A Neural Network Approach to Explaining Donation Behavior

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Abstract. When a call for help occurs, people are more likely to donate to members of the in-group. Taking college students as a special group, an experimental scheme including donation situation scale, altruistic personality scale, warm glow scale, empathy scale and donation willingness scale was designed, and based on the effective experimental questionnaire sample, a BP neural network model describing the relationship between influencing factors and donation willingness was proposed, and this model was used to analyze the weight of the influence of each influencing factor on college students' willingness to donate in the context of close relationship and relationship distance. The results showed that the main factors affecting the donation intention of college students were emotional empathy and warm glow, accounting for 30.03% and 27.21%, respectively. However, the main influencing factors in the far relationship context were cognitive empathy and altruistic personality, accounting for 31.30% and 26.41%, respectively. This indicates that different factors have different influence degrees in different situations, and it is also suggested that universities should adopt differentiated measures when carrying out donation work.

Keywords: College Students · Influencing Factors · Willingness to Donate · BP Neural Networks · Weight Analysis

1 Introduction

When someone seeks help due to illness, people are more likely to engage in prosocial behaviors with members of the inner group, that is, they are more willing to donate to acquaintances. People classify acquaintances as members of the inner group—socially close, and newly met or strangers as members of the outer group [1]. Altruistic behavior refers to the voluntary and non-rewarding behavior of people to help others [2], and prosocial behavior is a typical form of altruistic behavior [3]. This paper attempts to explore the formation mechanism of college students' willingness to donate in different contexts based on prosocial theory, which is of great significance for guiding the progress of social civilization.

Altruism is a persistent consideration of the welfare and rights of others, and the greater the propensity for altruistic behavior, the greater the willingness to donate [4]. The warm glow is the ability to obtain positive, self-perceived emotional experiences

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that have a significant positive effect on willingness to donate [5]. Empathy is an important motivator of prosocial behavior [6], Ding xianfeng divided empathy into cognitive empathy and emotional empathy, cognitive empathy refers to measuring the participant's understanding and experience of the situation from the perspective of others; Emotional empathy refers to measuring participants' emotional responses to unfortunate situations [7]. Willingness to donate refers to the subjective probability that an individual will engage in a particular act [8]. In terms of context, Neisser, the father of cognitive psychology, proposed that an individual's cognitive perception is real-time and often occurs in specific environments [9], and the intensity of the situational factor donation affects the willingness and amount of donation of college students [10].

Through reviewing the literature, it can be seen that the vast majority of studies use linear regression to analyze the degree of influence of independent variables on the dependent variable, but its prediction effect leads to a large error, and the BP neural network model can compensate for this shortcoming [11], and many studies are based on BP network weights analysis to make targeted suggestions [12]. Therefore, this paper attempts to use the BP neural network model to establish a weight learning mechanism, analyze the influence of altruistic personality, warm glow, cognitive empathy and emotional empathy on donation willingness, and determine the weights and main influencing factors of various indicators.

BP neural networks are composed of input layers, output layers, and output layers, with different numbers of neurons in each layer, neurons in the same layer not connected to each other, and neighboring neurons connected by rights [13]. In this paper, the trial method is used to determine the optimal number of hidden layer nodes, $j = \sqrt{i+1} + \alpha$, i represents the number of input layer nodes, where $i = 4$; j is the number of hidden layer nodes; α is an integer between 1–10. Through multiple training, the number of hidden layer nodes j with the minimum network error is 3, and the BP neural network structure is shown in Fig. 1.

In order to be able to describe it simply and clearly, we define the altruistic personality in the context of the relationship as x_1^1, the warm glow as x_2^1, the cognitive empathy as x_3^1, the emotional empathy as x_4^1, and the willingness to donate as y_1^1; Altruistic personality in the context of distant relationship is defined as x_1^2, the warm glow is x_2^2, cognitive empathy is x_3^2, emotional empathy is x_4^2, and the willingness to donate is y_1^2. (As can be seen from the altruistic scale, the range of values for x_1^1 and x_1^2 is [1,5]; The Warm Glow Scale, empathy scale, and willingness to donate scale can be known, and the values of

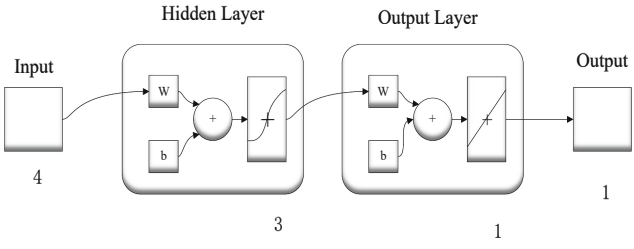

Fig. 1. BP neural network structure

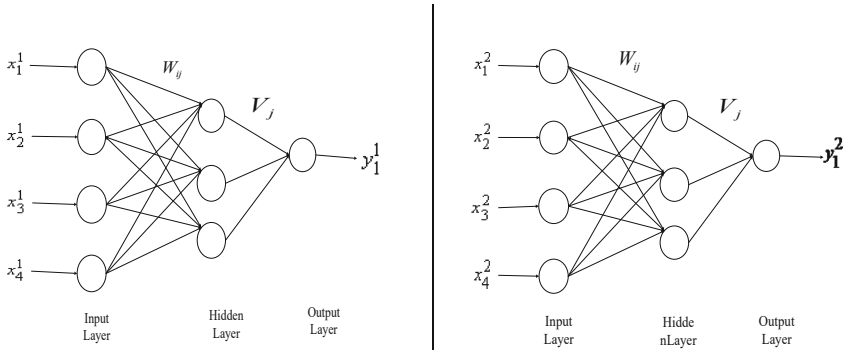

Fig. 2. Diagram of a relational near-context research model and relational far-context research model

x_2^1, x_3^1, x_4^1 and x_2^2, x_3^2, x_4^2 range [1,7]). Constructing a research model is shown in Fig. 2.

2 Experimental Design

This section explores the influencing factors affecting the willingness of the group to donate and the influencing characteristics of these influencing factors on the willingness to donate through experimental analysis methods.

2.1 Research Subjects

This paper uses randomly distributed questionnaires, filled in and recycled on the spot, and lasting 2 months. The two questionnaires received 273 and 278 questionnaires respectively, and the effective questionnaires were sorted and screened according to certain rules, and finally 250 valid questionnaires were obtained, with an effective rate of 91.5% and 89.9% respectively.

2.2 Research Methods

The questionnaire describes the tools of the experimental rules as follows:

(1) Online donation situation scale: Material description The helpers are students and online strangers of the university, and the word count of the materials is about 300 words. After the participants read the relationship between the evaluation and the help, choose the score that best represents the relationship. (2) Altruistic Personality Scale: This scale uses the measurement tool commonly used by Chinese research college students to measure altruism [14]. Using Likert's 5 point scoring, its Cronbach's α were 0.923 and 0.872, respectively.The following scale uses the Likert 7 point scoring method, (3) Temperature Effect Scale: The scale was modified to be a formulation suitable for the study in this paper [15], and its Cronbach's α were 0.891 and 0.751, respectively. (4) Empathy scale: This scale sets two dimensions of cognitive empathy and emotional

empathy [7], and the Cronbach's α of the cognitive empathy dimension in the two scales are 0.818 and 0.700, respectively. Cronbach's α in the emotional empathy dimension were 0.850 and 0.710, respectively. The correlation coefficients of cognitive empathy and emotional empathy in the two scales were 0.766 and 0.64, respectively, and $p < 0.05$, respectively. (5) Scale of Willingness to Donate: The scale of Zheng Chundong et al. was taken [16], and the scale was modified to be suitable for the formulation studied in this paper, and its Cronbach's α were 0.783 and 0.742, respectively.

3 Experimental Analysis

3.1 Situational Differentiation

The intensity of the situation perceived by the subjects under the conditions of the close-range situation of the relationship ($M = 4.79$, $SD = 1.40$) was stronger than that of the participants in the stranger situation (relational distance) ($M = 3.62$, $SD = 1.28$), $t(8.60)$, $P < 0.01$. Therefore, the situational factor reaches the level of situational differentiation.

3.2 Correlation Analysis

From the correlation analysis, it can be seen that there is a significant positive correlation between the variables in the near context and the distant context of the relationship; The multiple linear regression equations available from Table 1 is: $y_1^1 = 0.398 + 0.206 * x_1^1 + 0.298 * x_2^1 + 0.163 * x_3^1 + 0.363 * x_4^1$, and the factors affecting the willingness of college students to donate are ordered by decreasing weight contribution rate as: $x_4^1 > x_2^1 > x_1^1 > x_3^1$.

The multiple linear regression equations available from Table 2 is:$y_1^2 = 0.013 + 0.326 * x_1^2 + 0.227 * x_2^2 + 0.417 * x_3^2 + 0.148 * x_4^2$, the weight contribution rate is ordered as: $x_3^2 > x_1^2 > x_2^2 > x_4^2$, and the warm glow is the factor that is great affects the willingness to donate in different contexts.

Table 1. Multiple linear regression analysis of near-relational scenarios (n_1=250)

$\mathbf{n}_1$		B	β	t	p
Independent Variable	Constant	0.398	----	1.221	0.000
Near Relationship	x_1^1	0.206	0.169	3.553	0.000
	x_2^1	0.298	0.293	5.08	0.000
	x_3^1	0.163	0.155	2.659	0.008
	x_4^1	0.363	0.342	6.479	0.000

Table 2. Multiple linear regression analysis of far-relational scenarios (n_2=250)

$\mathbf{n}_2$		B	β	t	p
Independent Variable	Constant	0.013	---	0.04	0.000
Far Relationship	x_1^2	0.326	0.206	4.363	0.007
	x_2^2	0.227	0.211	3.906	0.000
	x_3^2	0.417	0.408	7.269	0.000
	x_4^2	0.148	0.137	2.658	0.000

Note: R_1^1=0.601,F_1 = 70.137, VIF_1< 5,p<0.05;R_1^2=0.600,F_2 = 74.907, VIF_2< 5,p<0.05

3.3 Simulation Result Analysis

The simulation experiment randomly selected 70% of the samples in the questionnaire for training, and the other 30% of the samples were run as test samples in Matlab, and the train() function was used to train the BP neural network to obtain the mean variance of training under the background of near and far relations, and then concluded that the BP training effect was better than that in the near relationship situation.

3.4 Comparative Analysis of Model Prediction Performance

The prediction accuracy of multiple linear regression models and BP neural network models can be measured by relative error [11], as shown in Eq. (1).

$$\Delta\beta = \frac{|\Phi(k)|}{x(k)}, \quad \Phi(k) = x(k) - x\left(\hat{k}\right) \tag{1}$$

In Eq. (1),$x(k)$ represents the k actual value and $x\left(\hat{k}\right)$ represents the k simulated value.

The relative errors of multiple linear regression model and BP neural network model in the near and far context are calculated as 0.12 and 0.05 and 0.13 and 0.07 respectively according to Eq. (1). Therefore, BP neural network models have higher accuracy, smaller errors and good simulation effects than multiple linear regression models.

3.5 Weight Analysis

The basic guiding principle of the BP network weight analysis method is to determine its importance by analyzing the weight of each input neural node as the proportion of the weight of the entire input neural node, and sorting it according to the weight contribution rate of the input neural node from large to small, and judging the degree of influence of the input neural node on the output [17]. It is calculated as follows:

$$\mathrm{b}_i = \sum_{j=1}^{3} |W_{ij}| . \left[|V_j| . \left(\ln |W_{ij}| / \ln \sum_{k=1}^{3} |W_{ik}| \right)' \right] \tag{2}$$

In the above equation, b_i is the weight contribution rate of the i input node; W_{ij} is the connection weight between the input layer node i and the hidden layer node j(positive and negative); $|\ |$ is the absolute value symbol, and V_j is the connection weight of the hidden node j to the output node (where there is only one output node). The weight contribution of the input layer node b b connection path to that node is shown in the product term on the right side of Eq. (1) and in equation. After normalization, the weight contribution rate C_i (that is, the contribution rate of the y^1, y^2 factors to the willingness to donate) of node i is:

$$C_i = b_i / \sum_{m=1}^{4} b_m \tag{3}$$

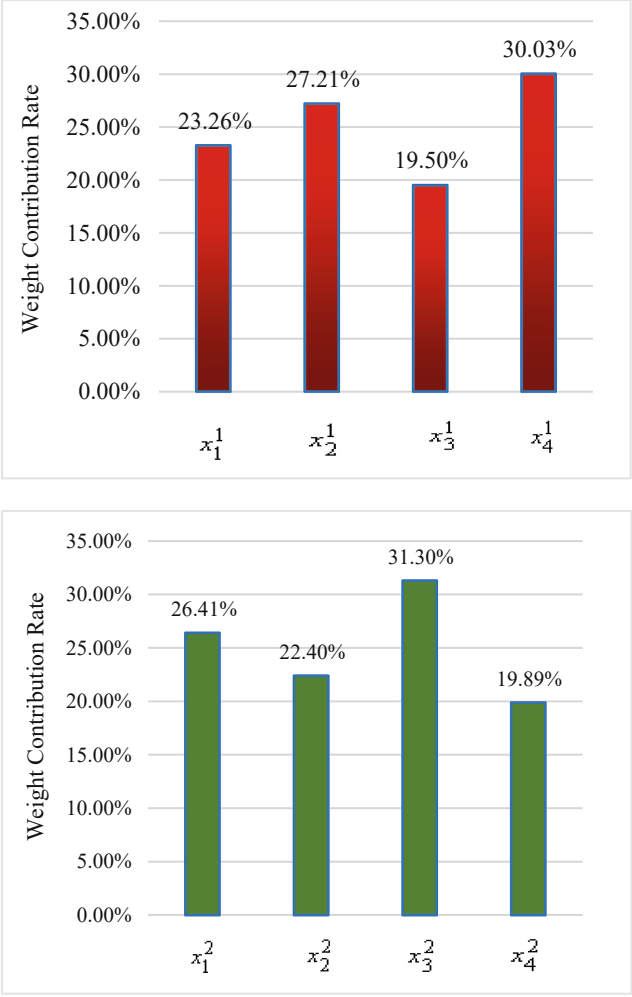

Fig. 3. Proportion of context weights near and far

Table 3. Weights trained for BP networks in the context of near and far relationships

j_1^1	1	2	3	j_2^1	1	2	3
W_{1j}	-0.848	0.551	0.285	W_{1j}	1.081	-0.602	-1.044
W_{2j}	0.642	0.117	-1.050	W_{2j}	1.380	1.380	0.548
W_{3j}	-0.879	0.099	0.253	W_{3j}	-1.100	0.288	1.379
W_{4j}	1.043	0.685	0.445	W_{4j}	-1.310	-0.278	0.553
V_j	0.760	0.375	0.648	V_j	0.669	0.152	1.311

Table 3 show that the respective neural networks of the near-relationship and far-relationship contexts have been trained weights, so that the weights of each input variable in the near-relationship and far-relationship scenarios can be calculated by formulas (2) and formula (3), and the calculation results are shown in Fig. 3.

4 Conclusions

Different degrees of situations have different effects on college students' willingness to donate. In the context of the relationship, the factors influencing the willingness of college students to donate are, in descending order of weight contribution rate as follows: $b_4^1 > b_2^1 > b_1^1 > b_3^1$. That is 30.03% > 27.21% > 23.26% > 19.50%; In the context of the relationship, the factors affecting the willingness of college students to donate are sorted by decreasing weight contribution rate as follows: $b_3^2 > b_1^2 > b_2^2 > b_4^2$.That is 31.30% > 26.41% > 22.40% > 19.89%.

This conclusion is consistent with the results of multiple linear regression equation, indicating that emotional empathy is the main factor affecting the willingness of college students to donate. In this near context, the help seekers are students in our school. Compared with ordinary online help seekers, people are more likely to empathize with each other, and are more willing to donate to others around them who also need help. However, in the far context, because the help information was published by strangers on the Internet, when the participants saw the help information, it was difficult to distinguish the authenticity of the information, so they were more rational, which also explained the important role of cognitive empathy.

Finally, the samples in this paper are all from college students, and the generalizability and practicality of their conclusions will be limited. Therefore, the subject population in future studies should be diversified to make the sample more representative.

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