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ENVIRONMENTAL COMPENSATION MECHANISM OF NIMBY FACILITIES CONSIDERING EMOTIONAL INFLUENCE

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SUMMARY

***Background**: Considering the influence of emotion on participants' behavior decision-making, an evolutionary game model of environmental compensation for adjacent avoidance facilities is constructed based on the hierarchical dependence expected utility theory.*

***Subjects and methods**: By discussing the Nash equilibrium solution under different emotional states, the influence of emotional factors on the strategic choice of surrounding people and local government is analyzed.*

***Results**: the results show that: environmental compensation is an effective method to resolve the adjacent avoidance conflict, and emotional factors have a significant impact on the game equilibrium strategy of environmental compensation. With the increase of emotion index, the probability of local government choosing compensation strategy is higher and higher. However, when the surrounding people are too pessimistic or too optimistic, the outline of choosing cooperation strategy will be reduced.*

***Conclusions**: This paper puts forward countermeasures and suggestions on environmental compensation of adjacent avoidance facilities from the aspects of emotion monitoring and counseling, in order to promote the effective resolution of adjacent avoidance conflict.*

***Key words:** NIMBY facilities - environmental compensation - emotion function - REDU evolutionary game*

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INTRODUCTION

As a kind of public facilities necessary for the promotion of urbanization, NIMBY facilities usually have significant negative externalities. Their social benefits are shared by the public, but the negative externalities are borne by the people around the facilities (O'Hare 1997). The asymmetry between social benefits and environmental costs borne by the region can easily lead to non-cooperation or even boycott of the surrounding people, which will eventually evolve into highly emotional group conflict events (Zhang & Liu 2017), bringing serious risks to social stability.

The contradiction between the increasing demand for NIMBY facilities brought by the expansion of urban scale and the proposition of ecological environment fair rights of people around the facilities is becoming more and more prominent. the incident of Wuxi Xidong waste incineration plant, the "Changfu Street substation incident" in Nanjing and the PX crisis in Ningbo and Dalian all show that the NIMBY conflict has become a common phenomenon (Gao et al. 2016). How to reduce the negative externalities of NIMBY facilities through economic, political, ecological and other measures, promote the cost-benefit equal development of surrounding people, and finally realize the "welcoming effect" of people around NIMBY facilities, so as to fundamentally resolve NIMBY conflicts is an important issue to realize social sustainable development.

Most scholars believe that environmental compensation can effectively alleviate the NIMBY conflict (Liu 2013), and the effective implementation of environmental compensation policies in Taiwan, China, Guangzhou and other places (Hsu 2006) also provides a typical example of solving NIMBY conflict in practice. Groothuis et al. (Groothuis & Miller 1994) explained the NIMBY phenomenon from endurance belief and avoidance belief, and proposed that economic compensation can significantly affect endurance belief. Kikuchi (Kikuchi & Gerardo 2009) and others proposed that the environmental compensation of NIMBY facilities includes health and safety protection, economic subsidies and necessary transportation and education services. Ferreia et al. (Ferreia & Gallagher 2012) investigated the public's preference for environmental compensation of NIMBY facilities by using the conditional valuation method, and found that the environmental compensation willingness of surrounding people increased with the phased promotion of NIMBY projects. Tang et al. (2011) pointed out that the appropriate compensation of the government is the key to solve NIMBY conflict, but the difficulty of measuring environmental loss and the lack of trust of the people often lead to a large deviation between the compensation amount and the expectations of surrounding people. Although environmental compensation is a potential method to solve NIMBY conflict, the complexity of NIMBY conflict determines the complexity of its environmental compensation mechanism. the public decision-making mode of NIMBY facilities, the government credibility, the way and amount of environmental compensation, the risk perception and value system of surrounding people all have an impact on the production and evolution of NIMBY conflict. The evolution process can be regarded as the decision-making and correction process of stakeholders based on bounded rationality under the condition of incomplete information.

Therefore, many studies use game theory to study the evolution law of subject behavior and environmental compensation mechanism in NIMBY conflict. Qian et al. (2017) pointed out that the key to resolving the NIMBY conflict is to change the uncooperative behavior of the surrounding people by building an evolutionary game model of environmental compensation. Kang & Du (2018) used the evolutionary game model to analyze the interest relationship between the government, NIMBY facility enterprises and the surrounding people, and put forward the evolutionary stability strategy of non-supervision by the government, cooperation between NIMBY facility enterprises and nonresistance by the surrounding people. Most game models explain the evolution process and compensation mechanism of NIMBY conflict, but the model assumptions ignore the important influence of emotion, which deviates from the logical evolution path of "cognition-emotion- behavior" (Fei & Wang 2014) in NIMBY conflict.

At present, the frequent NIMBY conflicts not only come from the NIMBY thinking centered on public risk perception, but also the result of the comprehensive action of a variety of psychological factors in the specific situation (Qin & Ju 2018). The collective action of the surrounding people is accompanied by the participation of many people and the disorder and chaos caused by participation. It is a social interaction full of uncertainty and unpredictable, in which emotion plays a key role (Wu et al. 2016). In the process of the occurrence and evolution of NIMBY conflict, emotion plays an important role (Feng 2007) from risk perception to action of the surrounding people, especially the emotional amplification effect brought by network public opinion (Yang & Wang 2020), so that the whole evolution process is shrouded in the subjective irrationality of the group. Individuals often show no objection, emotional and low IQ herd behavior under the infection of group emotion (Gao & Huang 2021). Based on this, exploring the evolution law of main behaviors of NIMBY conflict from the emotional level, so as to grasp the environmental compensation mechanism of NIMBY facilities, is an important prerequisite for properly solving NIMBY conflict. Therefore, based on the perspective of limited rationality and incomplete information of participants, this paper introduces the emotional state and degree of surrounding people and government under uncertain conditions into the evolutionary game model by using rank dependent expected utility theory, and explores the environmental compensation mechanism of NIMBY facilities by seeking the evolutionary stability strategy under the combination of random emotional states, so as to provide corresponding countermeasures and suggestions for the environmental compensation policy of NIMBY facilities.

SUBJECTS AND METHODS

Study setting

Basic game model

Focusing on the construction activities of NIMBY facilities, taking the local government where the NIMBY facilities are located and the surrounding people as the main body of the game, the basic model of environmental compensation of NIMBY facilities is constructed with the help of evolutionary game. The relevant assumptions are as follows:

Assumption 1 the leading party in the investment and construction of NIMBY facilities is the local government, and the NIMBY facilities have a negative effect on the ecological environment of the surrounding people. The local government and the surrounding people constitute a complete system without other constraints. Due to the incomplete decision-making information and the limitation of decision-making ability, both sides are limited rational individuals with learning ability.

Assumption 2 in the game system of environmental compensation for NIMBY facilities, both sides have the rights and schemes of their own behavior. The local government's strategy set is (compensation, non-compensation) and the surrounding people's strategy set is (cooperation, non- cooperation). In the process of learning and imitation, both sides adjust their strategy choices through continuous trial and error, in order to seek the best strategy combination until reaching equilibrium.

Assumption 3 The total economic and social benefits brought by the construction of NIMBY facilities to the local government is R, and its risk loss to the surrounding people (such as environmental pollution, house price decline, land depreciation and psychological unhappiness) is C due to the negative externality. The non-cooperation strategy by the surrounding people will urge the local government to pay attention to the negative environmental effects brought by the NIMBY facilities, and then find ways to reduce the negative environment impact. The actions taken can be technological transformation, increasing protective measures or reducing the construction scale. It is assumed that the change coefficient of the negative environmental effects is α, $\alpha \in (0, 1)$, which means that the negative ecological and environmental effects of NIMBY facilities can be technically reduced but cannot be completely eliminated, otherwise the local government will not choose the environmental compensation strategy (Qian et al. 2017).

Assumption 4 the constraint mechanism is introduced to encourage cooperation. When the local government chooses the environmental compensation strategy and the surrounding people choose non-cooperation, the compensation $A2$ received by the surrounding people will be lower than the compensation $A1$ when they choose cooperation with the government. When the surrounding people choose non-cooperation strategy, the resistance cost is D and the social risk cost to the local government is B. When the surrounding people choose cooperation and the local government does not give corresponding environmental compensation, the reputation punishment for local government is E.

Assumption 5 when the surrounding people choose non-cooperation strategy, the local government will face the dual choice of continuing projects or suspending

projects. When the cost of appeasing resistance behavior is higher than the benefits brought by the project continuation, the local government will choose to suspend the construction. If the project is suspended, the game is declared to end, which is not the scope of this study. This paper only aims at the continuation of the project.

Based on the above assumptions, assuming that the probability of surrounding people taking cooperation strategy is p, and the probability of local government taking compensation strategy is q ($p, q \in [0,1]$), the basic game model of environmental compensation for NIMBY facilities can be constructed, and the income matrix is shown in Table 1.

Table 1. The income matrix of the local government and surrounding people

Surrounding people	Local governments	
	Compensation (*q*)	Non-compensation (*1-q*)
Cooperation (*p*)	*-C+A1; R-A1*	*-C; R-E*
Non-cooperation (*1-p*)	*-C+αC+A2-D; R-A2-B*	*-C- D; R-B*

Rank-dependent expected utility

The Expected Utility Theory (EU) constructed by NEUMANN and MORGENSTERN describes the decision-making behavior of "rational person" under risk conditions. The limitation of the "rational person" hypothesis leads to the doubt of the descriptive validity of its risk decision-making, and the Allais paradox and Ellsberg paradox appear. Then Quiggin (1991) proposed the Rank-Dependent Expected Utility (RDEU) theory, which includes the psychological preference and emotion of decision makers. Based on the incomplete rationality of decision makers, this theory constructs the nonlinear decision weight of emotional attitude and degree under uncertain condition, so as to introduce the emotional factors of game players into the game process.

If the random variable $X = \{x_i; i = 1,2\cdots,n\}$ ($x_1 > x_2 > \cdots > x_n$) follows probability distribution $P\{X = x_i\} = p_i$, $i = 1,2,\cdots,n$, and $p_i \geq 0, p_1 + p_2 + \cdots + p_n = 1$, then ranking position (RP_i)of x_i is:

$$RP_i = P\{X \leq x_i\} = p_i + p_{i+1} + \cdots + p_n, \quad i = 1,2,\cdots,n \qquad (1)$$

In uncertain decision-making process, the RDEU decision model of decision makers are:

$$V(X,u,\pi) = \sum_{i=1}^{n} \pi(x_i) u(x_i) \qquad (2)$$

$\pi(x_i)$ is the decision weight of x_i , and $\pi(x_i) = w(p_i + 1 - RP_i) - w(1 - RP_i)$, $i = 1,2,\cdots,n$.

$w(x)$ is the emotion function of decision makers, which is a monotonically increasing function satisfying *w(0) = 0, w(1) = 1*. Learning from other studies in RDEU theory and group events, assuming $w_i(x) = x^{r_i}, r_i > 0, i = 1,2$ (r_i is the emotional index). When $0 < r_i < 1$, $w(x)$ is a concave function describing the optimism of decision makers; When $r_i > 1$, $w(x)$ is a convex function, describing the pessimism of decision makers; when $r_i = 1$, it means that decision makers are neither pessimistic nor optimistic (Gong 2012; Xiong et al. 2015).

REDU model of local government and surrounding people

Since the surrounding people strive for the living environment rights and interests through non-cooperation strategy during the construction of NIMBY facilities, the non-cooperation benefit of surrounding people is greater than the cooperation benefit if the government strategy is compensation, namely $-C+\alpha C+A2-D > -C+A1 > -C > -C-D$. Based on this, the probability distribution (*Pi*) ranking position (*RPi*) and decision weight ($\pi(xi)$) of income values (*xi*) for surrounding people are calculated in Table 2.

Table 2. Probability distribution, rank position and decision weights of income values for surrounding people

xi	*Pi*	*RPi*	$\pi(xi)$
-C+αC+ A2-D	*(1-p) q*	1	*w1 (q-pq)*
-C+ A1	*pq*	*1-q+pq*	*w1 (q)- w1 (q-pq)*
-C	*p(1-q)*	*1-q*	*w1 (p+q-pq)- w1 (q)*
-C-D	*(1-p) (1-q)*	*(1-p) (1-q)*	1- *w1 (p+q-pq)*

For the local government, compensation strategy mainly pays for economic cost. When the surrounding people take cooperation strategy and the government does not compensate, the government's reputation punishment will cause credibility loss. Meanwhile, the non-cooperation strategy of the surrounding people will lead to mass incidents, social risk costs and adverse effects on social stability. Therefore, in the government's income matrix, there is R-A1>R-E>R-B>R-A2- B. Based on this, the probability distribution, rank and decision weight for

local government are calculated in Table 3.

Table 3. Probability distribution, rank position and decision weights of income values for local government

xi	*Pi*	*RPi*	*π(xi)*
R-A1	*pq*	1	*w2 (pq)*
R-E	*p(1-q)*	*1- pq*	*w2 (p)- w2 (pq)*
R-B	*(1-p) (1-q)*	*1-p*	*w2(1-q+pq)-w2 (p)*
R-A2-B	*(1-p) q*	*(1-p) q*	*1- w2(1-q+pq)*

The REDU function of the surrounding people is:

$$V_{1(p,q)} = (\alpha C + A_2 - D - A_1)(q - pq)^{r_1} + D(p + q - pq)^{r_1} + A_1(q)^{r_1} - (C + D) \quad (3)$$

The REDU function of the local government is:

$$V_{2(p,q)} = (E - A_1)(pq)^{r_2} + (B - E)(p)^{r_2} + A_2(1 - q + pq)^{r_2} + (R - A_2 - B) \quad (4)$$

Design

Equilibrium solution analysis of RDEU game model for environmental compensation of NIMBY facilities

According to the Nash equilibrium method, in the RDEU functions of the surrounding people and the local government, the partial derivatives of p and q are calculated respectively, and the following formulas are obtained:

$$\frac{\partial V_1(p,q)}{\partial(p)} = -qr_1(\alpha C + A_2 - A_1 - D)(q - pq)^{r_1 - 1} + (1 - q)r_1 D(p + q - pq)^{r_1 - 1} \quad (5)$$

$$\frac{\partial V_2(p,q)}{\partial(q)} = p^{r_2} r_2 (E - A_1) q^{r_2 - 1} - (1 - p)r_2 A_2 (1 - q + pq)^{r_2 - 1} \quad (6)$$

Make the partial derivatives 0 to get the equilibrium solution of RDEU evolutionary game model, namely:

$$\frac{\partial V_1(p,q)}{\partial(p)} = -qr_1(\alpha C + A_2 - A_1 - D)(q - pq)^{r_1 - 1} + (1 - q)r_1 D(p + q - pq)^{r_1 - 1} = 0 \quad (7)$$

$$\frac{\partial V_2(p,q)}{\partial(q)} = p^{r_2} r_2 (E - A_1) q^{r_2 - 1} - (1 - p)r_2 A_2 (1 - q + pq)^{r_2 - 1} = 0 \quad (8)$$

It can be seen that the equations constituted by Equation (7) and (8) are transcendental equations, and it is difficult to obtain the analytical solution. Therefore, it is discussed from several typical cases.

When both sides show rational emotions, namely $r_1 = r_2 = 1$

When the surrounding people and local government show rational emotions, decision-making is not affected by emotions, the simultaneous equations are:

$$-q(\alpha C + A_2 - A_1 - D) + (1 - q)D = 0 \quad (9)$$

$$p(E - A_1) - (1 - p)A_2 = 0 \quad (10)$$

The solution is $p_1^* = \frac{A_2}{E + A_2 - A_1}$, $q_1^* = \frac{D}{\alpha C + A_2 - A_1}$. When both sides are rational, there is a mixed Nash equilibrium (p_1^*, q_1^*). That is, the surrounding people choose cooperation strategy with probability $\frac{A_2}{E + A_2 - A_1}$, while the local government chooses compensation strategy with probability $\frac{D}{\alpha C + A_2 - A_1}$. In terms of reality, the government and the public are decision makers under bounded rationality, which is difficult to make completely rational decisions. However, the rational solution can be used as a reference point for the Nash equilibrium solution when the emotions of both sides evolve.

When both sides show pessimism, namely $r_1 > 1, r_2 > 1$

Assuming that both sides are in excessive pessimism, then $r_i \to +\infty$, $r_i - 1 \to +\infty$, $i = 1, 2$, the simultaneous equations are transformed into:

$$-q(\alpha C + A_2 - A_1 - D)\left(\frac{q - pq}{p + q - pq}\right)^{r_1 - 1} + (1 - q)D = 0 \quad (11)$$

$$p^{r_2}(E - A_1)q^{r_2 - 1} - (1 - p)A_2(1 - q + pq)^{r_2 - 1} = 0 \quad (12)$$

In formula (11), as $q - pq < p + q + pq$, then $\left(\frac{q - pq}{p + q - pq}\right)^{r_1 - 1} \to 0$, so $(1 - q)D = 0$, and $q_2^* = 1$. Put them $q_2^* = 1$ into formula (12), $p_2^* = \frac{A_2}{E - A_1 + A_2}$ is

obtained. Therefore, when both sides show excessive pessimism, there is a mixed Nash equilibrium, that is, the surrounding people adopt cooperation strategy with probability $\frac{A_2}{E-A_1+A_2}$, and the local government adopts compensation strategy.

When both sides show optimism, namely $r_1>1, r_2>1$

Assuming both sides are overly optimistic, then $r_i \to 0, r_i - 1 \to -1, i=1,2$. The simultaneous equations are:

$$(\alpha C + A_2 - A_1)(p+q-pq) - D = 0 \quad (13)$$

$$(E - A_1 + A_2)(q-pq) - E + A_1 = 0 \quad (14)$$

According to the simultaneous equations, $p_3^* = \frac{D(E-A_1+A_2)-(E-A_1)(\alpha C+A_2-A_1)}{(\alpha C+A_2-A_1)(E-A_1+A_2)}$, and $q_3^* = \frac{(E-A_1)(\alpha C+A_2-A_1)}{A_2(\alpha C+A_2-A_1)-D(E-A_1+A_2)}$. If $p_3^*, q_3^* \in [0,1]$, the equations have solutions. The mixed Nash equilibrium is (p_3^*, q_3^*), that is, the surrounding people take cooperation strategy with probability $\frac{D(E-A_1+A_2)-(E-A_1)(\alpha C+A_2-A_1)}{(\alpha C+A_2-A_1)(E-A_1+A_2)}$, and the local government takes compensation strategy with probability of $\frac{(E-A_1)(\alpha C+A_2-A_1)}{A_2(\alpha C+A_2-A_1)-D(E-A_1+A_2)}$.

When the surrounding people show optimism and the local government shows pessimism, namely $r_1>1, r_2>1$

Assuming that the surrounding people show excessive optimism and the local government shows excessive pessimism, then $r_1 \to 0, r_2 \to +\infty, r_1 - 1 \to -1, r_2 - 1 \to +\infty$, the simultaneous equations are:

$$-q(\alpha C + A_2 - A_1 - D)(q-pq)^{r_1-1} + (1-q)D(p+q-pq)^{r_1-1} = 0 \quad (15)$$

$$p(E-A_1)\left(\frac{pq}{1-q+pq}\right)^{r_2-1} - (1-p)A_2 = 0 \quad (16)$$

When p, q ∈ [0, 1], equations have no solution. Therefore, there is no equilibrium strategy when the surrounding people show excessive optimism and the local government shows excessive pessimism.

Assuming that the surrounding people show excessive pessimism and the local government shows excessive optimism, then $r_1 \to +\infty, r_1 - 1 \to +\infty, r_2 \to 0, r_2 - 1 \to -1$, the simultaneous equations are:

$$-q(\alpha C + A_2 - A_1 - D)\left(\frac{q-pq}{p+q-pq}\right)^{r_1-1} + (1-q)D = 0 \quad (17)$$

$$p(E-A_1)(pq)^{r_2-1} - (1-p)A_2(1-q+pq)^{r_2-1} = 0 \quad (18)$$

In formula (17), as $q-pq < p+q+pq$, then $\left(\frac{q-pq}{p+q-pq}\right)^{r_1-1} \to 0$, so $(1-q)D = 0$, and $q_5^* = 1$. Put them $q_5^* = 1$ into formula (18), $p_5^* = \frac{A_2}{E-A_1+A_2}$ is obtained. As $E > A_1$, then $E - A_1 + A_2 > A_2$, so $0 < \frac{A_2}{E-A_1+A_2} < 1$ and $p_5^* = \frac{A_2}{E-A_1+A_2}$ is the valid solution.

Therefore, when the surrounding people show excessive pessimism and local government shows excessive optimism, there is a mixed Nash equilibrium ($\frac{A_2}{E-A_1+A_2}$, 1). The local government chooses compensation strategy, and the surrounding people choose cooperation strategy with probability $\frac{A_2}{E-A_1+A_2}$.

RESULTS

Numerical analysis

In order to reflect the influence of different emotional states on the decision-making behaviors of the surrounding people and local government, MATLAB software is used for numerical simulation to verify the nature and practicability of the model. Under the setting conditions of assumption 3, 4 and the income ranking of both sides, the variables in the RDEU game model of environmental compensation for NIMBY facilities are given real values. the specific parameters are set in Table 4.

Table 4. Parameter settings in RDEU game model

R	C	A1	A2	D	E	B	α
1000	100	60	50	10	70	90	0.3

According to the parameters, equations are shown as follows:

$$-q(q-pq)^{r_1-1} + (1-q)(p+q-pq)^{r_1-1} = 0 \quad (19)$$

$$p^{r_2}q^{r_2-1}-5(1-p)(1-q+pq)^{r_2-1}=0 \quad (20)$$

When $r_1=r_2=1$, $p1=0.8333$, $q1=0.5000$, the Nash equilibrium is (0.8333, 0.5000). That is, when the surrounding people and the local government are in a state of no emotion, the surrounding people take cooperation strategy with the probability of 0.8333, and the local government takes compensation strategy with the probability of 0.5000.

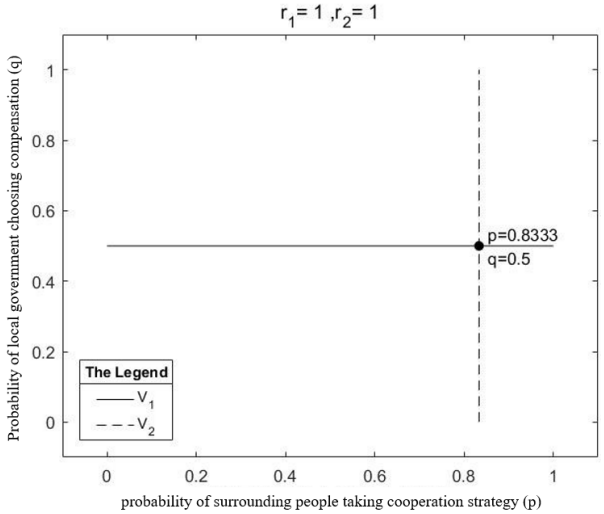

Figure 1. Nash equilibrium of rational state for both sides ($r_1=r_2=1$)

When $r_1, r_2 \neq 1$, the polar coordinate $\sqrt{p^2+q^2}$ of Nash equilibrium solution in RDEU game is used to determine the convergence trend of the trajectory curve, so as to obtain the trajectory curve of the solution by the preset accuracy calculating. When $r_1<1, r_2>1$, the numerical analysis equations have no solution, which is consistent with the analysis results in Section 3.4.

When both sides show optimism, $r_1=r_2\leq 1$

It can be seen from Figure 2 and Figure 3 that the solution trajectory curve does not converge when $r_1=r_2\leq 1$. It will always tend to the solution (0.8333, 0.5000) which is the solution when $r_1=r_2=1$. At the same time, the inflection point appears when $r_1=r_2=0.37$. With the changes of r_1, r_2 in the interval (0, 1], p increases from 0.3393 to 0.8333. q decreases firstly and then increases from 0.24747, and finally reaches 0.5000. Therefore, in the evolution process from over-optimism to emotional rationality, the probability of surrounding people choosing cooperation strategy gradually increases, while the probability of local government choosing compensation strategy decreases firstly and then increases, but eventually it will not exceed 0.5000.

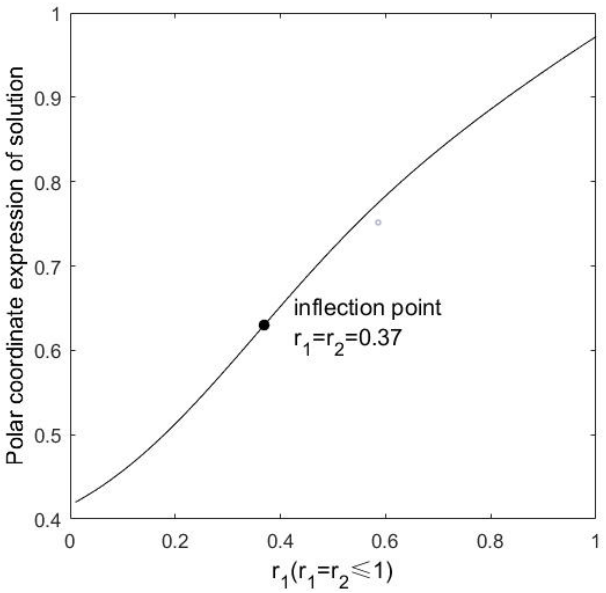

Figure 2. Polar coordinate expression of Nash equilibrium solution ($r_1=r_2\leq 1$)

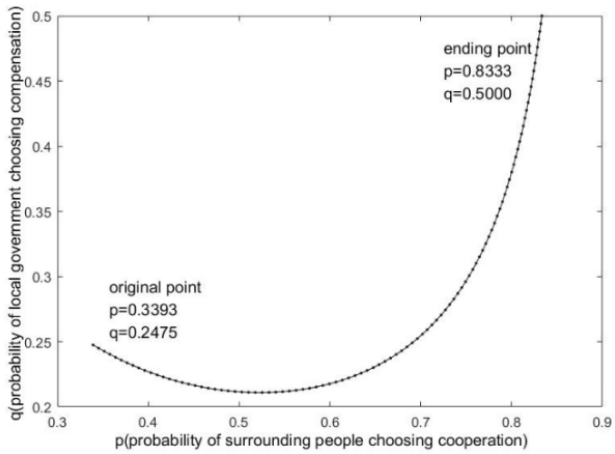

Figure 3. Trajectory of Nash equilibrium solution ($r_1=r_2\leq 1$)

When both sides show optimism but $r_1\neq r_2$ ***, take*** $r_1\leq 1, r_2=0.5$

It can be seen from Figure. 4 and Figure 5 that when $r_1\leq 1, r_2=0.5$, the trajectory curve of the solution does not converge and has no inflection point, showing a stable growth trend. With the change of r_1 in (0, 1], p increases from 0.4722 to 0.7671, q increases from 0.0654 to 0.5000. Therefore, when the local government's sentiment index is 0.5 and the surrounding people's mood changes from over optimism to rationality, the probability of the surrounding people choosing cooperation strategy increases gradually, while the probability of the local government choosing compensation strategy shows a steady growth trend, but no more than 0.5.

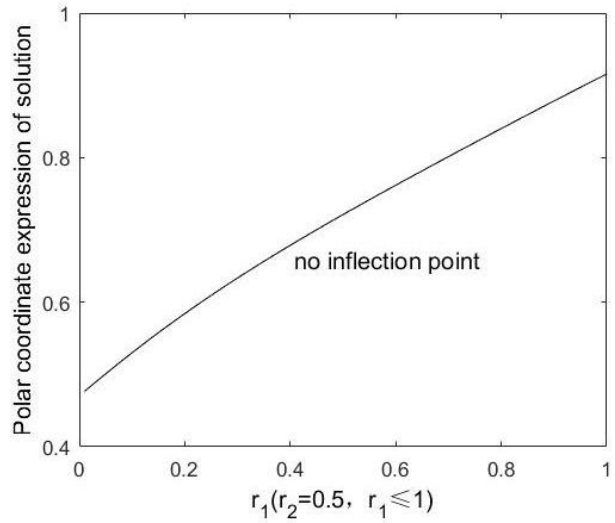

Figure 4. Polar coordinate expression of Nash equilibrium solution ($r_1 \le 1, r_2 = 0.5$)

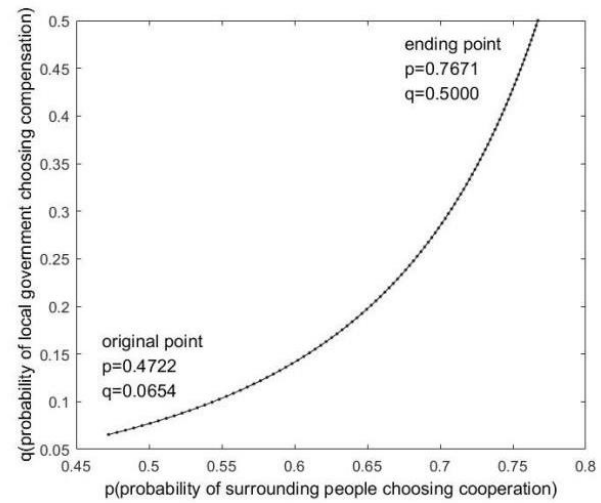

Figure 5. Trajectory of Nash equilibrium solution ($r_1 \le 1, r_2 = 0.5$)

When both sides show pessimism, $r_1 = r_2 \ge 1$

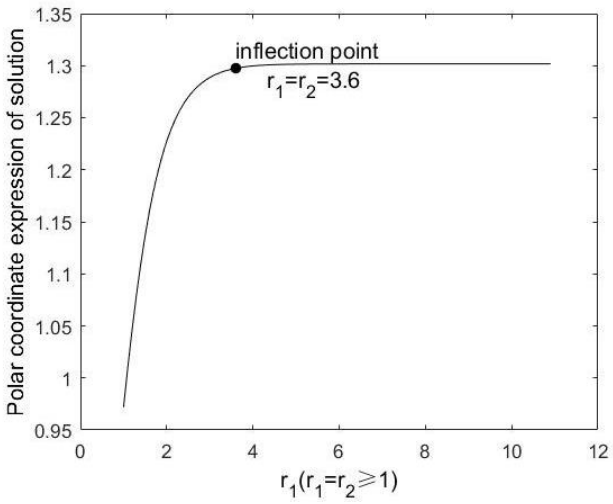

Figure 6. Polar coordinate expression of Nash equilibrium solution ($r_1 = r_2 \ge 1$)

It can be seen from Figure 6 and Figure 7 that when $r_1 = r_2 \ge 1$, the trajectory curve of the solution converges to $r_1 = r_2 = 3.6$. With the change of r_1, r_2 in $[1, +\infty)$, p increases from 0.8333firstly and then decreases, and finally reaches 0.8333. q increases from 0.5000 to 1. Therefore, in the evolution process from emotional rationality to excessive pessimism, the probability of surrounding people choosing cooperation strategy increases first and then decreases, but the probability of choosing cooperation strategy in emotional rationality and excessive pessimism are both 0.8333. The probability of local government choosing compensation strategy gradually increases to 1, that is, the local government chooses compensation strategy in excessive pessimistic situation.

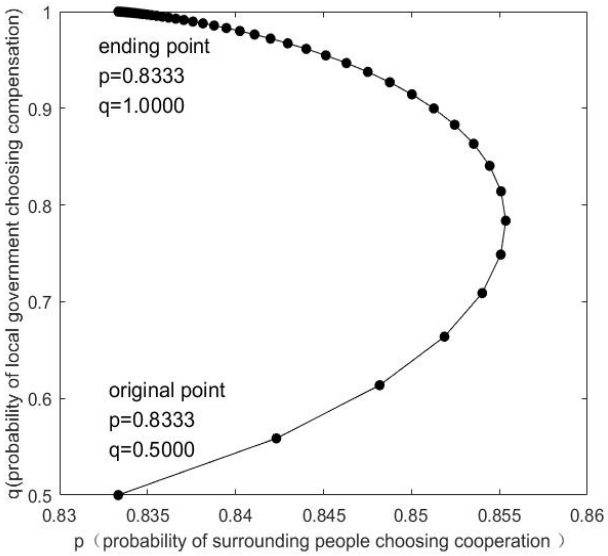

Figure 7. Trajectory of Nash equilibrium solution ($r_1 = r_2 \ge 1$)

When both sides show pessimism, but $r_1 \ne r_2$ ***, take*** $r_2 = 5, r_1 \ge 1$

It can be seen from Figure 8 and Figure 9 that when $r_2=5$, $r_1 \ge 1$, the trajectory curve of the solution converges to $r_1=3.2$, $r_2=5$. With the change of r_1 in $[1, +\infty)$, p decreases from 0.9880 to 0.8333; q increases from 0.5000 to 1. Therefore, when both sides show pessimism, if the local government's emotion index is 5, the probability of the surrounding people choosing cooperation strategy gradually decreases in the evolution process from emotional rationality to excessive pessimism, while the probability of the local government choosing compensation strategy gradually increases to 1.

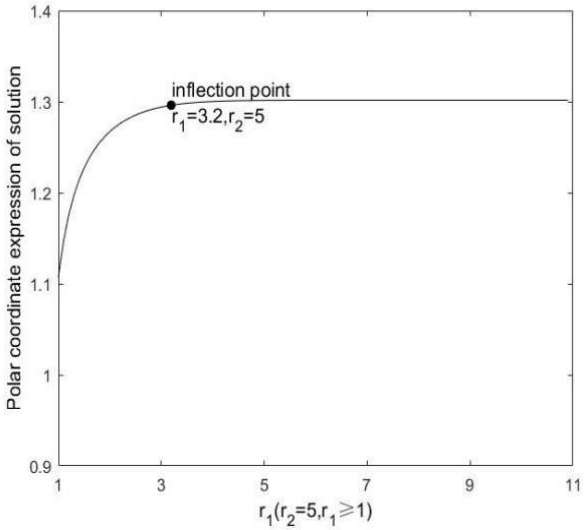

Figure 8. Polar coordinate expression of Nash equilibrium solution ($r_2 = 5, r_1 \geq 1$)

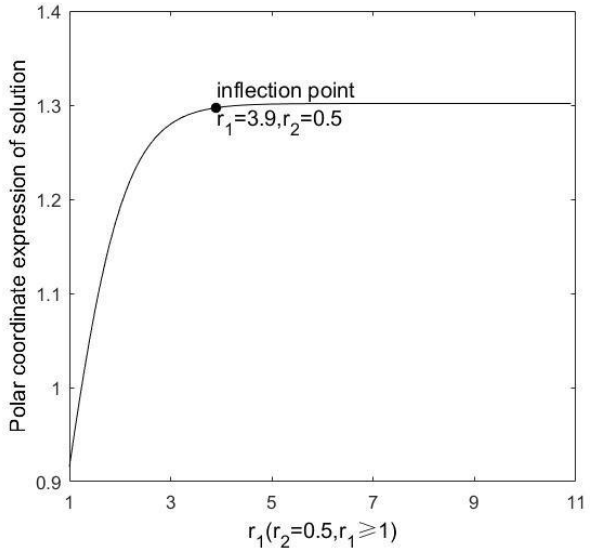

Figure 10. Polar coordinate expression of Nash equilibrium solution ($r_2 = 0.5, r_1 \geq 1$)

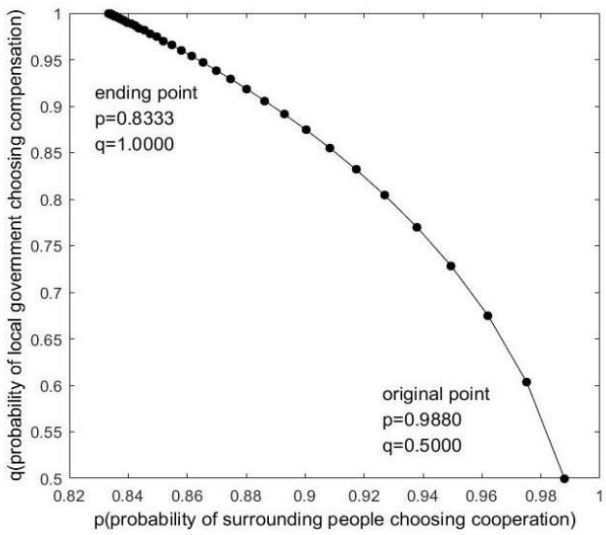

Figure 9. Trajectory of Nash equilibrium solution ($r_2 = 5, r_1 \geq 1$)

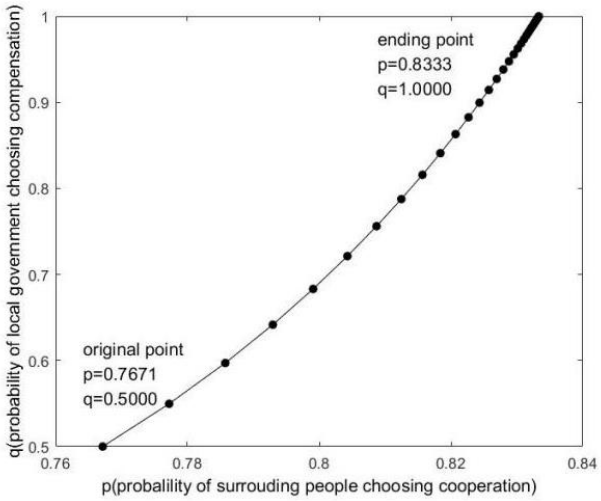

Figure 11. Trajectory of Nash equilibrium solution ($r_2 = 0.5, r_1 \geq 1$)

When the surrounding people show pessimism, the local government shows optimism, take $r_2 = 0.5, r_1 \geq 1$

It can be seen from Figure 10 and Figure 11 that when $r_2 = 0.5, r_1 \geq 1$, the trajectory curve of the solution converges to $r_1 = 3.9, r_2 = 0.5$. With the change of r_1 in [1, +∞), p increases from 0.7671 to 0.8333; q increases from 0.5000 to 1. Therefore, when the local government is optimistic (emotion index is 0.5) and the surrounding people are in the evolution process from emotional rationality to excessive pessimism, the probability of choosing cooperation strategy gradually increases to 0.8333, and the probability of choosing compensation strategy gradually increases to 1.

CONCLUSIONS

Based on the REDU theory, the influence of emotion on the game behavior between the surrounding people and local government in the environmental compensation of NIMBY facilities are studied. Through the analysis and numerical simulation of the game equilibrium strategy under the combination of rational, pessimistic, optimistic and pessimistic emotions of the surrounding people and the local government, the main conclusions are as follows:

(1) Whether for the surrounding people or the local government, emotions have a profound impact on their strategic choices in environmental compensation. With the emotion evolution of optimism- rationality-pessimism, the probability of the local government choosing compensation strategy gradually increases, that is, the higher the probability of the government expecting the non-cooperation of the surrounding people is, the

higher the probability of the government choosing compensation strategy is. the government hopes to resolve the NIMBY conflict through compensation strategy and promote the smooth implementation NIMBY facilities. With the emotion evolution of optimism–rationality–pessimism, the probability of surrounding people choosing cooperative strategy first increases. But when the emotion index is greater than a certain value, the probability of cooperation begins to decrease, that is, when the surrounding people are too pessimistic, they tend to choose non-cooperation strategy.

(2) Increasing the compensation *A1* can significantly improve the probability of the surrounding people choosing cooperation strategy. on this basis, increasing the difference between *A1* and *A2* can also improve the probability of surrounding people choosing cooperation strategy. Therefore, environmental compensation plays an important role in resolving NIMBY conflicts. Local governments need to determine effective environmental compensation through scientific and reasonable assessments to increase the willingness of surrounding people to cooperate and resolve NIMBY conflicts before construction. This is also consistent with the practice of resolving NIMBY conflicts in Taiwan and Guangzhou.

(3) When the surrounding people is too pessimistic or optimistic, the probability of choosing cooperation strategy will decrease. In the compensation of NIMBY facilities, the emotions of the surrounding people include not only the panic of the risk from facilities, the distrust of the local government, but also the expectation and measurement of the compensation strategy from the government, which is more complex than the emotions in the local government decision-making process. Therefore, too high or too low emotion index will lead the surrounding people to adopt a more risky and irrational non-cooperation strategy. Actively guiding the rational development of the surrounding people's emotions is of great significance to resolve the NIMBY conflict.

Based on the above conclusions, the following countermeasures and suggestions for the environmental compensation of NIMBY facilities are obtained.

(1) Promoting the construction of environmental compensation system for NIMBY facilities. Reasonable environmental compensation for people around NIMBY facilities is not only in line with the principle of fairness and risk-benefit, but also an important way to resolve NIMBY conflicts. Effective environmental compensation system should include scientific and reasonable compensation evaluation system, timely and transparent information disclosure mechanism, efficient and clear coordination guarantee mechanism.

(2) Emotion monitoring and counseling mechanism should be established. Emotion has an important impact on the decision-making of the surrounding people, and promoting the development of emotion rationality is conducive to resolving NIMBY conflicts. Effective emotional monitoring and counseling mechanism should be based on the new challenges of network public opinion, including scientific and effective emotional guidance mechanism, comprehensive emotional monitoring mechanism and efficient emotion counseling mechanism to promote the rational development of surrounding people's emotions.

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Contribution of individual authors:

Ying Sun & Zhiqiang Ma: conception and design of the manuscript and interpretation of data, literature searches and analyses, clinical evaluations, manuscript preparation and writing the paper;

Fan Yang: made substantial contributions to conception and design, literature searches and analyses, participated in revising the article and gave final approval of the version to be submitted.

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RESEARCH ON THE EFFECT OF ART THERAPY ON RELIEVING MENTAL STRESS OF COLLEGE STUDENTS

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SUMMARY

***Background**: As a new type of psychotherapy, art therapy is not only the product of interdisciplinary integration but also a manifestation of the interaction between art disciplines and psychology disciplines. To cope with the increasing demand for psychological counseling of college students, colleges and universities need to explore and enrich the forms of mental health education. While art therapy with its unique advantages has generated positive effects on the mental health education of college students. This paper analyzes the characteristics of some popular art therapies and discusses their effect on relieving the mental stress of college students.*

***Subjects and methods:** In this study, 84 student volunteers from a university in Zhejiang Province, China are selected as the research subjects. They are divided into four groups with 21 people in each group. The three experimental groups are treated with music therapy, painting therapy, and dance therapy respectively for two months, while the control group is not given any therapy. The PSS scores of each group are recorded every other week. The test data are uploaded and sorted out in Excel, and correlation analysis is conducted using SPSS24.0.*

***Results**: The PSS score of the control group has no significant change during the experiment ($t = -0.498$, $P > 0.05$). The PSS score of the music therapy group decreases significantly during the experiment ($t = -3.587$, $P < 0.01$), the PSS score of the painting therapy group decreases significantly during the experiment ($t = -3.711$, $P < 0.01$), and the PSS score of the dance therapy group decreases significantly during the experiment ($t = -3.428$, $P < 0.01$).*

***Conclusions**: Music therapy, painting therapy, and dance therapy can all greatly relieve the mental stress of college students. Relatively speaking, dance therapy has the most significant effect. Music therapy and painting therapy show a slightly weaker but more stable relieving effect.*

***Key words:** art therapy - mental stress - college students - music therapy - painting therapy - dance therapy*

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INTRODUCTION

Art therapy, also known as art psychotherapy, is an interventional method of psychotherapy, which mainly spans the two fields of art and psychology. The founder of art therapy was American psychiatrist Margaret Naumburg, who founded the Walden School in 1915 and began to incorporate art into psychotherapy, providing a way to recognize the subconscious (Samaritter 2018). Art therapy officially emerged in the 1940s with the overall goal that patients can apply art in a safe and relaxing environment to achieve change and progress on a personal level. Then it has evolved into an important psychotherapy method (Cheng et al. 2021).

In the 1980s, the American Art Therapy Association defined that art therapy provides non-verbal opportunities for expression and communication. There are two mainstream cognitions in the field of art therapy. One is that art creation is therapy, the process of which can ease emotional conflicts and help self-knowledge and self-growth. The other one is that if art learning is applied to psychotherapy, the works, and the thinking process during art creation are of great significance to maintaining a balanced and consistent relationship between the personal inner heart and the external world (Teoli 2020). Therefore, it can be seen that art therapy has two orientations. One is a psychoanalysis-oriented art therapy mode. In this mode, art becomes a non-verbal communication medium and helps people express negative emotions and open hearts through the ideas and interpretations related to art creation. The other orientation is towards the essence of art (Kaimal & Arslanbek 2020). Through artistic creation, emotional conflicts can be alleviated, perception ability enhanced, and emotions purified. Both two orientations regard art as a bridge between the personal inner heart and the outer world so that people can release their uneasiness through art creation. During the process of transforming ideas into specific images, individual needs and emotions are conveyed, personality can be adjusted, and art therapy can be improved through sharing and discussion (Gerlitz et al. 2020).

Most college students are in their youth stage, with gradually mature self-awareness, distinct personality characteristics, and rich emotional experience. When faced with multiple pressures from college campuses, families, and society, they have common psychological problems, including difficulty adapting to a new environment, academic problems, employment pressure, interpersonal communication, family relationships, romantic relationships, etc. Therefore, some college students fall into a mental sub-health state dominated by bad emotions under the influence of various stressors (Dugue et al. 2018). Especially since 2020, under the impact of COVID-19, the mental health of college students has been greatly affected, further leading to great psychological pressure and emotional manifestations