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Research on the Relationship between Network Centrality, Network Connection Strength and Innovation Performance in R&D Teams

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Abstract

Based on the perspective of social network and the theory of team conflict, this paper explores the relationship between network centrality, network connection strength and innovation performance of R&D teams, and the moderating effects of affective conflict and cognitive conflict. Through the empirical study on the questionnaire data of R&D teams of Shanghai listed companies, the results show that: team network centrality has a significant positive effect on team innovation performance, and the strength of network connection plays a mediating role between the two; Cognitive conflict negatively moderates the relationship between network centrality and team innovation performance, while positively moderates the relationship between network connection strength and team innovation performance.

Keywords

Network Centrality; Network Connection Strength; Team Innovation Performance; Cognitive Conflict.

1. Introduction

Research and development team, as the basic carrier of enterprise innovation, is always in a complex network, and needs to adjust and intervene various network relations and structural characteristics (such as strength and location, etc.) to adapt to team innovation[1]. In recent years, research on the relationship between team network location or strength and team innovation performance has received extensive attention. Some scholars conducted a meta-analysis of network embeddedness and innovation performance, and found that network relations and structural embeddedness have a significant positive impact on innovation performance[2]. Some scholars also used social network analysis to reveal that the network centrality of enterprises has a lagged positive effect on the innovation of enterprises[3]. Some scholars take network centrality as an intermediate or moderating variable to conduct empirical research and explore the relationship between social capital [4], knowledge diversity [5]and other factors and innovation performance.

The innovation level of enterprises plays an important role in the construction of national technological innovation system, so it is necessary to start from the research and development team to explore the path of innovation performance improvement. However, through systematic literature regression, it can be seen that there are few researches on the internal mechanism between the social network elements of R&D teams and team innovation performance at present. Based on this, from the perspective of social network and combining with team conflict theory, this paper introduces four variables, network centrality, network connection strength, cognitive conflict and team innovation performance, to construct a research framework, and explores the internal mechanism of the relationship between network centrality and team innovation performance.

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2. Conceptual Model and Research Hypothesis

2.1. Network Centrality and Team Innovation Performance

As the basic unit of innovation, the R&D team's knowledge resources often affect its innovation ability[6].Studies on social network show that the position in the overall relationship network is extremely important for the development of individual innovation[7].Whether the R & D team plays a focal role in its network and the degree of importance it plays determines the level of its network centrality[8].Some scholars have found that the higher the network centrality, the closer the R&D team is to the network core, and the individuals in the core position always show more outstanding innovation ability[9]. On the one hand, being at the core of the network can often attract other members of the network to cooperate and communicate, which can realize knowledge aggregation quickly and at low cost.On the other hand, when the research and development team is at the core, it will inevitably stimulate its will to maintain the central position, so as to encourage it to actively use the rich knowledge resources for innovation, improve its innovation ability, and thus promote the improvement of innovation performance[10]. In addition, the team in the core position, with a higher field status, is also helpful to cope with innovation risks[11], and the possibility of innovation success and innovation performance will be improved accordingly[12]. Based on the above analysis, this paper proposes the following hypotheses:

H1: Network centrality has a positive impact on team innovation performance.

2.2. The Mediating Role of Network Connection Strength

Research and development team innovation will inevitably go through the process of "acquisition, exchange, integration and innovation" of knowledge and other resources. However, knowledge and other resources among team members are limited, so it is necessary to acquire rich resources from the team outside[13]. Some scholars will be combined with the research team internal and external social network, including Rodriguez, etc.[14] and Long Jing and Cheng Dejun[15] scholar's research shows that the R&D team of internal and external social network has obvious interaction mechanism, the R&D team of external network centricity makes it easier to gather resources, including knowledge, and resource acquisition, How exchange, integration, and innovation take place within a team is related to the social network within the team. The strength of network connection is an important dimension to measure the strength of network relationship between behavioral subjects, and network connection is considered as the channel and carrier of knowledge transfer, which can be divided into strong connection and weak connection[16]. Many scholars' empirical studies have shown that strong network connection can promote the flow of knowledge within the team[17, 18] and promote the explicit tacit knowledge within the team[19]. Moreover, the improvement of network connection intensity is often accompanied by the improvement of communication frequency and creativity of team members[20], which has a significant positive impact on the improvement of team innovation performance[21,22]. Based on the above analysis, this study puts forward the following hypotheses:

H2a: Network centrality has a positive influence on network connection strength.

H2b: Network connection strength has a positive impact on team innovation performance.

H2c: Network connection strength plays a mediating role in the relationship between network centrality and team innovation performance.

2.3. The Moderating Effect of Cognitive Conflict

When dealing with the same problem, team members may not always have the same views, opinions or ideas, and cognitive conflicts may result from this[24, 25].There is no consensus among scholars on the effects of cognitive conflict in groups. Some scholars pointed out through

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empirical studies that the enhancement of cognitive conflict in a team would hinder the play of overall team effectiveness, reduce team members' focus on tasks, and have a negative impact on the improvement of team performance[29-31].Some scholars have also found that cognitive conflict makes team members actively communicate and discuss to form a closer connection, thus improving the learning level of team members and internal knowledge flow and integration, which has a positive impact on team innovation performance[32-34].Other scholars believe that with the increase of cognitive conflict, its positive effect will be reduced or even have a negative effect, that is, cognitive conflict has an inverted U-shaped effect on team development[26].In general, cognitive conflict will hinder team members' focus on the task, affect the completion of the team's current task or goal, and affect the team's overall central position in the external network.It will also enrich the internal knowledge and information resources of the team, thus bringing about the flow of knowledge and other resources and promoting the enhancement of the connection among members.Based on the above analysis, this paper proposes the following hypotheses:

H3a: Cognitive conflict plays a negative moderating role in the relationship between network centrality and team innovation performance.

H3b: Cognitive conflict plays a positive moderating role in the relationship between network connection strength and team innovation performance.

In summary, the theoretical model of this paper is obtained, as shown in Figure 1 below.

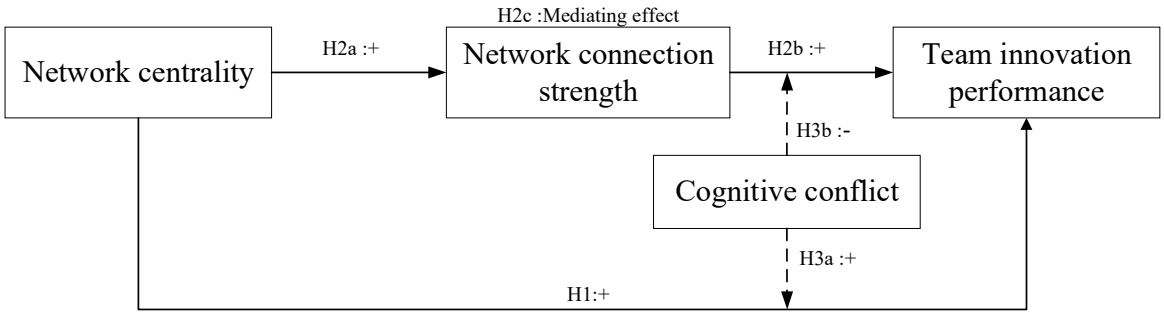

Fig 1. Theoretical model

3. Research Method

3.1. Samples and Data Collection

The research objects of this paper were members of the R&D team of Shanghai listed companies. Data were collected by questionnaire survey method. 201 questionnaires were sent out and 166 valid questionnaires were received with a recovery rate of 82.5%. Among them, gender is evenly distributed, and the majority of them are 30-50 years old (61.4%). Most of them have received bachelor's degree (54.2%), followed by master's degree (31.3%).

3.2. Variable Measurement

In order to ensure the validity and reliability of the measurement scale, the Likert five-point scale, which is relatively mature at home and abroad, is adopted to design the scale based on the purpose of this study and the research of scholars in related fields.

The scale for measuring team innovation performance was designed by referring to the studies of Prajogo and Ahmed[35] and Song Jing[36] and Peng Wei et al.[8]. It consisted of 5 items, including "Your team often solves problems with novel and original solutions".

In terms of the measurement of network centrality, by referring to the research of Ylirenko[37] and Chen Haifeng et al.[1], a scale containing 5 items was finally determined, representing the

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item "it is easy for other teams in the industry to establish contact with your team for experience or technology exchange.

In terms of the measurement of network connection strength, a scale with three items including "in the decision-making process, the team needs to resolve many differences before reaching a unity" was formed by referring to the measurement scale developed by Mu and Di[38]and the research of Peng Wei[8] and other scholars.

In terms of the measurement of cognitive conflict, based on the scale developed by Jehn[24]and referring to the research of Jiao Yemeng[39]and Zhao Khan[28], a scale consisting of three items was formed, including "in the decision-making process, the team needs to resolve many differences to reach a unity".

4. Data and Analysis Results

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4.1. Reliability and Validity Tests

The Cronbach's α values of team innovation performance, network centrality, network connection strength and cognitive conflict were 0.881, 0.896, 0.827, 0.946 and 0.881, respectively, and the overall Cronbach's α value of the scale was 0.871, all of which were greater than 0.8, indicating a high reliability of the scale.

In the validity test of the scale, the KMO value is 0.789, which is significant for Bartlett sphere test and suitable for factor analysis. Amos 21.0 was further used for the verification factor analysis. As can be seen from Table 1, the load of each item factor was higher than the threshold value of 0.5, and the average extraction variation (AVE) and combined validity of each variable met the standard (AVE>0.5, combined validity >0.7). Therefore, the scale had a good convergence validity in general. As can be seen from Table 2, the X2/ DF of the original model is less than 3, IFI and CFI are both greater than 0.9, and RMSEA is less than 0.08. All the fitting indexes of other models are worse than those of the original model, and they have passed the significance test (P <0.001), indicating good discriminative validity.

Table 1. Convergence validity analysis results

Variable	Factor loading	AVE	Composite reliability
Team innovation performance	0.633–0.869	0.5923	0.8775
Network centrality	0.612–0.902	0.5935	0.8771
Network connection strength	0.581–0.811	0.5198	0.8498
Cognitive conflict	0.550–0.998	0.6561	0.8444

Table 2. Results of discriminative validity analysis

Number	model	X^2	df	X^2/df	IFI	CFI	RMSEA
1	The original model	313.9	215	1.46	0.927	0.925	0.075
2	Three-factor model 1	403.522	221	1.826	0.864	0.861	0.1
3	Three-factor model 2	541.239	224	2.416	0.763	0.758	0.131
4	Two factor model	893.243	226	3.952	0.501	0.491	0.19
5	Single factor model	995.126	227	4.384	0.425	0.414	0.203

Note: F1: Team innovation performance, F2: Team connection strength, F3: Team centrality, F5: Cognitive conflict

Three-factor model 1: F1, F2+F3, F4; Three-factor model 2: F1, F2, F3+F4; Two-factor model: F1, F2+F3+F4; Single factor model: F1+F2+F3+F4

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4.2. Common Method Deviation Test

The data collected at the same time point cannot be excluded from the influence of common method bias, so Harman single factor test is required. Specifically, principal component analysis in exploratory factor analysis is required, the first factor is 21.446%, less than half of 68.972%(the total explained variance). Therefore, the data in this paper exclude the influence of common method bias.

4.3. Descriptive Statistics and Correlation Analysis

After verifying the reliability and validity of the scale, this paper conducted descriptive statistics and correlation analysis of the variables. As can be seen from Table 3, team size, network centrality and network connection strength are significantly correlated with team innovation performance respectively, network centrality and network connection strength are significantly correlated, and cognitive conflict and affective conflict are also significantly correlated. The correlation coefficients among the variables are all less than the threshold value of 0.7, indicating that the following tests can be carried out.

Table 3. Descriptive statistics and correlation coefficients

Variable	Mean	SD	1	2	3	4	5	6	7	8
1 Gender	1.458	0.501	1							
2 Age	2.976	0.999	0.022	1						
3. Educational Background	2.458	0.738	0.020	-0.183	1					
4 Team Size	2.675	1.483	0.088	-0.063	-0.052	1				
5. Network centrality	3.8506	0.593	-0.071	-0.084	-0.026	0.135	1			
6. Network connection strength	3.7912	0.636	-0.143	-0.222**	-0.097	0.102	0.562***	1		
7. Team innovation performance	3.8506	0.586	-0.063	-0.131	0.053	0.224**	0.578***	0.548***	1	
8 Cognitive Conflict	3.7590	0.849	-0.024	0.036	0.061	0.085	0.145	0.269**	0.128	1

Note: *** means P < 0.01, ** means P < 0.05; * means p< 0.1, the same as below.

4.4. Hypothesis Testing

4.4.1. Mediating Effect Test

Hierarchical regression analysis and Bootstrap method in Process macro program developed by Hayes[40]were used to jointly test the positive influence relationship and mediating effect among variables, and the analysis results were shown in Table 4 and Table 5. In Table 5, Model 2 added network centrality on the basis of Model 1.The results showed that network centrality had a significant positive effect on the performance of network connection strength (β=0.544, P <0.01). Hypothesis H1 was supported. Model 3 added network connection strength on the basis of Model 2. The results showed that network centrality had a significant positive effect on network connection strength (β=0.306, P <0.01). Hypothesis H2b was supported. Model 5 added network centrality on the basis of Model 4. The results showed that network centrality had a significant positive effect on network centrality (β=0.571, P <0.01). Hypothesis H2a was supported. Model 2 network centricity and team innovation performance of the positive significant relationship in the model 3 variables after joined the network connection strength is reduced, combined with the proposed by zhong-lin wen[40] intermediary effect inspection

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procedures, preliminary verify the network connection strength in the network centrality and team innovation performance relationship, the partial intermediary effect between assuming H2c preliminary support.

Table 4. Regression analysis results

Variable	Team innovation performance			Network connection strength	
	Model 1	Model 2	Model 3	Model 4	Model 5
Gender	-0.096	-0.044	-0.005	-0.181	-0.127
	(-0.73)	(-0.39)	(-0.05)	(-1.30)	(-1.12)
Age	-0.062	-0.037	0.001	-0.151**	-0.124**
	(-1.10)	(-0.60)	-0.02	(-2.45)	(-2.21)
Educational Background	0.037	0.051	0.082	-0.114	-0.099
	(-0.48)	(-0.81)	(-1.31)	(-1.00)	(-0.93)
Team Size	0.090**	0.06	0.058	0.04	0.009
	(-2.03)	(-1.62)	(-1.55)	(-0.75)	(-0.19)
Network centrality		0.544***	0.369**		0.571***
		(-3.56)	(-2.22)		(-4.75)
Network connection strength			0.306**		
			(-2.53)		
R^2	0.073	0.366	0.436	0.095	0.37
F-value	1.605	6.266	7.536	1.902	8.79

It can be seen from Table 5 that network connection strength has a partial mediating effect on the relationship between network centrality and team innovation performance, and hypothesis H2c is further supported.

Table 5. Bootstrap analysis results

Index	Effect value	Boot SE	Boot CI LLCI	Boot CI ULCI	Proportion	Result
The mediation effect	0.175	0.074	0.057	0.353	32.19%	Part of the intermediary
Direct effect	0.369	0.171	0.084	0.743	67.81%	
The total effect	0.544	0.151	0.285	0.867		

4.4.2. Moderated Mediating Effect Test

Model15 in SPSS macros compiled by Hayes (which is consistent with the theoretical model in this study) was used to test the moderating effects of cognitive conflict when gender, age, educational background and team size were controlled.

The results in Table 6 show that cognitive conflict has a negative moderating effect on the relationship between network centrality and team innovation performance (β= - 0.238, P <0.05), and cognitive conflict has a positive moderating effect on the relationship between network connection strength and team innovation performance (β=0.199, P <0.1). Hypothesis H3a and H3b were supported. The moderating effects were shown in Figure 2 and Figure 3.

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Table 6. Regression analysis of variables in the model

Variable	Team innovation performance	
	β	t
constant	3.2112	1.7002
Gender	-0.020	-0.277
Age	0.001	0.019
Educational Background	0.099	1.397
Team Size	0.051	1.483
Network centrality	1.24***	0.4534
Network connection strength	0.4041	0.3941
Cognitive conflict	0.1735	0.4329
Cognitive conflict × network centrality	-0.2382**	0.118
Cognitive conflict × network connection strength	0.1993*	0.1052
R^2	0.688	
F-value	7.277	

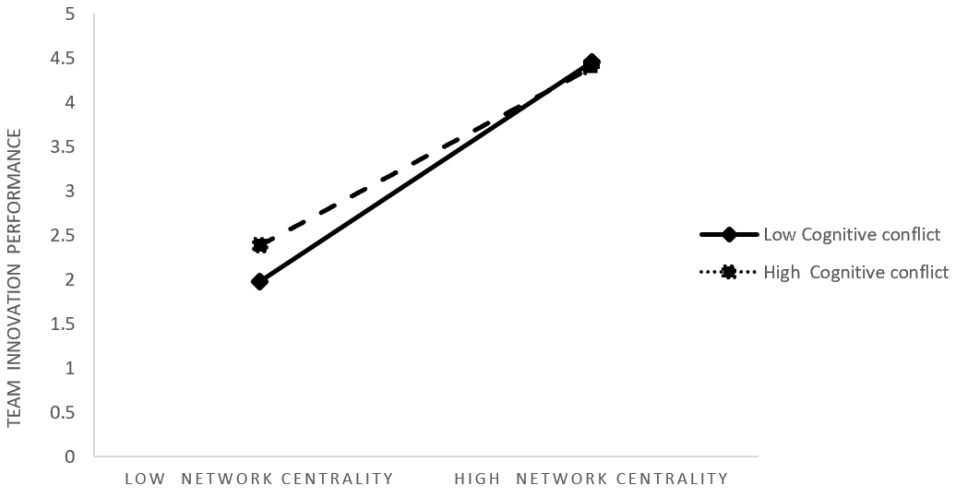

Fig 2. Moderating effect of cognitive conflict on the relationship between network centrality and team innovation performance

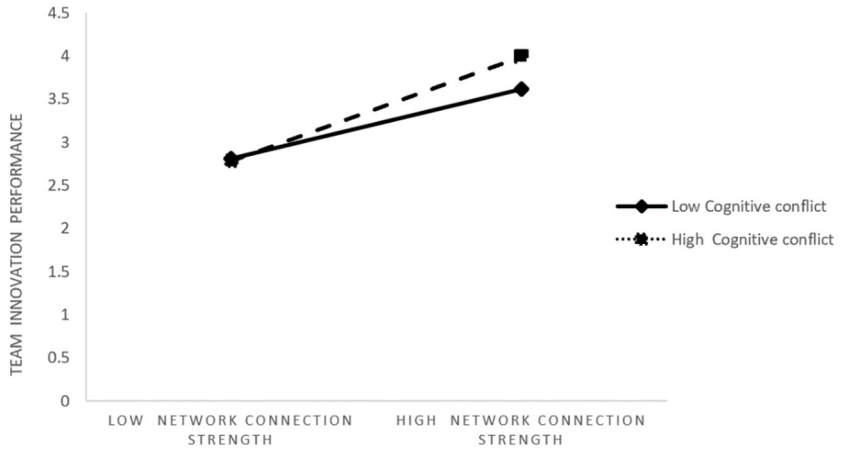

Fig 3. Moderating effect of affective conflict on the relationship between network connection strength and team innovation performance

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Next, the Bootstrap method was used to test the mediating effect of affective conflict and cognitive conflict with low (-1SD) and high (+1SD) levels, respectively. The results in Table 7 show that with the increase of cognitive conflict, the mediating effect of network connection strength on the relationship between network centrality and team innovation performance increases.

Table 7. Bootstrap analysis results with moderated mediating effect

	Index	Effect value	BootSE	BootLLCI	BootULCI
The mediating effect of cognitive conflict	eff1(M–1SD)	0.1275	0.0983	-0.0043	0.3824
	eff2(M)	0.2247	0.096	0.0887	0.4677
	eff3(M+1SD)	0.284	0.1303	0.0822	0.5987

5. Conclusion and Prospect

5.1. Research Conclusion and Value

Based on the social network perspective and team conflict theory, this paper explores the role of network centrality on team innovation performance, including the mediating effect of network connection strength and the moderating effect of cognitive conflict and affective conflict. The results show that team network centrality has a significant positive impact on team innovation performance, and network connection strength plays a mediating role between team network centrality and team innovation performance. Cognitive conflict negatively moderates the relationship between network centrality and team innovation performance, while positively moderates the relationship between network connection strength and team innovation performance.

In terms of theoretical value, it is helpful to make up for cognitive limitations and provide ideas and references for future research. At present, there are few studies on the relationship between team conflict, team network location and strength, and innovation performance. This study helps to promote the cognition of team conflict, but does not further expand the research scope, which is conducive to future related research.

In terms of practical value, the conclusion of this paper provides reference for the management of enterprise R & D team. First of all, it is necessary to adjust the management system, actively build a team communication platform, and improve the connection strength of team members to promote the positive effect of network centrality on the improvement of innovation performance. Secondly, the management needs to distinguish the types of conflicts. As for cognitive conflicts, it is necessary to remind the R&D team to take projects or tasks as the bond, so as to play its role in promoting intra-team communication and strengthening the bond among members.

5.2. Research Limitations and Prospects

There are still some shortcomings and limitations in this study. Firstly, in terms of research objects, this study takes R&D personnel of enterprises in Shanghai as research objects, which is not generalizable enough. The scope of research objects can be expanded in the future, and the sample size can be further expanded in the future to improve its universality. Secondly, cross-sectional data should be used to verify the causality in the future with longitudinal data research method or experimental method. Finally, there are many problems worth exploring in model building, this paper only investigates the mediating role of the network connection strength, but there may be other variables, such as innovation strategy, human capital factor, only considers the cognitive conflict on adjusting variable, the future can consider to join factors such as social capital, to improve the model, make stronger explanatory power.

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