Effects of Interaction and Environments on Growth of Students

Tomoko Kikuchi and Yoshiteru Nakamori
School of Knowledge Science
Japan Advanced Institute of Science and Technology
Ishikawa 923-1292, Japan
Email:{tkikuchi, nakamori}@jaist.ac.jp

ABSTRACT

This paper considers the changes in performance caused by interaction between members of a group. A number of rules were derived based on the theories in personality psychology, which provides useful information in analyzing the dynamics of human performance. Using a concrete data set and the genetic algorithm, we selected a set of important rules that describes the changes in human performance.

Keywords: interaction rules, personality psychology

1. INTRODUCTION

What is appropriate behavior in everyday life varies according to the situation **[1]**, and the relationship between the environment and the individual is said to be characterized by dynamic and interactive effects **[2][3]**. The aim of this research is to use modeling to seek an understanding of the dynamic and interactive effects which characterize the environment and individual.

In this paper, we propose an interaction model to analyze the changes of human performance in a group by defining performance factors that correspond to the five factors of personality. This research is positioned between the fields of group dynamics and psychology, and aims at connecting them based on the systems concepts. This paper, however, focuses only on the mathematical model that expresses the changes in performance due to interactions in a group. The model was derived from the investigation of literatures in psychology and the final rules were selected by the genetic algorithm based on a concrete data set.

In our understanding, the study of communication is to understand the information between human and human (human communication) or human and computers (human interface) or humans from computers (media communication). Although the model presented in this paper does not explicitly include the style or method of communication, it could be considered one of the communication models that treat communication between personalities.

2. PERFORMANCE VARIABLES

Based on the factor traits in the big five theory[4]:

- extroversion,
- agreeableness,
- conscientiousness,
- neuroticism, and
- intelligent or openness to experience,

we here define the following performance variables:

1. Variable “activeness” from the personality “extroversion”: Typical words related to extroversion are “claim”, “talkative”, etc., which express activeness of a person. It is a criterion of the real action on his/her conscientiousness to the outside system.
2. Variable “tenderness” from the personality “cooperativeness”: Related words to cooperativeness are love, sociality, alignment nature, etc., that are indices of sympathizing with a partner.
3. Variable “endurance” from the personality “diligence”: Diligence is related to the terms such as intention to achievement, thinking introversion, etc, that express the endurance of action.
4. Variable “composure” from the personality “emotional stability”: Emotional stability is related to ups and downs of feeling, that is, composure or calmness.
5. Variable “mentality” from the personality “intellect”: There are intelligence, a cultured person, abundant experience, etc. as terms related to intellect, which associate the concept mentality.

Based on these definitions, we will select the candidate rule classes from descriptive sentences as parameters between parts of “If” and “Then”.

Then we describe how to classify them into the following types.

- Types of describe sentences related to “Behavior”.
- Types of descriptive sentences related to “Concern for Others”
- Types of descriptive sentences related to “Persistence / Endurance”
- Types of descriptive sentences related to “Mood”.
- Types of descriptive sentences related to “Intelligence”

At last all these sentences are categorized into the effect of "the pair-wise" and "self-innovation", in which classes are models of pair-wise interaction as Model 1 (M1) and self-innovation as Model 2 (M2) in Table 1. If there are the keywords of the descriptive sentences which need or aware to another person to his or her act, then they are classified into M1. If there are no keywords in the sentences then they are classified into M2.

And then, we got the candidate rules into the 2 classes following Table 1 where second and third columns indicate the correspondence between personal traits and performances.

Table 1 The candidate rule classes, Model 1 and Model 2

M1: Pair-wise model

Rule number	IF		Then	
0	E	-	A	+ or -
1	E	+	A	+ or -
2	E	+	N	+ or -
3	A	-	O	+ or -
4	A	-	A	+ or -
5	A	+	A	+ or -
6	A	+	E	+ or -
7	A	+	O	+ or -
8	C	+	A	+ or -
9	N	-	A	+ or -
10	N	-	N	+ or -
11	N	+	A	+ or -
12	N	+	N	+ or -

M2: Self-innovation model

Rule number	IF		Then	
13	E	+	E	+ or -
14	E	+	A	+ or -
15	E	+	O	+ or -
16	E	-	C	+ or -
17	E	-	E	+ or -
18	E	-	O	+ or -
19	A	+	N	+ or -
20	A	+	A	+ or -
21	A	+	O	+ or -
22	C	+	E	+ or -
23	C	+	C	+ or -
24	C	+	N	+ or -
25	C	-	O	+ or -
26	C	-	E	+ or -
27	C	-	C	+ or -
28	N	-	E	+ or -
29	N	+	C	+ or -
30	N	+	E	+ or -
31	N	-	N	+ or -
32	N	+	N	+ or -
33	N	+	O	+ or -
34	O	-	E	+ or -
35	O	-	A	+ or -
36	O	-	N	+ or -
37	O	-	O	+ or -
38	O	+	O	+ or -
39	O	+	A	+ or -
40	O	+	N	+ or -

These candidate rule classes of two are called as the Model 1 and 2. The signal of [+], [-] means positive or negative influences, for example, in Model 1, signal of [+] means higher than another person relatively, and in Model 2, [+] means higher than before changed oneself. To estimate the magnitudes of changes in performance variables, we give a score to each sentence considering the strength of influence, and negative or positive influence.

3. RELATION BETWEEN PERFORMANCES

We assume that a performance variable of an agent (we use this term instead of person hereafter) is affected by the performance variables of other agents as well as by the changes in other variables of the same agent. Model 1 and 2 below correspond to the above changes respectively. Figure 1 shows the interaction Model used in this paper. Here, we defined the agent having the communication with person behaviors as 5 performance factors.

3.1 Model 1: Pair-wise Interaction

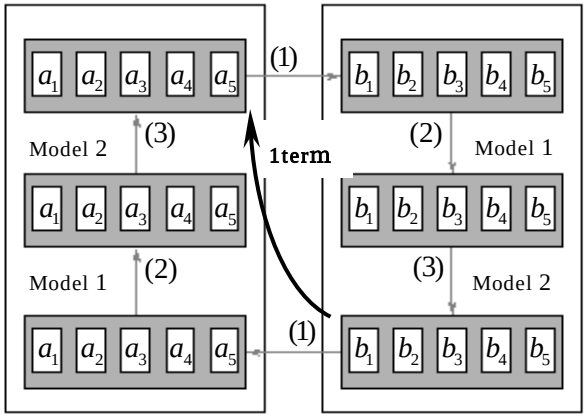

Fig.1 Structure of the interaction Model.

Let us consider two agents *A* and *B*, whose variables are denoted by a_i, b_i respectively. Here, $i = 1,2,3,4,5$ correspond to variables: activeness, tenderness, endurance, composure, and mentality.

When these agents happen to meet (step (1) in Fig. 1), one of the agents, say *A*, is affected by another according to the Model that consists of a set of if-then rules such as

$$\text{If } b_2\text{-}a_2 > 0 \text{ then } a_3' = a_3 + \alpha\left|b_2 - a_2\right| \qquad (1)$$

Here, a_i' is the tentative value of a_i just after the calculation of Model 1(step (2)).

3.2 Model 2: Self-innovation

After the interaction, the agent *A* has changed in some performance variables. It will justify its performance

variables by the Model consisting of a set of rules such as

$$\text{If } a_1'\text{-}a_1 > 0 \text{ then } a_5'' = a_5' + \beta\left|a_1' - a_1\right| \qquad (2)$$

The values of performance variables of the agent *B* will also change in the same way and same time with agent A.

4. OPTIMIZATION

We carried out a questionnaire survey that we call the real data to select rules. We asked graduate students in 6 laboratory members of the material science in our university to answer how they changed in terms of the research growth of oneself through the laboratory, at the same time we asked them to answer their personality traits using a standard check sheet; the latter was used to determine the initial values in the simulation.

Because it is difficult to obtain absolute values of performance changes using a simple model, we tried to estimate relative values of performance changes. That is, we assumed the parameters arbitrary. We used the genetic algorithm to select if-then rules to be used in the model. The number of codes in the genotype is 41 that correspond to the number of rules obtained from the literatures. If some rule is used then we set the corresponding entry as 1, otherwise 0. We set the initial values of genotypes randomly, and used the simple crossover to produce the next generation and set both α and β as 0.01.

4.1 The Genetic Algorithm

We assume that each agent meets other agents more than 10 times in the period. But, because the performance changes differently depending on the order of other agents to meet, we repeat the algorithm 10 times, changing the initial values of the genotypes. We here use a max-min strategy. That is, the score of genotype is determined by the worst case among 10 repetitions. Then 10 genotypes are selected among 20 genotypes, which have higher scores than others. We decided that the number of generations is 100 in this paper.

As our model easily overshoots the target value because of its structure, we introduce the sigmoid function as follows so that the algorithm is free from the values of parameters and the repetition times. Let $a_i(0)$ and $a_i(T)$ be the initial and target values of the performance i of an agent. We introduce an intermediate valuable $x_i(t)$, which is updated by

$$x_i(t+1) = x_i(t) + a_i''(t) - a_i(t)$$
$$x_i(0) = 0 \qquad (3)$$

Then, we transform $x_i(t)$ into another intermediate variable $y_i(t)$ by

$$y_i(t) = \frac{1}{1+\exp\{-x_i(t)\}} \qquad (4)$$

Finally, $a_i(t)$ is updated by the following formula:

$$a_i(t+1) = p\, y_i(t+1) + q \qquad (5)$$

Here,

$$\text{If } a_i(0) \le a_i(T) \text{ then} \quad p = 2\left(a_i(0) - a_i(T)\right),\ q = 2a_i(0) - a_i(T) \qquad (6)$$

$$\text{If } a_i(0) \ge a_i(T) \text{ then} \quad p = -2\left(a_i(0) - a_i(T)\right),\ q = a_i(T) \qquad (7)$$

4.2 Selected rules in the laboratory A

The table 5 shows the result of the set of the control rules in the laboratory A. In the Table, number of the 0-9 shows the pattern number in the set and “1” as selected and “0” as not. In the laboratory A, the common rule numbers are 6, 7, 9, 10, 11, 12, 13, 16, 17, 19, 20, 28, 29, 30, 31, 33, 34, 35, 38, in each of which totally “10” means that it is the necessary rule to evoke the 10 pattern about the communicative situation.

In the table 2, the bottom shows the fitness. The result shows all fitness values as 7, which mean the minimum differences between target values and calculate results within the each control rule pattern. The laboratory A consists of 14 members, and then the average of the differences are 0.5 per 1 person.

Hereby, Table 3 shows the result of 6 laboratories. In each laboratory, the rate of the selection rules within 10 set as 100 patterns in the control rules are calculated. Then, understanding the value of 100 within each rule as selected rules in all 10 set suggests the important rules to the evoking communicative interaction. The average of the selection time of the rules is shown in the “Average”. As result, the number 33 is almost common rule (99.3 % selected commonly in the all laboratory) which means a if-then rule such as the relationship to the influence of the +N on –O in the Model 2 as “self-innovation”. In this result, the rules differ from all 6 laboratories and then there is nothing of the common rules, because it may be addressed from the difference of the members in each laboratory. Consequently, using the each model selection of the rule classes differ from all 6 laboratories. Then, considering the model about Laboratory A only. In the Table 3 “result of the each selection rules of the 6 Labs”, Laboratory A uses the rule number of 6, 7, 13, 16, 17, 20, 28, 30, 33, 34, 35 as shown 100 within the control rules of the 10set.

Table 2 Result of the selection about the control rule 1set in the laboratory A

Rule number	Pattern number of Control rule within 1 set										Total
	0	1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0
3	0	1	1	1	1	1	0	1	1	1	8
4	0	0	0	0	0	0	0	0	0	0	0
5	1	1	0	0	1	1	1	1	1	1	8
6	1	1	1	1	1	1	1	1	1	1	10
7	1	1	1	1	1	1	1	1	1	1	10
8	1	1	0	0	1	1	1	1	1	1	8
9	1	1	1	1	1	1	1	1	1	1	10
10	1	1	1	1	1	1	1	1	1	1	10
11	1	1	1	1	1	1	1	1	1	1	10
12	1	1	1	1	1	1	1	1	1	1	10
13	1	1	1	1	1	1	1	1	1	1	10
14	1	1	1	1	0	0	1	0	0	1	6
15	1	1	0	0	1	1	1	1	1	1	8
16	1	1	1	1	1	1	1	1	1	1	10
17	1	1	1	1	1	1	1	1	1	1	10
18	0	0	0	0	0	1	0	0	1	0	2
19	1	1	1	1	1	1	1	1	1	1	10
20	1	1	1	1	1	1	1	1	1	1	10
21	0	0	0	0	0	0	0	0	0	1	1
22	1	1	0	0	1	1	1	1	0	1	7
23	0	0	0	0	0	0	0	0	0	0	0
24	0	0	1	1	0	0	0	0	0	0	2
25	1	1	0	0	1	1	1	1	1	1	8
26	0	0	0	0	0	0	0	0	0	0	0
27	0	0	1	1	0	0	0	0	0	0	2
28	1	1	1	1	1	1	1	1	1	1	10
29	1	1	1	1	1	1	1	1	1	1	10
30	1	1	1	1	1	1	1	1	1	1	10
31	1	1	1	1	1	1	1	1	1	1	10
32	0	1	1	1	1	1	0	1	1	0	7
33	1	1	1	1	1	1	1	1	1	1	10
34	1	1	1	1	1	1	1	1	1	1	10
35	1	1	1	1	1	1	1	1	1	1	10
36	0	0	1	1	1	1	0	1	1	0	6
37	1	1	0	0	0	0	1	0	0	1	4
38	1	1	1	1	1	1	1	1	1	1	10
39	1	0	0	1	0	0	0	0	0	0	2
40	0	0	1	1	0	0	0	1	1	0	4
fitness	7	7	7	7	7	7	7	7	7	7	

Table 3 Result of the each selection rules of the 6 Laboratory

Rule number	Lab.A	Lab.B	Lab.C	Lab.D	Lab.E	Lab.F	Average %
0	47	44	34	62	42	54	47.2
1	31	37	71	60	62	45	51.0
2	66	75	55	37	67	97	66.2
3	98	83	90	100	89	74	89.0
4	58	27	52	56	38	77	51.3
5	40	60	51	36	31	57	45.8
6	100	100	100	100	77	51	88.0
7	100	81	100	100	91	78	91.7
8	81	84	41	51	48	36	56.8
9	47	7	73	44	47	47	44.2
10	89	67	57	69	67	68	69.5
11	41	65	68	55	45	61	55.8
12	72	89	95	39	73	69	72.8
13	100	100	100	37	56	49	73.7
14	73	61	70	36	68	41	58.2
15	66	56	72	63	38	23	53.0
16	100	36	100	100	56	92	80.7
17	100	43	100	80	52	52	71.2
18	63	75	61	37	54	48	56.3
19	28	41	64	42	70	67	52.0
20	100	100	100	75	57	100	88.7
21	45	58	64	66	66	82	63.5
22	75	43	51	40	45	53	51.2
23	46	46	47	41	46	43	44.8
24	37	41	83	60	43	47	51.8
25	82	55	63	31	45	51	54.5
26	57	60	53	48	53	25	49.3
27	59	30	59	25	65	22	43.3
28	100	100	100	63	43	100	84.3
29	99	36	68	34	64	98	66.5
30	100	95	45	100	66	66	78.7
31	45	72	49	73	43	46	54.7
32	97	100	61	49	81	100	81.3
33	100	100	100	100	96	100	99.3
34	100	87	81	44	100	100	85.3
35	100	32	84	67	100	27	68.3
36	50	57	82	54	46	36	54.2
37	61	59	62	77	42	47	58.0
38	61	48	100	100	73	58	73.3
39	42	45	65	88	68	57	60.8
40	23	61	95	100	85	46	68.3

5. RESULT MODEL IN THE LABORATORY A

In the control rule of the set, the “selection” rules differ from the “adoption” rules of the each 14 agent because of the random agent selection as communication partner. Table 4 and 5 show the results of the control rule 10 set. In each rule number, the tables show the time of the rule selection as “Selection of Total” and of the rule adoption as “Adoption of the Total”. The time of the rule adoption is the total sum of the negative and positive adoption times. Here, within the adoption time, the rate of the adoption about positive and negative result as “Positive %” and “Negative %” in the following Tables. Table 4 shows the pair-wise model as Model 1 and the adaptation rate of only two rules, No.3 and 7, which are using 100 % as positive by all agents in the laboratory A. Other rules are used with both positive and negative. Table 5 shows the self-innovation model as Model 2 and the adaptation rate of only fourteen rules, No.13-18, 20, 21, 28-31, 33 and 34, which are using 100 % as positive or negative by all agents in Laboratory A. Another rules are used with both positive and negative or with nothing to adoption.

Table 4 Model 1：Pair-wise model

Rule No	Selection of Total	IF		Then			
				Factor	Adoption		
					Total	Positive %	Negative %
0	3298	E	-	A	286	30	70
1	1734	E	+	A	268	25	75
2	3864	E	+	N	324	41	59
3	4960	A	-	O	359	100	0
4	2734	A	-	A	220	62	38
5	2720	A	+	A	432	10	90
6	5508	A	+	E	388	48	52
7	5508	A	+	O	289	100	0
8	4434	C	+	A	523	17	83
9	2718	N	-	A	232	38	63
10	4970	N	-	N	326	59	41
11	2170	N	+	A	345	21	79
12	3914	N	+	N	458	31	69

Table 5 Model 2：Self-innovation model

Rule No	Selection of Total	IF		Then			
				Factor	Adoption		
					Total	Positive %	Negative %
13	5508	E	+	E	186	100	0
14	3874	E	+	A	21	100	0
15	4916	E	+	O	70	100	0
16	5508	E	-	C	94	0	100
17	5508	E	-	E	202	0	100
18	3404	E	-	O	55	100	0
19	1064	A	+	N	31	45	55
20	5508	A	+	A	332	100	0
21	2264	A	+	O	96	100	0
22	4290	C	+	E	0	0	0
23	2646	C	+	C	0	0	0
24	1620	C	+	N	0	0	0
25	4970	C	-	O	0	0	0
26	3876	C	-	E	0	0	0
27	3352	C	-	C	0	0	0
28	5508	N	-	E	186	100	0
29	5508	N	+	C	174	100	0
30	5508	N	+	E	369	100	0
31	3374	N	-	N	103	100	0
32	4960	N	+	N	291	53	47
33	5508	N	+	O	517	0	100
34	5508	O	-	E	648	100	0
35	5508	O	-	A	445	56	44
36	2132	O	-	N	223	33	67
37	3832	O	-	O	0	0	0
38	3880	O	+	O	0	0	0
39	3184	O	+	A	0	0	0
40	1678	O	+	N	0	0	0

6. FINAL MODEL

The rule number 6, 7, 13, 16, 17, 20, 28, 30, 33, 34, 35 are selected as model identify following the Table 6 about Laboratory A. Considering Tables 3, 4 and 5, Table 6, 7 show the final model. And then, each explanations of the interaction rules in the laboratory A is shown under the tables. In the table 9,10 the five term name “Activeness”, “Tenderness”, “Endurance”, “Composure”, “Mentality”, of the performance factors are used into understanding the creative situation of the students in Laboratory A. We get the one rule of the pair-wise model and eight rules of the self-innovation model which shows the rate as 100% in these tables.

Table 6 Final model 1 of the rule class in the Laboratory

M1：Pair-wise model

No	IF		Then		
			Factor	adaption	
				Positive %	Negative %
6	A	+	E	47.9	52.1
7	A	+	O	100.0	0.0

In the table 6, we got the rule No.7 as “IF Tenderness A +, Then Mentality O is affected positively ” which means if your “Tenderness” are higher than another, then you will get the chance of the considering situation to the creative research.

Table 7 Final model 2 of the rule class in the Laboratory A

M2：Self-innovation model

No	IF		Then		
			Factor	adaption	
				Positive %	Negative %
13	E	+	E	100.0	0.0
16	E	-	C	0.0	100.0
17	E	-	E	0.0	100.0
20	A	+	A	100.0	0.0
28	N	-	E	100.0	0.0
30	N	+	E	100.0	0.0
33	N	+	O	0.0	100.0
34	O	-	E	100.0	0.0
35	O	-	A	55.5	44.5

In Table 7, we got the eight rules as follows. The rule No.13 as “IF Activeness E +, Then Activeness E is affected positively as 100%” means if your motivation of “Activeness” are higher than previous yourself, then you will get your “Activeness” about the creative research more. The rule No.16 as “IF Activeness E -, Then Endurance C is affected negatively” means if your motivation of “Activeness” are lower than previous yourself, then you will lose your “Endurance” about the creative research more. The rule No.17 as “IF Activeness E -, Then Activeness E is affected negatively” means if your motivation of “Activeness” are lower than previous yourself, then you will lose your “Activeness” about the creative research more. The rule No.20 as “IF Tenderness A +, Then Tenderness A is affected positively” means if your motivation of “Tenderness” are higher than previous yourself, then you will get your “Tenderness” about the creative research more. The rule No.28 as “IF Composure N -, Then Activeness E is affected positively” means if your motivation of “Composure” are lower than previous yourself, then you will get your “Activeness” about the creative research more. The rule No.30 as “IF Composure N +, Then Activeness E is affected positively” means if your motivation of “Composure” are higher than previous yourself, then you will get your

"Activeness" about the creative research more. The rule No.33 as "IF Composure N +, Then Mentality is affected negatively "means if your motivation of "Composure" are higher than previous yourself, then you will lose the chance of your considering something of "Mentality" about the creative research more. Rule No.34 as "IF Mentality O -, Then Activeness E is affected positively" means if your motivation of "Mentality" are lower than previous yourself, then you will get your "Activeness" about the creative research more.

7. THE FACTORS NOT TO EVOKE SITUATION

Table 8 shows the result of each factor within the fitness and the average of member each factor about each laboratory. In the all, "Endurance" of the performance factor is not good result. The second is "Tenderness", next "Activeness".

Table 8 Final model 2 of the rule class in the Laboratory A

	Lab.	Activeness	Tenderness	Endurance	Composure	Mentality	fitness
Total	A	1	2	4	0	0	7
	B	0.0	0.0	5.0	0.0	0.0	5
	C	1.0	1.0	5.0	0.0	0.0	7
	D	0.0	4.0	5.0	0.0	0.0	9
	E	0.0	1.0	6.0	0.0	0.0	7
	F	0	1	4	0	0	5
	Total	2.0	9.0	29.0	0.0	0.0	40
	Lab.	Activeness	Tenderness	Endurance	Composure	Mentality	fitness average
Average	A	0.1	0.1	0.3	0.0	0.0	0.5
	B	0.0	0.0	0.3	0.0	0.0	0.3
	C	0.1	0.1	0.3	0.0	0.0	0.4
	D	0.0	0.3	0.4	0.0	0.0	0.7
	E	0.0	0.2	1.0	0.0	0.0	1.2
	F	0.0	0.1	0.3	0.0	0.0	0.4
	Total	0.1	0.8	2.6	0.0	0.0	3.5

8. CONSIDERATION

We selected the best interaction rules of the performance factors about growth of students considering the personality interactions. In this result, it shows "Endurance" of the performance factor is not good result. In this reason, the affection on the result may be decided by what and how many kinds of rules. However, the candidate rules are used as experience knowledge in our day life and not attempted to the how many and what kind of the rules. Consequently, it can be accord with the "Endurance" of the performance factors. And more, the model are considered of only the human, here, without environment interaction between human. Result may be included the effect of the environment also. In the future, we should consider the environment added to the result of the model rules as the third model.

9. CONCLUSION

The subjects of this study were students engaged in creative research, and two types of surveys were administered regarding the status of their research activities. In order to discover rule groups to predict "target values" based on the "starting values" obtained from the data, Model 1, which considers only individuals (model comparing others) and Model 2 (self modification) were used with agent-based modeling and GA searching. However, the results could not successfully predict the "target values," particularly for "endurance." This effect was not shown in Models 1 and 2, and for this reason Model 3, related to the environment, was thought to be necessary. Rules dealing with endurance are now contained in Models 1 and 2, but they are extremely few in number. It is believed that the target values for endurance could eventually be fulfilled with infinite calculations, but because the number of possible calculations is limited, the influence of endurance is not considered here. Seeing the connection between endurance and the environment, a survey focusing fully on the environment and modeling in Model 3 is planned.

In consideration of the future of education, we believe that there is benefit in studying what sorts of environments will lead certain types of individuals to easily show personal growth, as well as studying the problems behind weak growth. Normally each combination of individuals should be considered in a controlled environment, but this would be an extremely complex study which could take years to complete. Some issues remain in the construction of the model and in terms of the logic, but with this type of model in which surveying is carried out at the individual level and engineering is used to predict group interactivity, the variables obtained from modeling, while not a perfect reflection of reality, did result in types of rules that may affect and govern individual behavior within the research environment. These may result in some recommendations for education.

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REFERENCES

[1] Wicker, A.W.(1984), "An introduction to ecological psychological psychology", Cambridge

University Press.
[2] Krupat, E. (1986), The urban environment and its effects, Cambridge University Press.
[3] Takuma Taketoshi (Eds.) (1998), “Handbook of Personality Psychology”, Fukumura Syuppan (in Japanese)
[4] John, O. P. (1990), “The “Big Five” factor taxonomy: Dimensions of Personality in the natural Language and in questionnaires”, In L. A. Pervin (Ed.), Handbook of personality: Theory and research, NewYork: Guilford Press, pp.66-100.