Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AN15.20250214
Published: February 18, 2025

Exploring Key Factors and Performance Dimensions in Group Decision-Making: Scale Development and Empirical Analysis

Jiapeng Yang, Zuhua Jiang and Kexin Cheng
School of Mechanical Engineering
Shanghai Jiao Tong University
Shanghai, China
poloerya@sjtu.edu.cn, Zhjiang@sjtu.edu.cn, cheng259@sjtu.edu.cn

Abstract

Group decision-making plays a crucial role in organizational management, yet there is limited research focused on systematically identifying and quantifying its key dimensions. This research aims to explore the essential performance dimensions of group decision-making and develop a scale to measure these components. A comprehensive literature review identifies critical factors influencing group decision-making, such as individual factors, group dynamics, and decision-making performance. Based on these findings, a structural equation model is designed for empirical analysis. Using AMOS 24.0 software, confirmatory factor analysis is conducted to assess the validity and reliability of the measurement scale. The analysis suggests that individual factors impact group dynamics, while group decision-making performance is influenced by both individual and group factors. Path analysis reveals significant relationships among the performance dimensions, offering theoretical insights into effective group decision-making management. The research concludes with practical recommendations to help organizations enhance the efficiency and quality of their decision-making processes.

Keywords
Group Decision-making, Scale Development, Structural Equation Model

1. Introduction
In group decision-making management, the effectiveness of collective choices depends on various performance dimensions such as communication, coordination, leadership, and conflict management. Despite the significance of these factors, there is limited research on systematically identifying and quantifying these dimensions in a way that is both comprehensive and applicable across different organizational settings. This paper explores the composition of these performance dimensions and aims to develop a robust scale to measure them. By examining how these dimensions influence group performance, the study seeks to contribute to a deeper understanding of the processes that underpin successful decision-making in groups. The scale developed through this research is intended to serve as a practical tool for assessing and improving group decision-making processes, with potential applications in both academic research and organizational practice. Through this work, the paper highlights the importance of considering multiple performance factors and offers a methodological framework for evaluating group decision-making effectiveness. In addition, this paper uses Structural Equation Modeling (SEM) to conduct path analysis, revealing the significant relationships between the various performance dimensions and providing empirical support for the development of the scale.

2. Literature Review

Group decision-making is a critical process in organizational management, where the collective input and interaction of group members can greatly influence the quality of decisions made. Key performance dimensions in group decision-making include communication, coordination, leadership, and conflict management, which have been studied individually in different contexts. However, research on their combined effect and the development of a comprehensive scale to assess these dimensions remains limited.

2.1 Factors Affecting Group Decision-Making: Communication and Coordination

Effective communication within groups is crucial for sharing information, aligning objectives, and ensuring that all members are on the same page. Previous studies highlight that communication barriers can lead to misunderstanding, delayed decisions, and reduced collaboration (Jehn, 1995). Coordination, on the other hand, refers to how well group members align their efforts to achieve common goals. Coordination has been shown to enhance group performance by ensuring that tasks are distributed efficiently and members' efforts are harmonized (Berman et al., 2001). When communication is clear and coordination is strong, groups are better able to avoid redundancy and conflicts, leading to more effective decision-making processes (Kerr & Tindale, 2004).

2.2 Factors Affecting Group Decision-Making: Leadership

Leadership is another essential dimension that significantly impacts group decision-making. Leaders are often responsible for guiding the group, motivating members, and ensuring that the decision-making process runs smoothly. Research by Zaccaro (2007) emphasizes that leadership styles, such as transformational or transactional leadership, affect group performance by influencing the group's motivation and decision-making processes. Effective leadership can create an environment where members feel valued, which encourages active participation and facilitates better decision-making outcomes (Morgeson et al., 2010).

2.3 Factors Affecting Group Decision-Making: Conflict Management

Conflict, if not properly managed, can undermine group decision-making. However, conflict, when addressed constructively, can lead to better decision outcomes by encouraging diverse perspectives and ideas (De Dreu & Weingart, 2003). Studies suggest that the ability of a group to manage and resolve conflicts effectively is closely related to its overall performance, particularly in complex decision-making scenarios where differing viewpoints are common (Tjosvold, 2008). Constructive conflict management enhances creativity and problem-solving abilities, ultimately improving the quality of decisions made within the group (Eisenhardt, 1997).

2.4 Performance of Group Decision-making

Group decision-making performance is commonly assessed through several key dimensions: quality, efficiency, satisfaction, consensus, and acceptability. The quality of decision-making is influenced by factors such as information sharing, diversity of perspectives, and collective intelligence, with studies showing that effective communication and broader discussions lead to higher-quality decisions (Woolley et al., 2010). Efficiency is typically related to the time and resources required to make decisions, with clear rules and prompt feedback mechanisms improving the speed and resource usage (Tjosvold, 2008). Satisfaction with the process and outcome depends on fairness, transparency, and whether participants feel their input is valued (Li et al., 2024). The degree of consensus within the group reflects how closely members align on the decision, with moderate consensus being most beneficial to avoid groupthink and promote creativity (Jiang et al., 2023). Finally, the acceptability of the decision-making process is shaped by the perceived fairness and participation in the decision-making (Kyoji Ito et al., 2024). Together, these dimensions highlight the complexity of evaluating group decision-making and underscore the importance of balancing various factors for optimal performance.

2.5 Structural Equation Modeling (SEM) and Path Analysis

Structural Equation Modeling (SEM) has emerged as a powerful tool for analyzing the relationships between multiple variables in group decision-making research. SEM allows researchers to test complex models that include latent variables, providing insights into how communication, coordination, leadership, and conflict management interact to influence group performance. Path analysis, a subset of SEM, specifically helps to identify direct and indirect effects among the performance dimensions, offering empirical evidence to support theoretical frameworks (Hair et al., 2010). SEM has been effectively used in the context of organizational behavior to model group dynamics and decision outcomes (Kline, 2011).

Recent studies have used SEM to validate the relationships between these performance dimensions and group outcomes. For example, Anderson and Gerbing (1988) used SEM to develop a measurement model that captures the interrelations between communication, leadership, and group performance. Their findings showed that leadership directly influences communication, which, in turn, impacts group performance. This highlights the interconnected nature of these dimensions and supports the need for a scale that can simultaneously measure multiple factors. Additionally, SEM has been applied in assessing how group decision-making processes vary across different organizational contexts, providing a robust methodology for understanding the dynamics of group performance (Hoyle, 2012).

3. Scale and Structural Equation Model Design

3.1 Research Object and Scale Design

The main research object of the scale design was the dimensions of key factors and performance in group decision-making. Based on the relevant literature review, the scale is determined to consist of three parts: the individual factors of group decision-making, the group factors of group decision-making, and group decision-making performance. The specific number of items and composition are shown in Table 1.

Table 1 The design of scale

Part	Indicator	Number of Items
Individual factors	Willingness to Innovate and Explore New Solutions	5
	Interdisciplinary Team Leadership	2
	Pressure in Multidisciplinary Team Decision-Making	3
	Professional Competence and Perception	2
	Willingness to Share Knowledge	3
	Ability to Integrate Knowledge from Multiple Disciplines	2
	Trust in Other Members of the Group Decision-Making Team	3
Group factors	Team Communication and Coordination Ability	5
	Willingness to Collaborate in the Team	5
	Team Conflict Management Ability	2
Group decision-making performance	Quality of Group Decision-Making	3
	Efficiency of Group Decision-Making	2
	Satisfaction with the Decision Process and Outcome	4
	Degree of Consensus in the Decision-Making Process	4
	Acceptability of the Decision-Making Process	2

3.2 Structural Equation Hypothesis

We assume that individual factors of group decision-making influence the group indicators of group decision-making, and that group decision-making performance is jointly influenced by both individual and group factors. The specific structural equation model is shown in Figure 1.

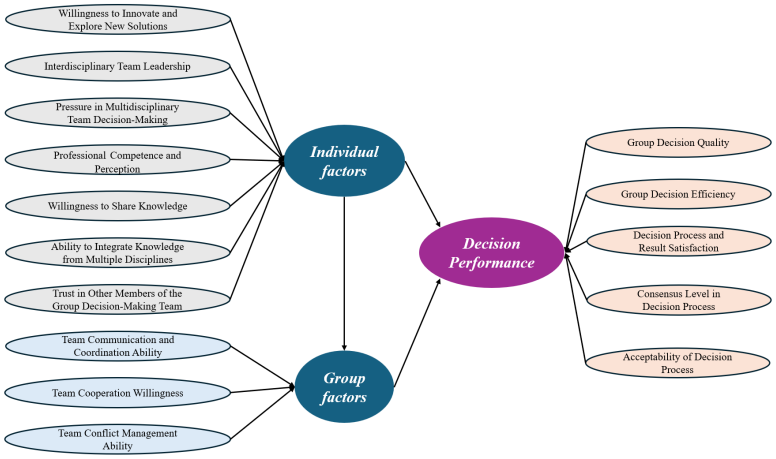

Figure 1. The design of structural equation model for group decision-making

4. Data Collection and Scale Validation

4.1 Data Collection and Respondent Information

The questionnaire was distributed to students at Shanghai Jiao Tong University. A total of 213 responses were collected. After excluding 26 invalid questionnaires (due to short completion time or consistent answers throughout), 187 valid questionnaires were retained. The descriptive analysis of the questionnaires is shown in Table 2. The study uses AMOS 24.0 software to perform confirmatory factor analysis on the measurement scale.

Table 2. Descriptive analysis of questionnaire

Variable	Option	Frequency	Percentage
Age	20-25	4	2.14%
	26-30	10	5.35%
	31-35	52	27.81%
	36-40	73	39.04%
	41-45	29	15.51%
	46-50	9	4.81%
	51-55	7	3.74%
	more than 56	3	1.60%
Gender	male	156	83.42%
	female	31	16.58%
Educational background	Associate's degree	4	2.14%
	Bachelor's degree	65	34.76%
	Master's degree	98	52.41%
	Doctor's degree	20	10.70%
Major field of study	Engineering	156	83.42%
	Science	17	9.09%
	Humanities and Social Sciences	14	7.49%
Area of expertise	Engineering	165	88.24%
	Science	12	6.42%
	Humanities and Social Sciences	10	5.35%
Number of years in the field of expertise	0	3	1.60%

	1-5	9	4.81%
	6-10	56	29.95%
	11-20	96	51.34%
	more than 20	23	12.30%
Have participated in interdisciplinary engineering or management projects	yes	129	68.98%
	no	58	31.02%
Leadership experience	yes	169	90.37%
	no	18	9.63%
Frequency of participation in management and group decision-making training	Never	34	18.18%
	Seldom	114	60.96%
	Frequently	29	15.51%
	Fairly frequently	7	3.74%
	Extremely frequently	3	1.60%

4.2 Reliability analysis

Reliability analysis refers to measuring whether the results are consistent across multiple tests, reflected by the Cronbach's α coefficient. A value between 0.7 and 0.8 indicates considerable reliability, while a value between 0.8 and 0.9 indicates excellent reliability.

Table 3. The result of reliability analysis

Indicator	Cronbach's Alpha	Number of Items
Willingness to Innovate and Explore New Solutions	0.895	5
Interdisciplinary Team Leadership	0.777	2
Pressure in Multidisciplinary Team Decision-Making	0.869	3
Professional Competence and Perception	0.825	2
Willingness to Share Knowledge	0.861	3
Ability to Integrate Knowledge from Multiple Disciplines	0.859	2
Trust in Other Members of the Group Decision-Making Team	0.887	3
Team Communication and Coordination Ability	0.9	5
Willingness to Collaborate in the Team	0.912	5
Team Conflict Management Ability	0.724	2
Quality of Group Decision-Making	0.835	3
Efficiency of Group Decision-Making	0.787	2
Satisfaction with the Decision Process and Outcome	0.903	4
Degree of Consensus in the Decision-Making Process	0.854	4
Acceptability of the Decision-Making Process	0.734	2

As shown in Table 3, the Cronbach's alpha coefficients for the indicators "Interdisciplinary Team Leadership," "Team Conflict Management Ability," and "Acceptability of the Decision-Making Process" are greater than 0.7, meeting the acceptable reliability threshold. The remaining indicators all have coefficients greater than 0.8, indicating good reliability.

4.3 Validity analysis

4.3.1 Confirmatory Factor Analysis of Individual Factors in Group Decision-Making

As shown in Table 4, the CFA model for individual factors in group decision-making demonstrates good fit. Next, we will further explore the convergent validity (AVE) and composite reliability (CR) for each dimension of the individual factors scale. According to the standards, the ideal AVE value should be greater than 0.5, with values between 0.36 and 0.5 considered an acceptable threshold for convergent validity. The CR value must meet a minimum of 0.7 to indicate good composite reliability.

Table 4. CFA Model fit test for individual factors

Indicator	Reference Standard	Measured Result	Fit Quality
CMIN/DF	1-3 Excellent, 3-5 Good	2.201	Excellent
RMSEA	<0.05 Excellent, <0.1 Good	0.080	Good
IFI (Delta2)	>0.9 Excellent, >0.8 Good	0.925	Excellent
TLI (rho2)	>0.9 Excellent, >0.9 Good	0.902	Excellent
CFI	>0.9 Excellent, >0.8 Good	0.924	Excellent

Table 5. Convergent Validity and Composite Reliability Test for Each Dimension of Individual Factors in Group Decision-Making

Path Relationship	Estimate	AVE	CR
CX5 <--- Willingness to Innovate and Explore New Solutions	0.812	0.631125	0.895285
CX4 <--- Willingness to Innovate and Explore New Solutions	0.767		
CX3 <--- Willingness to Innovate and Explore New Solutions	0.82		
CX2 <--- Willingness to Innovate and Explore New Solutions	0.787		
CX1 <--- Willingness to Innovate and Explore New Solutions	0.785		
LD2 <--- Interdisciplinary Team Leadership	0.794	0.634419	0.776321
LD1 <--- Interdisciplinary Team Leadership	0.799		
YL3 <--- Pressure in Multidisciplinary Team Decision-Making	0.773	0.699226	0.874106
YL2 <--- Pressure in Multidisciplinary Team Decision-Making	0.908		
YL1 <--- Pressure in Multidisciplinary Team Decision-Making	0.822		
ZY2 <--- Professional Competence and Perception	0.921	0.714443	0.832203
ZY1 <--- Professional Competence and Perception	0.762		
GX3 <--- Willingness to Share Knowledge	0.885	0.688276	0.868294
GX2 <--- Willingness to Share Knowledge	0.848		
GX1 <--- Willingness to Share Knowledge	0.75		
ZH2 <--- Ability to Integrate Knowledge from Multiple Disciplines	0.83	0.756682	0.86125
ZH1 <--- Ability to Integrate Knowledge from Multiple Disciplines	0.908		
XR3 <--- Trust in Other Members of the Group Decision-Making Team	0.838	0.724911	0.887456
XR2 <--- Trust in Other Members of the Group Decision-Making Team	0.908		
XR1 <--- Trust in Other Members of the Group Decision-Making Team	0.805		

Table 6. The explanation of notation in Table 6 and Figure 2

Willingness to Innovate and Explore New Solutions	Interdisciplinary Team Leadership	Pressure in Multidisciplinary Team Decision-Making	Professional Competence and Perception	Willingness to Share Knowledge	Ability to Integrate Knowledge from Multiple Disciplines	Trust in Other Members of the Group Decision-Making Team
A	B	C	D	E	F	G

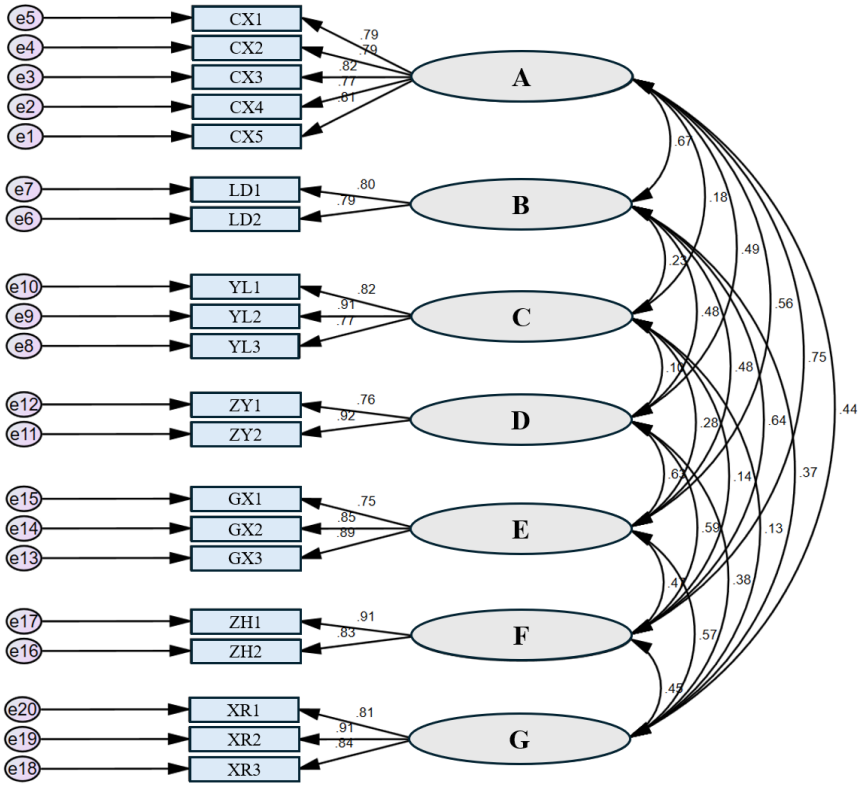

Figure 2. CFA Model for individual factors

Based on the analysis results in Table 5 and Figure 2, it can be observed that in the validity test of the individual factors scale for group decision-making, the AVE values for each dimension are within the acceptable range, and the CR values for all dimensions exceed 0.7. This indicates that, overall, each dimension demonstrates good convergent validity and composite reliability.

In this discriminant validity test, the standardized correlation coefficients between each pair of dimensions are all smaller than the square root of the AVE value corresponding to each dimension (shown in Table 6 and Table 7). This indicates that the dimensions exhibit good discriminant validity.

Table 7. Discriminant Validity Test Results for Each Dimension of the Individual Factors Scale in Group Decision-Making

	A	B	C	D	E	F	G
A	**0.631**						
B	0.667	**0.634**					
C	0.180	0.226	**0.699**				
D	0.494	0.477	0.105	**0.714**			
E	0.563	0.478	0.281	0.632	**0.688**		
F	0.754	0.640	0.144	0.589	0.468	**0.757**	
G	0.444	0.374	0.130	0.381	0.573	0.447	**0.725**
$\sqrt{AVE}$	**0.794**	**0.797**	**0.836**	**0.845**	**0.830**	**0.870**	**0.851**

4.3.2 Confirmatory Factor Analysis of Group Factors in Group Decision-Making

As shown in Table 8, the CFA model for group factors in group decision-making demonstrates good fit. Next, we will further explore the convergent validity (AVE) and composite reliability (CR) for each dimension of the group factors scale.

Table 8. CFA Model fit test for group factors

Indicator	Reference Standard	Measured Result	Fit Quality
CMIN/DF	1-3 Excellent, 3-5 Good	2.158	Excellent
RMSEA	<0.05 Excellent, <0.1 Good	0.079	Good
IFI (Delta2)	>0.9 Excellent, >0.8 Good	0.961	Excellent
TLI (rho2)	>0.9 Excellent, >0.9 Good	0.949	Excellent
CFI	>0.9 Excellent, >0.8 Good	0.961	Excellent

Table 9. Convergent Validity and Composite Reliability Test for Each Dimension of Group Factors in Group Decision-Making

Path Relationship	Estimate	AVE	CR
TDGT5 <--- Team Communication and Coordination Ability	0.765	0.644339	0.900467
TDGT4 <--- Team Communication and Coordination Ability	0.785		
TDGT3 <--- Team Communication and Coordination Ability	0.85		
TDGT2 <--- Team Communication and Coordination Ability	0.812		
TDGT1 <--- Team Communication and Coordination Ability	0.799		
TDHZ5 <--- Team Cooperation Willingness	0.826	0.678128	0.913169
TDHZ4 <--- Team Cooperation Willingness	0.856		
TDHZ3 <--- Team Cooperation Willingness	0.83		
TDHZ2 <--- Team Cooperation Willingness	0.843		
TDHZ1 <--- Team Cooperation Willingness	0.759		
TDCT2 <--- Team Conflict Management Ability	0.848	0.584673	0.735293
TDCT1 <--- Team Conflict Management Ability	0.671		

Table 10. The explanation of notation in Table 10 and Figure 3

Team Communication and Coordination Ability	Team Cooperation Willingness	Team Conflict Management Ability
H	I	J

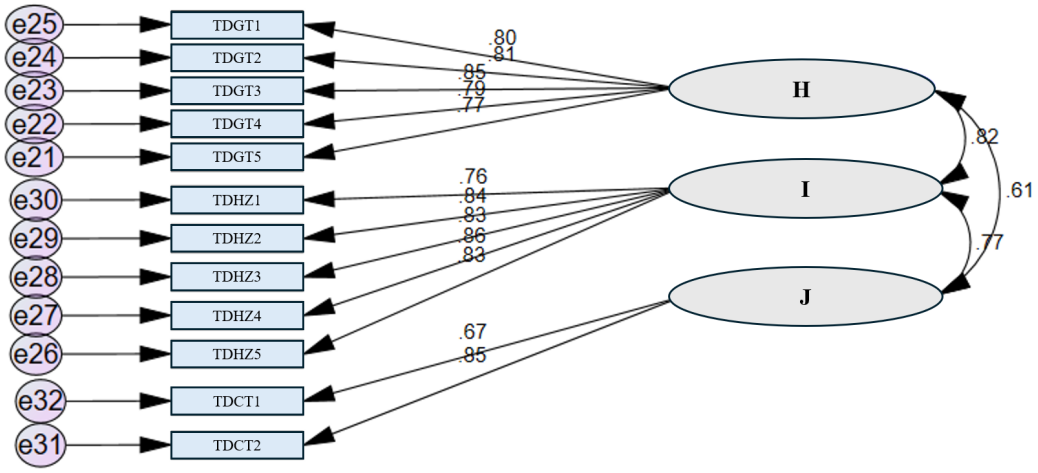

Figure 3. CFA Model for group factors

Based on the analysis results in Table 9 and Figure 3, it can be observed that in the validity test of the group factors scale for group decision-making, the AVE values for each dimension are within the acceptable range, and the CR values for all dimensions exceed 0.7. This indicates that, overall, each dimension demonstrates good convergent validity and composite reliability.

Table 11. Discriminant Validity Test Results for Each Dimension of the Group Factors Scale in Group Decision-Making

	H	I	J
H	**0.644**		
I	0.822	**0.678**	
J	0.605	0.768	**0.585**
$\sqrt{AVE}$	**0.8027**	**0.8235**	**0.7646**

In this discriminant validity test, except H-I pair, the standardized correlation coefficients between each pair of dimensions are all smaller than the square root of the AVE value corresponding to each dimension (shown in Table 10 and Table 11). This indicates that the dimensions exhibit good discriminant validity. And H-I pair should be considered at SEM model.

4.3.3 Confirmatory Factor Analysis of Group Decision-Making Performance

As shown in Table 12, the CFA model for group decision-making performance demonstrates good fit. Next, we will further explore the convergent validity (AVE) and composite reliability (CR) for each dimension of group decision-making performance scale.

Table 12.. CFA Model fit test for group decision-making performance

Indicator	Reference Standard	Measured Result	Fit Quality
CMIN/DF	1-3 Excellent, 3-5 Good	1.989	Excellent
RMSEA	<0.05 Excellent, <0.1 Good	0.073	Good
IFI (Delta2)	>0.9 Excellent, >0.8 Good	0.958	Excellent
TLI (rho2)	>0.9 Excellent, >0.9 Good	0.945	Excellent
CFI	>0.9 Excellent, >0.8 Good	0.958	Excellent

Table 13. Convergent Validity and Composite Reliability Test for Each Dimension of Group Decision-Making Performance in Group Decision-Making

Path Relationship	Estimate	AVE	CR
ZL1 <--- Group Decision Quality	0.770	0.6286	0.8354
ZL2 <--- Group Decision Quality	0.798		
ZL3 <--- Group Decision Quality	0.810		
XL1 <--- Group Decision Efficiency	0.781	0.6511	0.7885
XL2 <--- Group Decision Efficiency	0.832		
MY1 <--- Decision Process and Result Satisfaction	0.860	0.7068	0.9059
MY2 <--- Decision Process and Result Satisfaction	0.832		
MY3 <--- Decision Process and Result Satisfaction	0.788		
MY4 <--- Decision Process and Result Satisfaction	0.880		
GS1 <--- Consensus Level in Decision Process	0.804	0.5937	0.8539
GS2 <--- Consensus Level in Decision Process	0.760		
GS3 <--- Consensus Level in Decision Process	0.760		
GS4 <--- Consensus Level in Decision Process	0.757		
JS1 <--- Acceptability of Decision Process	0.758	0.5837	0.7371
JS2 <--- Acceptability of Decision Process	0.770		

Table 14. The explanation of notation in Table 14 and Figure 4

Group Decision Quality	Group Decision Efficiency	Decision Process and Result Satisfaction	Consensus Level in Decision Process	Acceptability of Decision Process
K	L	M	N	O

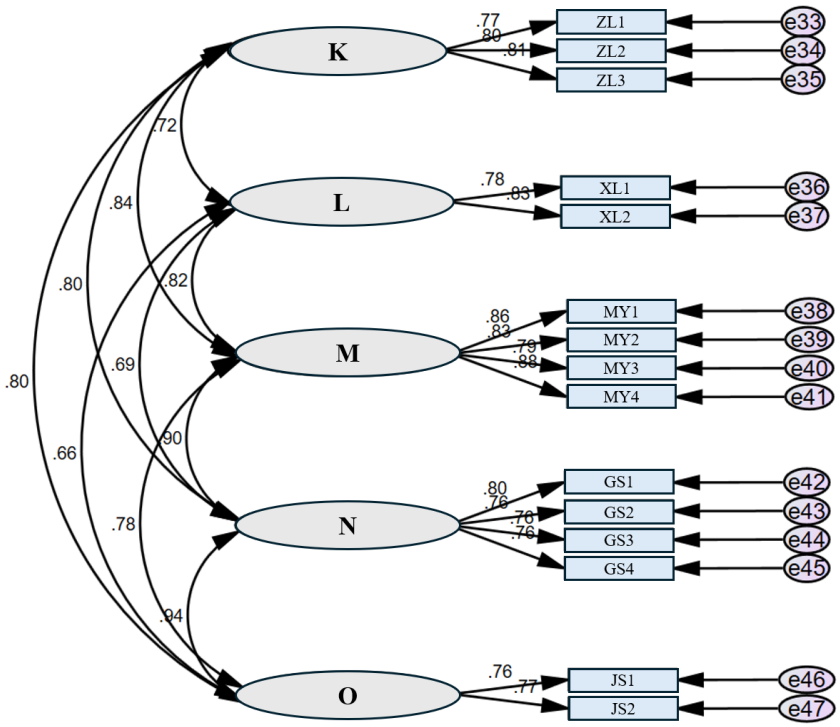

Figure 4. CFA Model for group decision-making performance

Based on the analysis results in Table 13 and Figure 4, it can be observed that in the validity test of the group decision-making performance scale for group decision-making, the AVE values for each dimension are within the acceptable range, and the CR values for all dimensions exceed 0.7. This indicates that, overall, each dimension demonstrates good convergent validity and composite reliability.

Table 15. Discriminant Validity Test Results for Each Dimension of the Group Decision-Making Performance Scale in Group Decision-Making

	K	L	M	N	O
K	**0.629**				
L	0.718	**0.651**			
M	0.840	0.819	**0.707**		
N	0.796	0.905	0.688	**0.594**	
O	0.802	0.936	0.662	0.777	**0.584**
$\sqrt{AVE}$	**0.793**	**0.807**	**0.841**	**0.770**	**0.764**

In this discriminant validity test (shown in Table 14 and Table 15), K-M, K-N, K-O, L-M, L-N, L-O and N-O pairs show a high degree of correlation, indicating that the relationships between these indicators should be carefully considered in subsequent SEM modeling.

4.4 Descriptive Statistics and Normality Validation

Table 16 presents the descriptive statistics and normality test results for the factors used in this study. According to the descriptive statistical analysis, the mean scores for each variable range from 3 to 4.5. Since the scale uses a 1-5 scoring system with positive values, it can be inferred that the study participants' cognition and behavior regarding group decision-making are generally at a slightly above-average level.

Table 16. Descriptive Statistics and Normality Test Results for Each Dimension and Measurement Item

Measured Item	Mean	SD	Skewness	Kurtosis
CX1	3.80	0.727	-0.347	0.082
CX2	3.87	0.725	-0.477	0.347
CX3	3.73	0.805	-0.538	0.621
CX4	3.96	0.710	-0.577	0.684
CX5	3.72	0.767	-0.560	0.541
LD1	3.71	0.720	-0.291	0.493
LD2	3.65	0.728	-0.355	0.454
YL1	3.28	0.828	-0.329	-0.498
YL2	3.30	0.866	-0.284	-0.576
YL3	3.49	0.947	-0.284	-0.408
ZY1	3.88	0.701	-0.307	0.106
ZY2	3.84	0.715	-0.199	-0.154
GX1	4.04	0.590	-0.325	1.090
GX2	4.14	0.666	-0.385	0.120
GX3	4.20	0.646	-0.454	0.399
ZH1	3.76	0.673	-0.208	0.040
ZH2	3.76	0.648	-0.199	0.083
XR1	3.98	0.639	-0.482	1.011
XR2	3.95	0.662	-0.279	0.234
XR3	3.91	0.682	-0.404	0.434
TDGT1	3.60	0.643	-0.376	0.017
TDGT2	3.58	0.702	-0.232	-0.121
TDGT3	3.67	0.686	-0.273	0.030
TDGT4	3.70	0.646	-0.216	0.045
TDGT5	3.59	0.745	-0.602	0.427
TDHZ1	3.69	0.656	-0.616	0.505
TDHZ2	3.73	0.660	-0.432	0.364
TDHZ3	3.68	0.689	-0.290	0.057
TDHZ4	3.76	0.732	-0.516	0.768
TDHZ5	3.74	0.725	-0.594	0.894
TDCT1	3.71	0.699	-0.479	0.282
TDCT2	3.78	0.648	-0.475	0.589
ZL1	3.74	0.655	-0.261	0.154
ZL2	3.86	0.610	-0.492	0.991
ZL3	3.86	0.615	-0.470	0.928
XL1	3.55	0.742	-0.496	0.288
XL2	3.53	0.792	-0.411	-0.006
MY1	3.76	0.605	-0.274	0.255
MY2	3.72	0.654	-0.109	-0.082
MY3	3.64	0.693	-0.353	0.047
MY4	3.74	0.623	-0.425	1.325
GS1	3.78	0.633	-0.420	0.520
GS2	3.89	0.586	-0.305	0.755
GS3	3.82	0.619	-0.695	1.279
GS4	3.91	0.584	-0.315	0.846

JS1	3.82	0.548	-0.279	0.440
JS2	3.94	0.619	-0.235	0.419

For the normality test of each measurement item, skewness and kurtosis were used for assessment. According to the standards proposed by Kline (2011), if the absolute value of the skewness coefficient is within 3, and the absolute value of the kurtosis coefficient is within 8, the data can be considered to meet the requirement for approximate normal distribution. Based on the analysis results shown in Table 16, the skewness and kurtosis coefficients for each measurement item in this study are within the standard range. Therefore, it can be concluded that the data for each measurement item meet the assumption of approximate normality.

5. Empirical Results and Discussion

5.1 Structural Equation Model

As shown in Table 17, the results of fit test indicate that the constructed SEM model shows excellent performance on indicators CFI and IFI (Delta2), and the remaining test indicators are all passed.

Table 17. SEM Model Fit Test

Indicator	Reference Standard	Measured Result	Fit Degree
CMIN/DF	1-3 Excellent, 3-5 Good	1.7	Excellent
RMR	<0.05 Meets the standard	0.022	Meeting the standard
RMSEA	<0.05 Excellent, <0.1 Good	0.061	Good
IFI (Delta2)	>0.9 Excellent, >0.8 Good	0.903	Excellent
TLI (rho2)	>0.9 Excellent, >0.9 Good	0.882	Good
CFI	>0.9 Excellent, >0.8 Good	0.901	Excellent
PNFI	>0.5 meeting the standard	0.669	Meeting the standard
PGFI	>0.5 meeting the standard	0.614	Meeting the standard

5.2 Path Relationship Results and discussion

Table 18. The Results of SEM Path relationship test (*** means p-value < 0.001)

Path Relationship	Standardized Estimate	S.E.	Significance T-Value (C.R.)	P-Value
Group Decision Quality <--- Willingness to Innovate and Explore New Solutions	-0.406	0.193	-3.456	***
Group Decision Efficiency <--- Willingness to Innovate and Explore New Solutions	-0.307	0.222	-2.672	0.008
Decision Process and Result Satisfaction <--- Willingness to Innovate and Explore New Solutions	-0.424	0.182	-3.939	***
Consensus Achievement in Decision Process <--- Willingness to Innovate and Explore New Solutions	-0.452	0.191	-3.92	***
Acceptability of Decision Process <--- Willingness to Innovate and Explore New Solutions	-0.47	0.173	-3.709	***
Group Decision Quality <--- Interdisciplinary Team Leadership	-0.059	0.122	-0.695	0.487
Group Decision Efficiency <--- Interdisciplinary Team Leadership	-0.24	0.177	-2.301	0.021

Decision Process and Result Satisfaction <--- Interdisciplinary Team Leadership	-0.078	0.107	-1.098	0.272
Consensus Achievement in Decision Process <--- Interdisciplinary Team Leadership	-0.01	0.108	-0.137	0.891
Acceptability of Decision Process <--- Interdisciplinary Team Leadership	-0.045	0.11	-0.493	0.622
Group Decision Quality <--- Pressure in Multidisciplinary Team Decision-Making	-0.045	0.051	-0.686	0.493
Group Decision Efficiency <--- Pressure in Multidisciplinary Team Decision-Making	0.019	0.061	0.287	0.774
Decision Process and Result Satisfaction <--- Pressure in Multidisciplinary Team Decision-Making	0.005	0.041	0.088	0.93
Consensus Achievement in Decision Process <--- Pressure in Multidisciplinary Team Decision-Making	0.04	0.045	0.688	0.491
Acceptability of Decision Process <--- Pressure in Multidisciplinary Team Decision-Making	0.065	0.046	0.9	0.368
Group Decision Quality <--- Team Communication and Coordination Ability	0.417	0.256	1.456	0.145
Group Decision Efficiency <--- Team Communication and Coordination Ability	0.855	0.26	3.455	***
Decision Process and Result Satisfaction <--- Team Communication and Coordination Ability	0.634	0.232	2.518	0.012
Consensus Achievement in Decision Process <--- Team Communication and Coordination Ability	0.144	0.213	0.611	0.541
Acceptability of Decision Process <--- Team Communication and Coordination Ability	0.431	0.228	1.406	0.16
Group Decision Quality <--- Team Collaboration Willingness	-1.098	0.554	-1.696	0.09
Group Decision Efficiency <--- Team Collaboration Willingness	-1.067	0.545	-1.968	0.049
Decision Process and Result Satisfaction <--- Team Collaboration Willingness	-1.028	0.498	-1.821	0.069
Consensus Achievement in Decision Process <--- Team Collaboration Willingness	-0.531	0.464	-0.99	0.322
Acceptability of Decision Process <--- Team Collaboration Willingness	-1.187	0.494	-1.709	0.087
Group Decision Quality <--- Team Conflict Management Ability	1.489	0.546	3.028	0.002
Group Decision Efficiency <--- Team Conflict Management Ability	1.022	0.53	2.519	0.012
Decision Process and Result Satisfaction <--- Team Conflict Management Ability	1.317	0.489	3.084	0.002
Consensus Achievement in Decision Process <--- Team Conflict Management Ability	1.233	0.46	3.011	0.003
Acceptability of Decision Process <--- Team Conflict Management Ability	1.562	0.486	2.97	0.003
Group Decision Quality <--- Professional Competence and Perception	-0.116	0.097	-1.286	0.199

Group Decision Efficiency <--- Professional Competence and Perception	-0.145	0.116	-1.574	0.116
Decision Process and Result Satisfaction <--- Professional Competence and Perception	-0.185	0.085	-2.398	0.016
Consensus Achievement in Decision Process <--- Professional Competence and Perception	-0.099	0.089	-1.2	0.23
Acceptability of Decision Process <--- Professional Competence and Perception	-0.13	0.086	-1.341	0.18
Group Decision Quality <--- Willingness to Share Knowledge	-0.158	0.114	-1.636	0.102
Group Decision Efficiency <--- Willingness to Share Knowledge	-0.257	0.138	-2.596	0.009
Decision Process and Result Satisfaction <--- Willingness to Share Knowledge	-0.105	0.096	-1.329	0.184
Consensus Achievement in Decision Process <--- Willingness to Share Knowledge	-0.141	0.105	-1.603	0.109
Acceptability of Decision Process <--- Willingness to Share Knowledge	-0.045	0.1	-0.441	0.659
Group Decision Quality <--- Trust in Other Team Members in Group Decision	0.087	0.172	0.943	0.346
Group Decision Efficiency <--- Trust in Other Team Members in Group Decision	-0.028	0.204	-0.299	0.765
Decision Process and Result Satisfaction <--- Trust in Other Team Members in Group Decision	0.046	0.155	0.568	0.57
Consensus Achievement in Decision Process <--- Trust in Other Team Members in Group Decision	-0.011	0.166	-0.124	0.901
Acceptability of Decision Process <--- Trust in Other Team Members in Group Decision	0.077	0.154	0.774	0.439
Group Decision Quality <--- Interdisciplinary Multi-domain Knowledge Integration Ability	0.116	0.098	1.369	0.171
Group Decision Efficiency <--- Interdisciplinary Multi-domain Knowledge Integration Ability	0.005	0.116	0.055	0.956
Consensus Achievement in Decision Process <--- Interdisciplinary Multi-domain Knowledge Integration Ability	0.107	0.088	1.419	0.156
Decision Process and Result Satisfaction <--- Interdisciplinary Multi-domain Knowledge Integration Ability	0.148	0.081	2.174	0.03
Acceptability of Decision Process <--- Interdisciplinary Multi-domain Knowledge Integration Ability	0.036	0.087	0.404	0.686

At a significance level of $P = 0.01$, the significance tests of the path relationships indicate that (Table 18):

- *Team Conflict Management Ability* has a significant positive impact on *Group Decision Quality*, *Satisfaction with Decision Process and Results*, *Consensus Reached in the Decision Process*, and *Acceptability of the Decision Process*, with standardized path coefficients of [1.489, 1.317, 1.233, 1.562], respectively. This suggests that the higher the team's conflict management ability, the easier it is for team members to manage differing opinions during the decision-making process, thereby reaching a consensus and improving the quality, acceptability, and satisfaction of the decision results.

- *Team Communication and Coordination Ability* has a significant positive impact on *Group Decision Efficiency*, with a standardized path coefficient of 0.855. This indicates that the higher the team's communication and coordination ability, the less likely team decision-making discussions are to deviate from the topic, with greater focus on achieving a unified decision goal, making the decision-making process more efficient.
- *Willingness to Innovate and Explore New Solutions* has a significant negative impact on *Group Decision Quality*, *Group Decision Efficiency*, *Satisfaction with Decision Process and Results*, *Consensus Reached in the Decision Process*, and *Acceptability of the Decision Process*, with standardized path coefficients of [-0.406, -0.307, -0.424, -0.452, -0.47], respectively. This suggests that if a team becomes overly divergent, focusing on innovation and exploring new solutions, the decision-making efficiency will significantly decrease. Additionally, the diverse range of opinions will make it difficult to reach a consensus, ultimately affecting decision quality, satisfaction, and acceptability. Therefore, group decision-making needs to manage the team's willingness to diverge and explore innovative solutions.
- *Willingness to Share Knowledge* has a significant negative impact on *Group Decision Efficiency*, with a standardized path coefficient of -0.257. This suggests that if a team places excessive emphasis on knowledge sharing, it can lead to inefficiency in decision-making. Therefore, the extent of knowledge sharing among team members should be controlled.

For those potentially significant paths with $p<0.05$ but not below 0.01, such as 'Group Decision Efficiency <--- Interdisciplinary Team Leadership', 'Decision Process and Result Satisfaction <--- Team Communication and Coordination Ability', 'Group Decision Quality <--- Willingness to Share Knowledge' and so on. This does not mean that there is no significant path relationship between them, which may be due to "insufficient sample size" or "biased sample (mainly in engineering)". This may be due to 'insufficient sample size' or 'biased sample (mainly focusing on the engineering field)', which needs to be further discussed and researched in the future.

Limitations worth mentioning are that since the vast majority of the sample population was from an engineering background, the conclusions may be specific to decision-making processes and decision-making tasks in engineering only, and decision-making processes in other domains may not be applicable, and team decision-making of different sizes is not discussed in this study.

6. Conclusion

This study developed a scale to measure individual factors, group factors, and group decision-making performance in group decision-making, and validated the scale's effectiveness through confirmatory factor analysis and structural equation modeling. The findings not only provide a new perspective on the dimensions of group decision-making performance, but also offer both theoretical and empirical support for organizations to optimize their group decision-making processes in practice. Future research could further explore the impact of other potential factors on group decision-making performance, as well as how to apply this scale for broader evaluation and improvement in different organizational settings.

References

Jehn, K. A., A multimethod examination of the benefits and detriments of intragroup conflict, *Administrative Science Quarterly*, vol. 40, no. 2, pp. 256-282, 1995.

Berman, E. M., West, J. P., & Cohn, L. S., Information systems and coordination in group decision-making, *Journal of Organizational Behavior*, vol. 22, no. 5, pp. 471-485, 2001.

Zaccaro, S. J., Trait-based perspectives of leadership, *American Psychologist*, vol. 62, no. 1, pp. 6-16, 2007.

De Dreu, C. K. W., & Weingart, L. R., Task versus relationship conflict, team performance, and team member satisfaction: A meta-analysis, *Journal of Applied Psychology*, vol. 88, no. 4, pp. 741-749, 2003.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E., Multivariate data analysis (7th ed.), *Pearson Education*, 2010.

Kerr, N. L., & Tindale, R. S., Group performance and decision making, *Annual Review of Psychology*, vol. 55, pp. 623-655, 2004.

Morgeson, F. P., DeRue, D. S., & Karam, E. P., Leadership in teams: A functional approach to understanding leadership structures and processes, *Journal of Management*, vol. 36, no. 1, pp. 5-39, 2010.

Tjosvold, D., The conflict-positive organization: It depends upon trust, *Journal of Organizational Behavior*, vol. 29, no. 1, pp. 19-28, 2008.

Eisenhardt, K. M., Strategic decision-making in organizations, *Strategic Management Journal*, vol. 18, no. S2, pp. 11-13, 1997.

Kline, R. , Kline, R. B. , & Kline, R. Principles and practice of structural equation modeling. J*ournal of the American Statistical Association*, vol. 101, no. 12, 2011.

Anderson, J. C., & Gerbing, D. W., Structural equation modeling in practice: A review and recommended two-step approach, *Psychological Bulletin*, vol. 103, no. 3, pp. 411-423, 1988.

Hoyle, R. H., Handbook of structural equation modeling, *Guilford Press*, 2012.

Tjosvold, D., & Tjosvold, M. M., Building the cooperative organization, *Organization Studies*, vol. 24, no. 4, pp. 565-586, 2003.

Hackman, J. R., Leading teams: Setting the stage for great performances, *Harvard Business Press*, 2009.

Kozlowski, S. W. J., & Ilgen, D. R., Enhancing the effectiveness of work groups and teams, *Psychological Science in the Public Interest*, vol. 7, no. 3, pp. 77-124, 2006.

Woolley, A. W., et al., Evidence for a collective intelligence factor in the performance of human groups, *Science*, vol. 330, no. 6006, pp. 686-688, 2010.

Tjosvold, D., The conflict-positive organization: It depends upon us, *Journal of Organizational Behavior*, vol. 29, no. 1, pp. 19-22, 2008.

Lu, J., Chen, Y., & Fang, Q., Promoting decision satisfaction: The effect of the decision target and strategy on process satisfaction, *Journal of Business Research*, vol. 139, pp. 1231-1239, 2022.

Li, G., Zhao, X., & Li, Y., Two-stage group ordinal consensus optimization ranking approach considering multiple optimal consistency adjustment solutions, *Computers & Industrial Engineering*, vol. 198, 110724, 2024.

Jiang, J., Xie, W., Wang, S., Zhang, Y., Gao, J., Assessing team creativity with multi-attribute group decision-making in a knowledge building community: A design-based research, *Thinking Skills and Creativity*, vol. 48, 101304, 2023.

Ito, K., Kawaguchi, Y., Nishioka, Y., Miyata, A., Ichida, A., Akamatsu, N., Kokudo, N., & Hasegawa, K., Step-by-step decision-making for achieving oncologically acceptable but avoiding over-invasive surgery for gallbladder cancer, *HPB*, 2024.

Acknowledgment

This research was supported by the National Natural Science Foundation of China (No. 72271163).

Biographies

Jiapeng Yang began his Master's studies in the Department of Industrial Engineering and Management at Shanghai Jiao Tong University in 2024, under the supervision of Zuhua Jiang. His research interests primarily include statistical learning and decision neurocognitive science.

Zuhua Jiang graduated in 1987 from Harbin Engineering University with a Bachelor's degree in Mechanical Manufacturing, obtained a Master's degree in Mechanical Engineering from Harbin Engineering University in 1990, and a Ph.D. in Mechanical Manufacturing from Shanghai Jiao Tong University in 1998. His research interests include knowledge management and industrial engineering.

Kexin Cheng is a third-year master's student in the Department of Industrial Engineering and Management at Shanghai Jiao Tong University, under the supervision of Zuhua Jiang. Her research interests primarily include neurocognitive science and knowledge management.