Formation of Social Norms in Communicating Agents with Cognitive Frameworks

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Abstract

This article deals with the process of formation of norms in societies in which individuals act according to their own cognitive framework under communication. The individuals acquire information from others and interpret it. The way of individual's action is revised through changing the source of information and reforming the method of interpretation. Through the revising mechanisms, assemblages sharing cognitive frameworks establish. At first individuals adopt the same source of information and then arrange the shared cognitive framework. The assemblage are considered as groups with common norms, since the same cognitive framework gives actions coherency. In the process of formation the two revising mechanisms function in turn. The intensity of interaction among individuals affects the period to build norms and the size of groups sharing norms. The size develops under strong interaction but the period comes to long. The dependency of average size of norms on the strength is a power.

Keywords: Formation of Norms; Cognitive Framework; Multi Agent Model;

1 Introduction

We study how individuals' actions form social norms and the actions are affected by the norms in a social system. Action is a set of oriented processes [1], namely individuals[1] act toward some objects, whether intentionally or unintentionally. Orientations to objects from individuals are conceived as structured or patterned in a social system. Namely, there are some consistencies or regularities between the orientations and actions of different individuals[2]. The structure forms the ground of the social system. We define the norms here as entities giving the consistencies or regularities in orientations to objects or actions among individuals (Fig.1).

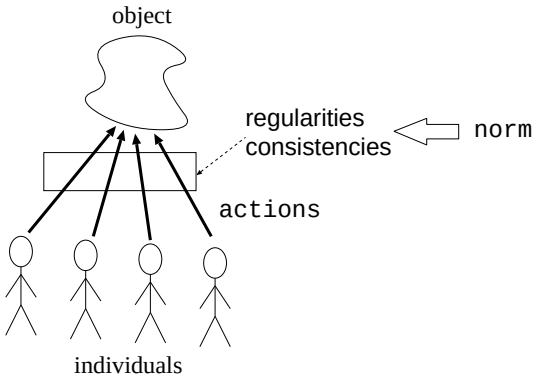


Figure 1: The norms in a social system. They give some regularities or consistencies in actions to some objects among individuals in a social system.

We can categorize the norms into external and internal ones in terms of the cause of the regularities. Rules and lows in societies or sanction by others construct the regularities in actions with their force to conform individuals to the order in a society. They have the external regulatory function and are called the regulative norms. In addition to this type of norms, we can find another aspect in norms. Since actions and orientations are based on subjective meaning of objects, the cognitive framework of individuals give some consistency of the world to the individuals and compose the patterns in actions. This is identified as the internal function and called as the cognitive norms[2].

Our central concern here is the cognitive norms. The methodology adopted in this paper is multi-agent simulations. There exist some simulation studies

[1]In this paper, we treat individuals' subjective interpretations of information and their actions based on the interpretations. Therefore the terms individual, subject and agent are used as the same meaning.

[2]Scott[3] has described the category of institutions as the regulative, normative, and cognitive ones. In our context, the norms and institutions are considered as having the same functioning. The regulative and cognitive institutions in Scott's categorization correspond to the external and internal norm, respectively, in our context.

about the norms [10, 11, 12, 13, 14]. They have mainly treated the external one by focusing on how sanctions or rules work for establishing norms. In contrast, we focus on the process of formation of the internal consistency and the external regularity of actions among individuals in a society.

A harmonious uniformity in the way of interpreting information is a source of the internal consistency among individuals. In usual societies, individuals obtain various information, interpret it and act according to the information interpreted. The way of interpreting information depends more or less on each individual. However, it is hardly isolated, since it continue to vary under influence of the results of actions and communication with others. The pattern of actions in a society may become internalized as part of the individuals orientations [1].

When we think of an individual as a system, it is a cognition-action system which obtains signals as inputs and interchange them with actions as outputs. Actions consist of orientations and approaches to objects. The objects may be external environment, entities, other individuals, or the individual system itself. The inputs to the system is obtained through observation, communication, imitation of others or introspection. Individuals interpret the inputs as information and give subjective meaning at the process of interchanging. Since the consistency in interpretative methods gives regularity in actions, the way of interpreting the external inputs is one of the cognitive norms.

We should take account of communication between individuals and information senders. In social actions in the modern societies, we hardly observe objects of action directly. We usually get information about the objects from others, mass media, or some agents. For example, suppose a situation in which a merchant handles some goods which revenue depends on the result of an election on the next Sunday. He/she reads newspapers carefully and decides how many goods he/she buy in. In this example, the communication occurs between the merchant who is the information receiver and the newspaper who is the information supplier, although it is one way. He/she should appropriately interpret information from the newspaper.

The situation involving communication between individuals is schematically characterized in Fig. 2. The scheme become more complex than that of in Fig. 1. Another kind of agent, called the information suppliers or senders, appears in the social system.

In this article, we regard information as fundamentally imperfect[3]. Because there must be a limit of subjectivity and ability of human cognition, we have no way of confirming whether or not we understand what information from senders really means. We can not assume even the existence of the mutual knowledge or the shared code for interpretation between the information suppliers and receivers [5]. Since the information suppliers also interpret the information which they have got, the interpretation by the information receivers involves guessing the cognitive frameworks of the suppliers.

To act well under fundamentally imperfect information, each individual

[3]The fundamental imperfectness of information is discussed in [4] more thoroughly.

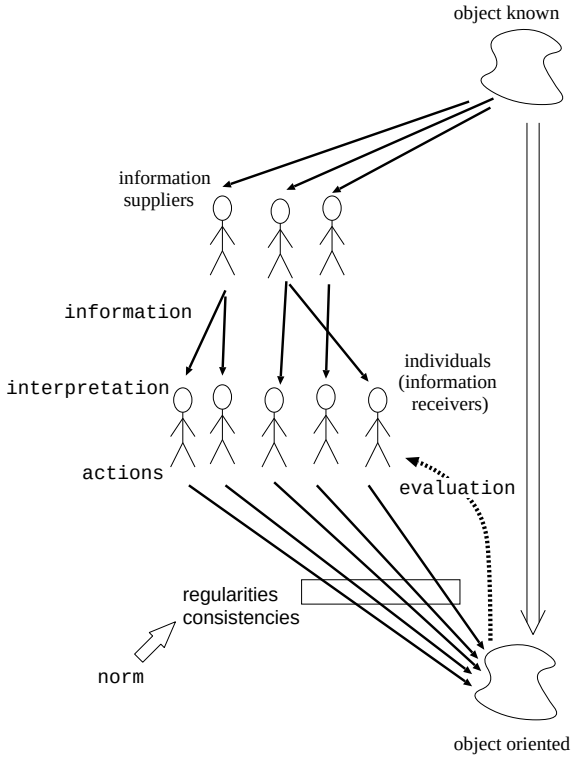


Figure 2: Individuals get information about an object from information suppliers and interpret it, They act according to the interpretation. The actions are evaluated in terms of the object oriented.

should improve his/her way of action. One way to do is inferring the interpretative framework of the information supplier according to the outcome of his/her own action. The action is evaluated in the objective situations. In the above example, the merchant knows whether his/her decision is appropriate or not by the actual sales of the goods after the election. If his/her action is not apposite, he/she should change his/her way of interpretation of the articles in the newspaper. He should improve his/her way by guessing and learning by himself.

Another way to improve actions is to change the information suppliers. It is based on the observation of other individuals' action. In the above example, the merchant looks how the other merchants act and then imitates the way which a merchant who gets better results does. We should note that we can directly imitate only externally observable behaviour, in the example what newspaper the better merchant subscribes. He can not imitate the way to interpret the newspaper. Because of this essential limit of observation ability, to mimic the

others action may cause a change for the worse. When an individual changes his/her information supplier by mimicing the other individual, he/she cannot gain a good result without preparing a suitable cognitive framework to that of the supplier. As we have mentioned, there is no assurance that the framework is the same with the individual whom he/she imitated. Furthermore, we can not assume in the full conviction that the previous method works well for the new supplier. If we made effort to improve the cognitive framework to be suitable for the former supplier, the effort may come to naught.

To summarize, we should consider two kind of interaction among individuals. The first is the communication between the receivers and suppliers of information. The second is imitation of actions among individuals. In the orthodox economics, individuals are supposed to be isolated and to be able to decide their actions by themselves. The game theory shows that others' action affect the isolated agent's decision making [6, 7]. New Institutional Economists have correctly pointed out that social institutions are established as a result of interaction of human action [8, 9]. However, in new institutional economics, the cognitive framework of each individual is treated as fixed. When we consider the role or function of the cognitive norms in social systems, it is important to take into account the changes of individual's interpretation of information because while the social norms come from interaction of individual action, they affect formation of the cognitive frameworks.

In the next section we formalize the problem addressed here with a multi agent system. The results of simulation of the system is reported in the third section. By analyzing the collective structure and its dynamics, we show that the agents construct cluster structure, which supports the cognitive norms of agents. We investigate the effect of the interval to revise the cognitive framework on the dynamics and structure of norms. From the investigation, it is revealed that the size of clusters has a power low dependency on the interval. The fourth section is devoted to the discussion on our model and results. The conclusion is stated in the last section.

2 Model

We construct a multi agent model to express the situation described in Fig.2. This section explains the model[4].

2.1 The agents and the world

There are two kind of agents, information suppliers and receivers. Each one has his/her own cognitive framework which is used to interpret information that he/she gains. The receivers act toward objective situations in terms of the information interpreted.

[4]The present model have become simpler than one studied in [4]. In order to focus on the formation of norms in information receivers, we omit the dynamics of information suppliers and the probabilistic chance to change the cognitive framework of receivers.

The world of our model consists of objective situations and two layers with $W_X^S \times W_Y^S$ and $W_X^R \times W_Y^R$ cells, for the suppliers and receivers, respectively, as illustrated in Fig.3. Each cell in one layer is occupied by a receiver and the other by a supplier. The boundaries of the cell-planes are periodic.

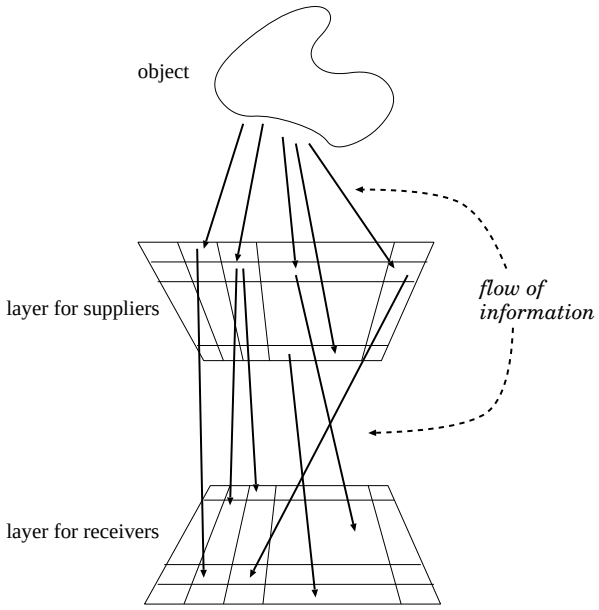


Figure 3: The configuration of the object and agents in our model.

2.2 Information flow

Information flows from the objective situations to the receivers through the suppliers.

The flow is represented as follows using formalized expressions:

- An objective situation consists of L aspects. Each aspect has two states, 0 or 1. The objective situation is expressed by a vector $\boldsymbol{o}$,

$$\boldsymbol{o} = (o_1, o_2, \cdots, o_L) \ .$$

- The information suppliers observe and interpret the objective situations, namely they get information about the objective situations directly. The cognitive framework of a supplier, denoted by $\boldsymbol{f}^S$, is expressed by a bit string with length L,

$$\boldsymbol{f}^S = (f_1^S, f_2^S, \cdots, f_L^S).$$

Each elements corresponds to the each aspect of the objective situation.

The way of interpretation is implemented by XOR bit operation which is defined as

$$\mathrm{XOR}(x,y) = \begin{cases} 0 & (x = y) \\ 1 & (x \neq y) \end{cases}$$

The information about an objective situation, $\boldsymbol{o}$, interpreted by a supplier is

$$\boldsymbol{I}^S = \mathrm{XOR}(\boldsymbol{o}, \boldsymbol{f}^S) \ ,$$

where $\mathrm{XOR}(\boldsymbol{o}, \boldsymbol{f}^S)$ means that XOR operation is applied to each corresponding pair of elements.

- Each information receiver selects a supplier as the source of information about the objective situations. He is afforded the information which he interpreted by the supplier who is select by him/her.

  The receiver interprets the information afforded in terms of his/her own cognitive framework, denoted by $\boldsymbol{f}^R$. It is expressed also by a bit string with the length L,

  $$\boldsymbol{f}^R = (f_1^R, f_2^R, \cdots, f_L^R) \ .$$

  The interpretation way uses also XOR operation for receivers. The information interpreted by a receiver is

  $$\boldsymbol{I}^R = \mathrm{XOR}(\boldsymbol{I}^S, \boldsymbol{f}_i^R)) \ .$$

- Action by each receiver is supposed to directly reflect information interpreted.

  $$\boldsymbol{a} = \boldsymbol{I}^R \ .$$

The information flow is illustrated in Fig.4.

2.3 Evaluation and change of the cognitive framework

After the decision of action, the action is evaluated by the bit matching between the action $\boldsymbol{a}$ and the object situation $\boldsymbol{o}$. The score of a receiver, denoted by P, is the number of bit matched.

$$\begin{aligned} P &= \text{the number of bit which } a_i = o_i \\ &= \sum_{i=1}^{L} (1 - \mathrm{XOR}(a_i, o_i)) \end{aligned}$$

After the evaluation, each receiver compares his/her score with neighboring eight receivers. If a receiver has the lowest score alone in the neighbour, then a randomly selected element in his/her cognitive framework, $\boldsymbol{f}^R$, is flipped.

When a receiver stays at the bottom alone during longer than r times continuously, he/she switches the supplier to one who is employed by the best

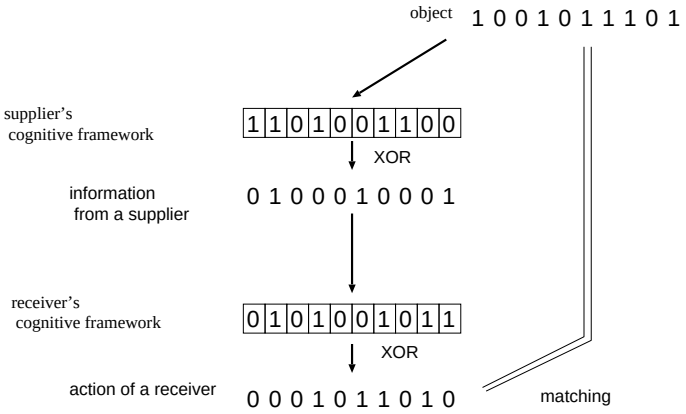


Figure 4: Information flow from an object to a supplier and then from a supplier to a receiver.

receiver in his/her neighbours. If more than one receiver has the best score, one of them are selected randomly. Otherwise, receivers' cognitive frameworks and their suppliers do not change. The parameter r is called 'the interval of revision', since it reflects how often receivers observe their neighbours.

2.4 Algorithm for simulation

We summarize the procedure of simulation. One sequence of the following procedure is called 'one turn', which is denoted by t.

1. The objective situation, $\boldsymbol{o}$, is randomly generated.
2. The information flows from the object to the receivers through the suppliers. Each receiver decides his/her action.
3. The action is evaluated for all receivers.
4. The receivers who satisfy the condition described in §2.3 change their cognitive frameworks and suppliers.
5. The score of all receivers are cleared, the turn t is incremented and go to 1.

3 Simulation Results

The significant results of simulations are clarified in this chapter. The size of the world is $W_X^S = W_Y^S = W_X^R = W_Y^R = 20$. Therefore the number of both suppliers and receivers are 400. Each one is indexed by l for suppliers, and k for receivers. The number of aspects in an objective situations and the length of the

framework of both receivers and suppliers are $L = 10$. The initial framework, $\boldsymbol{f}_k^R$ and $\boldsymbol{f}_l^S$, are randomly composed for all agents. The frameworks of suppliers are fixed on the initial state in the course of a simulation. Each receivers adopts his/her initial supplier at random.

3.1 Dynamics of the System

3.1.1 Score

At first, we observe the average score for all receivers, defined by

$$\langle P \rangle = \frac{\sum_k P_k}{W_X^R \times W_Y^R} \ .$$

The score P_k appraises how kth receiver appropriately behaves for objective situations. In the present settings, it is synonymous with how he/she construes information from the suppliers. Furthermore, it is the same with the degree of coincidence between the framework of the receiver, $\boldsymbol{f}_k^R$, and that of the supplier selected by him/her, $\boldsymbol{f}_k^S$, since we substitute the interpretation process by XOR operation for both the receivers and the suppliers. An example of the transition of the average score $\langle P \rangle$ is shown in Fig.5.

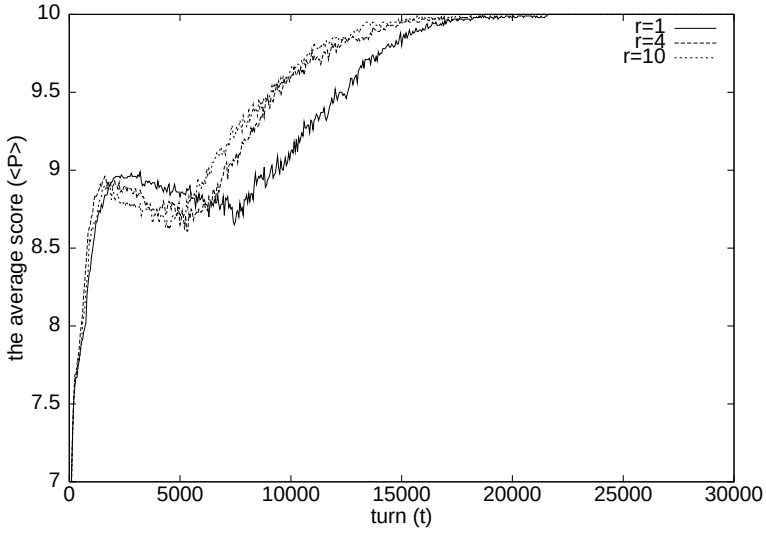


Figure 5: Time series of the average score of receivers for $r = 1, 4, 10$.

The course of change of the value is divided into four phases. The first one is the monotonic increase toward about $\langle P \rangle \cong 9$. It rounds to the decrease direction at around 2000th turn and continues to go down until $t \cong 5000 \sim 7500$ (2nd phase). Then, it ascends between $t \cong 5000$ and 20000 (3rd phase) and

eventually achieves a maximum score around 20000th turn. Finally, the system reaches a stationary state (4th phase).

3.1.2 Suppliers and cognitive frameworks

In order to consider what occurs in the four phases, changes of the framework and the supplier by each receiver are assessed. In the course of the simulation, receivers change their adopting suppliers. In other words, the suppliers change their clients. We can estimate the transition of the number of receivers who change suppliers by observing the average number of clients, since the number of clients changes when a receiver switches his/her supplier[5]. The number of clients of lth supplier is written as c_l and its average is defined by

$$\langle c \rangle = \frac{\sum_l c_l}{\sum_{l(c_l \neq 0)}} \ ,$$

where the denominator is the number of suppliers who are adopted by at least one receiver. We count the number of receivers who change their frameworks, which is denoted by n^f, and the accumulated number of receivers who change their suppliers, denoted by n^s. The transitions of $\langle P \rangle$, $\langle c \rangle$, n^f and n^s for $r = 1$ are shown in Fig. 6.

In the first phase ($t \cong 0 \sim 2000$), $\langle c \rangle$ and n^s increase. The receivers' selection of suppliers concentrates on around one of ten suppliers and the other suppliers lose their clients. This is the first expansion period of popular suppliers. On the other hand, n^f decreases in this phase. By selecting adequate suppliers, most of receivers can perform fairly well ($\langle P \rangle \cong 9$) and do not need to change the framework, while receivers search appropriate frameworks.

During the second phase ($t \cong 2000 \sim 7500$), the performance is getting worse. The value of n^s rises but the growth rate is lower than that of in the first phase. This is because many receivers have the same degree of scores and do not find ones with the better performance among their neighbours.

Fig. 7(a) shows the transition of framework of receivers for $r = 1$. A line is a history of framework of a receiver. We plot the bit string of a framework by regarding as a binary number. The history of framework of all receivers are superposed. The same kind of plot for the suppliers adopted by receivers is Fig. 7(b). In this figure, each supplier is expressed by the coded index l^c. The code of a supplier l is calculated as

$$l^c = (x_l^S - 1) \times W_X^S + y_l^S - 1 \ ,$$

where x_l^S $(1 \leq x_l^S \leq W_X^S)$ and y_l^S $(1 \leq y_l^S \leq W_Y^S)$ represent the position of lth supplier in the suppliers' plane.

We can see from Fig. 7 that few receivers change the suppliers and not all receivers change their frameworks in the second phase. In addition to the

[5]There are some cases that the change of suppliers does not reflect on the change of average number of clients. For example, when the same number of receivers moves between two suppliers at the same time.

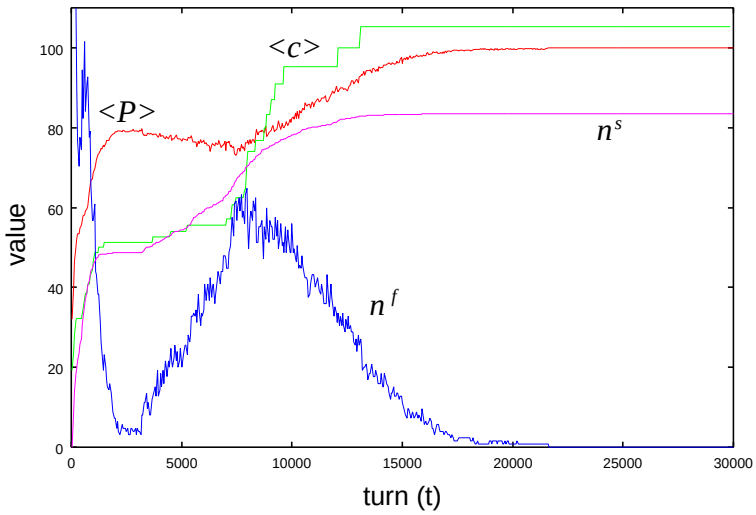


Figure 6: Time series of the average score, $\langle P \rangle$, the average number of clients of suppliers, $\langle c \rangle$, the number of receivers who change their framework, n^f, and the accumulated number of receivers who change their suppliers, n^s. The interval of revision is $r = 1$. Each values are appropriately scaled to easily compare the relative dynamics.

observation, the fact that the growth rate of $\langle c \rangle$ is lower than that of n^s in Fig. 6 shows that receivers who switch their suppliers adopt non-popular suppliers or that the switch occurs among popular suppliers. These types of change require large change of cognitive framework for the receivers to perform well. Therefore n^f surges rapidly. Since 90% of the frameworks are correctly configured at the previous phase, it is difficult to search the residual 10% by random bit flipping. Resultingly, the performance comes down rather than improvement.

Judging the increase of $\langle c \rangle$ with the large rate in the third phase, the popular suppliers again enlarge their influence. This phase should be divided into two at $t \cong 13000$. After this turn, the receivers do not switch the suppliers and make effort to do well by only modifying their frameworks by themselves. Eventually, after $t \cong 22000$, all receivers perform at the highest level and no change occurs. It is the fourth phase.

We can summarize the dynamics of receivers as follows. At first the receivers use both internal change of frameworks and switching suppliers in the first phase. Then the change of frameworks and the suppliers function alternately. Finally they attain the full marks by changing the frameworks.

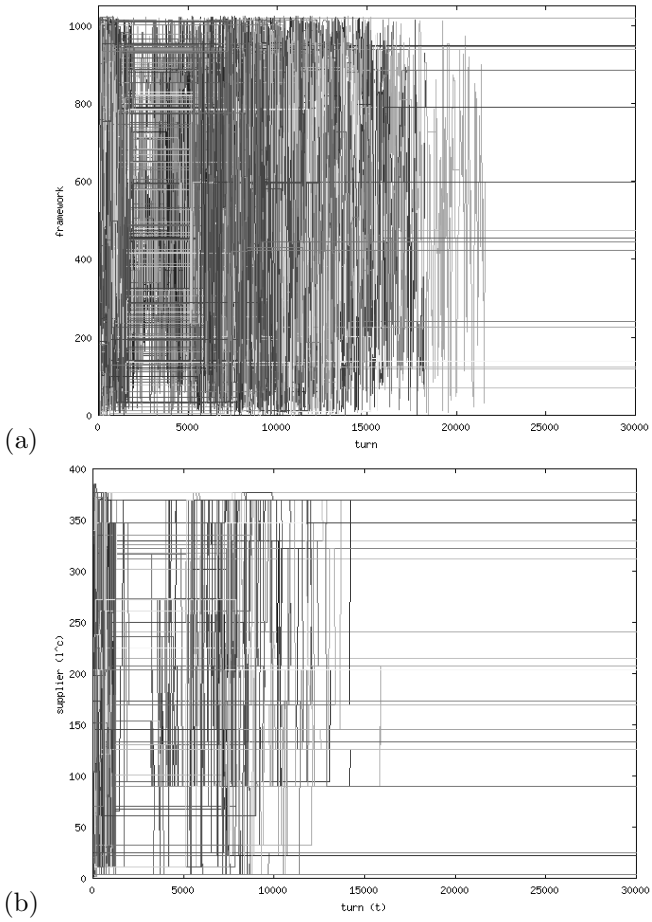


Figure 7: History of the cognitive frameworks of all receivers (a) and the supplier selected by the receivers (b). The horizontal axis is turn t. The vertical axis of (a) depicts the cognitive frameworks as binary numbers. That of (b) shows the coded suppliers selected by all receivers. The interval of revision is $r = 1$.

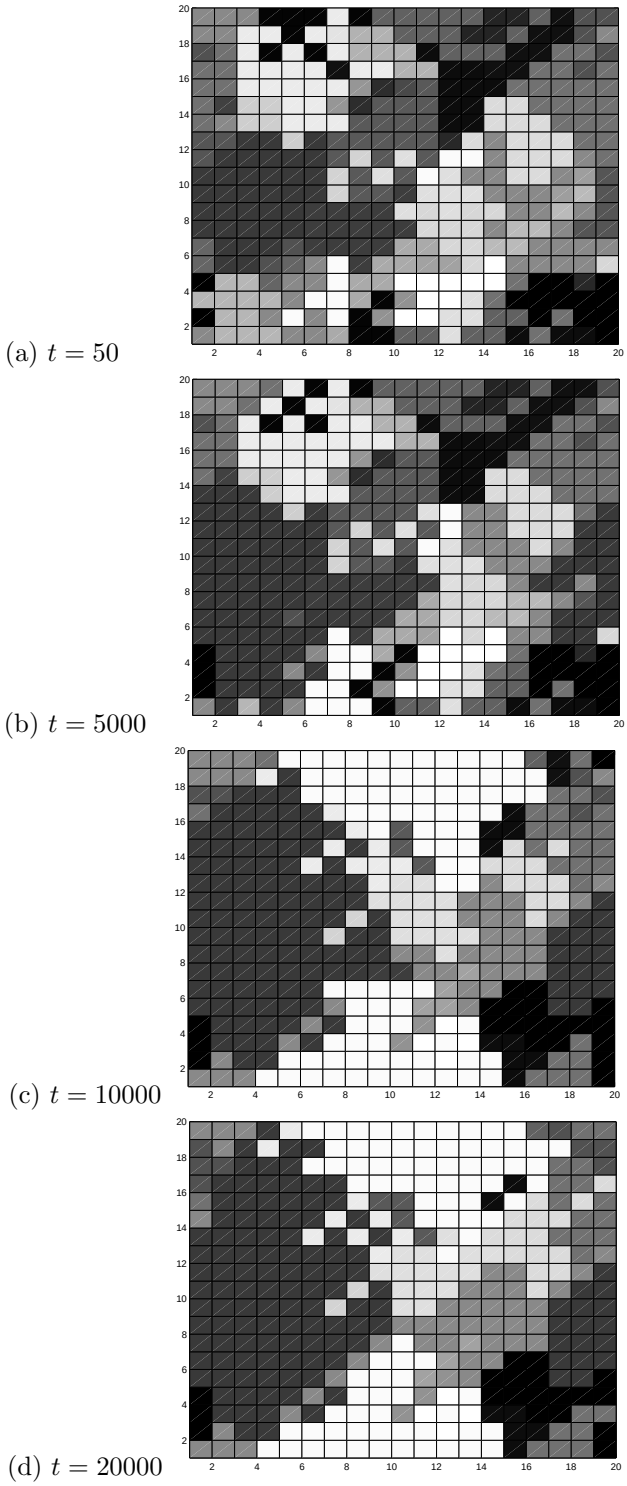


Figure 8: Transition of the distribution of suppliers adopted by the receivers at turn t =50 (a), 5000 (b), 100000 (c), and 200000 (d) for $r = 1$. The figures express the receivers' plane. Each cell displays the supplier whom a receiver employs. An area with the same brightness denotes that the receivers in the area employ the same supplier.

3.2 Clustering

From the observation in the last subsection, the receivers converge finally into some groups adopting the same supplier. We can conclude that the receivers make clusters in the two aspect as in Fig. 7. One is the selection of suppliers and the other is the configuration of cognitive framework.

We inspect the spatial structure of the clusters and their change. Figure 8 depicts the transition of distribution of suppliers adopted by receivers for $r = 1$. The receivers in a region with the same color in this figure employ the same supplier. From the random distribution at the initial state, clusters grow in size and eventually it converges on some major ones at around $t = 10000$. Few changes occur after 10000th turn. The cluster formation is caused by the action of revision by the receivers to adopt the same supplier as the top scored receiver in their neighbour.

Figure 9 is the same type of snapshots for the cognitive framework. In spite that the receivers can not directly observe the others' cognitive frameworks, they form the clusters in their frameworks which gradually become uniform in a cluster. The transition of the spatial structure in the clusters of the cognitive framework chases that of the selection of suppliers. Finally the structure of the former accords with that of the latter.

3.3 Effect of the Interval of Revision

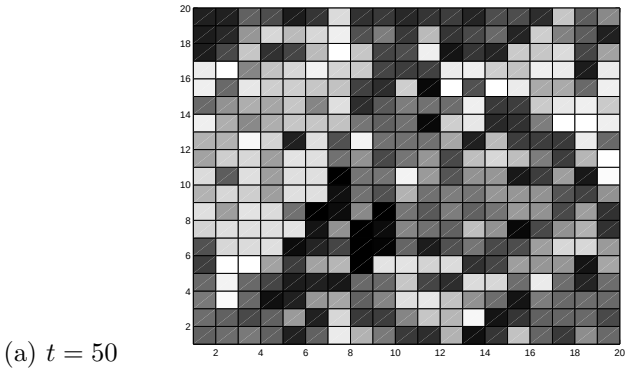
While the dynamics reported in the previous sections are common in all intervals of revision, the turn to switch the phases depends on the parameter. It is likely that each turning over becomes late for the small value of r as shown in Fig. 5.

When the interval of revision is short, receivers purpose to improve their performance by switching the suppliers more often rather than by modifying the frameworks. This results in the difference of extrema of n^f as shown in Fig. 10. The minima of it at the end of the first phase are smaller for the longer interval of revision. This fact retards the phase change from switching suppliers to modifying frameworks. The maxima at the end of the second phase are also smaller for the shorter interval of revision.

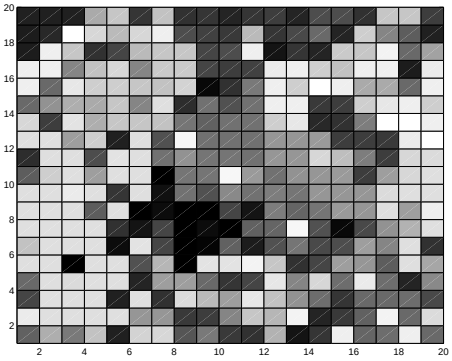
The spatial expansion of clusters implies that the change of suppliers are frequent at the boundary of clusters. Improving the score is hard work for receivers at boundaries of clusters if they switch their suppliers very often. The receivers at the boundaries are likely to adopt the different supplier from the previous one. The action of switching suppliers is not necessarily rational for receivers, at least in short term, because, when they change suppliers, they must abandon their effort to adapt to suppliers whom they have selected. This effect at the boundaries of clusters is stronger for the shorter interval of revision than the longer one.

The smaller the value of r is, the longer the duration of the second expanding period for the popular suppliers is (Fig. 11), and the larger the value of $\langle c \rangle$ is in all time regions.

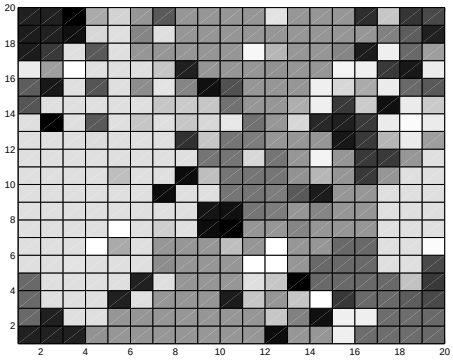
The curve of $\langle c \rangle$ is like the logistic curve between the second and fourth



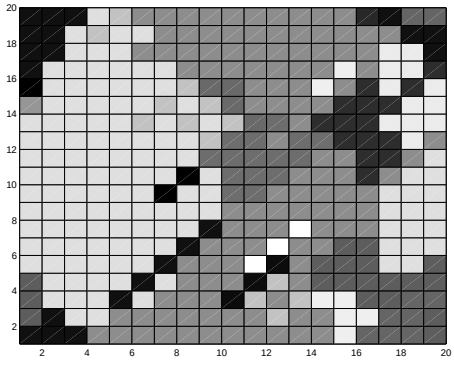
(a) $t = 50$



(b) $t = 5000$



(c) $t = 10000$



(d) $t = 20000$

Figure 9: Transition of distribution of the receivers' cognitive frameworks at turn t =50 (a), 5000 (b), 100000 (c), and 200000 (d) for $r = 1$. An area with the same brightness denotes that the receivers in the area has the same framework.

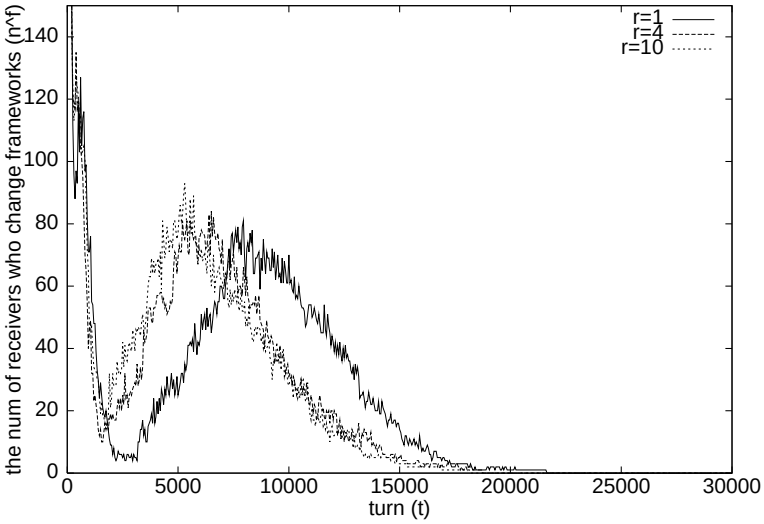


Figure 10: Time series of the number of receivers who change cognitive frameworks n^f for $r = 1, 4, 10$.

phases as in Fig. 11. The curve in these phases are approximated by

$$\langle c(t)\rangle = \frac{\langle c\rangle_{\max}}{1 + e^{-\frac{r_0}{r}t}} \ ,$$

where $\langle c\rangle_{\max}$ is the maximum of $\langle c\rangle$, namely $\langle c\rangle$ at the end of the third phase, and r_0 is a parameter to adjust the approximate curve to the actual data. The slope of the curve at the third phase is decided by r. The smaller r is, the steeper the curve is. The formulae of the approximated curve comes from the logistic equation

$$\frac{d\langle c\rangle}{dt} = \frac{r_0}{r}\langle c\rangle \left(\frac{\langle c\rangle_{\max} - \langle c\rangle}{\langle c\rangle_{\max}}\right) \ .$$

As from this equation, r_0/r is the proportional coefficient and is related to the strength of interaction of the receivers between inside and outside of a cluster. The large value of r_0/r means the strong interaction. Since the change of suppliers is induced by surveying the neighbours, it is natural to consider r as the control parameter of intensity of interaction among receivers.

3.4 The size of clusters

Since we have confirmed that the value of the interval of revision, r, changes the intensity of interaction, the dependency of the size of clusters on the value is interested. The maximum size of clusters, denoted by $c_{\max}$, as a function of

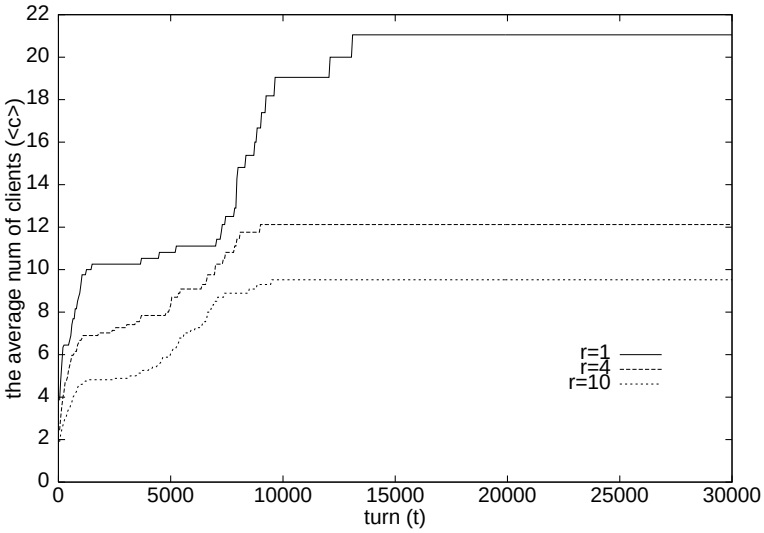


Figure 11: The transition of the average number of clients $\langle c\rangle$ for $r = 1, 4, 10$.

the interval of revision is shown in Fig. 12. The calculation for the maximum is done for 200 simulation runs with the same parameters and different initial conditions. The graph (Fig. 12) is drawn by averaging the results of 200 runs. The maximum size of cluster is approximately a monotonic decrease function of r. We find that it depends on r logarithmically as

$$c_{\max} = -a\ln(r) + b \ ,$$

where $a = 13.41, b = 79.06$.

We also evaluate the dependency of the average size of clusters on r. The result of this calculation is exhibited in Fig. 13. Different from $c_{\max}$, we confirm that the relationship between the interval of revision and the average size of clusters is a power low,

$$\langle c\rangle = b' r^{-a'} .$$

(The value of a' is 16.73 for $1 \leq r \leq 20$ and 31.31 for $r > 20$.) This fact supports the cluster formation in our system and reveals that receivers make clusters even when the interval of revision is extremely long.

4 Discussions

Information and cognitive framework is fundamentally inseparable, since the meaning of information is decided in accordance with the relationship between information and the cognitive framework of a particular person. At social situations information is interpreted coherently in the society to some extent. That

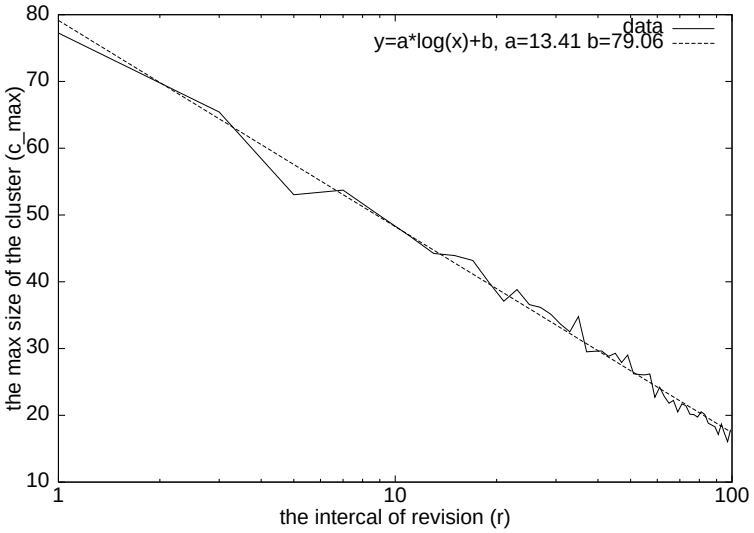


Figure 12: The maximum size of clusters $c_{\max}$ v.s. the interval of revision r. The horizontal axis is in the log scale. The straight line is a function $c_{\max} = -a\ln(r) + b$, where $a = 13.41, b = 79.06$.

is, we should share appropriate cognitive framework to act well in our society. Therefore the cognitive framework must be a basis of social norms.

In our model the receivers form clusters through two kind of adaptive behaviour, selecting the information suppliers and modifying the cognitive framework. Since in a cluster the receivers interpret information in the same way and act coherently, the clusters can be interpreted as an assemblage of individuals with a common norm. At the process of norm formation, the assemblage of receivers sharing a source of information are established at first and then they come to share the cognitive frameworks in the assemblies. It is revealed that in this process the two kind of adaptive behaviour work in turn.

When the receivers observe others more frequently, larger groups of sharing norms are formed. This result explains the phenomenon that some kind of life style comes to be a fashion. A fashion is likely to occur in a society in which people are sensitive to other people. From our results, it is also suggested that too strong interaction among individuals delays the formation of norms. This delay is caused by the receivers at boundaries between clusters. Since they are likely to belong to plural groups sharing the suppliers in a short period, they can not confirm their cognitive frameworks. And then effectivity of information transfer and performance of action of such receivers go down. This may be an abuse in the formation of norms. In the modern society, we are in the same state as such receivers that are at the boundary between some norms. For, we are usually members of many social groups simultaneously and receive

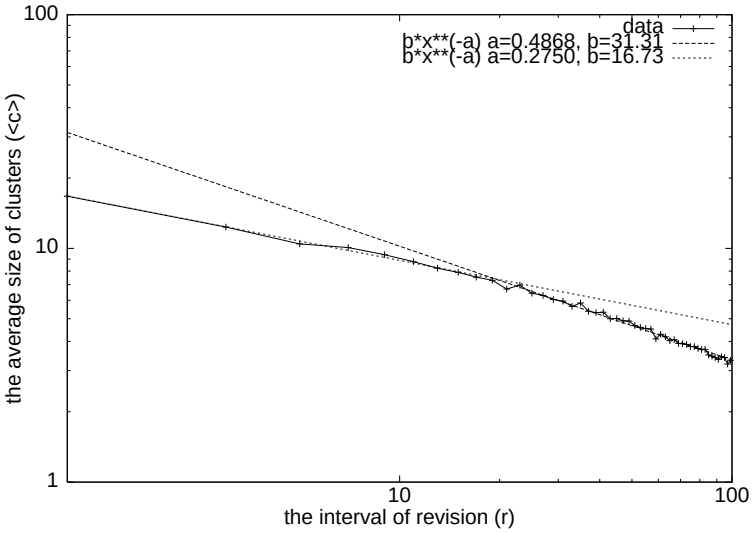


Figure 13: The average size of clusters $\langle c \rangle$ v.s. the interval of revision r. Both axes are scaled by logarithm. The straight line is a function $\langle c \rangle = b' r^{-a'}$. It is clearly shown by the plot that the relation between average number of clients and the revising interval obeys a power low.

various information even about one object from many source of information. This fact suggests that being too sensitive to others action and opinion may cause obstruction of information transfer and effectual behaviour.

It is shown that the relationship between the intervals to change the information suppliers and the size of clusters is a power, even though the maximum size of them decays more rapidly for the long intervals. This result makes a suggestion about the possibility to form norms even in a society with rare communication. In modern economics, it has been assumed that if a degree of isolation of individuals occurs, then they hardly behave as a group. That is to say, we tend to deduce that it is difficult to form norms when the interaction is unusual, because making a group depends on the local interaction between agents. However, the results obtained here shows the possibility to share norms in less interacting society. We can use this result to explain, for example, the spread of social institutions or fashions between rather isolated societies, such as villages in the Middle Ages [15]. In such villages, habitations with small number of families are isolated and only few people travel between habitations. Despite of these situations, the possibility of spreading of the same kind of custom is expected.

Our model expresses the inseparability between information and cognitive framework of individuals. The model is fundamentally based on the subjectivism. Individuals can not know others' internal cognitive framework and

should act according to information interpreted by themselves. Non-interpreted inputs to an individual system should be thought of as mere signals. Information is the entity which is interpreted and given subjective meaning. Knowledge is accumulated experiences to form the cognitive framework which works to give subjective meaning to inputs. In this sense, knowledge is not an objective entity but a kind of device to know something, to give meaning and to act [17]. Therefore the knowledge as an objective entity is not implemented explicitly in our model. However, this viewpoint gives an exposition of our results. Knowledge as accumulated experiences of communication and interaction shapes the cognitive framework and knowledge cause the formation of norms[6].

Giving subjective meaning is indispensable for any action. Weber[18] says that "we shall speak of 'action' insofar as the acting individual attaches a subjective meaning to his behavior." Subsequently to the sentence, he describes 'social action' as follows: "action is 'social' insofar as its subjective meaning takes account of the behavior of others and is thereby oriented in its course". According to his definition of social action, actions are classified into social and individual by its orientation, namely the direction or intensionality of the action. Beside this classification, it can be divided by its causation or origin of acquisition[19]. Actions are fall into social and individual by this classification, too. In other words, action is classified by two axes, its orientation and its acquisition.

Let us classify the actions treated in our model according to the two axes. Both altering the information suppliers and modifying the cognitive framework are socially-acquired action, since both actions are induced by comparing a receiver's performance with neighbours'. In addition to the comparison, a receiver imitates the other's adoption of information suppliers. The receivers select suppliers and therefore the former is a social-oriented action. On the other hand, the other action is individually acquired since he/she changes his/her cognitive framework randomly. Action toward objects is socially-acquired since it is based on the interpretation of information obtained from the supplier. It can be both social-oriented and individual-oriented. The example in the introductory section is social-oriented. An example of socially-acquired and individual-oriented action is that an individual decides whether he goes to the mountain on next Sunday according to the weather. He gets information about weather on next Sunday from newspapers or TV programs. Since the model have constructed at the appropriate level of abstraction, it can treat both social-oriented and individual-oriented actions. And therefore the results and implications of the model have the generality.

5 Conclusion

In this paper, we have considered the norm formation in information transfer between the information suppliers and receivers revising their way to interpret

[6]The relationship between information, knowledge and norms are discussed in [16]

information given. The norms as the shared cognitive frameworks among receivers are formed through altering the information suppliers and modifying the cognitive framework. The process of norm formation is as follows. At first some information suppliers are selected and the receivers conform their suppliers locally. Then the receivers finally accord their framework with the others sharing a supplier. The two revising mechanisms work in alternation in the process of norm formation. The size of group having the same norm rises in the course of time. Too strong interaction which is expressed by the small value of interval to revise the information suppliers delays the formation of norms. The final size of groups depends on the intensity of interaction. We find that the relation between the average size of groups sharing norms and the strength of interaction obeys the power law.

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