

# Relationships Between Temporal Leadership, Transactive Memory Systems and Team Innovation Performance

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**Background:** In recent years, temporal leadership has gradually attracted academic attention.

**Purpose:** This paper discussed the impact of temporal leadership on team innovation performance.

**Methodology:** Through the sample analysis of 385 team members in 98 teams. The measurements of temporal leadership, team innovation performance, transactive memory system, and team reflection were used to measure the relationships between temporal leadership, transactive memory systems and team innovation performance.

**Findings/Results:** It is found that temporal leadership has a positive impact on team innovation performance, which is transmitted through the credibility dimension and coordination dimension of transactive memory systems. Positive team reflection regulates the relationship between temporal leadership and transactive memory systems.

**Value:** This paper reveals the specific impact mechanism of temporal leadership on team innovation performance and provides a new perspective on how to improve team innovation performance in limited time resources.

**Keywords:** temporal leadership, transactive memory systems, team innovation performance, team reflection

## Introduction

The increasingly competitive market environment has witnessed constantly updated technology and products, dynamically changed customer demand, and considerable time pressure for enterprises.<sup>1</sup> How to achieve effective dynamic coordination among multiple tasks, how to deal with the imminent “deadline” at any time, and how to flexibly adjust task objectives will affect the survival and development of enterprises. As a new perspective for understanding team operation, time perspective has attracted more attention in management research.<sup>2</sup> As a significant element of managing and coordinating team operation, team leadership plays a decisive role in team time resource management. Therefore, some scholars gradually turn their research perspective to the time factor at the team leadership level and re-examine the role of temporal leadership in the team.<sup>3-9</sup>

Temporal leadership focuses on team tasks and time-related issues. Strong temporal leadership can guide team members to coordinate and cooperate with each other to perform work tasks at the same pace, thus enabling them to allocate team time resources effectively and finally complete all team tasks on time.<sup>10</sup> The existing literature also generally follows this pattern to explore the role of team temporal leadership on individual creativity,<sup>11-14</sup> while the research on how team temporal leadership affects team innovation performance is scarce, and its influence mechanism is still under-researched. Therefore, an increasing number of scholars are calling for exploration on influencing factors of team innovation performance.<sup>15-18</sup>

Since the cognitive process can identify all types of information useful for strategic decision-making from the dynamic and complex environment, to improve the innovation performance of the team,<sup>19</sup> the role of cognitive process cannot be ignored in discussing the impact mechanism of temporal leadership on innovation performance. Transactive memory system is a cognitive process of team information processing, which determines the way how information resources are used, allocated and operated in the decision-making process. It is closely related to knowledge sharing, knowledge transfer and information processing ability.<sup>20</sup> According to the Information Processing Theory, under the influence of temporal leadership, the team increases the opportunities to access to information and acquire knowledge,<sup>21,22</sup> while the transactive memory system can manage and process key information resources, form knowledge social networks, and affect the innovation performance of the team. Therefore, transactive memory system may play an internal role in the relationship between temporal leadership and innovation performance, but this inference has not been effectively reasoned and empirically tested.<sup>23</sup>

Concurrently, many obstacles in coordinating task time and integrating time perspectives will not be avoided when adopting temporal leadership. A great deal of management is required within the team to identify setbacks and plan solutions, which refers to team reflection.<sup>20</sup> Strong team reflection can make sufficient preparations for dealing with complex and changeable time arrangements,<sup>24</sup> and help to understand the specific team situation of temporal leadership in time coordination.<sup>6,25</sup> Therefore, if the influence of contextual factors on the outcome of temporal leadership is emphasized, it is necessary to consider the contextual factor of team reflection.

In summary, this paper attempts to reveal the mechanism of the impact of temporal leadership on team innovation performance. Specifically, this paper focuses on two issues: first, the mechanism of the influence of temporal leadership on team innovation performance; and second, the moderating effect of team reflection on the above relationship.

## Theoretical Background

### Temporal Leadership

The uncertainty of innovation tasks creates many paradoxes in allocating time resources, such as quality and speed, long-term and short-term.<sup>26,27</sup> For example, in the different processes of the same innovation task, some need to be carefully polished, and some need to respond quickly to market demand. In addition, team members' time characteristics show diversity, manifested by different time pressure, pacing rhythm, and time focus. Different time characteristics can bring about conflicts in work scheduling and affect the overall innovation process.<sup>27</sup> Therefore, time is an essential factor affecting the functioning of organizations,<sup>28</sup> and the focus on "temporality" in the modern organizational field has gradually come to involve leadership.<sup>22,29-31</sup> The role of temporal leadership has received increasing attention from scholars when it comes to the time or time-related needs of organizations.<sup>32</sup> Temporal leadership is a behavior in which leaders help construct, coordinate, and manage the pace of task completion in teams.<sup>33</sup> Strong temporal leadership can assist to rationalize the time schedule and needs, based on task characteristics, and to integrate employees with different time traits into a unified team time process. It can effectively exploit the time differences among individuals to maximize team performance.<sup>34</sup> The series of conscious and perceptible leadership behaviors provide teams with clear and standard time norms that form the temporal structure of team activities<sup>33</sup> and help to solve the problems of communication and cooperation among individuals due to differences in temporal diversity.<sup>35</sup> However, strong temporal leadership can interfere with employees' accustomed work rhythms while reaching team time consensus, impacting individual time perceptions, and bringing uncertainty.<sup>22</sup>

Information Processing Theory suggests that in an environment of uncertainty, individual team member's knowledge or experience is not sufficient to support the judgments and decisions they make. In order to achieve their goals, group members need not only to obtain information but also to plan effective information processing mechanisms.<sup>36-38</sup> Team information processing mechanisms require information collection, coding, storage, and retrieval, a process that occurs not only at the individual level but also at the group level, which reflects how team members' information influences team information processing through interaction.<sup>39</sup> Specifically, group members first collect and process information individually, then share the acquired information with other team members, and finally the team further processes the information during the integration process until it can make judgments and decisions.<sup>40</sup>

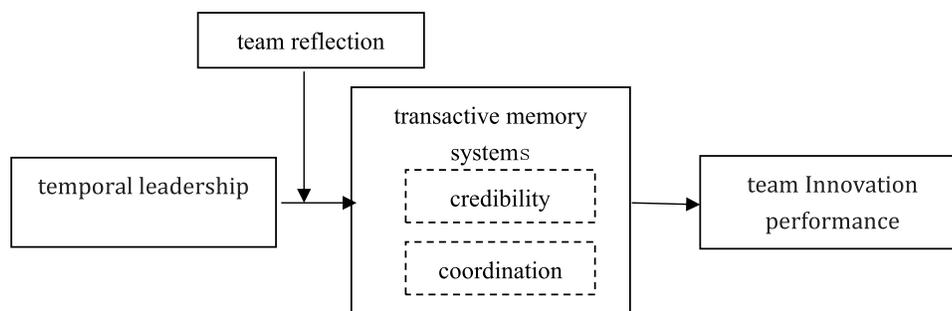
Previous studies on the impact of temporal leadership on team creative performance are mainly based on the Conservation of Resource Theory and Team Coordination Theory. These studies mainly focused on the relationship between temporal leadership and group creative performance in terms of the mediating roles of team learning behavior,<sup>41</sup> work ethic,<sup>42</sup> efficiency, and dynamism,<sup>43</sup> and these studies have focused on how temporal leadership has developed positive but similar cognitive patterns or mindsets for team members, thereby promoting team innovation. However, previous studies have failed to investigate, based on Information Processing Theory, how temporal leadership enables team members to eliminate uncertainty through continuous information communication and exchange to achieve a state of cognitive trust and coordination, thus ultimately promoting team innovation performance, given the differences in information and ideas possessed by group members. This is what the present intends to solve.

## Transactive Memory System

Interactive memory systems are a shared division of cognitive labor that coordinates information encoding, storage, and retrieval among team members.<sup>31</sup> Members of effective teams assign cognitive labor to their tasks, specialize in different skills and missions, and rely on each other's domain-specific responsibilities to augment the collective information and knowledge needed for the particular tasks.<sup>44</sup> The Information Processing Theory suggests temporal leadership helps team members coordinate their time in a variety of ways, as team members collect and organize information, spontaneously learn about each other's progress on tasks, understand each other's task nodes and task completion deadlines, and reduce uncertainty in their own decisions.<sup>45</sup> This collaborative behavior enables team members to establish positive cognitive connections,<sup>46</sup> enabling them to more effectively identify the right person to finish the specific task, form memories influenced by other members' knowledge, promote trust and coordination, and form the basis of an interactive memory system,<sup>47</sup> and ultimately facilitate the integration and application of team knowledge.<sup>48</sup>

Considering that team innovative performance requires the accumulation of multifaceted knowledge and access to information, the current study explores the role of the memory interaction system in the influence of temporal leadership on team innovative performance from the perspective of Information Processing Theory, which has not been focused on in previous studies. This discussion helps to understand how temporal leadership enables group members to reach a state of cognitive trust and coordination that ultimately promotes team innovation performance, given the differences in the information and ideas they possess, and better reveals the different processes by which temporal leadership affects innovation performance.

In addition, according to Gibson's four-stage model of information processing, team cognition requires interaction, retrieval, and communication among members, as well as corresponding negotiation, interpretation, and evaluation.<sup>49</sup> Whereas team reflection can influence information exchange, member cognition, and knowledge configuration,<sup>24</sup> this cognitive enhancement can effectively increase the level of the interactive memory system. Therefore, it is inferred that team reflection is an important boundary condition for the impact of temporal leadership on the memory interaction system. The research model is shown in Figure 1.



**Figure 1** Research model.

## Hypotheses

### Temporal Leadership and Team Innovation Performance

Temporal leadership motivates team members to pay attention to the time component of their work and enables them to organize their resources efficiently within the given time constraints.<sup>33</sup> The proposal of temporal leadership has initiated a new direction for research in the field of leadership. Many studies have proposed the positive effects of temporal leadership on employee behavior and attitudes from the individual level.<sup>22,50</sup> Team innovation performance is inseparable from individual creativity because factors such as personality characteristics, motivation, emotions, and self-innovation efficiency that affect individual creativity levels will also affect team innovation performance through individuals.<sup>17,51</sup> However, team innovation performance is not a simple accumulation of individual creativity in the team.<sup>52</sup> It requires the team to generate innovative ideas, based on which, through the joint efforts of the team, the innovative ideas can be turned into reality and ultimately improve team innovation performance.<sup>53,54</sup> The control of temporal leadership over the time and working pace can positively motivate subordinates to focus on work tasks. Team members' continuous focus on the completion of team tasks can better stimulate employees' innovative thinking.<sup>55</sup> Concurrently, temporal leadership can effectively alleviate employees' time pressure on task completion, promote team members' intrinsic motivation at work, reduce the psychological burden caused by the shortage of time resources, and improve the efficiency of task time usage. These factors have a positive impact on the effectiveness of innovation work to a large extent, which can promote the improvement of team innovation performance.<sup>18,56</sup> Therefore, this paper puts forward the following hypothesis:

H1: Temporal leadership has a positive impact on team innovation performance.

### Temporal Leadership and the Transactive Memory System

As a mechanism that explains how individuals use external assistance to expand their memory,<sup>57,58</sup> the transactive memory system is a system that facilitates the sharing of knowledge and information across domains,<sup>59</sup> and is an important mechanism for team knowledge processing and a cognitive division of labor among team members.<sup>60</sup> Members of a group with transactive memory system can distinguish who has specialized information and the credibility of that information, and members are able to organize and coordinate information effectively.<sup>61</sup> Transactive memory systems include a series of behaviors or processes for identifying and integrating knowledge in terms of behavioral elements, involving both credibility and coordination dimensions.<sup>62</sup> Theoretically, the analysis suggests that temporal leadership primarily enhances the behavioral elements of the transactive memory system, thus positively influencing it.

First, the trustworthiness dimension of the interactive memory system is the individual's trust in the expertise and competence of other team members.<sup>44</sup> According to Social Information Processing Theory, people do not passively receive social information but try to find the reasons for external social information and change their behavior accordingly.<sup>22</sup> The communication of the team in the work situation will promote the team members to have a more detailed perception of work-related issues and information. Temporal leadership in coordinating task progress and timing allows team members to perceive each other's attention to the team's task process, prompting members to spontaneously understand each other's task progress, task nodes and task completion deadlines.<sup>45</sup> This facilitates the exchange of information among team members to stop focusing on some explicit and trivial knowledge and to start the exchange and integration of tacit knowledge. It then enables members to deepen their understanding of each other's expertise and capabilities, thus promoting trust in expertise and competence among team members.

Second, the coordination dimension of the transactive memory system is an advanced manifestation of the transactive memory system, which is reflected in the fact that the differentiated knowledge of team members can be effectively organized.<sup>47</sup> It presupposes a deep understanding of members' mutual expertise and capabilities, as well as effective information exchange among them.<sup>63</sup> Temporal leadership enhances the exchange of information within the team, which enables team members to more accurately recognize the true capabilities and knowledge of other members, improves the efficiency of knowledge transfer among team members, and facilitates the organization of various types of knowledge.<sup>47</sup> Meanwhile, stronger temporal leadership can help teams generate a team atmosphere in which members feel comfortable

with each other. It inspires team members to communicate and cooperate, and to enhance the coordination dimension of the transactive memory system. Therefore, this paper proposes the hypothesis that:

H2a: Temporal leadership has a significant positive impact on the credibility of the transactive memory system.

H2b: Temporal leadership has a significant positive impact on the coordination dimension of the transactive memory system.

## Transactive Memory System and Team Innovation Performance

The positive influence of the credibility dimension of the transactive memory system on the team's innovation performance is manifested in two aspects. First, emotional trust relationships are more likely to be established among team members based on satisfying trust in each other's knowledge and abilities.<sup>63</sup> Higher emotional trust helps teams create a comfortable and pleasant team environment, which motivates team members' willingness to participate in the creative process. When team members are interested and willing to engage in interaction, they are more likely to freely share their ideas, discuss ideas with other members, and generate better alternatives<sup>64</sup>. Second, a highly credible team can be more tolerant of and accept different ideas and opinions, and members can devote more energy to communicating with and supporting each other.<sup>65</sup> When team members have a high level of trust in each other's knowledge and abilities, their related information will establish a certain connection and generate new alternatives through team discussions, thereby improving the efficiency of team members' information processing, and thereby improving team innovation performance.<sup>66</sup>

The coordination dimension of the transactive memory system helps the team gather knowledge in different fields, to improve the team's capability to integrate various knowledge quickly and effectively into persuasive and coordinated innovation actions and contribute to the quality of innovation.<sup>47</sup> Coordination mechanism enables team members to embed professional knowledge more quickly into the team and search information and application knowledge faster. Concurrently, coordination between different knowledge supports real-time generation of creative solutions,<sup>67</sup> which helps to improve team innovation performance. Therefore, this paper proposes the hypothesis that:

H3a: The credibility dimension of the transactive memory system has a significant positive effect on team innovation performance.

H3b: The coordination dimension of the transactive memory system has a significant positive effect on team innovation performance.

## The Mediating Role of the Transactive Memory System

In summary, this paper argues that stronger temporal leadership can facilitate information exchange among team members, share tacit knowledge, and make team members mutually recognize each other's expertise, attitudes, and behaviors. It is conducive to enhancing the credibility dimension of the transactive memory system. Stronger temporal leadership can help information exchange and generate a team atmosphere in which members feel comfortable with each other, enabling team members to more accurately recognize the true capabilities and knowledge of other members, facilitates the organization of various types of knowledge among members, and thus enhances the coordination dimension of the interactive memory system. In the innovation process, the credibility dimension of the transactive memory system can enable teams to benefit from knowledge and information management and improve team innovation performance. The coordination dimension of the interactive memory system can facilitate the transfer, integration and sharing of knowledge among team members and help improve team innovation performance.<sup>12,13,62</sup> Thus, temporal leadership influences the credibility and coordination dimensions of the transactive memory system. The credibility and coordination dimensions of the transactive memory system contribute to the improvement of team innovation performance. This process reflects the mediating role of the credibility and coordination dimensions of the transactive memory system. Therefore, this paper proposes the hypothesis that:

H4a: The credibility dimension of the transactive memory system has a mediating role between temporal leadership and team innovation performance.

H4b: The coordination dimension of the transactive memory system has a mediating role between temporal leadership and team innovation performance.

## Moderating Role of Team Reflection

Team reflection is the process by which team members publicly reflect on the team goals, team strategies, and the entire course of team action to adapt to their changed environment.<sup>67</sup> Temporal leadership is conducive to information exchange and sharing among team members, and team reflection enables members to reflect on the mistakes in teamwork and express them openly and boldly within the team. Excessive temporal leadership may overemphasize internal consistency, so that members of the team can absorb and accept the task schedule without thinking, and do not pose insightful questions or challenge. In this case, without good team reflection, team members will fully accept the time coordination and integration without more information exchange and processing, therefore, tacit knowledge exchange and integration is not possible and does not contribute to team members' trust in each other's expertise and capabilities. Team members are worried that their different views will bring potential embarrassment to other team members, as well as the maladjustment of members' work and even damage to their interests. Therefore, they choose not to express different voices.<sup>11,68</sup> De Dreu's empirical study shows that high-quality minority dissent facilitates innovative behavior, but only if a high level of team reflection occurs. This means that team reflection promotes minority dissent and handles minority dissent appropriately.<sup>69</sup> Therefore, with a high level of team reflection, members are better able to exchange in-depth information within the team and promote cognitive trust among team members. Team reflection enhances a good atmosphere for information exchange and facilitates the formation of coordination in the interactive memory system. Therefore, it is assumed that:

H5a: team reflection plays a positive moderating role in the impact of temporal leadership on the credibility dimension of transactive memory system.

H5b: team reflection plays a positive moderating role in the impact of temporal leadership on the coordination dimension of transactive memory system.

## Methods

### Procedure and Sample

The study was conducted by means of a questionnaire survey with a research sample of 29 high-tech companies in China, and questionnaires were distributed and collected from teams that had been established for more than six months within the companies and were willing to participate in this study. To avoid homophily, targeted questionnaires were administered to team leaders and team members at different time points. At the initial time point (noted as time point 1), the first questionnaire was administered to team members, and the questionnaire collected demographic information on team members (including age, gender, education level, and length of employment in their current position), while measuring variables such as temporal leadership, transactive memory system, and team reflection. One month after the initial time (noted as Time Point 2), a second questionnaire was administered to the team leaders of the same teams, which also collected demographic information about the team leaders and asked the team leaders to rate the innovation performance of the teams they were responsible for. A total of 420 paper questionnaires were distributed to 119 teams in this study, of which 301 valid questionnaires were collected from 116 teams in the first phase; 116 valid questionnaires were successfully obtained from team leaders in the second phase. The overall valid return rate of the questionnaires reached 81.33%. After the questionnaires were collected, based on the non-default principle, matching principle and sufficiency principle, some questionnaires were excluded, and the final valid sample was 385 valid questionnaires from 98 teams. In the team sample, the participation rate of all sample teams who received the questionnaire was over 80%. The percentage of male members was 67.2%, the average age of team members was 28.5 years old, the average tenure was 3.08 years, 63.1% had a bachelor's degree, and 12.7% had a postgraduate degree or above. The characteristics of the sample companies and teams are shown in Table 1. As shown in Table 1, all ownership types of enterprises and various scales of teams are covered, and the sample distribution is representative.

## Measures

### Temporal Leadership

The measurement of temporal leadership was based on the 7 items of Mohammed and Nadkarni and Wei et al<sup>22,70</sup> Items include "Your team leader will remind members of important deadlines", "Your team leader will prioritize tasks and

**Table 1** Sample Frame

Statistical Content		Frequency	Percentage (%)	Statistical Content		Frequency	Percentage (%)
Enterprise age	0~8	11	37.9	Team scale	Less than 10 people	14	14.3
	9~16	12	41.4		10~19 people	15	15.3
	17+	6	20.7		20~49 people	17	17.3
Ownership type	State-owned	7	24.1		50~99 people	16	16.3
	Private	11	38.0		100~499 people	14	14.3
	Joint Ventures	6	20.7		500+ people	22	22.4
	Others	5	17.2				

allocate time to each task” and “For emergencies, difficulties and emerging problems, your team leader can prepare and fix them in time” etc. The Cronbach  $\alpha$  coefficient is 0.855.

## Team Innovation Performance

The measurement of team innovation performance was based on Srinivasan et al’s single-dimensional measurement scale of team innovation performance.<sup>71</sup> It contains four measurement items, among which there are three normal scoring items and one reverse scoring item. Normal scoring items includes items like “We are an innovative team”, and reverse scoring item is “The team rarely produces new or alternative methods or procedures to complete tasks.” The Cronbach  $\alpha$  coefficient is 0.881.

## Transactive Memory System

Referring to the scale by Lewis, Tang et al and Yang et al,<sup>44,72,73</sup> credibility dimension includes 4 items and coordination dimension includes 5 items. Cronbach  $\alpha$  coefficient of two dimensions are 0.878 and 0.905, respectively.

## Team Reflection

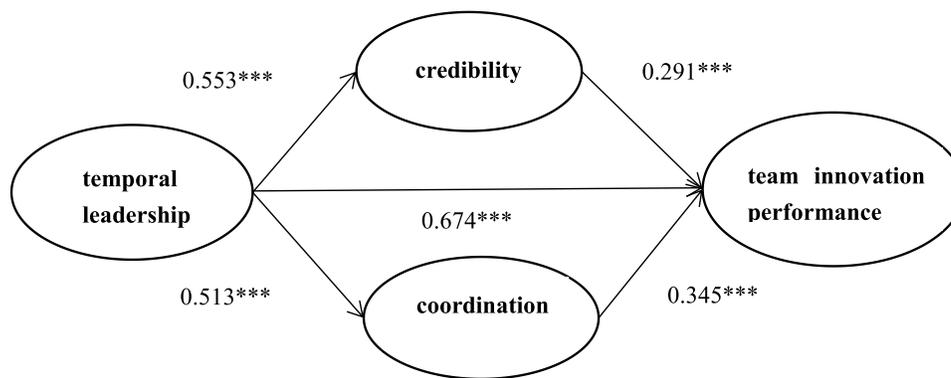
This paper employed the single-dimensional scale developed by West and Breugst et al,<sup>20,24</sup> which contains 9 normal scoring items, including items like “the team often reflects on the workflow and steps to complete the task”. The Cronbach  $\alpha$  coefficient is 0.899.

## Control Variables

A review of the literature revealed that team size is negatively related to team innovation performance.<sup>74</sup> In addition, studies have shown that the number of years of team establishment and team nature also affect team innovation.<sup>72</sup> Therefore, in this study, team size, duration of team history and team nature were selected as control variables to exclude explanatory mechanisms other than the independent variables.

## Data Analysis

This paper analyzes the data based on the following steps: (i) The consistency test of the variable measurement filled by the employees, and aggregated to the team level; (ii) The confirmatory factor analysis of the research variables is performed to test the differentiation of the team-level variables in the theoretical model Validity; (iii) Perform descriptive statistics and correlation analysis on research variables to provide preliminary evidence for research model verification; (iv) Test the direct effects between variables, and judge the mediation effect through the test of indirect effects Significance; (v) Verify whether the moderating effect is established by testing the interaction term. The research Hypotheses are shown in [Figure 2](#).



**Figure 2** Direct effect and mediating effect test results of path analysis.

**Note:** \*\*\*  $p < 0.001$ .

## Results

### Aggregation Analysis

To test the rationality of aggregating data on individual team members' variables to the team level, intra-group consistency coefficient  $R_{wg}$  (j) and inter-group correlation coefficients ICC (1) and ICC (2), as well as the F-statistic of ICC (1), were examined. For the constructs of temporal leadership and team innovation performance, the internal consistency coefficient  $R_{wg}$ , intra-group correlations ICC (1) and ICC (2) were calculated using R3.3.1, as shown in Table 2. Table 2 demonstrates that the internal consistency coefficients  $R_{wg}$  for all sample teams for each construct are greater than the critical value of 0.7, and ICC (1) is greater than 0.05 and ICC (2) is greater than the critical value of 0.5 (James et al, 1984), which fully indicates that the data at the individual level can be aggregated to the team level for analysis.

### Common Method Deviation Test

To test the common method deviation, the Harman one-factor method is used in our study.<sup>75</sup> We combined the five variables together in a factor analysis with all entries. The first factor explained 20.381% of the variance, which is lower than 40% of the standard, indicating that the common method deviation in this study was within the acceptable range and would not significantly impact the analysis results.

### Confirmatory Factor Analysis

To verify the discriminant validity of the data, this paper conducted confirmatory factor analysis on five constructs: temporal leadership, team innovation performance, credibility dimension and coordination dimension of transactive memory system and team reflection. It can be seen from Table 3 that the goodness of fit of the five-factor model is the best ( $\chi^2=349.561$ ,  $\chi^2/df=1.421$ , RMSEA=0.073, CFI=0.962, TLI=0.953), and it is significantly better than the goodness of

**Table 2** Convergent Test Results

Concept	$R_{wg}$			ICC (1)	ICC (2)
	Ranges	Mean	Median		
TL	0.752–0.976	0.832	0.858	0.250	0.824
TI	0.838–0.943	0.874	0.894	0.361	0.798
CRE	0.794–0.977	0.912	0.924	0.265	0.862
COO	0.746–0.921	0.834	0.861	0.317	0.618
TR	0.785–0.987	0.871	0.889	0.187	0.586

**Notes:** TL indicates Temporal Leadership, TI indicates Team Innovation Performance, CRE indicates Credibility, COO indicates Coordination, and TR indicates Team Reflection.

**Table 3** Confirmatory Factor Analysis: Fit Indices

Study and Model	$\chi^2/df$	NFI	IFI	TLI	CFL	RMSEA
Hypothesized model Five-factor: TL, TI, CRE, COO, TR	1.421	0.943	0.987	0.938	0.962	0.040
Four-factor: TL, TI, CRE+COO, TR	2.657	0.895	0.877	0.822	0.896	0.111
Three-factor: TL+TI, CRE+COO, TR	3.746	0.823	0.796	0.784	0.812	0.749
Three-factor: TL, TI, CRE+COO+TR	3.690	0.734	0.698	0.792	0.804	0.722
Two-factor: TL+TI, CRE+COO+TR	4.563	0.698	0.621	0.677	0.726	0.693
One-factor: TL+TI+CRE+COO+TR	4.671	0.582	0.479	0.687	0.531	0.647

**Notes:** TL indicates Temporal Leadership, TI indicates Team Innovation Performance, CRE indicates Credibility, COO indicates Coordination, and TR indicates Team Reflection.

fit of other factor models, which shows that the five-factor measurement model has good discriminant validity and can better represent the factor structure of the measurement model.<sup>76</sup>

## Descriptive Statistics and Intercorrelations

Table 4 demonstrates the mean, standard deviation, and correlation coefficient matrix of variables. It can be seen from Table 3 that there is a correlation between temporal leadership and team innovation performance ( $r = 0.416$ ,  $P < 0.01$ ), credibility ( $r = 0.376$ ,  $P < 0.01$ ) and coordination ( $r = 0.376$ ,  $P < 0.01$ ), which preliminarily verifies the role of team temporal leadership in promoting team information exchange and team creativity. Further testing the average variance extraction (AVE) of each variable, it is found that AVE is greater than the minimum critical value of 0.5, and the square root of AVE of each variable is higher than its correlation coefficient with other variables, which further shows that there is good discriminant validity between variables.

## Hypotheses Testing

### Direct Effect

Mplus7.4 is used in this paper to test the hypothesis of the theoretical model and build the model for independent variables (temporal leadership), mediating variables (credibility and coordination), moderating variables (team reflection) and dependent variables (team innovation performance). The results of the model are shown in Table 5. As can be seen from Table 5, temporal leadership has a significant positive impact on team innovation performance ( $\beta = 0.674$ ,  $P < 0.01$ ), therefore, H1 was verified. Similarly, temporal leadership significantly positively affects the credibility dimension of transactive memory system ( $\beta = 0.553$ ,  $P < 0.01$ ) and coordination dimension ( $\beta = 0.513$ ,  $P < 0.01$ ), H2a and H2b were verified. Credibility dimension of

**Table 4** Descriptive Statistics and Correlation Analysis of Main Variables

Variables	Mean	SD	1	2	3	4	5
1 TL	1.683	0.499	(0.638)				
2 TI	1.691	0.546	0.416**	(0.677)			
3 CRE	2.188	0.730	0.376**	0.395**	(0.632)		
4 COO	2.149	0.684	0.373**	0.438**	0.482**	(0.748)	
5 TR	2.046	0.553	0.522**	0.484**	0.499**	0.503**	(0.722)

**Notes:** Nteam=98. TL: TL indicates Temporal Leadership, TI indicates Team Innovation Performance, CRE indicates Credibility, COO indicates Coordination, and TR indicates Team Reflection \*  $p < 0.05$  \*\* $p < 0.01$ ; The Square Root of AVE is on the diagonal.

**Table 5** Test Results of Path Analysis

Effect	Path	Path Coefficient	SE	95% Confidence Interval	
				Lower Limit	Upper Limit
Direct effect	TL→TI	0.674***	0.044	0.587	0.762
	TL→CRE	0.553***	0.069	0.417	0.688
	TL→COO	0.513***	0.065	0.385	0.641
	CRE→TI	0.291***	0.036	0.221	0.361
	COO→TI	0.345***	0.037	0.272	0.418
Indirect effects of mediation	TL→CRE→TI	0.078***	0.022	0.038	0.124
	TL→COO→TI	0.099***	0.024	0.055	0.151
Indirect effects of moderation	TR→CRE	0.061***	0.015	0.025	0.031
	TR→COO	0.037***	0.026	0.028	0.064
	TL*TR→CRE	0.155***	0.013	0.129	0.181
	TL*TR→COO	0.153***	0.012	0.125	0.177

**Notes:** Nteam=98. TL: TL indicates Temporal Leadership, TI indicates Team Innovation Performance, CRE indicates Credibility, COO indicates Coordination, and TR indicates Team Reflection. \*\*p<0.05 \*\*\*p<0.01. The control variables include team size, team establishment years and team nature.

transactive memory system ( $\beta = 0.291$ ,  $P < 0.01$ ) and coordination dimension ( $\beta = 0.345$ ,  $P < 0.01$ ) had a significant positive impact on team innovation performance, then, H3a and H3b were verified.

## Mediating Effect

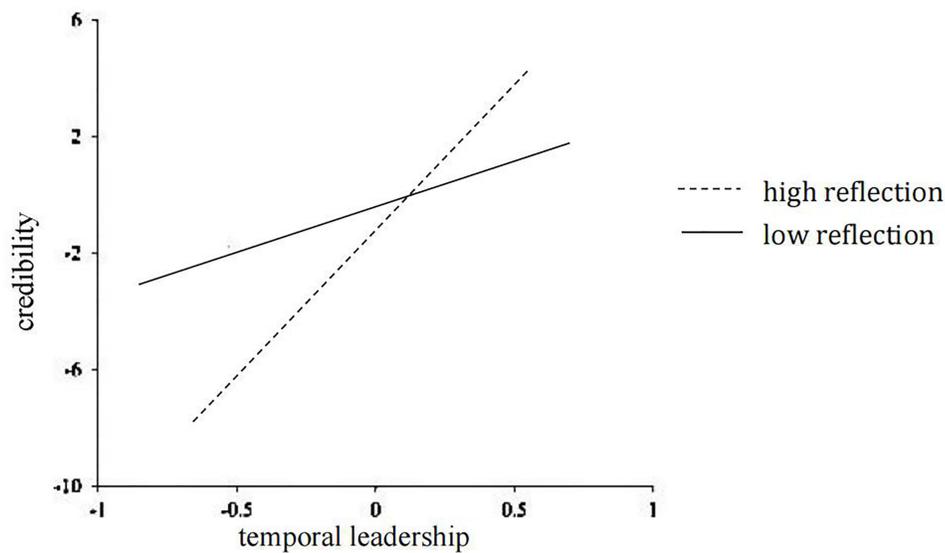
To further verify the mediating effect of team information exchange, 1000 sample data are obtained by bootstrap method, and the confidence interval of the indirect effect value of the sample data is estimated. Finally, the significance of the mediating effect is verified by testing the significance of the indirect effect value and its confidence interval. As can be seen from Table 5, the indirect effect of temporal leadership on team innovation performance through the credibility dimension ( $\beta = 0.078$ ,  $P < 0.01$ , 95% confidence interval = [0.038, 0.124], excluding 0) and coordination dimension ( $\beta = 0.078$ ,  $P < 0.01$ , 95% confidence interval = [0.038, 0.124], excluding 0) of transactive memory system is very significant, therefore, H4a and H4b were verified.

## Moderating Effect

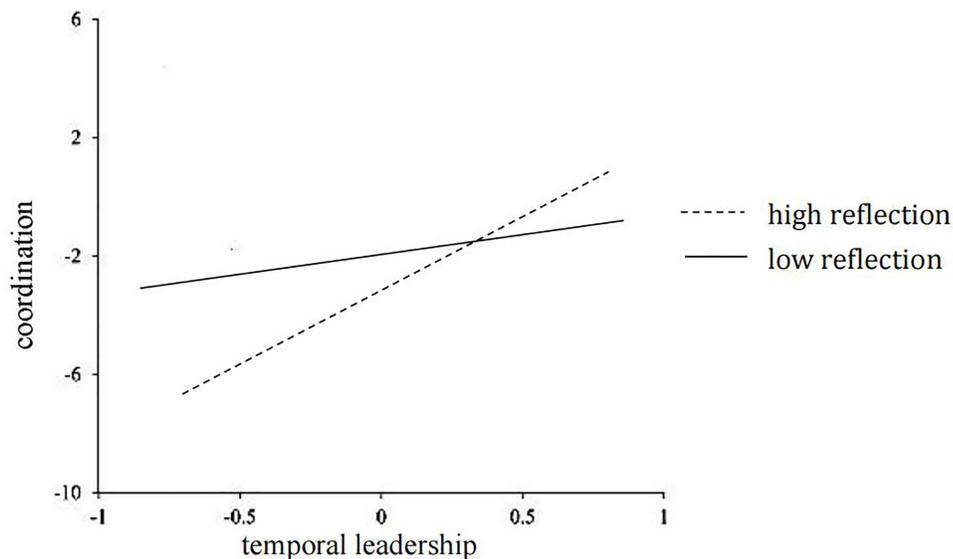
We use the product indicator approach to measure the moderating effect. We standardized independent variables, and the interaction effects of the temporal leadership and team reflection are shown in Table 5. The interaction term temporal leadership×team reflection is significant on credibility dimension ( $\beta = 0.155$ ,  $P < 0.01$ ) and coordination dimension ( $\beta = 0.153$ ,  $P < 0.01$ ). Further analysis of its simple effect shows that when the team has a high degree of reflection, temporal leadership has an impact on the credibility dimension ( $\beta_H = 0.291$ ,  $P < 0.01$ ) and coordination dimension ( $\beta_H = 0.232$ ,  $P < 0.01$ ), while when the team has a low degree of multi time view, team temporal leadership has a significant impact on the credibility dimension ( $\beta_L = 0.185$ ,  $P > 0.05$ ) and coordination dimension ( $\beta_L = 0.116$ ,  $P > 0.05$ ). The result shows that in the context of high team reflection, the effect of temporal leadership on transactive memory system is easier to be activated. Taken together, these results support H5a and H5b. The moderating effect is shown in Figures 3 and 4.

## Endogeneity Test

Although our study adequately selected control variables involving important characteristics of firms and employees based on relevant literature, some important variables may still be missed. For example, managers' overseas experience is widely considered an important variable affecting team innovation performance.<sup>73</sup> In addition, managers' overseas experience may also influence temporal leadership. Managers with extensive overseas experience may construct time perceptions that match the dynamic changes. To exclude the interference of managers' overseas experience on the study results, we included managers' overseas experience in our model to explore its effects on temporal leadership and team innovation performance, respectively. We measured managers' overseas experience as "1" if managers had overseas



**Figure 3** Moderating effect of team reflection on the relationship between temporal leadership and credibility.



**Figure 4** Moderating effect of team reflection on the relationship between temporal leadership and coordination.

study or work experience and “0” otherwise. The empirical results reveal that managers’ overseas experience significantly affects team innovation performance ( $\beta = 0.165$ ,  $p < 0.01$ ), which is consistent with previous studies. However, managers’ overseas experience had no significant effect on temporal leadership ( $\beta = 0.105$ ,  $p > 0.05$ ). This may be due to the high stability of temporal leadership as an innate trait of individuals.<sup>70</sup> Once formed, it hardly shifts by other disturbances. This finding robustly confirms our conclusions that temporal leadership affects team innovation performance.

## Discussion

This paper empirically investigates the relationship between temporal leadership and team innovation performance based on corporate team questionnaire data. The findings indicate that temporal leadership has a direct positive effect on team

innovation performance. The result is in line with the findings of Wei et al,<sup>22</sup> whose study showed that the enhancement of team creativity requires team members to continuously focus on the completion of team tasks, and that team temporal leadership can better stimulate employees' innovative thinking when they adopt effective time reminders and task scheduling.

The credibility and coordination dimensions of the transactive memory system have mediating effects between temporal leadership and team innovation performance, and similar findings were found in Ali's study.<sup>67</sup> It showed that the transactive memory system enables team members to have different cognitive abilities and mutual understanding of expertise, promotes effective coordination among team members, creates a shared vision and collective commitment to team innovation by enhance supportive behaviors among team members. It may create an environment for unconventional approaches to problem solving, thereby promoting team innovation. The mediating effect of the transactive memory system also suggests that temporal leadership in teams is embedded in complex cognitive and interactive processes among members, and that exploring only the direct effects of temporal leadership and team innovation has its limitations.

The finding of this paper also reveals that team reflection played a positive moderating role in the relationship between temporal leadership and the transactive memory system. The result is in line with the findings of Tsay et al's (2018) study,<sup>77</sup> indicating that when teams are faced with unreliable information unrelated to their level of reflection, it does not help team coordination even if the information can be further refined. This suggests that stronger temporal leadership and higher levels of team reflection can improve the team's transactive memory system, which in turn facilitates decision-making performance. This finding helps explain the limitations of analyzing the relationship between temporal leadership and team innovation from the leader's "God's perspective" alone.

## Theoretical Contributions

First, responding to the call for more empirical research on team temporal leadership and team innovation performance,<sup>22</sup> the findings of our study further confirm that time has become a precious and scarce core resource in the team innovation process. It also confirms that teams and leaders need to use this resource adequately and wisely to improve team innovation performance. This finding also supports Mohammed and Nadkarni's conclusion that high levels of temporal leadership are conducive to creating consistent, clear, and understandable schedules that reduce disagreements among team members over time, thereby enhancing team creativity<sup>33</sup>.

Second, the findings confirm that the transactive memory system is a vital mediating variable for the influence of temporal leadership on team innovation performance and provides a clear account of the mediating mechanism of the transactive memory system. While mediating mechanism of temporal leadership affecting team innovation is under-researched in prior studies, this paper examines the mechanism of the influence of temporal leadership on team innovation performance based on Social Information Processing Theory, which better reveals the different processes by which temporal leadership affects innovation performance. The current study helps to comprehensively understand the mechanism to guide the management practice of companies. This finding also supports, to some extent, the view of Self-Determination Theory that in a coherent innovation process, the transactive memory system formed by temporal leadership through a complex cognitive interaction process among members helps to reduce the constraints of external environmental dissonance on team innovation.<sup>78</sup>

Third, this paper reveals the moderating role of team reflection in the relationship between temporal leadership and team innovation performance. This result deepens the study of the relationship between temporal leadership and team innovation performance by incorporating team reflection into the research framework. It also adds to the literature on the "teamwork paradox", as called for by Ma et al.<sup>53</sup> The "teamwork paradox" suggests that effective temporal leadership can cause cognitive conflict by impacting individual perceptions of time while achieving team consensus.<sup>9</sup> This paper shows that team innovation depends not only on temporal leadership and transactive memory systems, but also on the team's ability to reflect, ie, the extent to which the team is able to examine the temporal alignment of tasks and the allocation of time resources from different perspectives. The result leads to further refinement of information among team members and promotes team trust and coordination, thereby facilitating team innovation.

## Practical Implications

This study has several implications for team management: First, team leaders can improve team innovation performance by synchronizing schedules, coordinating time conflicts, and integrating time resources. Therefore, team members can achieve a state of credibility and coordination through more detailed information exchange. Organizations should focus on the need for time resource management at both the strategic and tactical levels, train existing leaders in temporal leadership, engage professional organizations to train team leaders in the use of time management tools, design schedules and time contingency plans, and improve their sensitivity to time resources.

Second, interactive memory systems play a direct and mediating role on team innovation performance, suggesting that teams with weak temporal leadership can improve innovation performance through other policies and practices that enhance interactive memory systems. For example, prior research has shown that emotional team trust is an important factor influencing team coordination.<sup>40</sup> Leaders should foster emotionally trusting relationships among employees to promote the coordination dimension in the interactive memory system and thus effectively accomplish team innovation tasks. Cognitive trust is a prerequisite for team coordination, and fostering cognitive trust improves team members' ability to identify and trust each other's knowledge and expertise. To cultivate cognitive trust, when forming teams, organizations should consider whether there are consistent values among employees, because team members with inconsistent values can easily distrust each other's abilities and values.

Finally, team leaders need to develop reflective behavior among team members. Temporal leadership is conducive to information refinement, but if the degree of team reflection is low, even if temporal leadership is high and is conducive to information exchange and discussion, but the lack of in-depth thinking of information by team members is not conducive to the in-depth processing and application of information, which will ultimately affect information refinement and innovation performance. Therefore, leaders of organizations or designers of systems can try to promote the impact of team temporal leadership on transactive memory systems by using reflection ability as a selection criterion and incorporating it into the promotion, performance appraisal, and training modules of human resource management.

## Conclusion

To conclude, there is no attempt to capture the impact of temporal leadership and the interaction of internal cognition in the team and its impact on team innovation. Therefore, the goal of this paper is to expand the theory and conduct empirical tests by combining temporal leadership with transactive memory systems and explaining the process of promoting team innovation performance. The research results show that the transactive memory system is a key mediating factor explaining how temporal leadership affects team innovation performance. When team leaders adopt effective time reminders and task arrangements, they can better promote the process of credibility and coordination among team members. The transactive memory system based on credibility and coordination can improve the team innovation performance. Concurrently, an important aspect of the research model also takes into account the team's ability to reflect. Team reflection promotes credibility and coordination among team members by further examining the time integration of team leaders and the allocation of time resources. This research provides a theoretical analysis framework for how the temporal leadership of integrated innovation tasks affects the results of team innovation.

## Limitations and Future Research Avenues

Some limitations of this paper provide direction for future research. First, this paper focuses on the impact of temporal leadership at the team level. In fact, the impact of temporal leadership on innovation performance is very complex. As the "connection center" between team members and organizations, team leaders are bound to have a cross-level impact on the individual work attitude or cognitive structure of team members, such as individual satisfaction. Whether the interaction between temporal leadership and team members' individual work attitude or cognitive structure will have an impact on team innovation performance highlights the need for a more complex theoretical interpretation model in future research.

Second, this paper did not further refine the task type, industry environment and other situational factors, which may bring a certain degree of measurement error. For example, in highly interdependent task situations, temporal leadership and team reflection may have a greater impact on team creativity; In industries that focus on innovation, team innovation

performance may depend more on individual initiative, and temporal leadership may have a greater impact. Future work should take into account the differences in task types and industry environment, so as to better capture when and why temporal leadership will contribute to individual performance in the team.

Third, some studies have investigated one or more individualized components of team innovation. However, other studies prefer to discuss overall team innovation in an integrated manner.<sup>14,71</sup> We follow the latter approach. This would lead to the inadequate discussion of the more specific dimensions of team innovation, such as product innovation, process innovation, and management innovation. Future research can explore the specific dimensions of team innovation and more comprehensively measure the relationship between temporal leadership and team innovation performance to examine this study's findings further.

## Data Sharing Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Ethical Approval

The present study was carried out following the ethical standards of the institutional and national research committees and with the 1964 Helsinki Declaration and later amendments, and all other related ethical commitments. Our study was conducted with the consent of the Ethics Committee of Henan University of China.

## Informed Consent

The corresponding author is sure that informed, written consent was obtained from all participants and was clearly stated. Written informed consent to participate was obtained from the parents/ guardians of the minors included in this study.

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## Disclosure

The authors report no conflicts of interest in this work.

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