we proposed a method which analyses the Mathematical Kansei by applying the fuzzy reasoning. It is very useful for us to recognize the Mathematical Kansei without questions of likes and dislikes about mathematics. Although the case study we explained has been experimented about mathematics, our analytical method could be available to any other subjects.

References

1. T.Matsuoka : Color and Personality(Japanese), Kanekoshobo(1995).
2. H.Yamashita, J.Inaida : Fuzzy Theory and its Application(Japanese), Gakubunsha(1997).
3. M.Yanai, H.Uesu, E.Tsuda : Color Imaging Analysis Applying Fuzzy Theory and its Application I-IV(Japanese), Conference of Japan Society of KANSEI Engineering(1999-2002).
4. J.Inaida, H.Yamashita : Mathematical Method of Fuzzy Reasoning, Memoirs of the Research Institute for Mathematical Sciences Kyoto University 1129(2000).
5. M.Yanai, H.Suda, A.Yanai : Color Image Analysis of Mathematics by SD Method, Int'l Congress of Mathematical Education IX(2000).
6. T.Tanahashi, M.Yanai, J.Inaida : Color Imaging Analysis Applying Fuzzy Theory(Japanese), Journal of Japan Society of Kansei Engineering,(2000).