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Creativity in research and development laboratories: A new scale for leader behaviours

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Abstract In this paper, we report an inventory of leader behaviours that can promote creativity among R&D professionals. Specifically, we constructed and quantitatively validated a scale that was previously developed using a qualitative approach. We surveyed 584 scientists from 11 R&D laboratories in India. Exploratory and confirmatory factor analyses of the rating responses disclosed five leader behaviour factors: task-orientation; recognising and inspiring; empowering; team building and developing; and leading by example. Given acceptable evidence for convergent and discriminant validities of the factors, we argue for the use of this scale in future research in and management of creativity in R&D laboratories.

Introduction

Employee creativity, typically defined as the production of novel and useful ideas for organisational products, services, or processes (Amabile, 1983; Zhang & Bartol, 2010), has become one of the key drivers of growth, performance, and valuation in organisations today. Research and Development (R&D) teams provide an organisation with competitive advantage by generating, deploying, transferring, and integrating new technological knowledge (Ángel & Sánchez, 2009). Engaging in behaviours conducive to creative outcomes is an integral part of an R&D professional's role requirement (Montag, Maertz, & Baer, 2012). The identification of key factors that can foster and sustain R&D professionals' engagement in creative behaviours, therefore, carries significant implications for enhancing organisational competitiveness (Manolopoulos, 2006; Zheng, Khoury, & Grobmeiher, 2010).

The self-image of R&D employees is usually that of individuals who are independent in thought and action, who make things work, but avoid wasting time, capital, or labour. When an occupational group sees itself, and is also

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seen by others, as playing a critical role in the achievement of broader societal goals, it tends to demand a different kind of authority relationships as compared to those who are seemingly performing less critical roles (Clarke, 2002; Elkins & Keller, 2003; Kakar, 1971, 1977). These characteristics of R&D professionals pose unique challenges to leadership (Ángel & Sánchez, 2009; Zheng et al., 2010). However, leaders of R&D teams are often more experienced in technical than in managerial tasks (Elkins & Keller, 2003). The effectiveness of such leaders can be substantially improved if the skills necessary to lead R&D professionals are known. Berson and Linton (2005) lamented that there is no such information in the extant literature.

Through the present study we examine the behaviours of R&D leaders to understand their effectiveness in R&D organisations. Specifically, we build on a set of studies carried out in government-owned R&D laboratories in India and develop a scale to measure important leader behaviours that promote creativity in a R&D work environment.

Literature review

Measuring leadership in R&D environments

Most studies testing the impact of leadership on employee creativity have been inspired by the popular two-factor behavioural conceptualisation (e.g. initiating structure/task-oriented and consideration/relation-oriented — Blake & Mouton, 1964; Fleishman, 1953; transformation and transactional — Bass, 1985). The apparent differences between the leadership requirements of traditional and R&D environments suggest that conventional measures of leadership may apply only partially to empowered R&D environments (Arnold, Arad, Rhoades, & Drasgow, 2000; Khatri, 2005; Yukl, 1999, 2008). For example, the transformational leadership, as conceptualised by Bass (1985) and measured by the popular Multifactor Leadership Questionnaire (Bass & Avolio, 1990), does not include behaviours like inspiring, developing, empowering, team building, and leading by example (Yukl, 1999). Thus, a new behavioural measure of leadership that is sensitive to the requirements of R&D environment is needed.

Gupta and Singh (2013) identified a set of leader behaviours that may impact employee creativity in the R&D context. The item inventory was derived through an inductive or bottom—up investigation of leadership behaviour in R&D laboratories across India. Such an approach circumvented the difficulties associated with relying on incomplete or poorly integrated theory and research. Further, it improved the comprehensiveness and validity of the leader behaviour instrument (Arnold et al., 2000; Khatri, Templer, & Budhwar, 2012). The study was based on in-depth interviews conducted with 52 scientists of five Indian R&D labs located in different parts of India. The interview transcripts were content coded and a list of behaviour items was generated. The list of items was given to five doctoral students for sorting into different behaviour categories. Each incident was coded using a modified version of the leader behaviour taxonomy presented in the Managerial Practices Survey (MPS) (Yukl, Wall, & Lepsinger, 1990). Based on the consistency score, a final list of 52 behaviour items representing 13 behaviour categories was generated. The leader behaviours identified included the following: clarifying, problem solving, monitoring, buffering, inspiring, supporting, developing, informing, recognising, consulting, delegating, team building, and leading by example. Table 1 lists those behaviours along with their definitions.

In this article, we validate the item inventory developed by Gupta and Singh (2013) for measuring effective leadership in R&D environments. We perform a quantitative analysis of the behavioural items to (a) provide evidence regarding the underlying factor structure; and (b) assess the psychometric properties using data collected from professionals in R&D laboratories across India.

Method

Participants

We collected data from 11 R&D laboratories of the largest civilian research organisation in India. With 37 laboratories and more than 5000 researchers, the organisation is one of the world's largest collections of industrially-oriented public research laboratories and is India's main producer of scientific and technical publications and patents (Dahlman, Dutz, & Goel, 2007). The laboratories were sampled from the set of 37 R&D laboratories such that at least two laboratories operating in each of the major research domains of the organisation, namely, biological sciences, chemical sciences, physical sciences, and engineering sciences, were selected.

One researcher stayed for one week in each laboratory, and collected data, using a survey questionnaire. Each respondent received an envelope in which to return the completed questionnaire. Responses were anonymous and respondents were asked not to mention any personal details on the envelopes. All cases where subordinates had been associated with a senior for less than two years were dropped from the sample to ensure that subordinates understood their leader's leadership style very well. Of the 1260 distributed surveys, 584 usable ones (males = 438, females = 146) were returned (return rate = 46%). They had an average tenure of 13.4 years. Of the respondents, 5% were graduates, 33% were post graduates, and 62% had a doctoral degree; 41% were from the junior level, 39% from the middle level, and 20% from the senior level.

Measure

R&D leader behaviours

Research and development leader behaviours were measured using the 55-item inventory developed by Gupta and Singh (2013). Each scientist was asked to rate how frequently his/her leader exhibited the listed behaviours. The responses were measured using a 5-point Likert scale (1 = *not at all*, 5 = *great extent*). Before conducting the large sample survey, the leader behaviour items were tested for their clarity and redundancy. The survey was

Table 1 Leader behaviours identified by Gupta and Singh (2013).

Behaviour	Definition
Task-oriented	
Clarifying	Assigning tasks, providing directions about how to do the work, and communicating a clear understanding of job responsibilities, task objectives, deadlines, and performance expectations.
Problem solving	Identifying work-related problems, pointing out problems and giving suggestions to improve, and acting decisively to implement solutions to resolve important problems or crises.
Monitoring	Gathering information about work activities and external conditions affecting the work, checking on the progress and quality of the work, evaluating the performance of individuals through regular meetings.
Buffering	Serving as the main buffer between their teams and the labs, in order to filter down unnecessary administrative duties to protect staff time, while ensuring communication between the lab and the members.
Empowering	
Consulting	Checking with people before making changes that affect them, encouraging suggestions for improvement, inviting participation in decision-making, and incorporating the ideas and suggestions of others in decisions.
Empowering	Allowing subordinates to have substantial responsibility and discretion in carrying out work activities, handling problems, and making important decisions.
Relation-oriented	
Inspiring	Using influence techniques that appeal to emotion or logic to generate enthusiasm for the work, commitment to task objectives, and compliance with requests for cooperation, assistance, support, or resources.
Supporting	Acting friendly and considerate, being patient and helpful, showing sympathy and support when someone is upset or anxious, and being like a friend.
Developing	Showing concern for development, helping identify skill deficiencies, doing things to facilitate a person's skill acquisition, professional development, and career advancement, and allowing access to resources and facilities.
Recognising	Providing praise and recognition for effective performance, significant achievements, and special contributions, and expressing appreciation for someone's contributions and special efforts.
Informing	Disseminating relevant information to people who need it to do their work, providing written materials and documents, and answering requests for technical information.
Team building	
Team Building	Facilitating the constructive resolution of conflict, and encouraging cooperation, teamwork, and identification with the work unit.
Leading by example	
Leading by example	Setting high standards of behaviours, working hard, and leading by example in terms of punctuality, doing work, meeting deadlines, and optimisation of time.

administered in 3 of the 11 R&D laboratories. One hundred and seven responses were collected. Scientists were given an option of marking "?" (*not applicable*) against the leader behaviour items that they felt were not applicable in their organisational context or against the one whose meaning was ambiguous. The items that were marked as "not applicable" most number of times within a behaviour category were dropped from the item list. This criterion reduced the list of items from 55 to 39. The list of retained and dropped items is provided in Table 2. The remaining 39 items were then used in the final survey.

Results

The main goal in data analysis was to uncover the latent variables underlying the responses. Accordingly, we first randomly divided the 584 respondents into two groups, one of 304 for exploratory factor analysis (EFA) and another of 280 for confirmatory factor analysis (CFA). We report the results from these analyses below.

Exploratory factor analysis

To understand the common variance shared by the correlated variables, we extracted five factors, using principal axis factoring and oblique rotation. We listed the rotated pattern matrix for the responses to the items used and the name and reliability of the responses forming each factor in Table 3. We checked reliability of each factor by computing Cronbach Alpha (α).

As Table 3 shows, there were five factors in the responses. Factor 1, labelled as *task oriented behaviour*, comprised of the leader behaviour items of clarifying, monitoring, problem solving, and buffering. Factor 2 consisted of the item recognising and inspiring behaviours and was labelled as *recognising and inspiring behaviour*. Factor 3 consisted of the item delegating and consulting behaviour and was labelled as *empowering behaviour*. Factor 4 consisted of team building and developing behaviours and was labelled as *team building and developing behaviour*. Factor 5 consisted of the items leading by example and supporting

Table 2 Scale items retained and dropped after pilot testing.

Items	Number of times reported "not applicable (?)"
Items retained	
1. Empowers me to resolve problems on my own	4
2. Allows me substantial freedom in making important decisions	4
3. Provides me decision-making autonomy	4
4. Incorporates my suggestions into decisions	4
5. Listens to my ideas seriously	3
6. Gives me a chance to voice my opinions	3
7. Encourages interaction amongst colleagues	3
8. Emphasises common interests and values	4
9. Encourages cooperation and teamwork	5
10. Shows concern for my development	5
11. Helps me find ways to acquire necessary skills	5
12. Nominates me for relevant training courses	7
13. Is polite and considerate, not arrogant and rude	5
14. Shows acceptance and positive regard	3
15. Provides support for my work	6
16. Reduces unnecessary paperwork	3
17. Arranges for the funding and resources required for the project	7
18. Avoids unnecessary administrative duties to protect productive time	6
19. Clarifies priorities and deadlines	9
20. Clarifies my responsibilities and scope of authority	8
21. Clearly explains the assignment to me	9
22. Points out possible problems in my ideas	8
23. Provides suggestions to resolve my work-related problems	6
24. Resolves work-related problems quickly to prevent unnecessary costs or delays	8
25. Is an expert in his/her field	4
26. Works as hard as he/she can	5
27. Accepts failures and does not blame others for them	5
28. Asks specific questions about the progress of work	4
29. Conducts periodic progress review meetings	3
30. Monitors key process variables as well as outcomes	3
31. Appreciates specific contributions and achievements	3
32. Provides recognition that is timely	4
33. Praises commendable efforts that failed	3
34. Says things that make me feel proud to be part of this research organisation	5
35. Develops in me the proud feeling of giving something back to society	5
36. Encourages me to see the situation as one full of opportunities	6
37. Disseminates relevant information related to work	7
38. Provides constructive feedback about my performance	12
39. Freely discusses problems and issues with me	4
Items dropped	
40. Encourages juniors to determine themselves how to carry out a task or assignment	5
41. Allows voice in decision-making process	5
42. Increases incentives for mutual cooperation	22
43. Has taught me the necessary skills required for my job	14
44. Allows me to use the lab's facilities (e.g. equipments, hardware, software, chemicals, manpower, other similar resources)	8
45. Provides sympathy and support when the person is anxious or upset	12
46. Serves as the main buffer between individuals and seniors to filter down unnecessary political interference	19
47. Arranges for the funding and resources required for the project	10
48. Assigns work carefully depending on each employee's strengths	9
49. Handles work-related problems in a decisive and confident way	6
50. Leads by example in terms of abiding by the rules of the institute.	5
51. Sets high standards for performance by his/her own behaviour	5
52. Observes operations directly when it is feasible	6

Table 2 (*continued*)

Items	Number of times reported "not applicable (?)"
53. Gives credit (e.g. name in the journal publication) to people involved in a project based on their contributions	5
54. Expresses confidence in me when there is a difficult task	7
55. Provides written materials and documents, and answers requests for technical information	13

$N = 107$.

Table 3 Results of exploratory factor analysis.

Factor label, reliability and items	Factor*				
	1	2	3	4	5
Factor 1 — Task-oriented behaviour (Cronbach $\alpha = .94$)					
1. Monitors key process variables as well as outcomes	**.95**	.07	.07	−.18	−.07
2. Conducts periodic progress review meetings	**.82**	.07	.06	−.17	−.02
3. Asks specific questions about the progress of work	**.79**	.04	−.02	−.09	.10
4. Clarifies priorities and deadlines	**.73**	−.12	−.04	.08	.14
5. Resolves work-related problems quickly to prevent unnecessary costs or delays	**.64**	−.03	.00	.12	.12
6. Points out possible problems in my ideas	**.64**	−.13	−.03	.35	−.04
7. Provides suggestions to resolve my work-related problems	**.60**	−.01	−.04	.30	.02
8. Clarifies my responsibilities and scope of authority	**.59**	.02	.01	.27	−.02
9. Clearly explains the assignment to me	**.59**	.05	−.03	.25	.01
10. Arranges for funding and resources required for the project	**.53**	.02	−.08	.15	.12
11. Avoids unnecessary administrative duties to protect productive time	**.47**	−.06	.01	−.03	.34
12. Provides constructive feedback about my performance	**.42**	.40	−.03	.13	−.05
13. Reduces unnecessary paperwork	**.39**	.01	.09	−.06	.32
14. Disseminates relevant information related to work	**.36**	.33	.02	.13	−.01
Factor 2 — Recognising and inspiring behaviour (Cronbach $\alpha = .94$)					
1. Develops in me the proud feeling of giving something back to society	.08	**.86**	−.02	−.04	−.02
2. Says things that make me feel proud to be part of this research organisation	−.03	**.86**	−.03	.01	.08
3. Encourages me to see the situation as one full of opportunities	.17	**.70**	−.01	.13	−.12
4. Provides recognition that is timely	.01	**.67**	.04	.07	.16
5. Praises commendable efforts that failed	−.04	**.65**	.09	.10	.08
6. Appreciates specific contributions and achievements	−.05	**.64**	.07	.07	.15
7. Freely discusses problems and issues with me	.24	**.35**	.05	.26	−.06
Factor 3 — Empowering behaviour (Cronbach $\alpha = .88$)					
1. Allows me substantial freedom in making important decisions	−.12	.09	**.87**	−.15	.05
2. Provides me decision-making autonomy	.01	.03	**.86**	−.10	−.03
3. Empowers me to resolve problems on my own	−.08	.01	**.72**	−.05	.05
4. Incorporates my suggestions into decisions	.22	−.04	**.62**	.08	−.10
5. Listens to my ideas seriously	.14	−.05	**.60**	.22	−.04
6. Gives me a chance to voice my opinions	.08	−.11	**.53**	.34	.01
Factor 4 — Team building and developing behaviour (Cronbach $\alpha = .91$)					
1. Emphasises common interests and values	.04	.01	−.04	**.78**	−.02
2. Encourages interaction amongst colleagues	.01	.04	.02	**.69**	.03
3. Encourages cooperation and teamwork	.07	.09	−.03	**.64**	−.02
4. Helps me find ways to acquire necessary skills	.20	.12	−.08	**.63**	−.07
5. Shows concern for my development	.12	.14	.03	**.61**	−.04
6. Provides support for my work	.07	.05	−.04	**.53**	.23
7. Nominates me for relevant training courses	.15	.15	.04	**.51**	−.06
Factor 5 — Leading by example behaviour (Cronbach $\alpha = .86$)					
1. Works as hard as he/she can	.29	.04	.01	−.19	**.67**
2. Is an expert in his/her field	.17	.15	−.07	−.15	**.64**
3. Is polite and considerate, not arrogant and rude	−.18	−.08	.06	.36	**.60**
4. Accepts failures and does not blame others for them	.06	.09	.01	.08	**.58**
5. Shows acceptance and positive regard	−.10	−.01	.13	.44	**.47**

Extraction method: principal axis factoring; rotation method: promax with Kaiser normalisation.
$N = 304$.
* Boldface indicates primary factor loadings.

behaviour. The factor was labelled as *leading by example* behaviour.

Confirmatory factor analysis

We performed CFA on the second sample, using LISREL 8.52 (Jöreskog & Sörbom, 1993). This analysis was crucial for confirming the five factor solution suggested by EFA, and for justifying the retention of some of the items that seemingly formed two factors (e.g. items 12, 13 and 14 of Factor 1; item 7 of Factor 2). To check the convergent and discriminant validities of the factors, we further used the test suggested by Bagozzi and Phillips (1982, see also Anderson & Gerbing, 1988). This test involves comparing the five factor model to a similar model in which the correlations among the factors are all constrained to 1. A significantly lower χ^2 value for the model in which the correlations are not constrained to unity would indicate that the constructs are not perfectly correlated and that discriminant validity is achieved. We also considered a number of alternative factor models in the process of evaluating the proposed factor structures.

The fit of the hypothesised five factor model to the data was excellent, $\chi^2(677) = 1515.26$, $p < .01$; non-normed fit index (NNFI) = .99, incremental fit index (IFI) = .99, root mean square error of approximation (RMSEA) = .05, standardised root mean residuals (SRMR) = .04. All items had significant loading ($p < .01$) on their respective factors. The model with all inter-factor correlations constrained to 1 showed a very poor fit compared to the hypothesised five factor model ($\Delta\chi^2/\Delta df = 14.6$, $p < .01$). These results confirm the model suggested by EFA.

Table 4 reports factor means, standard deviations, alphas, composite reliability of the measurement model, and average variance extracted (AVE) for each leader behaviour factor. AVE, reported in the parentheses along the diagonal, for the five leader behaviours is greater than .5. This result indicates convergent validity of the factors (Fornell & Larcker, 1981; Ping, 2005). Moreover, the squares of correlations between any two factors (values above the diagonal in Table 4) are not greater than the individual AVEs of the two factors, suggesting that the factors each have internal (extracted) variance greater than variance shared between the factors and have adequate discriminant validity (Fornell & Larcker, 1981; Ping, 2005).

We checked for internal consistency of the measurement model by computing composite reliability. These composite reliability coefficients ranged from .85 to .94, and are greater than the benchmark of .60 recommended by Fornell and Larcker (1981). Thus, results as a whole in Table 4 provide evidence of the convergent and discriminant validities of the leader behaviour instrument. Following Gupta and Singh (2013), we call the measurement instrument as "Leader Behaviour Scale for R&D Context" (LBS-RnD).

Discussion

Theoretical contributions

In their qualitative study of R&D leaders, Gupta and Singh (2013) found that behaviours conducive to creativity can be categorised into task-oriented, relation-oriented, empowering, team building, and leading by example. Results from the present quantitative study further support that tack. Responses formed five reliable factors of task-oriented, recognising and inspiring, empowering, team building and developing, and leading by example behaviours. No less important, the five latent factors evinced acceptable levels of convergent and divergent reliabilities. Thus, the leader behaviour instrument (LBS-RnD) is a reliable and valid measure of leaders' behaviours conducive to creativity in an R&D setting.

Results from the qualitative and quantitative studies can diverge at times. For example, the items of developing and team building behaviours loaded on a single factor in both EFA and CFA, and not on separate factors as originally suggested by the qualitative study. This discrepancy is notable, for it suggests that any instrument based on purely qualitative data cannot be completely valid. We recommend that future researchers always use both methods. While results from a qualitative study may be useful for generating items for an instrument, those from a quantitative study can be useful for establishing psychometric properties of the instrument as illustrated in this article.

Table 4 Descriptive statistics and correlations.

Leader behaviours	CR[a]	α[b]	*M*	SD	1	2	3	4	5
1. Task-oriented behaviour	.94	.94	3.55	.88	(.58)	.53	.22	.58	.40
2. Recognising and inspiring behaviour	.93	.94	3.59	.95	.73**	(.67)	.31	.54	.42
3. Empowering behaviour	.86	.88	3.82	.79	.47**	.56**	(.51)	.39	.31
4. Team building and developing behaviour	.90	.91	3.73	.90	.76**	.74**	.62**	(.58)	.44
5. Leading by example behaviour	.85	.86	4.03	.81	.63**	.65**	.56**	.66**	(.54)

Average variance extracted (AVE) for each factor is provided in parenthesis along the diagonal; values below the diagonal are inter-factor correlations; values above the diagonal (i.e. AVE) are square of correlations.

**$p < .01$(two-tailed); $N = 584$.

[a] CR: composite reliability of the measurement model.

[b] α: Cronbach alpha reliability.

The behaviours identified in the study have important implications for leadership training and development. This list of behaviours can help practitioners who often wrestle with the task of identifying appropriate behaviours that can ensure leader effectiveness. Development of training modules around these behaviours should lead to better return on investment for the organisations and will make training programmes more useful for managers and employees alike. The set of behaviours identified can also be used to appraise performance of leaders of R&D departments. Leaders who exhibit such behaviours while managing an R&D team may have a higher chance of producing better results. Alternatively, the list of behaviours presented here can help managers understand the reasons for their failure and in determining remedial steps. Managers can go through the leader behaviour inventory themselves or ask their subordinates to provide feedback on how often they display each of these behaviours. This can then help them understand better the areas where they can improve.

Although we offer the LBS-RnD as a reliable and valid measure of leaders' behaviours, we also wish to point out that construct validation alone is not enough for any instrument to be usable in field situations. Criterion-related validities are also necessary and by no means less important. If a measure is valid, it should correlate with other current indices of the same construct. For example, leaders who score high and low on our LBS-RnD should reliably differ in their behaviours in the laboratories. If they differ, our measure will have concurrent validity. Likewise, leaders selected on the basis of LBS-RnD should promote higher levels of creativity in the future. Such evidence on the predictive validity of our measure will lend further support to its utility in R&D laboratories. Future work should, therefore, be directed at the criterion-related concurrent and predictive validities of the present measure.

Until results from the above studies are available, we can state that the leader behaviour scale presented in this article is much more comprehensive, well-developed, and psychometrically robust than traditional leadership models developed in non-R&D contexts. We hope that both researchers and practitioners will find it useful in their respective domains.

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