Chinese Validation of the Team Climate Inventory: A Measure of Team Climate for Innovation in R&D Teams

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Abstract Innovation has long been an area of interest to social scientists and psychologists. The team climate inventory (TCI) is a facet-specific measure of team climate for innovation that provides a picture of the level and quality of teamwork using a series of Likert scales. The present study assessed the psychometric properties and the validity of the Chinese translation of TCI in 208 group members from 31 teams employed in R&D context. The data were evaluated by means of $r_{wg(j)}$ values, Cronbach's alpha coefficient, confirmatory factor analysis, and Pearson's product moment correlations. The acceptable $r_{wg(j)}$ values showed appropriate internal consistency of the scales, Cronbach's alpha revealed satisfactory reliabilities and exploratory factor analysis successfully extracted a five-factor structure of the inventory, and Pearson's product moment correlation matrix indicated adequate levels of intra-scale correlation. Criterion validity was explored by correlating TCI scores with self-reported innovativeness scores. Significant positive relationships were found between five TCI scales and perceived innovativeness. Compared to the original TCI, Chinese version of the TCI is a reliable and valid instrument for measuring team climate for innovation also in R&D context.

Key words team climate inventory, R&D teams, validation

1 Introduction

Innovation management has become an important topic for researchers and managers. Innovation is "the intentional introduction and application within a role, group, or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit role performance, the group, the organization or the wider society" (West & Farr, 1989[1]). Recent years, Teams has been a basic organization unit to produce innovation. Team members with different skills, perspectives, and backgrounds work together. It is more likely to generate new and useful products and processes (Lipman-Blumen & Leavitt, 1999[2]). In research and development (R&D) work field, team is especially important to produce innovations.

Studies support the positive relationship between climate for innovation and innovative outcomes (Burningham & West, 1995[3]; Ekvall, 1996[4]; Ekvall & Ryhammar, 1999[5]). "Climate for innovation" means "shared perceptions at the work group or organizational level" or "the manner of working together that the team has evolved" (Anderson & West, 1994[6]). Climates conducive to innovation have been investigated at the organizational level (Abbey & Dickson, 1983[7]; Amabile & Gryskiewicz, 1987[8]). Team climate differs from organizational climate, as it focuses on the proximate work environment of individuals who relate to each other more closely. Therefore, most studies of climate for innovation have been conducted on a team level (Burningham & West, 1995[3]; Anderson & West, 1998[9]; Bain, Mann & Pirola-Merlo, 2001[10]).

2 Team Climate Inventory

The most popular model of team climate for innovation was pointed out by West (1990[11]). He developed a four-factor model of team climate for innovation, comprising: "Participative Safety", "Support for Innovation", "Vision" and "Task Orientation", which was called the Team Climate Inventory (TCI). The original version consisted of 61 items and a short form consisting of 38 items is also available. In the latter version, "Interaction Frequency" was separated from "Participative Safety" as the fifth factor (Anderson & West, 1998[9]). In this study, we select the short form of the TCI. In accordance with West's original model, the five scales relate to:

(1) Participative Safety. How participative the team is in its decision-making procedures and how psychologically safe team members feel it is to propose new and improving ways of doing things (8 items).

(2) Support for Innovation. The degree of practical support for innovation attempts contrasted with the rhetoric of professed support (8 items).

(3) Vision. How clearly defined, shared, attainable and valued are the team's objectives and vision (11 items).

(4) Task Orientation. The commitment of the team to achieve the highest possible standard of task performance, including the use of constructive progress-monitoring procedures (7 items).

(5) Interaction Frequency. The frequency of team members to meet and communicate both formally and informally (4 items).

The TCI has been psychometrically tested in samples including healthcare teams, social service teams, and management teams in an industrial company in the UK (Anderson & West, 1998[9]). It also has been translated into several languages including Swedish (Agrell & Gustafson, 1994[12]), Finnish (Kivimaki et al, 1997[13]), Italian (Ragazzoni et al, 2002[14]) and Norwegian (Mathisen et al, 2004[15]).

Results from Cronbach's alpha tests consistently suggest that the reliability of the TCI is acceptable with alphas ranging between 0.84 and 0.94 for the UK version (Anderson & West, 1998[9]), 0.86 and 0.91 for the Swedish version (Agrell & Gustafson, 1994[12]), 0.83 and 0.94 for the Finnish version (Kivimaki et al, 1997[13]), 0.56 and 0.91 for the Italian version (Ragazzoni et al, 2002[14]), 0.91 and 0.94 for the Norwegian version (Mathisen et al, 2004[15]).

However, construct validity tests have produced mixed results. Exploratory factor analyses revealed a five-factor solution in the UK, Italian and Norwegian samples (Anderson & West, 1998[9]; Ragazzoni et al, 2002[14]; Mathisen et al, 2004[15]), and a four-factor solution in the Swedish sample (Agrell & Gustafsen, 1994[13]).Regarding the Finnish version, a five-factor solution was the best in one sample and both a five and four factor solution was acceptable in the other sample (Kivimaki et al, 1997[13]). The fifth factor consists of items from the factor named participative safety concerning interaction frequency.

How are the reliability and validity of TCI in China? How are the relationships between the five scales of TCI in China? Thus, the aim of this paper is to prove the Chinese validation of the TCI in R&D teams. A team's climate for innovation may also be supportive of a team's innovativeness more generally. Teams characterized by clear objectives, a high concern for task performance, and a participative atmosphere, are likely to perform better than teams that are weak on these factors. Although team's climate for innovation has been associated with the production and implementation of new and useful ideas in other settings, its importance in producing innovations has not been examined in China. Hence the association between team climate for innovation and R&D team innovativeness is also examined.

3 Methodology

3.1 Participants

The participants were from three different research institutes in Chinese Academy of Sciences and one research center in a high-tech company with a wide range of professions in both basic research and technology development areas, including computer system, integrated circuit, LCD&LED and materials chemistry. Of the whole sample, only those who reported participating in a work team permanently were selected. The final sample comprised 31teams, 208 individuals (Table 1). The team size ranged from 3 to19 persons with a median size of 6.7 members (SD = 3.7).

Table1 Total Sample Characteristics

Gender	Male		Female	
No. (%)	134 (64.4)		74 (35.6)	
Age	20-25	26-35	36-45	above 46-55
No. (%)	103(49.5)	93(44.7)	11(5.3)	1(0.5)
Degree	Below bachelor	Bachelor	Master	Above doctor
No. (%)	47(22.6)	48(23.1)	87(41.8)	26(12.5)
Area	Computer system	Integrated circuit	LCD&LED	Materials chemistry
No. (%)	75(36.1)	32(15.4)	33(15.9)	68(32.6)

3.2 Instruments

The Team Climate Inventory (TCI). Two expert psychologists translated the 38 items version of the TCI into Chinese. A native English speaker who knew Chinese then back translated the Chinese version, and the two versions were compared for differences in meaning. The Chinese version of the TCI consists of 38 items corresponding with the five theoretical factors.

Innovativeness. In the questionnaire sent to the respondents of the samples, there was a 7-item scale assessing the innovativeness of the respondent's work unit. This scale assesses how encouraging the respondent's work unit is in doing things in a new and innovative way.

All team members fill in the questionnaire individually and respondent is asked to what extent he or she agrees or disagrees with each item using a five-point scale. The questionnaire is scored separately for each dimension by summing the marked figures.

3.2 Data Analysis

To test the psychometric properties of the TCI, descriptive analyses, Cronbach's alpha, principal component factor analysis, and inter-correlations between factors were performed using SPSS version 13.0. These analyses were conducted using the whole sample. The level of agreement between team members within each team was calculated using the multiple-item estimator for within group inter-rater reliability ($r_{wg(j)}$), as proposed by James, Demaree, and Wolf (1993[16]). The $r_{wg(j)}$ as computed for each item and, thereafter, the mean $r_{wg(j)}$ coefficient for each factor was computed.

4 Results and Analysis

4.1 Descriptive Analysis and Reliability

The results from descriptive analyses, presented in Table 2, showed that the Chinese sample scored lower and showed lower standard deviations on most of the TCI scales compared to the British sample(Anderson & West, 1996[17]). Cronbach's alpha analysis of the scales revealed alphas ranging between 0.88 and 0.94, indicating an acceptable reliability of the instrument. The level of agreement between the team members within each team was calculated using James et al.'s (1993[16]) formula $r_{wg(j)}$ and Table 2 showed that the average $r_{wg(j)}$ for the five scales ranged from 0.73 to 0.85. All the scales were above the 0.70 level that recommended as an acceptable level for internal consistency.

Table 2 Descriptive Statistics, Reliability and Internal Consistency for the Chinese and British Sample

	Chinese sample					British sample		
scales	Sum	SD	Mean	$r_{wg(j)}$	Alpha	Sum	SD	Alpha
Support for innovation	31.26	5.39	3.91	0.77	0.93	31.87	8.25	0.95
Vision	46.16	6.49	4.20	0.85	0.94	46.59	11.81	0.93
Task orientation	26.35	4.67	3.77	0.73	0.89	28.76	7.02	0.88
Participative safety	32.61	4.93	4.08	0.79	0.90	30.28	7.76	0.91
Interaction Frequency	16.21	2.87	4.06	0.77	0.88	14.82	8.25	0.79

4.2 Exploratory Factor Analysis

Pre-analysis tests for the suitability of the sample for factor-analysis were computed as recommended by Comrey (1978[18]).The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.945, and Bartlett's test of sphericity was significant at $p<0.001$ indicating the suitability for factor analytic procedures.Application of the scree-test (Cattell, 1966[19]) indicated that a five-factor structure was most appropriate. A principal component factor analysis using Kaiser's criterion (suggesting to retain only factors with eigenvalues higher than 1.0) also indicated that five factors should be retained. Table 3 presents the factor solutions and the factor loadings after varimax rotation.

Table 3 Factor Loadings for the Chinese Version of the TCI

Scales	Factor 1	2	3	4	5	Scales	Factor 1	2	3	4	5
	.826								.825		
	.807								.730		
	.770								.645		
	.761					Participative			.613		
	.753					safety			.532		
vision	.730								.522		
	.726								.458		
	.671								.444		
	.665									.754	
	.604									.692	
	.603					Task				.647	
		.729				orientation				.599	
		.728								.593	
		.719								.562	
		.662									.769
Support for innovation		.647				Interaction				.424	.729
		.618				frequency					.681
		.616									.648
		.610		.434		Percentage of	19.83	15.33	11.46	11.36	8.91
		.531	.410			variance(%)					

Most items load on their theoretical scale with only three had high factor loadings ($r > 0.40$) on

more than one factor. The five-factor solution accounted for 66.89% of the variance and proved to be appropriate in statistical terms. Factor 1, which accounted for 19.83% of the variance, exclusively included items related to the theoretical "vision" scale. Factor 2 accounted for 15.33% of the variance and included items from the theoretical "support for innovation" scale, as well as one item originally intended for the "participative safety" scale. Factor 3 accounted for 11.46% of the variance and included items from the theoretical "participative safety" scale, except from one item belonging to the theoretical "task orientation" scale. Factor 4 accounted for 11.36% of the variance and exclusively included items from the theoretical "task orientation" scale. The fifth factor, accounting for 8.91% of the variance, included all four items from the "interaction frequency" scale.

4.3 Correlation Analysis

Table 4 showed Pearson's product moment correlation matrix for the scales calculated on the basis of the results of the English factorial analysis (of the original scale) and the data of the Chinese factorial analysis, which indicated adequate levels of intra-scale correlation. All TCI scales for the Chinese sample were significantly and positively inter-correlated. The strongest inter-correlation was found between "support for innovation" and "task orientation" ($r = 0.78$, $p < 0.001$) while the lowest inter-correlation was found between the scales "Interaction frequency" and "vision" ($r = 0.53$, $p < 0.001$). And there were no significant differences in the levels of relationship between Chinese version and the original version.

Table 4 Inter-correlations between Scales for the Chinese and British Version

Scales	1	2	3	4
TCI: original version				
Support for innovation	1.000			
vision	0.629***	1.000		
Task orientation	0.722***	0.657***	1.000	
Participative safety	0.767***	0.605***	0.633***	1.000
Interaction frequency	0.731***	0.567***	0.610***	0.777***
TCI: Chinese version				
Support for innovation	1.000			
vision	0.666***	1.000		
Task orientation	0.777***	0.602***	1.000	
Participative safety	0.721***	0.654***	0.716***	1.000
Interaction frequency	0.613***	0.534***	0.672***	0.631***

Notes: *** $p<0.001$

Correlation analysis between TCI and team innovativeness was run using aggregated ratings of overall innovativeness. These correlations were presented in Table 5. Also all scales were significantly and positively inter-correlated. The strongest relationship was found between the scale "support for innovation" and team innovativeness, and the second strongest between the scale "task orientation" and team innovativeness. The correlations between the scales "vision," "participative safety," and "interaction frequency" and team innovativeness were also significant with "participative safety" having the weakest correlation.

Table 5 Inter-correlations between TCI scales and Team Innovativeness

Scales	Support for innovation	vision	Task orientation	Participative safety	Interaction frequency
innovativeness	.751***	.602***	.742***	.589***	.608***

Notes: ***$p<0.001$

5 Conclusions

As innovation is an essential goal for R&D teams, they provide a unique context in which to examine the impact on innovation of a positive team climate for innovation. Within this domain, results from this study indicate that TCI is a reliable and valid instrument for measuring team climate for innovation also in a Chinese context according to the following criteria: (a) acceptable $r_{wg(j)}$ values, (b) acceptable internal reliability, as measured by Cronbach's alpha coefficient, (c) confirmatory factor analysis showed that a five-factor structure was appropriate for the Chinese sample, (d) Pearson correlation coefficient indicated that all five scales were significantly and positively inter-correlated, (e) acceptable criterion validity when applying perceived innovativeness as the criterion.

All analyses in this study have been conducted on a team level using aggregated scores. To establish an aggregate climate, a minimum level of agreement should exist between the members of the unit. It seems that James et al.'s (1993[16]) method calculating $r_{wg(j)}$ has been most widely used for

measuring within group agreement in the climate research (Anderson & West, 1998[9]). The values for the TCI scales in the present study were all above 0.70, indicating that using the instrument at team level was appropriate.

The reliability of the Chinese TCI is good, but since most Cronbach's alphas were above 0.90, indicating overlap between items, a shortening of the TCI could be recommended. A short version of the Finnish TCI has already been developed, with only 14 items, showing acceptable psychometric quality (Kivimäki & Elovainio, 1999[20]).

An important finding from the present study was that the translation into Chinese did not change the factor structure of the TCI, meaning that the items showed cross-cultural similarities. The five-factor finding is in accordance with previous studies of the TCI (Anderson & West, 1998[9]; Kivimäki et al., 1997[13]; Ragazzoni et al., 2002[14]; Mathisen et al, 2004[15]). Hence, studies of the UK, Finnish, Norwegian, Italian and the Chinese version all suggested five scales of TCI.

The inter-correlation analysis among TCI scales showed that all scales were significantly and positively inter-correlated. The relationships between all scales were also in keeping with results of the previous studies of the TCI (Anderson & West, 1998[9]; Kivimäki et al., 1997[13]; Ragazzoni et al., 2002[14]; Mathisen et al, 2004[15]).

The results from the present study documented a relationship between team climate for innovation and perceived innovativeness. Consistent with expectations, a team's climate for innovation was related to team innovativeness. Significant and strong relationships were found between the scales "support for innovation," "task orientation," and perceived innovativeness. Significant but moderate relationships were found between the scales "vision," "interaction frequency" and perceived innovativeness. The relationship between scale "participative safety" and perceived innovativeness was the weakest.

Overall, the present study is a new contribution to both the study of criterion validity of the TCI, and the link between internal working climate on the one hand and team innovativeness on the other. As R&D work is focused on producing innovations, a team's climate for innovation is expected to be vitally important in this setting. Participative Safety may be crucial, as a non-threatening and participatory atmosphere is likely to facilitate the generation and evaluation of creative ideas, and provide a safe forum for radical ideas that may catalyze major innovations. Support for Innovation is also important, as new ideas that arise in the team are likely to require significant supports and resources for further investigation and testing. Acceptance of objectives is important in ensuring that the innovation goals pursued are consistent with customer requirements, and a high Task Orientation will guide the search for the most elegant, effective, or parsimonious solution to the team's innovation task. Interaction Frequency is essential in helping team members to have frequent and sufficient communication, thus will produce much more innovative ideas.

However, there is a need to replicate this study with a larger sample of R&D teams, and it would be interesting to compare the results between research teams and development teams. And it also may be a limitation in this study that only one criterion variable, self-reported innovativeness, was measured. Still, follow-up studies should be conducted including other measures of team innovativeness.

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