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Computer Simulation for Free Association of Single Stimulating Word by Using Normal Random Number (First Approximation)

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Abstract

About the study on association of group, we need to acquire the knowledge of the theoretical quantity of association. In this paper, authors have represented on the computer simulation for the free association of single stimulating word (SSW) by using normal random number. As results, we obtained the good results of simulation for the association of SSW.

In this simulation, authors have been employing three distributions, which have the different standard deviation, of normal random number. Moreover, we discuss on the effect of standard deviation of three, so SD_1, SD_2 and SD_3, for each distribution, in detail.

Key Words: Association, Association Entropy, Computer Simulation, Normal Random Number

1. INTRODUCTION

We can obtain the data of recalled words from a stimulating word in the reaction of association. What do these data show for us? For example, authors had been obtaining the recalled words such as "Atomic Bomb", "Peace", "Exotic", "Chanpon (the famous foods of Nagasaki)", "Slope", "Rain" and etc. from the stimulating word "Nagasaki" [1].

As shown in the recalled words, these recalled words indicate the knowledge, concept and image of answerer. Namely, in the reaction of association almost of all recalled words correspond to the schema of human being as a group [2].

In cognitive psychology, learning is defined to be the change of schema through experience [3]. So, the change of schema can be obtained by measuring the change of recalled words for the stimulating word. In case of learning by a group like as a class, it is indicated that the change of schema as results of

learning can be measured by association method [2].

When we consider on the reaction of association for human being as a group, it is very important to know the total number of recalled word, kinds of recalled word and the degree of scattering of recalled word.

K. Itoyama et al. had presented paper about the association of group and proposed new quantities, which are the association entropy (H), the association distance (D) and the quantity of association (ΣA) as the quantities that express the properties of group [4]. Moreover, K. Itoyama et al. had presented a paper about class assessment by using two association methods [2]. About the class assessment, the degree of scattering of recalled words, which is association entropy, after class decreases in almost of all class which is "teach in" type [2]. As mentioned, we can assess the type of class by association entropy.

Up to now, the standard table of association had been made and "association value" and "meaningfulness" has been calculating on the study of association. And the property of a particular reaction of association was discussed by the difference of the appearance frequency of each recalled word in the standard table and the value of "association value" [5].

However, the appearance frequency of each recalled word and the degree of scattering for recalled words change with changing quality of answerer group. So there are many cases that the standard table can not be applied as the standard.

Up to present, we had proposed the "Association Method" as the measuring method for the change of concept acquisition in learning, in other word as the method of class assessment, and we had presented the usefulness of this method [6], [7].

In the case that authors discuss on the reaction of association for group, we have been paying attention the changes of kinds of recalling word and association entropy, although it is a matter of course that the quality of recalling words changes. And, K. Itoyama et al. have clarified that "association value" and "meaningfulness" are included in association entropy [4].

If we will forces to kinds of recalled word and association entropy, we will be able to simulate the reaction of association. And we consider that such simulation has a great significance from view point that these values can be estimated.

In case that we treat on association of mass group theoretically, we need to treat on the simulation of association with acquiring the relation of new quantities of association as a function of number of answerer and the recalling time.

In this work, authors have presented the computer simulation for the free association of SSW by using normal random number. We have been employing different three distributions; the standard deviation is SD_1, SD_2 and SD_3, for normal random number in this simulation. And authors discuss on the reasonableness of this simulation with comparing the real n this paper.

2. SIMULATION FOR FREE ASSOCIATION

2-1. Idea for Simulation by Normal Random Number

When we discuss on a distinctive feature of an appearance of response words on the free association of single stimulating word (Free Association of SSW), we can summarize three points as follows;

(1) An appearance of response words is an irregular.

(2) The response words appear at random, but do not appear uniformly for every stimulating word.

(3) The response words that few persons can recall are many as against the response words that many answerers can recall is few.

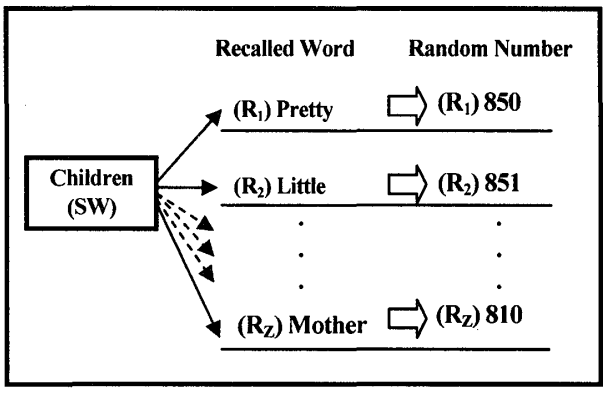

Fig.1 Conceptual Shape of computer simulation by normal random number

We considered that fee association of SSW can be curried out the computer simulation by replacing recalled words with random numbers from above mentioned. For example, we assume that we obtain recalled words, which are "Pretty", "Little" ··· "Mother" etc., from stimulating word "Children" as shown in Fig.1. In this work, we replace the recalled word with a random number like that "Pretty" is "850", "Little" is "851", "Mother" is "810" of random number and so on.

2-2. Condition of Simulation by Normal Random Number

We set up the condition of simulation as follows;

(1) Assuming that all answerers recall n words for one stimulating word. In this work, n was fixed 5 and 7. The number of answerer is 100.

(2) The random number is calculated from three distributions of which the standard deviation (SD) is different as shown in Fig.2.

(3) As the numerical value appears in the range of 3σ, the mean value (μ) is fixed that (μ-3σ) is larger than zero. As SD_3 is the largest value as shown in Fig.2 in this paper, SD_3 is fixed such that (μ-$3SD_3$) is larger than zero.

(4) In case that there is the same value in numerical values for five or seven recalled words, all of data in this group do not employ in this work.

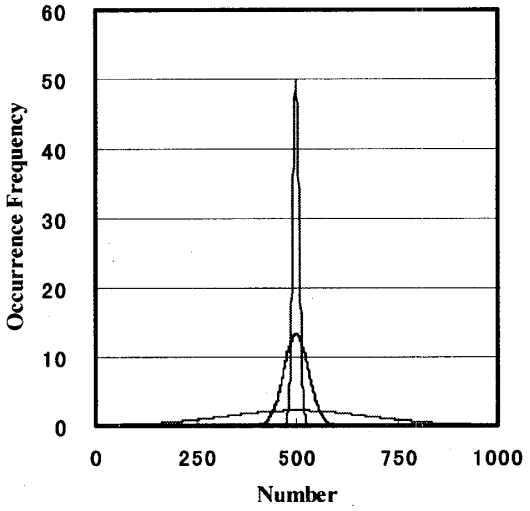

Fig.2 Three distribution for normal random number;
(Mean value: 500, SD_1: 8, SD_2: 30, SD_3: 180)

Each numerical value obtained based on the condition mentioned above is regarded to each recalled word and is treated by Program of Association Processing developed by T. Fujiki [8]. Table 1 shows the example of input for Program of Association Processing.

Table 1 the example of input for Program of Association Processing.

Normal Random Number	Integer	R_i	No.1	No.2	No.3
851.9169477	851	849	1		
852.0660252	852	848	1		
850.1944318	850	857	1		
1053.796731	1053	950	1		
790.4894879	790	1018	1		
850.6159178	850	851		1	
851.4312604	851	852		1	
848.0946041	848	850		1	
666.6930482	666	1053		1	
1178.704459	1178	790		1	
		850			1
		851			1
		848			1

Table 1 is the example of n=5 (5 recalled words for each answerer). The normal random number is calculated the following equation.

$$RN=NORMINV(RAND(), \mu, SD) \quad (1)$$

Where RN is a random number, μ is a mean value and SD is standard deviation.

In this simulation, we are employing the integer part of this random number as the response word and are placing one hundred data in order to the column of

R_i. We are obtaining the kinds of response word (Z) and Association Entropy (H) by Program of Association Processing.

2-3. Distribution of Number of Recalled Word

For discussing the distribution of the number of recalled word, we will rewrite the schematic diagram for free association of SSW. Now assuming that there are Z kinds of recalled word, each recalled word is shown by the order of less of recalled word as shown in Fig.3. In case that we will treat the association entropy, we ought to study the distribution of m_i.

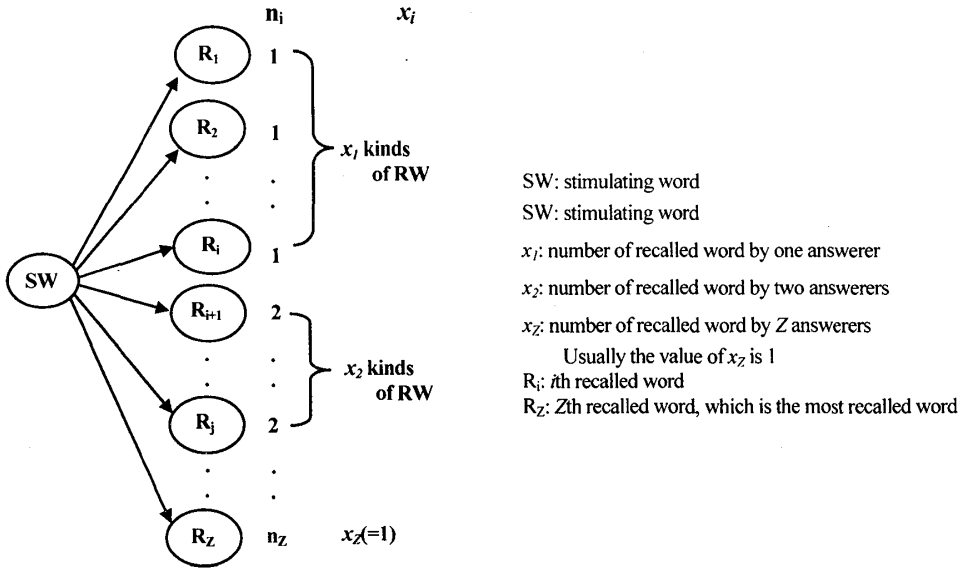

Fig.3 schematic diagram of the free association for SSW and association entropy

$$N=n_1+n_2+\ldots+n_Z$$
$$=\underbrace{1+1+\ldots+1}_{x_1}+\underbrace{2+2+\ldots2}_{x_2}+\ldots+\underbrace{nz}_{x_Z=1}$$
$$=(x_1\times 1)+(x_2\times 2)+\ldots+(x_Z\times n_Z) \qquad (2)$$

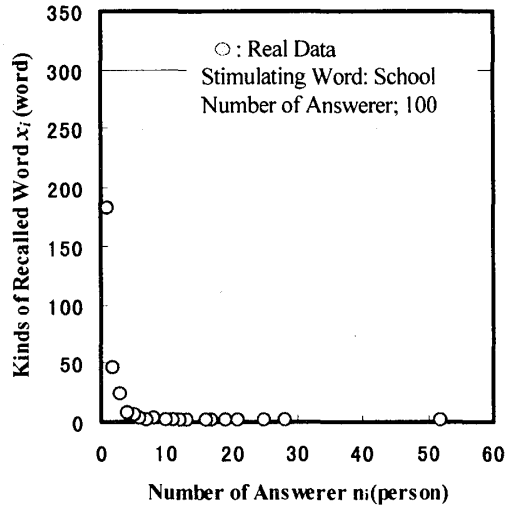

Fig.4 The relation between m_i and n_i

In equation (2), 1, 2 and n_Z are the number of answerer for each x_i and x_1, x_2 and x_Z are the kinds of recalled word for the value of each n_i as shown in Fig.3. And N is the number of total recalled word. It is very important to evaluate results of the computer simulation that we obtain the relation between m_i and n_i. Fig.4 shows the relation between x_i and n_i in case that the stimulating word is "School". The relation between x_i and n_i is given in equation (3).

$$x_i = k \times \exp(-1 \times n_i) \tag{3}$$

3. RESULTS AND DISCUSSION

3-1. Simulation for Real Data

Fig.5 shows the result of simulation for "School". The condition is employed such that mean value is 850, and SD_1, SD_2, SD_3 are 1.5, 20, 285, respectively. The value of k in equation (3) was calculated by using method of least squares. Comparing with Fig.4 and Fig.5, simulation data are in good agreement with real data. On the relation between real and simulation data, the values of association entropy and kinds of recalled word are almost same. As results, the simulation for association of SSW can be obtained by using normal random number.

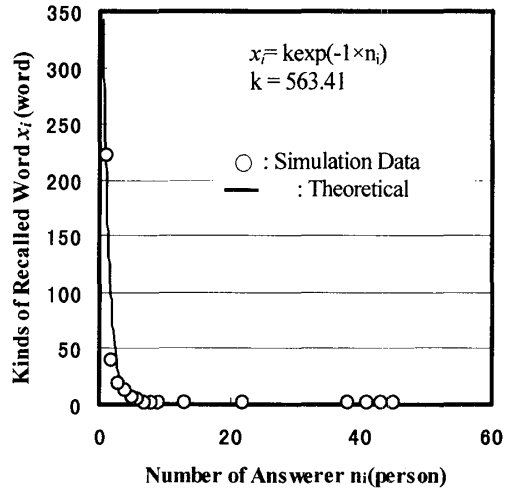

Fig.5 The result of Simulation for "School"
(mean; 850 SD_1; 1.5, SD_2; 20, SD_3; 285)

3-2. Effect of Standard Deviation

Table 2, Table 3 and Table 4 show values of number of answerers for most recalled word, association entropy (H) and kinds of recalled word (Z) with changing SD_1, and SD_2 and SD_3, respectively.

As results from these Tables, we can summarize as follows;

(1) Number of answerers for most recalled word is much affected by the change of SD_1.
(2) Association entropy (H) is much affected by the changes of SD_1 and SD_2.
(3) Kinds of recalled word (Z) are affected by the changes of SD_2 and SD_3. But, the effect of SD_3 is larger than it of SD_2.

Table 2 Effect of the Change of SD_1

Mean Value; 850, SD_2; 25, SD_3; 250					
SD_1	1	1.5	3	5	10
n_Z	62	53	31	30	16
H (bit)	7.144	7.216	7.418	7.387	7.629
Z (word)	311	308	311	310	313

n_Z : Number of answerers for most recalled word.
H : Association entropy.
Z : Kinds of recalled word

Table 3 Effect of the Change of SD_2

Mean Value; 850, SD_1; 1.5, SD_3; 250				
SD_2	3	15	25	5
n_Z	74	57	53	30
H (bit)	6.326	7.047	7.224	7.387
Z (word)	275	298	309	310

n_Z : Number of answerers for most recalled word.
H : Association entropy.
Z : Kinds of recalled word

Table 4 Effect of the Change of SD_3

Mean Value; 850, SD_1; 1.5, SD_2; 25					
SD_3	150	175	200	225	250
n_Z	47	48	49	49	53
H (bit)	7.076	7.144	7.149	7.173	7.216
Z (word)	269	290	292	297	308

n_Z : Number of answerers for most recalled word.
H : Association entropy.
Z : Kinds of recalled word

It is necessary to suppose three distributions which have the different standard deviation (SD) to carry out the better reasonable simulation. About the value of SD_3, authors are employing fallowing equation from mentioned above (3).

$$SD_3 = A \times (\text{Kind of Response Word } (Z))/6 \tag{4}$$

(The value of A is 3 to 5.)

The computer simulation should be done with an adjustment of values of SD_1, SD_2 and SD_3 from above mentioned viewpoint.

3-3. Results of Simulation

For the simulation of the stimulating word "School", we had curried out the simulation under the condition that SD_1 is 1.5, SD_2 is 25 and SD_3 is 238. The number of recalled word is 7 words for each answerer, and two recalled words corresponded by SD_1, two recalled words corresponded by SD_2 and three recalled words by SD_3, respectively.

Fig.6 and Fig.7 show the results which compare the real data with result of computer simulation. Fig.6 shows the relation between kinds of recalled word (Z) and the number of answerer (M). Fig.7 shows the relation between kinds of recalled word (Z) and association entropy (H).

From Fig.6 and Fig.7, the difference of simulation and real data slightly increases with increasing the number of answerer about kinds of recalled word (Z). This means that we need to discuss on SD_2 and SD_3. About association entropy, simulation data are almost same as real data.

4. DISCUSSION ON SIMULATION

Authors have been studying on association for group like as class and have been employing association for class assessment. In this assessment, we had curried out association before and after class by using stimulating word which is regarded the key word in class. From these association tests, we had obtained some conclusions about class assessment with high reappearance. We summarize results as shown in Table 5.

Table 5 the relation between the properties of class and the quantities of association

	Step by step "teach in" type	Discovery learning by group
The most recalled word	increase and sometimes shift	increase and sometimes shift
Total of recalled words (N)	increase	increase
Kinds of recalled word (Z)	decrease	increase
Association entropy (H)	decrease	almost same or slightly increase

From Table 5, in the class of "teach in" type, the number of recalled words per one answerer increase. So, the value of SD_2 and SD_3 become smaller. And the value of SD_1 also becomes smaller, because kinds of recalled word decrease and the most recalled word increases. If the values of SD_1, SD_2 and SD_3 become smaller, so association entropy becomes essentially lower.

In case of the discovery learning by group, total of recalled word increases. And kinds of recalled word increases after class as shown in Table 5. Further, association entropy is almost same or slightly increases after class. So, the value of SD_1 becomes smaller, but the values of SD_2 and SD_3 become larger. By the increase of values of SD_2 and SD_3, the association entropy becomes higher.

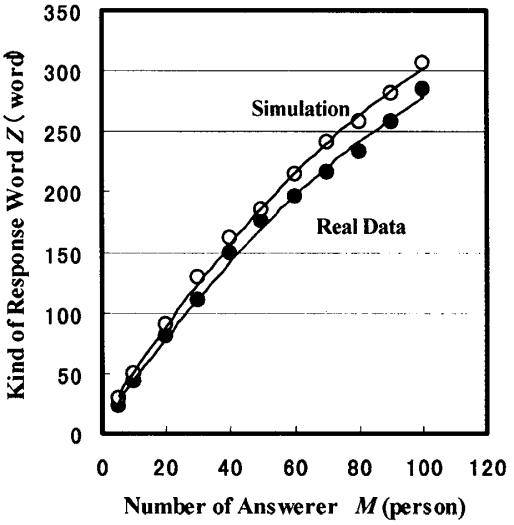

Fig.6 The relation between kinds of recalled word (Z) and the number of answerer (M);

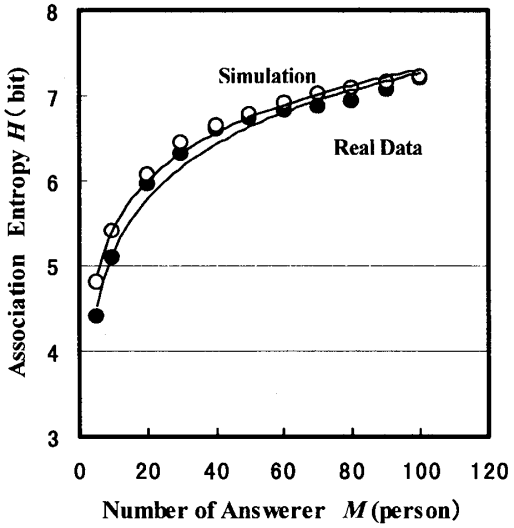

Fig.7 The relation between association entropy (H) and the number of answerer (M);

This simulation is the first approximation for free association of SSW and there are many points which must be improved.

However, we will be able to estimate the class, if we can know the property of class based on relation between quantities of association, which are kinds of recalled word, number of recalled word and association entropy, and an instruction for learning, the concrete example for learning by a class assessment by using association method

The present study is the first approximation for free association of SSW by using normal random number. In this paper, we suppose that each answerer recall the same number of recalled word, 5 or 7 words. Of course each answerer does not recall the same number of recalled word in the real data. So we must improve the simulation against the real condition.

In this work, we have been employing different three distributions for normal random number. This idea will lead to successful results and is easily to discuss on the process of association for group. But, as mentioned 3-2 and 3-3, we need discuss on values of SD_1, SD_2 and SD_3 in detail.

4. CONCLUSION

We summarize on this study;

(1) It is able to simulate for free association of SSW by using normal random number.
(2) It is reasonable to employ three distributions for normal random number.
(3) Most recalled word depends on the value of SD_1 largely.
(4) Association entropy is mainly affected to the values of SD_1 and SD_2.
(5) Kind of response word is affected to the values of SD_2 and SD_3. Usually, the effect of value of SD_3 is rather than large.

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