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A combined model of segregation and cultural dissemination models: Searching for conditions of successful nonterritorial offices

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Abstract

This paper develops a new simulation model by combining the two typical models of social differentiation: Cultural dissemination model and segregation model. In this combined model, the agents can move around and communicate with one another on a space of non-partition and free-address setting. Non-partition and free-address setting is called nonterritorial office in office management. Nonterritorial offices have been adopted by many Japanese firms in recent years. This paper searches successful nonterritorial offices by using the combined simulation model and two case studies of Japanese firms. This paper suggests that "moderate" office density is a condition for successful nonterritorial offices. This paper also suggests that nonterritorial offices are likely to fail under “high” or “low” office density.

Keywords

Multi-agent simulation; Office management; Cultural dissemination model; Segregation model; Nonterritorial office; Office density

1. Introduction

This paper develops a new model of social differentiation by combining the two existing models. This combined model not only will be a general model covering the two, but also will offer a new logic of social differentiation. The results of this model are supported by the cases of two Japanese firms introducing nonterritorial offices.

There are two typical simulation models dealing with social differentiation: “Cultural Dissemination Model (CDM)” developed by Axelrod (1997) and “Segregation Model (SM)” proposed by Schelling (1971). In both models, the agents interact with one another on a space being a two-dimensional coordinated lattice. Though CDM is a cellular automaton in which agents are fixed in particular locations, SM is a basic multi-agent model in which agents can move around.

These two models explain social differentiation in different spatial settings and rules of agents. A feature of spatial settings of CDM is non-partition, in which there are no physical barriers that hinder the agents from communicating with others around them. The communication rule of CDM is that neighboring agents communicate and become even more similar to one another with probabilities depended on their degree of similarity. The result is that the agents split into several stable clusters having the same character, and that no more communication across different clusters occurs. That is, the differences among the agents’ characters do not disappear as a whole. A feature of spatial settings of SM is free-address, in which all agents have no fixed locations and can move around freely. The movement rule of SM is that agents move to be near others who are similar to themselves. This result is that the clusters of the agents having the same character emerge, and social differentiation becomes increasingly prominent.

These models leave the problem outstanding whether the agents can retain their differences under non-partition and free-address setting, in which they can move around freely and communicate with many others easily. The agents of CDM may retain their differences because of not moving around. On the other hand, the agents of SM may retain their differences because of not communicating with one another. We can tackle the problem by combining the two models.

In the combined model, the agents can retain their differences while moving around and communicating with one another though some conditions should be satisfied. One condition is “moderate” spatial density. When spatial density is “high,” the agents cannot move around freely. When spatial density is “low,” the agents split into several clusters. The agents do not move around and do not communicate across the clusters.

These results have a suggestion for office management studies. In office management,

non-partition and free-address setting is called nonterritorial office. Allen and Gerstberger (1973) conduct an experiment with an R&D organization, in which one or two people were assigned to each of the several desks or rooms surrounded by partitions. They removed all physical barriers (non-partition setting) and enabled employees to work anywhere (free-address setting), and they called this arrangement nonterritorial office.

The nonterritorial office seems to encourage employees to move around and to communicate with colleagues. Allen and Gerstberger (1973) studied how long each employee spent at a single place and clarified that, rather than staying in any one specific place, the employees preferred to move around. They also recorded each employee's interactions during a day chosen at random every week and clarified that the number of individuals with whom each employee communicated as well as the amount of communication increased after the experiment. These results are interpreted as follows: "The best explanation for this finding probably is that each employee's neighbors changed from time to time, and employees tended to talk to their more numerous neighbors, especially those with whom they were relatively unacquainted" (Sundstrom and Sundstrom 1986, p. 268).

The nonterritorial office would be a driver of knowledge creation if the employees can retain the differences of their thoughts while behaving as reported by Allen and Gerstberger (1973). It is assumed that moving around in an office enhances the possibility of meeting a variety of people (e.g., Becker and Steele 1995). Previous studies show that frequent contact with many colleagues having different thoughts is related to generating, sharing, and assessing new ideas (Peltz and Andrews 1966, Allen 1977, Katz 1982). Some other researchers suggest that interaction with various people stimulates knowledge creation (e.g., Nonaka and Takeuchi 1995, Wenger et al. 2002). Kujirai (2005) sees the nonterritorial office as a place for knowledge creation and points out the effectiveness of the nonterritorial office. Becker and Steele (1995) refer to cases where companies introduce nonterritorial offices not for cost reduction but for lively communication and organization reforms. Therefore, we can say that nonterritorial offices are successful when the employees move around, communicate with many others, and can retain their differences of their thoughts.

As the new combined model suggested, nonterritorial offices with "moderate" office density would be successful. This is supported by the cases of two Japanese firms. The first firm's nonterritorial office performed well. This office is so ingenious that the density is appropriate. The second firm's nonterritorial office worked well in the initial phase. In the second phase, however, the company outgrew its office, and the nonterritorial office worked less than it used to because of "high" office density. Although the company moved to a large nonterritorial office in the third phase,

the new office wasn't effective either because of "low" office density.

2. Two Typical models of social differentiation

2.1. Cultural Dissemination Model proposed by Axelrod (1997)

At a micro level, this model assumes that each agent has a common tendency to become similar to each other through communication with neighbors.

Initial setting.

(1) Each agent is placed on a fixed lattice (there is no vacant site). There are no physical barriers that hinder the agents from interacting with one another (non-partition setting).

(2) Each agent holds "culture" represented in a character string. This "culture" is determined randomly. If "culture" has five features ("width of culture" is 5) with 10 possible traits in each feature ("depth of culture" is 10), an agent's culture could be "18943," for example.

Rule.

(1) An agent is picked up at random and becomes active.

(2) The agent picks up one of its neighbors and calculates cultural similarity (CS). CS is the proportion of the number of common features in the "width of culture." For example, the agent whose "culture" is "18943," shares three features with its neighbor whose culture is "19743" (first, fourth, and fifth feature), the CS is 60 percent.

(3) The probability that the agent communicates with the neighbor is equal to the CS between the two agents. Once communication between them has been established, the agent picks up one of its cultural features and changes its trait to that of the neighbor. In the previous example, the probability that the agent communicates with its neighbor is 60 percent, and may change the culture to "19943" if it picks up the second feature. If two agents share no cultural features (CS is 0), they do not interact. If two agents have the same "culture" (CS is 1), their "culture" do not change, although they always interact.

(4) The simulation ends if any agent does not change its "culture."

At a macro level, the agents split into several stable cultural groups, and no more communications across different cultural groups occur though we tend to consider, from the tendency of convergence at micro level, that all the agents have the same "culture."

2.2. Segregation Model proposed by Schelling (1971)

At a micro level, this model assumes that each agent follows a rule such as “If few members of the same group are my neighbors, I will move.”

Initial setting.

(1) Each agent is placed randomly on a fixed lattice (there are some vacant sites). This does not mean the agents are fixed in these locations (free-address setting).

(2) Each agent is a member of one or another group and has a threshold for moving. This threshold is the minimum proportion of the agent’s neighbors who are in the same group.

Rule.

(1) The agent calculates the proportion of neighbors who are in the same group.

(2) If this number is greater than or equal to the threshold, the agent satisfies it, in which case end; else continue.

(3) The agent looks for the nearest unoccupied site that satisfies its threshold and moves there.

(4) The simulation ends if all agents satisfy and do not move.

At a macro level, segregated settlement patterns emerge from this rule. The agents are segregated into groups and eventually stop moving around. This occurs even if the thresholds of each agent are not very high though we tend to consider that social differentiation does not become prominent in this case.

3. Combining the two models

Initial setting

(1) Each agent is placed randomly on a fixed lattice (there are some vacant sites). There are no physical barriers (non-partition). The agents are not fixed in particular locations (free-address).

(2) Each agent has the same “culture” as CDM and the same threshold as SM. They have also “Move range” and “Vision.” “Move range” means the distance each agent can move around. This is set at 1; that is, each agent can move within one site. “Vision” means the distance each agent can communicate. This is set at 2; that is, each agent can communicate with an agent within two sites[1].

[1] The range within eyeshot or earshot is wider than the range we can move about.

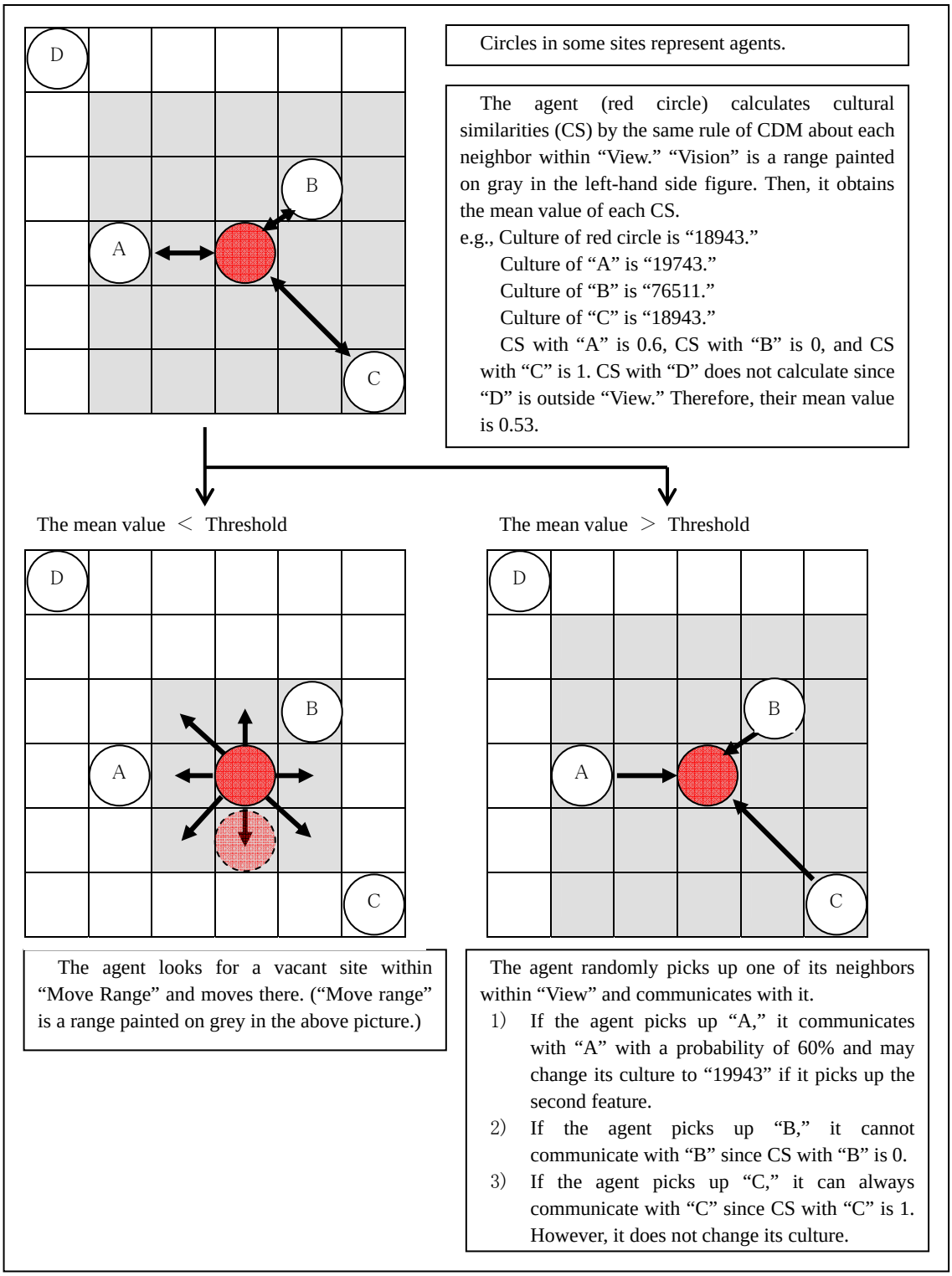


Figure 1: Rules of the Combined Model

Table 1: Input parameters and output data

(a) Input parameters

Notation	Definition	Range of setting
THRESHOLD	Threshold to move	From 0.1 to 0.9
SIZE	Size of space	From 100 sites (10 × 10) to 400 sites (20 × 20)
W-CUL	Width of culture = Number of features each culture has.	From 1 to 9
D-CUL	Depth of culture = Number of possible traits in each feature.	From 1 to 9

(b) Output data

Notation	Definition
NOTMOVE	Number of agents who cannot move because there are no vacant sites in the neighboring area.
MOVE	Number of agents who find an unoccupied site and move there.
COM	Number of agents who can communicate with other agents and change own culture.
DIV	Diversity of culture of the agents, obtained from subtracting the total mean value of CSs calculated for each agent from 100.

Note: Number of agents = 100.

Rule

(1) An agent becomes active[2].

(2) The agent calculates CS using the same rule of CDM about each neighbor within "Vision." Then, it obtains the mean value of each CS.

(3-a) If this mean value is less than the threshold, the agent looks for a vacant site within "Move Range" and moves there[3].

(3-b) If the mean value of each CS is greater than the threshold, the agent randomly picks up one of

[2] The order to become active is determined at random. A new period does not start until all the agents' trial ends.

[3] If there are some vacant sites, the agent picks up one of them randomly and moves there. Schelling moves agents to the nearest satisfactory site, whereas the agents of this paper simply select an acceptable site at random. Epstein and Axtell (1996) show the same result as Schelling's from the same rule as ours (Epstein and Axtell 1996, p. 165–170).

its neighbors within “View” and communicates with them. The communication rule is the same as the CDM.

Input parameters and output data are summarized in Table 1. Input parameters are THRESHOLD, SIZE, W-CUL (the width of culture), and D-CUL (the depth of culture). Changing the SIZE means changing the space density, because the number of agents is always 100. Output data are NOTMOVE, MOVE, COM, and DIV.

4. Results of the combined model

This paper will tackle the problem whether the agents can retain their differences though they keep moving around freely and communicating with one another. According to the combined model, this non-convergent state can be interpreted as follows:

Criterion 1: NOTMOVE is 0 or almost 0. If this is not the case, the agent cannot move around freely. If the state where NOTMOVE is greater than 5 continues for ten periods, the run ends.

Criterion 2: MOVE is more than 0. If MOVE is 0, this indicates the agents do not move around. If the state where MOVE is less than 5 continues for ten periods, the run ends.

Criterion 3: COM is more than 0. If this is not the case, the agents do not communicate with various others. If the state where COM is less than 5 continues for ten periods, the run ends.

Criterion 4: The state where the above three criteria are satisfied, continues for 8000 periods. Axelrod (1997) reports that it takes about 800 periods to reach an equilibrium (the state where the agents stop communicating with others) in the case of W-CUL = 5, D-CUL = 10, and the number of agents = 100. Then, we can consider that the agents continue to move around and communicate with others, if 8000 periods (ten times more than the report of Axelrod (1997)) can pass.

As inferred from the rules of the model, DIV is kept high when MOVE and COM are more than zero.

We have to run more than 10000 patterns of settings to test all combinations of the four parameters (THRESHOLD, SIZE, W-CUL, and D-CUL). Because of limited time, as a preliminary test, I selected parameter settings randomly and conducted a few runs for each. As a result, I realized there is a correlation between THRESHOLD and D-CUL. Therefore, I decided to hold THRESHOLD at 0.25 and change the others. I conducted 50 runs for each combination of the three parameters and confirmed whether there was a case, in which all the four criteria were satisfied.

I found that, when SIZE is 12×12, W-CUL is 3, and D-CUL is 5 (hereafter called Successful-Case), the four criteria are satisfied. Of the 50 runs, 29 continued to satisfy the first three criteria even after

8000 periods[4]. Figure 2, which is the result of a run, shows that MOVE is kept about 40 and COM is kept about 15 for 8000 periods. Therefore, the agents move freely and communicate with various others in this case.

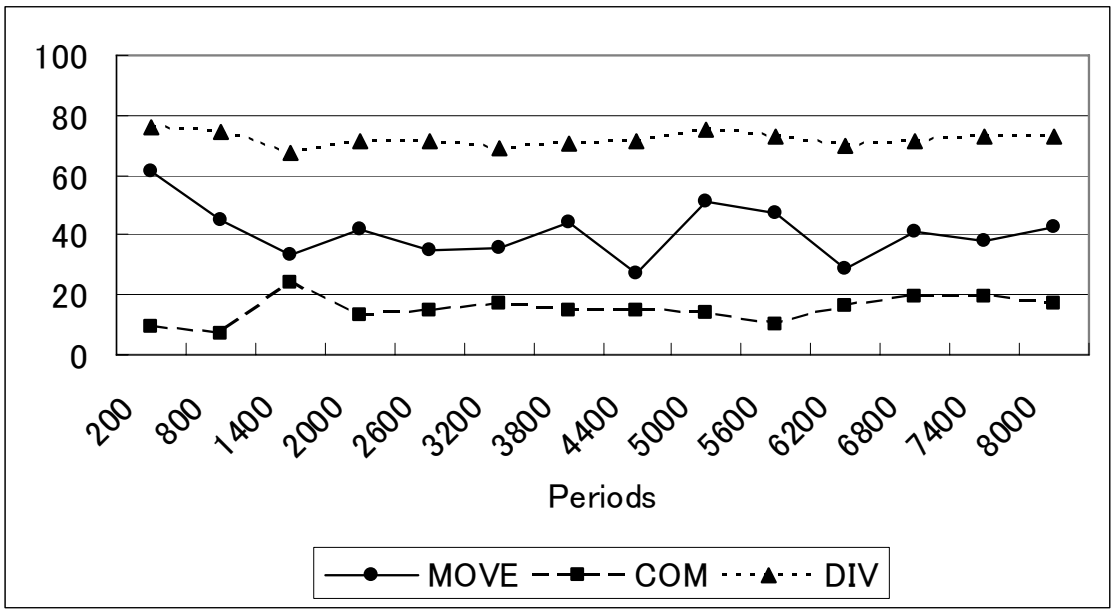
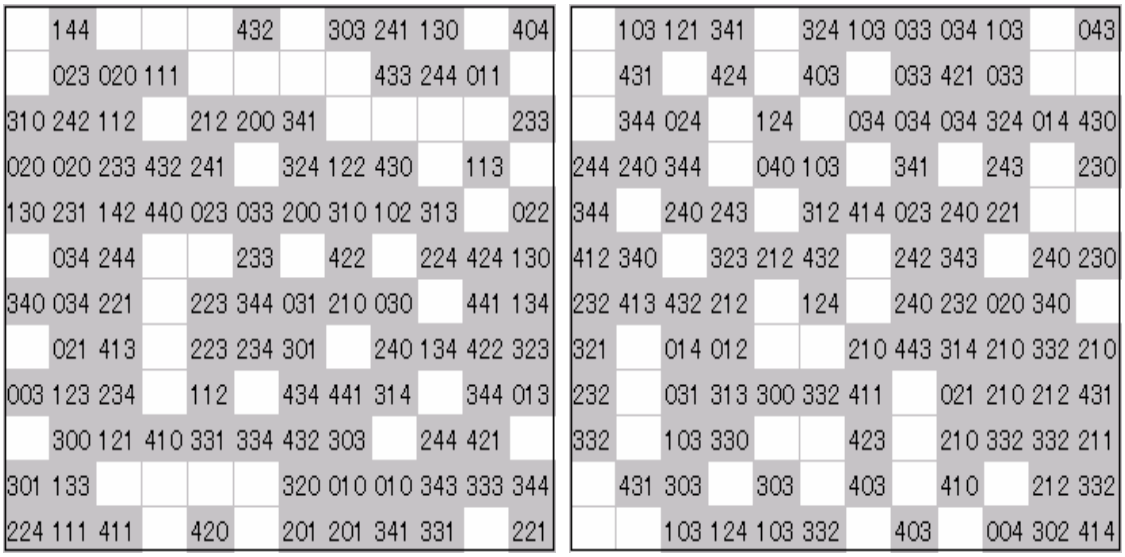


Figure 2: Output data of a Successful-Case. When SIZE is 12 × 12, W-CUL is 3, and D-CUL is 5, MOVE, COM, and DIV are remained fairly constant for 8000 periods.

We tend to consider from the two models (SM and CDM) that the agents have a tendency to develop some cultural groups over time, if MOVE and COM are kept at more than 0. However, DIV is kept around 70 in that case (Figure 2), indicating that the tendency cannot be observed. To confirm this, I pictured an initial arrangement of the agents (Figure 3 (a)) and the one after the 8000 periods (Figure 3 (b)). These pictures show that there are no distinct cultural groups even after 8000 periods.

When SIZE is smaller than that of the Successful-Case, Criterion 1 is not satisfied. The case of SIZE = 10 × 10 is similar to CDM. The agent does not move as in CDM, and therefore the run ends at ten periods (see Table 2 (a)). When SIZE is 11 × 11, only 21 sites are vacant. As shown in Figure 4, many agents have no vacant sites within their "Move range." Therefore, NOTMOVE is more than 5 and the run ends immediately.

[4] When continued, 13 of the 29 runs do not reach equilibrium after 16000 periods (two times more than Criterion 4).



(a) An initial arrangement (b) After 8000 periods

Figure 3: Agents' locations and cultures of a Successful-Case. The number in each cell represents the agent's "culture." These pictures show that the agents do not split into any cultural groups.

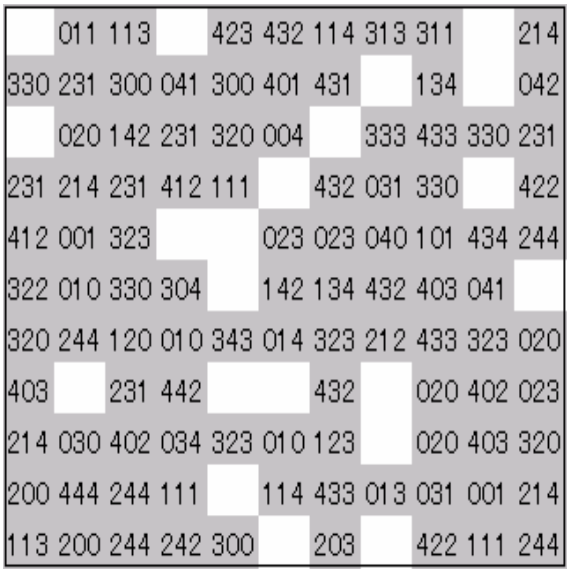


Figure 4: Result of Small SIZE. The number in each cell represents the agent's "culture." This figure shows many agents have few vacant sites to move.

Table 2: The effects of SIZE, W-CUL, and D-CUL

(a) The effects of SIZE

W-CUL	D-CUL	SIZE	Periods to exit*	Criteria to exit
3	5	10 × 10	10.00	1
3	5	11 × 11	12.64	1
3	5	12 × 12	>8000.00	4
3	5	13 × 13	1159.12	2
3	5	14 × 14	454.30	2
3	5	15 × 15	248.92	2
3	5	16 × 16	178.80	2
3	5	17 × 17	125.02	2
3	5	18 × 18	105.62	2
3	5	19 × 19	80.54	2
3	5	20 × 20	67.00	2

Note: The mean value of 50 runs.

(b) The effects of W-CUL

W-CUL	D-CUL	SIZE	Periods to exit	Criteria to exit
1	5	12 × 12	10.00	3
2	5	12 × 12	165.92	2
3	5	12 × 12	>8000.00	4
4	5	12 × 12	1892.28	2 (in many runs)
5	5	12 × 12	2383.68	2 (in many runs)
6	5	12 × 12	1109.50	3 (in many runs)
7	5	12 × 12	427.76	3 (in many runs)
8	5	12 × 12	376.04	3 (in many runs)
9	5	12 × 12	31.56	3

(c) The effects of D-CUL

W-CUL	D-CUL	SIZE	Periods to exit	Criteria to exit
3	1	12 × 12	10.00	2 and 3
3	2	12 × 12	10.00	2 and 3
3	3	12 × 12	67.86	2
3	4	12 × 12	1631.44	2
3	5	12 × 12	>8000.00	4
3	6	12 × 12	16.00	3
3	7	12 × 12	10.54	3
3	8	12 × 12	10.00	3
3	9	12 × 12	10.00	3

When SIZE is larger than that of the Successful-Case, Criterion 2 is not satisfied. In this case, although the agents move around and communicate with the others at first, they gradually split into groups with same culture and eventually stop moving. As shown in Figure 5, the agents are separated into cultural groups.

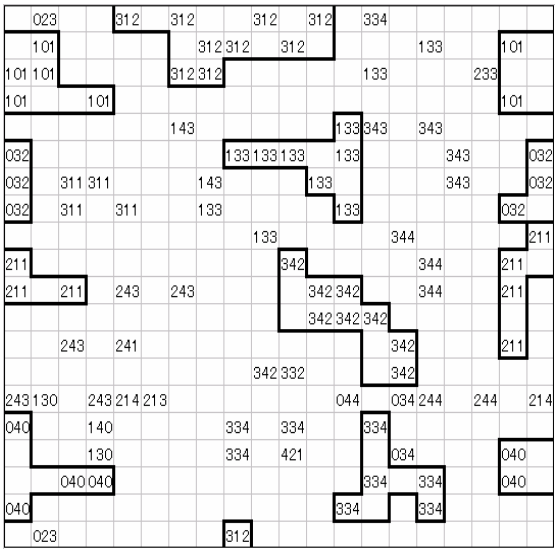


Figure 5: Result of Large SIZE. The number in each cell represents the agent's "culture." Heavy lines are the boundaries of the agent groups having the same culture. This picture shows agents separating into cultural groups.

When W-CUL is narrower than that of the Successful-Case, Criterion 3 is not satisfied (see Table 2 (b)). The case of W-CUL = 1 is similar to SM. Each agent is a member of a cultural group. Therefore, the agents move around but do not communicate with others. When W-CUL is 4 or 5, many runs do not satisfy Criterion 2. The results of these cases are similar to that of the large SIZE. The agents split into several cultural groups and eventually do not move. When W-CUL is more than 5, many runs do not satisfy Criterion 3. In these cases, the agents move around but cannot communicate with the others because of high mutual differences.

When D-CUL is shallower than that of the Successful-Case, Criterion 2 is not satisfied in many cases (see Table 2 (c)). The agents split into cultural groups and end up not moving because of the low mutual difference (DIV= 49.0 at the start in the case of D-CUL = 2). When D-CUL is deeper than that of the Successful-Case, Criterion 3 is not satisfied. As in the case of quite wide W-CUL, the agents cannot communicate because of the high mutual difference (DIV = 87.39 at the start in the

case of D-CUL = 8).

In sum, the combined model shows that the agents move around freely, communicate with one another easily, and retains differences between them under the conditions: SIZE = 144, W-CUL = 3, and D-CUL = 5. As the number of agent is constant (=100), SIZE of 144 means the spatial density of 69.4 percent (= 100/144). This condition of spatial density is a discovery not having been pointed out by the existing two models.

5. Two Japanese firms' cases

I will describe the cases of two Japanese firms introducing nonterritorial offices, focusing on their office density. From the results of the combined model, we can consider nonterritorial offices are successful when the employees move around freely and communicate with various others. I consider office density from two perspectives. The first is, as usual, the number of employees present within a given space (Szilagyi and Holland 1980). The second is the proportion of the number of occupied seats to the total number of seats.

5.1. The successful nonterritorial office and "moderate" office density

The first case is of a company in the telecommunications industry, which I refer to as "X." The company's corporate marketing division originally assigned one desk to each employee and used partitions to hinder the line of vision. In 2001, the division moved to a nonterritorial office. Although several years have passed, it still performed well as a nonterritorial office.

This case is based on interviews, observations of that division's office, and a simple questionnaire survey. I interviewed the executive in charge of the office relocation (the interview lasted for two hours on June 4, 2004), as well as a general manager and two managers of the corporate marketing division (one hour on December 7, 2004). I was allowed to observe the office on the days I interviewed. In addition, I conducted a simple questionnaire survey, consisting of 9 multiple-choice questions on daily behavior in the office and 21 "yes or no" type questions on employees' attitudes[5].

5.1.1. Employees' behavior in the nonterritorial office.

This study clarified that the employees move around daily and communicate with various

[5] This survey was conducted on the web site from August 25 to September 9, 2005. I circulated the survey to about 100 employees of a section of that division, of which 43 responded; 86 percent of them were male, and about 80 percent of them were engaged in sales. Most of them had been in that division for several years.

colleagues. I will show this by focusing on the results of the following five questions in my questionnaire survey:

XQ1: Compared with two days before, did you change your seating position yesterday?

XQ2: Compared with two days before, do you think the people who sat next to you yesterday changed?

XQ3: Why do you and your neighbors sit next to each other?

XQ4: Do you think that the office members with whom you had discussions changed?

XQ5: Does the atmosphere enable you to consult a member of another group (divisions or units) about problems in your business?

Most of the employees engage in sales and do work outside the office; the proportion of employees remaining in the office on a typical day is between 40 percent and 50 percent. Therefore, only 15 percent to 25 percent of the employees stay in the office for two successive days. As a result, only 13 respondents answered XQ1, XQ2, and XQ3. However, we can draw conclusions from these questions because they are supported by other questions, interviews, and the observations in the office.

First, the results of the study suggest that the employees move around in the office daily. About half of the respondents to XQ1 said that they changed their seating positions. The executive said that within three or six months after the move, employees started to position themselves wherever they could work effectively, rather than remaining in the same seat. During the observation of the office, some employees said that they relocated every day.

Second, the results of the study suggest that the employees communicate with various colleagues. To XQ2, about a half of the respondents said that the people sitting next to them changed. For XQ3, about a half of the respondents answered that it was by chance that they and their neighbors sat next to each other. That is, the probability of the employees meeting various others is many, whether they intend or not. Besides, for XQ4, 62.8 percent of the respondents answered that the people with whom they had discussions changed. For XQ5, 90.3 percent of the respondents answered that the atmosphere enabled them to consult with members of other groups. That is, the employees feel that they can communicate with a variety of colleagues rather than being limited to a specific group. These results are supported by the interviews. The employees in the office of Company “X” move about freely and communicate with various other members, as Allen and Gerstberger (1973) report.

The office density is adjusted appropriately in this office. Only 40 percent or 50 percent of the

employees stays in the office because many employees spend most of their time outside the office. At first glance, it might seem that the office density is low. However, this office is so ingenious that it can increase its density, according to the executive I interviewed. The first idea is to reduce the number of desks in the office to 70 percent of all employees. If the proportion of employees staying at the office is 42 percent, the proportion of occupied desks becomes 60 percent by dividing 0.42 by 0.70. In a similar way, the proportion of occupied desks becomes 70 percent if the proportion of employees staying at the office is 49 percent. The idea is to adjust the proportion of occupied desks; that is, the office density to 60 percent or 70 percent. The second idea was to remove the employees' personal cabinets beside their desks, to give employees an appropriate feeling of crowding. Removal of the cabinets shortens the distance to the next desk from 240 to 210 cm, which is enough to see the neighbor's personal computer screen, and this promotes discussion between them.

5.2. The failure of the nonterritorial office and inappropriate office density

The second case is of a venture company in the telecommunications industry, which I refer to as "Y." The company's office was nonterritorial, with no one having a particular desk, and almost no partitions could be seen (the first phase). However, by October 2004, the nonterritorial office ceased to work well (the second phase). Although the company moved to a new nonterritorial office in November 2004, the new office also eventually ceased to work well (the third phase).

This case is based on simple questionnaire surveys, some interviews, and observations of the company's office. At first, I conducted questionnaire surveys about two weeks before the move (mid-October, 2004), and again about three months after the move (end of January 2005). The questionnaires were identical, with 65 "yes or no" type questions on the atmosphere and behavior in the office[6]. I also conducted 20 interviews with 11 people (45 minutes to one hour each) from September 2004 to November 2005[7]. In these interviews, I asked about their work patterns and their attitudes in the office. In addition, I observed the employees' behavior in the office about twice a week from October 2004 to March 2005.

5.2.1. The first phase: Employees' behavior in the office until the summer of 2004.

[6] I administered the pre-move survey to 51 employees and obtained 48 respondents; and post-move survey to 50 employees and obtained 41 respondents. 86 percent of the respondents were male. About 60 percent of them are engineers. About 60 percent of them are regular staff. There was no significant difference between the proportions in the pre-move survey and those in the post-move survey.

[7] From the point of status, the interviewees are executives, general managers, managers, or ordinary employees. From the point of affiliation, they belong to sales, engineering, or administrative affairs.

At Venture Company “Y,” it was the top management that decided to introduce a nonterritorial office. According to interviews with a company executive and the company secretary in September 2004, it was necessary as a top management to offer an environment, in which employees were able to work comfortably and freely. Therefore, right from the time when the company was established, they distributed a notebook computer and a cellular phone to each employee, and enabled the employees to work anywhere. They showed me their office, in which no one has a specific desk and no walls or partitions could be seen. When I told them about the office of Company “X,” they said the office was similar to their own.

The nonterritorial office of Company “Y” seemed to work well until the summer of 2004. As the number of employees was about 30 in the spring of 2004, and as there were vacant seats and plenty of spaces, the employees were able to move and work anywhere they liked. They also communicated with a variety of members. Indeed, in the interviews, a manager said that when he joined the company in January 2004 he was told to change his seating position daily, work near various employees and learn how they did their job. Another employee said that, as Company “Y” had an atmosphere similar to group activities at school, the employees got together and dispersed flexibly in each project, and communicated with one another while developing their projects. Therefore, the employees’ behavior in the office at the time corresponds to the report of Allen and Gerstberger (1973).

5.2.2. The second phase: Employees’ behavior in the office in October 2004.

The company had outgrown its office by October 2004. The number of employees in the office increased to about 50 by October, and the office density became too high. The high office density restricted the employees’ freedom of movement. This is shown in the questionnaire survey (see Table 3). I asked the respondents whether they thought it was difficult to stand up and move around in the office (YQ1), to which 23.4 percent answered yes, although no one was expected to answer yes to this question. I also asked whether there was enough space to gather together at once if necessary (YQ2), to which 66.0 percent of the respondents answered no. These results are supported by the interviews and observations of the office at the time. In the interviews, an employee said that he and his project members had to go to a restaurant outside the office to discuss, because there was little space to gather in the office. In the observations at the time, employees coming to work late had few alternatives of seating position. Therefore, each employee thought it difficult to move around freely in the office in October 2004.

Table 3：Questionnaire survey results of the employees in Company "Y"

(a)

YQ1: Do you feel it difficult to stand up and move around in the office?

	Yes	No	Total
Pre-move	11	36	47
	(23.4)	(76.6)	
Post-move	4	37	41
	(9.8)	(90.2)	
Total	15	83	88

$\chi^2 = 2.885$, Cramer's V = 0.181 †

(b)

YQ2: Is there enough space to gather at once if necessary?

	Yes	No	Total
Pre-move	16	31	47
	(34.0)	(66.0)	
Post-move	36	5	41
	(87.8)	(12.2)	
Total	52	36	88

$\chi^2 = 26.183$, Cramer's V = 0.545**

(c)

YQ3: Is the atmosphere helping you to consult a member of another group (divisions or units) about problems in your business?

	Yes	No	Total
Pre-move	42	6	47
	(87.5)	(12.5)	
Post-move	25	16	41
	(61.0)	(39.0)	
Total	52	36	88

$\chi^2 = 8.360$, Cramer's V = −0.306**

Note: † p< .1; * p < .05; ** p < .001

5.2.3. The third phase: Employees' behavior in the new office since November 2004.

Because of the scarcity of space in the previous office, the company moved to a new office on November 1, 2004. Although the new office is similar to the previous one in terms of its

nonterritorial setting, it is different in its large space. This is shown in the results of the post-move questionnaire survey (see Table 3). For YQ1, only 10 percent of the respondents answered yes, and this shows a significant decrease at the 10 percent level with the pre-move survey. For YQ2, 90 percent of the respondents answered yes, and this shows a significant increase at the 1 percent level. The observations of the new office in November 2004 revealed that the employees used only half the office space.

The new nonterritorial office, however, has failed in the employees' movement According to the observations, the employees tended to establish their own seats and workspaces more than ever before. They drew up a seating chart, which means each of them had their own desk. They also made their own workspace comfortable at their own judgment. For example, some employees bought liquid-crystal displays with their own funds and put them on their desk, whereas before the move they had had nothing on their desks apart from their notebook computers. Because the displays are immovable, no one else could use their desks.

The new nonterritorial office has also failed in the employees' communication. According to the questionnaire surveys, the employees tended not to communicate across work groups. For YQ3, about 40 percent answered no, and this shows a significant increase at the 1 percent level from the results of the pre-move survey (see Table 3). This is supported by the interviews, in which I heard that the office became too large for the employees to get a glimpse of others at work and to hear useful information (see Appendix). Besides, the comments suggesting that each work group has evolved its own rule or pace were heard in the interviews (see Appendix). When I put these comments together, the large office space would promote each group's development of rules or pace, and once each team has its own rules or pace, employees found it difficult to communicate across the groups.

6. Discussion: implications of the combined model for office management

From the combined model and the cases of the two firms, we can draw a suggestion; nonterritorial offices succeed under "moderate" office density (69.4 percent) and fail under extremely "high" or "low" office density. The optimum office density of 69.4 percent offers practical suggestions for nonterritorial office design and management. If only half of the employees stay at the office, we should achieve the optimum density either by using a small office or by creating a close seating arrangement. If all employees stay at the office, we should use an office that is 1.5 times larger than the existing one. In this case, introducing a nonterritorial office leads to an increased

facility cost in the short run.

This paper is one of the few studies to consider the effects of office density on human behaviors in nonterritorial offices. The office density has been considered as a factor influencing human behaviors in offices. Many studies on the effect of the office density on communications in a non-partition setting can be seen. For example, Szilagyi and Holland (1980) report that, in a non-partition office, high office density increases the chance to communicate with neighbors. Oldham (1988) reports that, in a non-partition office, low office density limit interactions with neighbors. However, there are few studies on the effects of the office density on not only employees' communications but also their movements in nonterritorial offices (non-partition and free-address setting).

Several limitations of this study must be mentioned. First, this paper focuses on the movements and communications of employees, and does not consider the effects of their privacy, identity, job satisfaction, etc. Some previous studies on the non-partition setting suggested that these factors have effects on employees' behaviors (Oldham and Brass 1979, Hedge 1982). Second, the agents of the model in this paper have the same rules, and the effects of types of work are not considered. Some previous studies on open-plan setting insist that differential effects across types of work, organizational positions, and job complexity can be observed (Hedge 1982, Sundstrom et al. 1982, Zalesny and Farace 1987, Carlopio and Gardner 1992).

7. Conclusion

The combined model of this paper offers a new explanation of social differentiation. The model was developed by combining the two typical models of social differentiation: CDM and SM. This model has a space of non-partition and free-address setting and has rules of communication and movement. Though these settings and rules tend to lead convergence, the agents of this model can retain their differences while moving around and communicating with one another under some conditions. One condition is the spatial density of 69.4 percent. When spatial density is higher, the agents cannot move around freely. When spatial density is lower, the agents split into several stable clusters. The agents do not move around and do not communicate across the clusters. The existing two models have not pointed out the spatial density as a factor behind social differentiation.

These results of the combined model are supported by the cases of the two Japanese firms introducing nonterritorial offices. In office management, a non-partition and free-address setting is called nonterritorial office. Nonterritorial offices are considered to be successful if the employees

keep moving around and communicating with many others and retain the differences of their thoughts, because their introduction is for knowledge creation. The first firm's nonterritorial office performed well. Its office is so ingenious that the density is appropriate. The second firm's nonterritorial office worked well in the first phase. In the second phase, however, the company outgrew its office, and the nonterritorial office worked less than it used to. The employees could not move around freely in the high-density office. Although the company moved to a large nonterritorial office in the third phase, the new office was not effective either. The employees split into several groups, did not move around, and did not communicate across the groups very well in the low-density office.

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Appendix

The results of the questinnaire surveys at Company “Y” show that the employees tended not to communicate across work groups. This is supported by the interviews, in which I heard the following comments.

Comment 1: “In the previous office, I knew instantly what incidents occurred in other groups because I could see how others were working. In addition, I was aware, however vaguely, of how other projects were progressing because discussions from other groups could be overheard. However, it became difficult now to see what others were doing and to hear what others were discussing.”

Comment 2: “I cannot see what problems other groups faced with.”

Comment 3: “The office became quiet after the move.”

Comment 4: “In the previous office, I could see other peoples’ painstaking ways of working, and a healthy rivalry was stirred up. However, in the new office, I was unable to see those with whom I possess a sense of rivalry.”

These comments suggest that the office became too large for the employees to get a glimpse of others at work and to hear useful information.

Other interesting comments were heard in the interviews. These comments suggest that each work group has evolved its own rule or pace.

Comment 5: “In the previous office, employees never thought help from another project team as interrupting. In the new office, however, each team developed its own rules and employees started to feel that help from other groups was bothersome because it did not follow their own rules.”

Comment 6: “I went to lunch with members of other workgroups in the previous office. After the office move, each group works at its own pace. As a result, I go to lunch with the members of my own group when I reach a stage where we can take a rest.”

These comments suggest that each team has evolved its own rule or pace. When we put the first four comments together, the large office space could be seen as promoting each group’s development of rules or pace. Once each team has its own rules or pace, employees would find it difficult to communicate across the groups.