

Extending the Balance Theory by Measuring Bidirectional Opinions with Interactive Language

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ABSTRACT

The signs of social relationship in balance theory is objective and undirected which cannot characterize participants' bidirectional subjective opinions on social relationships. By redefining the signs with the bidirectional opinions according to homogeneity principle, we extend the balance theory by measuring the opinions with interactive language. Initial experimental results on Enron emails shows that the extended model supports the homogeneity principle of balance theory and make it possible to use balance theory to predict the directed opinions besides undirected signs.

Categories and Subject Descriptors

J.4 [Computer Applications]: Social and Behavior Sciences

General Terms

Measurement, Experimentation, Human Factors, Verification

Keywords

Balance theory; homogeneity; opinions; interactive language

1. INTRODUCTION

Balance theory [1] is a classical social theory and is widely used in social network studies. The theory signs each social relationship in a triangle as positive '+' or negative '-' and results in four combinations: '+++', '+--', '-+-' and '---'. The theory raises two hypotheses: (1) the former two combinations are balanced and the other two are unbalanced; (2) the balanced ones are more stable than unbalanced ones, thus the triangles in a social network tend to be balanced in majority.

We argue that the balance theory can be described in both objective and subjective ways. Current studies often measure the social relationship objectively ignoring the participants' opinions. However, in order to predict the individuals' behavior in social network, their subjective opinions are more important than the objective properties of relationships because the behavior is mainly determined by their opinions instead of the objective properties. For example, in influence analysis, though classical method believes the undirected strength of a relationship determines the information propagation probability on it, the one who respects the relationship tend to pass/receive more

information than the other one who despises the relationship. Therefore, if the balance theory can be extended by measuring the participants' opinions, it will benefit the analysis of the social behaviors using extended theory as topological features.

2. THE EXTENSION OF BALANCE THEORY

2.1 Characterize opinions on social relationship

In sociolinguistics, Sapir-Whorf hypothesis [2] states that the semantic structure of language use is related to speaker's conceptions of social relationships. Following this hypothesis and Holmes' dimensions to study social language use [3] we propose four important features of interactive languages to characterize the opinions on social relationship, including frequency, length, fluency and sentiment. The calculation and detailed explanation of the features can be found in our previous work [4] with natural language processing technologies.

2.2 Extension of the Balance Theory

Homogeneity explanation of balance theory: The balance theory can be explained by the homogeneity principle, i.e., in a triangle, the more consistent the two persons' opinions on a third person are, the more positive their opinions on their interrelationship is. The homogeneity based explanation extends the balance theory from binary signs to real value. Furthermore, this explanation can also extend the balance theory from undirected relationship to directed relationship by defining the balance with two participants' bidirectional opinions on each other and their opinions on a third person.

We extend the balance theory according to the principle of homogeneity. In the extension, a person A 's opinion on another person B , is measured by a real-value $|AB|$ in $[0, 1]$ on directed edge (A, B) , and vice versa. Then, the extended model can be illustrated as a triangle with four directed edges including (A, B) , (B, A) , (A, C) and (B, C) as shown in Fig 1.

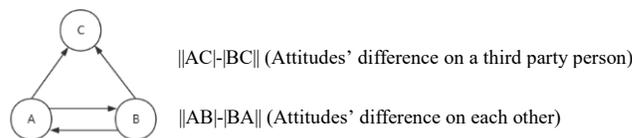


Figure 1. Extend the balance theory with directed opinions.

The balance of this triangle is measured by comparing two differences: (1) When $\|AC|-|BC\|$ is smaller than a threshold θ , we recognize the 'third party difference' between A and B 's opinions on C as '-', which means A and B have similar opinions on C . Otherwise, we recognize 'third party difference' as '+'. (2) When $\|AB|-|BA\|$ is smaller than θ , we recognize the

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'bidirectional difference' as '-' which means A and B have similar opinions on each other. Otherwise, we recognize 'bidirectional difference' as '+'. θ can be determined by the average of all bidirectional differences on every interrelationships in given social network. Then, if the 'third party difference' and 'bidirectional difference' have same signs, we identify the directed triangle as balanced, otherwise, it is unbalanced.

3. EXPERIMENTS

We utilized Enron email dataset containing the social network and interactive language (email content) in experiments. We used a filtered set containing 1078 relationships, on each relationship, there are at least 15 mails on both direction. For each pair of email users in communication, we calculated four language features on both direction to represent bidirectional opinions.

Verifying traditional balance theory: First, we investigated whether the balance hypothesis in traditional theory is still valid with bidirectional opinions measurement. The hypothesis states that in a social network, the signed triangles tend to be balanced in majority. Since the hypothesis is based on undirected signs, on an interrelationship, we compare the sum of bidirectional opinion values with a tunable threshold. Then, the relationship is signed '+'/'-' if the sum value is higher/lower than the threshold.

In order to verify the traditional balance hypothesis, we should firstly determine the random baseline for the distribution of balanced triangles. In a social network, given the proportion of '+' edges noted as p_+ , and the proportion of '-' edges $1-p_+$, the random baseline is the proportion of balanced triangles when '+' and '-' edges are randomly distributed. The random baseline can be calculated with Formula (1), where p_+^3 is the proportion of balanced triangles labeled '+++', and $3p(1-p_+)^2$ is the proportion of balanced triangles labeled '+--', '-+-', and '--+'.

$$P_{balanced_traditional_baseline} = p_+^3 + 3p(1-p_+)^2 \quad (1)$$

Fig 2.(a) illustrates the proportion of balanced triangles with different p_+ . Red curve indicates the random baseline and the other curves indicate the balanced triangles proportion measured by different language features. In Fig 2.(a), (1) the proportion of balanced triangles and that of '+' edges are positively correlated. This accords with the fact that in traditional balance theory, two balanced triangles have more '+' edges than two unbalanced triangles; (2) the proportions of balanced triangles on all four language features increase faster than the baseline with the increase of p_+ . When p_+ is bigger than 0.5, the proportions of balanced triangles exceed the baseline on all language features.

The observations indicate that when more relationship turn to be positive in a social network, the triangles will turn to be balanced at a faster rate. The balanced triangles may not always have advantages than unbalanced triangles. Its advantage is more significant in the social network where positive relationship accounted for the majority.

Verifying extended balance theory: Second, we investigated whether the extended model in Fig.1 accords with the homogeneity explanation of balance theory. We suppose the proportion of positive difference (signed by '+') is p'_+ . According to the homogeneity explanation of balance theory, in extended model, the triangles with signs combinations '++' and '--' are balanced. Therefore, given p'_+ , we can calculate the random baseline of balanced triangles proportion using Formula (2).

$$P_{balanced_extended_baseline} = p'^2 + (1-p'_+)^2 \quad (2)$$

Fig. 2(b) illustrates the proportion of balanced triangles with different p'_+ . The curves have the same meaning with Fig. 2(a).

In Fig. 2(b), (1) when p'_+ is around 0.5, the proportion of balanced triangles reaches the lowest point. The explanation is that when the proportion of positive difference is equal to that of negative difference, there is the maximum probability to form triangles with '+-' signs which are unbalanced; (2) the proportion of the balanced triangles is higher than the random baseline with the decrease of p'_+ (move to the left side on X-axis). This result can give a new interpretation to the balance theory based on the bidirectional opinions measurement. The homogeneity explanation of the balance theory states that in a social triangle, the more consistent the two individuals' opinions on the common friends are, the more positive the relationship between them is. Based on observation (2), we can extend this explanation: in a social triangle, the more consistent the two individuals' opinions on the common friends is (less 'third party difference'), the more similar the two individuals' opinions on each other are.

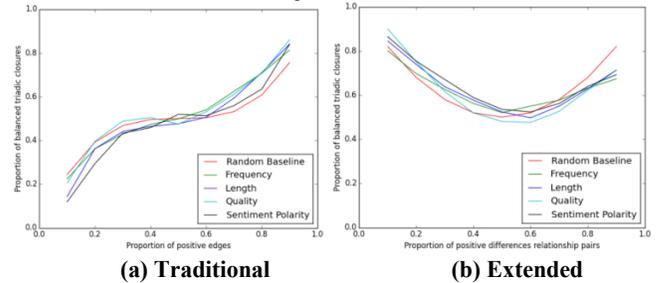


Figure 2. Comparing balanced triangles with random baseline in traditional and extended balance theory.

4. CONCLUSIONS

According to the homogeneity principle, we extend the balance theory by measuring bidirectional opinions on social relationship with interactive language features. Experiments on emails shows that: (1) There is positive correlation between the consistency of two participants' opinions on the third party and the consistency of their opinions on each other; (2) In a social network, the amount of balanced triangles defined by the traditional or extended balance theory are all exceed the random distribution. (3) The extension gives a new evidence as well as a new interpretation for the balance theory by measuring the opinions.

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