

# Expression of Fashion in Female Preferences for a Mate by Conformity and Differentiation Genes

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## Abstract

It is generally thought that living things have desires for conformity as well as desires for differentiation, which makes their preferences show fashion. Recently, it was shown that there were fashion in preferences of how female birds chose their mates. We think fashion in female preferences for a mate is related to their desires and that the strengths of desires among living species are genetically different from one to another. We describe the strength of desires among living species as being artificial agents of genes. In this paper, we simulate the phenomenon of fashion in female preferences for a mate by using an agent model that consists of imported conformity and differentiation as genes. In this experiment, we found that there were two kinds of periodic phenomena of fashion and reported the influence of conformity and differentiation on the transition of female preferences.

## Introduction

Fashion expresses the process of the penetration and spread of particular ideas into society. Factors for the generation of different fashions in each era have been attributed to the antithetical desires for conformity and differentiation (Simmel, 1957). In the animal world, many behaviors have been observed that suggest the existence of desires for conformity and differentiation, such as imitation, herd, staking territory, and individual actions.

Generally, fashion is considered to be present in preferences. Until recent years, it was believed that in the animal selection of mates, factors for the evolution of male ornamentation are usually uniform even as time passes; in other words, there was no fashion in the preferences of females. However, the research of Chaîne et al. has shown the existence of a species of bird called the Lark Bunting (*Calamospiza melanocorys*) whose preference of male ornamentation by females change every year (Chaîne and Lyon, 2008). However, the reason for this is not understood. We believe that the phenomenon of fashion in preferences, seen in some female birds, contribute to the existence of desires for conformity and differentiation in mate selection. We study this using computational simulation.

Conformity behaviors are behaviors that are similar in one's environment. Conformity behaviors make an orga-

nization uniform and establish the majority (Asch, 1951). However, the entire population is not just made up of the majority as a result of conformity behaviors. According to Simmel, fashion is created not just by conformity to others (conforming behaviors), but also by antagonism to exclusive desires, that is, by the desire to differentiate oneself from others (non-conforming behaviors) (Simmel, 1971). It is believed that non-conformity behaviors can preserve diversity, and that conformity behaviors create fashion. Fujii et al. carried out simulation experiments on the effects of conformity and non-conformity behaviors by individuals in a population. The results showed that many non-conforming individuals were needed to create fashion (Fujii et al., 2002).

Until now, we have expressed inborn bodily characteristics as genes, and acquired preferences as memes. We proposed an evolutionary model of artificial life (agents) that combine genes and memes, and observed their influence on changes in preferences concerning mate selection (Mizuno et al., 2005)(Tokuhara et al., 2005). In this paper, we propose a model that adds genes that express strength of desires for conformity and differentiation in order to represent different value systems for agents created in our previous model. By doing so, we can observe computationally mate selection behaviors by agents. We discuss the evolution and expression of fashion by the agents' responses to the environment as generations proceed.

## Agent Model

We have described an enhanced Lerena model (Lerena, 2000) in the form of an agent model consisting of both hereditary traits (genes) and acquired traits (memes) (Mizuno et al., 2005)(Tokuhara et al., 2005). This agent model introduces memes into the existing Lerena model. The concept of memes was proposed by R. Dawkins (Dawkins, 1989). He described a meme as both a base factor and a unit of cultural information. Our agent model was able to represent constant (i.e., hereditary) and variable (i.e., acquired) information as genes and memes, respectively. In this paper, we describe a new model that reflects the concept of conformity and differentiation.

## Agents

An agent  $a_i$  consists of the sex  $sex_i$ , age  $age_i$ , energy  $energy_i$ , dyad genes  $gene_i$  and dyad meme pools  $meme\ pools_i$  as follows.

$$a_i(sex_i, age_i, energy_i, gene_i, meme\ pools_i). \quad (1)$$

Genes are hereditary: the first one is for gene traits, and the second relates to preferences for gene traits. Meme pools are acquired: the first one is for meme traits, and the second relates to preferences for meme traits.

$$gene_i = (g_i^{trait}, g_i^{pref}), \quad (2)$$

$$meme\ pools_i = (m_i^{trait}, m_i^{pref}), \quad (3)$$

where  $g^{trait}$  is a gene trait,  $m^{trait}$  is a meme trait, and  $g^{pref}$  and  $m^{pref}$  are preferences for the  $g^{trait}$  and  $m^{trait}$ , respectively. Preference works to evaluate corresponding traits; for example,  $g^{pref}$  means the preference of the  $g^{trait}$  in mate choice. The expression of both preferences is limited to females ( $sex_i = \text{female}$ ), and the expression of both traits is limited to males ( $sex_i = \text{male}$ ).

## Conformity-desire genes

We add conformity-desire genes to above-mentioned agents as follows.

$$g_i^{trait} = (\mathcal{G}_i^t, \mathcal{G}_i^{tclv}), \quad (4)$$

$$g_i^{pref} = (\mathcal{G}_i^p, \mathcal{G}_i^{pclv}). \quad (5)$$

The  $\mathcal{G}_i^t$  is a gene trait, and the  $\mathcal{G}_i^p$  is a gene preference. The  $\mathcal{G}_i^{tclv}$  and the  $\mathcal{G}_i^{pclv}$  are conformity-desire genes of an agent  $a_i$ . They have a real-value between 0 and 1. In our model, the nearer a conformity-desire gene value is to 0, the stronger the differentiation desire the agent has. Conversely, the nearer a conformity-desire gene value is to 1, the stronger the conformity desire the agent has. Using Equations (1)-(5), we represent individuals having desires for conformity and differentiation as genes.

## Plainness and ornateness

Male and female agents have gene traits and preferences. They consist of bit string data. Since we present the plainness or ornateness of them, we use a  $cf(\mathcal{G}_j^t)$  function that counts the number of 1s in the bit string data of a gene trait  $\mathcal{G}_j^t$ . If  $cf()$  of the agent is over half of a bit length, we call the trait and preference of the agent ‘trait (preference)  $a$ ’ also known as a ornateness trait and preference. If not, we call the trait and preference of the agent ‘trait (preference)  $b$ ’, also known as a plainness trait and preference. This model uses a  $cf()$  function to calculate the consumption energy of the agents. The more ornate the agent, the more energy is required to act.

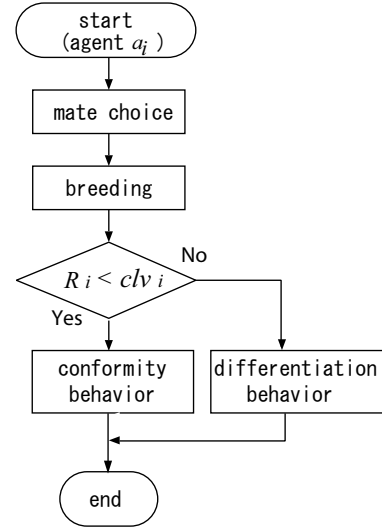


Figure 1: A flowchart of agent actions during each step.

## Action

A single run is the repetition of three procedures:

1. mate choice
2. breeding
3. decision between conformity and differentiation behavior
4. conformity or differentiation behavior

A flowchart of agent actions is shown in Figure 1. First, each female selects a male as a mate on the basis of preference. After breeding, each female and male agent selects and performs a conformity or differentiation behavior. These behaviors are operations that rewrite memes. Agents age 1[age] during each step.  $L_m[age]$  females and  $L_f[age]$  males are removed from the population. Agents burn energy by each action and recover after one step. Next, we explain each action.

**Mate choice** A female  $a_i$  selects the best-matched male  $a_j$  as a mate from  $L$  reference males. The reference population consists of randomly selected  $L$  males. The female evaluates a male by calculating the hamming distance between her own preferences and the traits displayed by the male. The evaluation value  $P_{i,j}$  for mate choice is determined using agent  $a_i$ 's gene preference  $\mathcal{G}_i^p$  and meme preference  $m_i^{pref}$ , and agent  $a_j$ 's gene trait  $\mathcal{G}_j^t$  and meme trait  $m_j^{trait}$  as follows.

$$P_{i,j} = w_1 H(\mathcal{G}_i^p, \mathcal{G}_j^t) + w_2 H(m_i^{pref}, m_j^{trait}), \quad (6)$$

where  $H(A, B)$  is the hamming distance between  $A$  and  $B$ , and  $w_1$  and  $w_2$  are weight parameters. Agent  $a_i$  prefers  $a_j$

to  $a_k$  when  $P_{i,j} < P_{i,k}$ . After choicing a mate, a female  $a_i$  is added to the queue  $waiting_j$  for selected male  $a_j$ .

**Breeding** Suppose that female  $a_i$  selects male  $a_j$ . A new agent  $a_l$  is produced as the child of  $a_i$  and  $a_j$ . This new agent  $a_l$  has the following composition.

$$a_l(sex_l, 0, energy_{DV}, ((\mathcal{G}_l^t, \mathcal{G}_l^{tclv}), (\mathcal{G}_l^p, \mathcal{G}_l^{pclv})), (m_{DV}^{trait}, m_{DV}^{pref})), \quad (7)$$

$$(\mathcal{G}_l^t, \mathcal{G}_l^{tclv}) = (mutb(crb(\mathcal{G}_i^t, \mathcal{G}_j^t)), mutr(crr(\mathcal{G}_i^{tclv}, \mathcal{G}_j^{tclv}))), \quad (8)$$

$$(\mathcal{G}_l^p, \mathcal{G}_l^{pclv}) = (mutb(crb(\mathcal{G}_i^p, \mathcal{G}_j^p)), mutr(crr(\mathcal{G}_i^{pclv}, \mathcal{G}_j^{pclv}))), \quad (9)$$

where  $sex_l$  is either male or female with an even probability;  $age_l$  is zero;  $energy_l$  is default  $energy_{DV}$ ; genes  $(g_l^{trait}, g_l^{pref})$  are determined by genetic operations of Equation (8) and (9);  $mutb(A)$  is a mutate-function that reverses each bit of  $A$  with probability  $\gamma$ ;  $mutr(A)$  is a boundary mutate-function for real-value  $A$  with a probability  $\gamma$ ;  $crb(A, B)$  is a cross-function that returns either  $A$  and  $B$  with an even probability;  $crr(A, B)$  is Blend cross-function (Eshelman, 1991) with  $A$  and  $B$ . In this model, we think that all agents should mature before they are included in the population. Thus, we abbreviate the process by supposing the growth of agents. Memes  $(m_i^{trait}, m_i^{pref})$  are not inherited from parents. Thus, their defaults are  $(m_{DV}^{trait}, m_{DV}^{pref})$ .

By breeding, male  $a_j$  uses energy  $C_j^{crs}$  as follows.

$$C_j^{crs} = \alpha^{crs}(cf(\mathcal{G}_j^t) + cf(m_j^{trait})) + 1. \quad (10)$$

The more ornate the agent, the more energy is needed to breed. Thus, ornate traits are a disadvantage for childbirth.

A female  $a_i$  is limited to only one round of breeding for each step. On the other hand, a male  $a_j$  is not limited. He can breed repeatedly with femeles in the queue  $waiting_j$  while their energy is greater than zero.

**Decision between conformity and differentiation behaviors** An agent decides between conformity and differentiation behaviors after breeding. First, an agent  $a_i$  selects  $M$  agents of the same sex randomly from a population. Then, an agent  $a_i$  perceives the local proliferation rate  $R_i$  as follows.

$$R_i = \max(num(a), num(b))/M, \quad (11)$$

where  $num(a)$  is the number of agents having a trait (preference)  $a$  in  $M$  agents. Agents in this model have a trait (preference)  $a$  or trait (preference)  $b$  as mentioned above. Thus, the range of the local proliferation rate  $R_i$  is 0.5 to 1.

As mentioned above, we assume that living species have desires for conformity and differentiation. The proposed

model has the following mechanism. If an agent feels that a local proliferation rate is high, he desires differentiation. If not, he desires comformity.

We define the local proliferation rate that an agent considers high as a bifurcation value. The bifurcation value  $clv_i$  of an agent  $a_i$  is calculated using conformity-desire genes as follows.

$$clv_i = \frac{\mathcal{G}_i^{tclv} + 1}{2}. \quad (0.5 \leq clv_i \leq 1) \quad (12)$$

In addition, Equation (12) is a calculus equation for either male or female agents. An agent  $a_i$  decides between conformity and differentiation behavior by using its own bifurcation value  $clv_i$  and the perceived local proliferation rate. In particular, if the magnitude relation of their values is  $R_i < clv_i$  (i.e., the agent does not feel the local proliferation rate is high), the agent excutes a conformity behavior. On the other hand, if  $R_i \geq clv_i$  (i.e., the agent feels the local proliferation rate is high), the agent excutes a differentiation behavior.

**Conformity behavior** The conformity behavior means that an agent  $a_i$  imitates the meme  $m_k^{trait}$  of a male  $a_k$  who is the most popular as indicated by mate choice. Specifically, the imitation target is the male agent who breeds the most times out of  $N$  males selected randomly from a population.

In imitation, an agent  $a_i$  can change its own meme  $m_i^{trait}$  ( $m_i^{pref}$ ) by reversing one bit in its bit string data to come close to the meme  $m_k^{trait}$  ( $m_k^{pref}$ ) of target male  $a_k$ . By its behavior, the male  $a_i$  uses energy  $C_i^{imt}$  as follows.

$$C_i^{imt} = \alpha^{imt}(cf(\mathcal{G}_i^t) + cf(m_i^{trait})) + 1. \quad (13)$$

Equation (13) is a calculus equation for either male or female agents. Conformity behaviors are repeated while their energy is over zero, i.e., multiple bits are imitated. On the basis of  $C_i^{imt}$ , the more ornate an agent  $a_i$ , the larger the energy cost it requires. Thus, the more ornate it is, the smaller the number of bits that can be changed.

**Differentiation behavior** The differentiation behavior means that an agent  $a_i$  imitates reversely the meme  $m_k^{trait}$  of a male  $a_k$  who is the most popular as indicated by mate choice. Specifically, the reverse-imitation target is the male agent who breeds the most times out of  $N$  males selected randomly from a population.

In reverse-imitation, an agent  $a_i$  can change its own meme  $m_i^{trait}$  ( $m_i^{pref}$ ) by reversing one bit in its bit string data to back away to the meme  $m_k^{trait}$  ( $m_k^{pref}$ ) of target male  $a_k$ . By its behavior, the male  $a_i$  uses energy  $C_i^{crt}$  as follows.

$$C_i^{crt} = \alpha^{crt}(cf(\mathcal{G}_i^t) + cf(m_i^{trait})) + 1. \quad (14)$$

Equation (14) is a calculus equation for either male or female agents. Differentiation behaviors are repeated while

their energy is over zero, i.e., multiple bits are imitated. On the basis of  $C_i^{crt}$ , the more ornate an agent  $a_i$ , the larger the energy cost it requires. Thus, the more ornate it is, the smaller the number of bits that can be changed.

## Experiments

Next, we explain an experiment with the proposed model, where many male and female agents exist and are evolvable.

### Experimental settings

All agents are dead after 5[step] (life time). A population of 1000 agents, consisting of 500 females and 500 males, is evolved from an initial state where: (1) the genes  $\mathcal{G}^t$  and  $\mathcal{G}^p$ , the memes  $m^{trait}$  and  $m^{pref}$  are encoded by bit-strings; the length of these strings is 10 bits each; (2) the initial values of the genes  $g^{trait}$  and  $g^{pref}$  are given randomly to all agents; (3) the initial values of the memes  $m^{trait}$  and  $m^{pref}$  are given median ( $cf(m_{DV}^{trait}) = cf(m_{DV}^{pref}) = 5$ ). The parameterization used in these sets of simulation runs is as follows: (1) reference population size for mate choice and conformity and differentiation behavior ( $L = N = M = 40$ ); (2) weight parameters in mate choice ( $w_1 = w_2 = 0.5$ ); (3) initial values of energy ( $energy_{DV} = 100$ ); (4) parameters in costs ( $\alpha^{crs} = 3.5$ ,  $\alpha^{imt} = 2.0$ ,  $\alpha^{crt} = 4.0$ ,  $\gamma = 0.005$ ).

We defined cases with  $cf(\mathcal{G}^p) + cf(m^{pref}) > 10$  and  $cf(\mathcal{G}^p) + cf(m^{pref}) \leq 10$  as ornate and plain cases, respectively. In this experiment, we examine survival ratio of female agents with ornate and plain preferences.

### Results

In our experiment, we set the preference of more than half of the female agents as preference for the majority, and the rest as preference for the minority. We then focused on the turnover between majority and minority. The results of the 10,000-step simulation, run 20 times, showed that turnover between preference for the majority and the minority occurred frequently in all the trials. Figure 2 provides an example of the change in the preference of females that is often seen in the experiment. We could confirm repetition of turnover between the two different preferences of the majority and minority.

Also, Figure 3 shows by generation the average values of the conformity-desire gene of male  $\mathcal{G}^{tclv}$  and female  $\mathcal{G}^{pclv}$  agents for 20 trials. Whereas the female conformity-desire gene  $\mathcal{G}^{pclv}$  did not change in the vicinity of strength 0.5 through 10,000 steps, the male conformity-desire gene  $\mathcal{G}^{tclv}$  increased immediately after the start of the experiment, and after 2000 steps, it stabilized between 0.62 and 0.67.

### Discussion

Figure 2 shown is similar to periodic phenomena of fashion. In the proposed model, the process by which periodic phenomena of fashion of preference  $a$  and preference  $b$  is expressed is repeated in the following way:

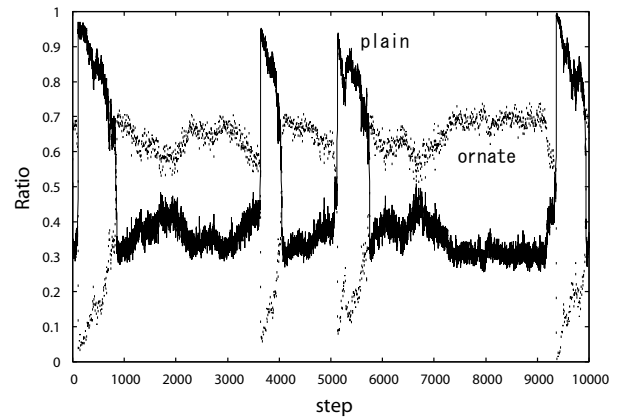


Figure 2: Survival ratio of female agents at each step. A solid line shows a plain preference. A broken line shows a ornate one.

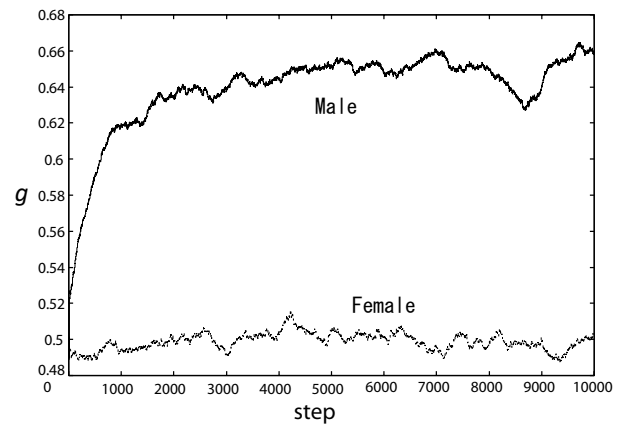


Figure 3: Averag values of the conformity-desire gene of male  $\mathcal{G}^{tclv}$  and female  $\mathcal{G}^{pclv}$  at each step.

- (i) Preference  $a$  increases due to conformity behaviors, and it becomes easy for the local proliferation rate of preference  $a$  to increase.
- (ii) An agent with preference  $b$  is created by an agent that takes a differentiation behavior when the local proliferation rate of preference  $a$  exceeds the agent's bifurcation value.
- (iii) Female with preference  $b$  selects male mates with trait  $b$ , so preference  $b$  increases as a result of females' conformity behaviors in the environment.

In Figure 3, the reason that the male conformity-desire gene is higher in strength compared to females is that in this model, the power to select mates belongs to the females. Because males that copy traits that are popular to females are more easily selected, males with strong differentiation

desires—that is, males with weak conformity-desire gene—are easily selected out. On the other hand, the conformity-desire gene of females do not attain a high level compared to males because 1) male are popular as a result of female conformity behaviors, so there are females born that cannot find a mate, and 2) females have the power to select mates, so they are successful in mating even if they act in a differentiating manner.

From our results, we found that there is a high probability that agents that carry out differentiation behaviors, which trigger the conversion of fashion in process(ii), are females with weak conformity-desire gene.

Furthermore, change was also observed in female agents' preference for plainness or ornateness. As can be seen from the results shown in Figure 2, when preference for plainness becomes the majority over preference for ornateness, plainness' ratio of survival becomes greater, but its duration becomes shorter. When ornate preference becomes the majority over plain preference, its survival does not become great, but its duration is long. This set of phenomena was confirmed in all 20 trials.

The reason for the difference seen in the change of fashion as a result of such change in preferences is believed to be attributable to the difference in the cost of assuming behaviors by agents. For agents with plain preference, the cost of behaviors compared to agents with ornate preference is low, so it is easier to beget progeny and for the number of individuals to increase. Because the local proliferation rate perceived by each agent becomes high, it becomes easier for each agent to assume a differentiation behavior. As a result, it becomes easier for the switching of fashion by differentiation behavior to occur.

On the other hand, the behaviors for ornate preference incur greater cost compared to plain preference, so it is harder to beget progeny and for the number of individuals to increase. The local proliferation rate perceived by each agent does not become high, so it becomes hard for agents to take differentiation behaviors. As a result, the traits and preferences homogenize and stabilize.

The appearance of the sudden increase and decrease of female agents with plain preference confirmed in our experiment approximates a “craze” phenomenon. Also, the appearance of a stable fashion among female agents with ornate preference approximates a “boom” phenomenon.

### Compare with the Lark Bunting

According to the report presented by Chaine et al., for the Lark Bunting, whose females have preferences that show traits of fashion, many males with small bodies are successful in mating compared to males with large bodies when the small-body phenotype is in fashion. Furthermore, the duration of the fashion is short. If having a big body is hypothesized to be disadvantageous for survival compared to having a small body (incurring a high cost for behaviors), in our

model we can consider a big body as ornate phenotype and a small body as plain phenotype. The phenomena observed in our experiment, namely that survival ratio is high when plain preference is in fashion and this duration is short, and that the survival ratio is low when ornate preference is in fashion and this duration is long, match a part of the fashion phenomena of preference observed in female Lark Bunting.

### Effects of the reference population size

Next, we carry out experiments to determine the effects that reference population size  $M$ , a parameter inherent in our proposed model for deciding learned behaviors, have on changes in fashion.

Here, we define the change in the survival ratio of agents with target traits (preferences) in the stabilized period (which is the period after 2000 steps that stabilize the conformity-desire gene according to the diagram) of each experiment as either “craze” or “boom”.

“Craze”:

The survival ratio increases from less than 50 percent to more than 90 percent and again drops to less than 50 percent within 1000 steps.

“Boom”:

The survival ratio increases from less than 50 percent to more than 50 percent, and maintains the state of greater than 50 percent for more than 1,500 steps before dropping to less than 50 percent again.

We changed the size of the reference population,  $M$ , in the range of  $5 \leq M \leq 100$ , and studied the number of occurrences of “craze” and “boom” as defined above. Figure 4 shows the average frequency of occurrences of “craze” in plain preference and “boom” in ornate preference over 20 trials.

The results of the experiments showed that when  $M = 5$ , “craze” and “boom” were almost never observed. However, as the size of the reference population increases, their frequency increases. “Craze” occurred most frequently when  $M = 40$ , and “boom” occurred most frequently when  $M = 20$ .

For “craze” to occur, there must be rapid increase of the majority by conformity behaviors and switching between majority and minority due to differentiation behaviors. It is expected that as the reference population size becomes smaller, the average value of the local proliferation rate becomes higher, so differentiation behaviors occur more easily and conformity behaviors occur with more difficulty. Inversely, as the reference population size becomes bigger, the average value of the local proliferation rate becomes lower, so differentiation behaviors occur with more difficulty and conformity behaviors occur more easily. The results of Figure 4 also suggest that the size of the reference population size when deciding on learning actions contribute to the frequency of “craze” and “boom”.

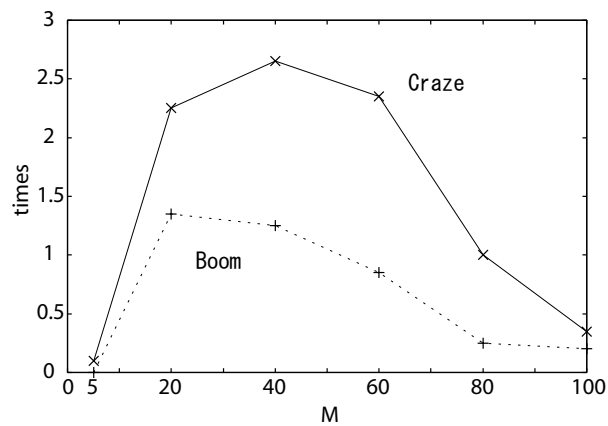


Figure 4: Average frequency of occurrences of “craze” and “boom” at each number of reference populations  $M$ . A solid line shows “craze”. A broken line shows “boom”.

### Conclusion

In this paper, we proposed a new model for mate choice involving genes and memes that introduces conformity-desire genes that correspond to the value systems of individual agents. We expressed agents that combine desire for conformity, which is believed to belong to some animals via conformity-desire genes, and desire for differentiation. Furthermore, we created a model that sought to carry out conformity behaviors and differentiation behaviors through conformity-desire genes possessed by agents themselves and the local proliferation rate perceived from the environment. From the results of experiments using our proposed model, we confirmed two types of periodic phenomena of fashion expression. For preferences that incur a high cost for behaviors, a stable “boom” was often observed. For preferences that incur a low cost, a “craze”-like fashion phenomenon, with sudden penetration and then decay, was often observed. We also discovered that the existence of female agents that carry out differentiation behaviors is important for the expression of periodic phenomena of fashion.

From here, it is necessary to match the results of this experiment in detail against real-world animals whose females have preferences that can be seen as fashion, and are the targets of this model. However, we expect that verification of the model will face great difficulty because of the very few case studies of animals whose female have preferences that can be seen as fashion when it comes to mate choice. Therefore, it is desirable to collect data on a variety of fashion phenomena in the real world, including mate choice. Also, mate choice in the real world is not simple like the model. There are a variety of factors involved in propagation, such as the asymmetry in roles between males and females. It is necessary to improve the model based on the findings of this paper so that it better conforms to the real world.

The characteristics of the two types of periodic phenomena of fashion as a result of the difference in cost expressed in our model can be applied to fashion phenomena in general society. For example, because an expensive product cannot be possessed by many people, a moderate degree of differentiation desire is maintained, and a hypothesis can be made that a “craze” will not occur easily. From the results of last experiments, it is also possible to discuss the relationship between the differences in information space between individuals and the ease with which a “craze” occurs. From here on, we want to extend our proposed model to be a model of general society.

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