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Measuring Innovative Work Behaviour

Jeroen de Jong and Deanne den Hartog

Both scientists and practitioners emphasize the importance of innovative work behaviour (IWB) of individual employees for organizational success, but the measurement of IWB is still at an evolutionary stage. This article is concerned with developed a measure of IWB with four potential dimensions: the exploration, generation, championing and implementation of ideas. From a pilot survey among 81 research professionals and their supervisors, we derived an initial version of ten items. Next, analysis of validity drew on survey data from 703 matched dyads of knowledge workers and their supervisors in 94 knowledge intensive services firms. It included confirmatory factor analyses and hierarchical multilevel regressions to test hypothesized relationships of IWB with related constructs, including participative leadership, external work contacts and innovative output. These analyses demonstrated sufficient reliability and criterion validity. Evidence for the distinctiveness of the four dimensions was, however, weak, suggesting that IWB is one-dimensional. We conclude that further research on this issue is merited.

Introduction

Nowadays, the ability to continuously innovate products, services and work processes is crucial for organizations. Accordingly, the past 20 years has seen increased attention for innovation as a scholarly research topic. Innovation studies deal with the management of innovation at the levels of organizations, work groups, networks and individuals (King & Anderson, 2002). In this research we focus on innovation at the level of individuals in organizations. Individuals' actions are of crucial importance for continuous innovation and improvement. This conception is not just found in the academic literature on innovation (e.g., Van de Ven, 1986; Janssen, 2000), but is also stressed in work on related management principles including total quality management (McLoughlin & Harris, 1997) and corporate entrepreneurship (Sharma & Chrisman, 1999).

We aim to contribute to the field of individual innovation research by developing a multi-dimensional measure of innovative work behaviour (IWB). In previous literature, a distinction is often made between creativity (including exploring and generating ideas) and innovation (including the championing and implementation of ideas). Others have, however, included the generation and implementation of ideas in single measures of individuals' innovative work behaviour (e.g., Van de Ven, 1986; Scott & Bruce, 1994). While early studies focused mainly on the generation of creative ideas, recently researchers have called for the scope to be extended and for more scientific attention to be devoted to the implementation of ideas (e.g., Mumford, 2003). In line with this, IWB is currently typically seen to encompass a broad set of behaviours related to the generation of ideas, creating support for them, and helping their implementation (e.g., Scott & Bruce, 1998; Janssen, 2000).

Although IWB is theoretically treated as multi-dimensional, available measures of IWB are mostly one-dimensional (e.g., Scott & Bruce, 1994; Reuvers et al., 2008). Also, the empirical evidence for the validity of IWB measures is limited. Most studies relied solely on single source data, where individual employees provide the ratings of IWB as well as its correlates. Here, in two multi-source studies, we develop a measure of IWB and investigate its validity by relating the measure with some constructs that have been empirically demonstrated to be correlates of innovative work behaviour (participative

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leadership, external work contacts and employees' innovative output).

In what follows we first define IWB and elaborate on its proposed dimensions. We also develop hypotheses in order to validate our measure. We then go on to report on a pilot and main study that have been carried out in order to explore the dimensions of IWB and to validate the proposed measure. Finally, we discuss our findings and make suggestions for future research.

Innovative Work Behaviour

Farr and Ford (1990) define IWB as an individual's behaviour that aims to achieve the initiation and intentional introduction (within a work role, group or organization) of new and useful ideas, processes, products or procedures. IWB differs from employee creativity – the production of new and useful ideas concerning products, services, processes and procedures (Amabile, 1988) – because it also includes the implementation of ideas. Unlike creativity, IWB is explicitly intended to provide some kind of benefit. It has a clearer applied component and is expected to result in innovative output. Creativity can be seen as a crucial component of IWB, most evident in the beginning of the innovation process when problems or performance gaps are recognized and ideas are generated in response to a perceived need for innovation (West, 2002). Here, we address a broad range of innovative work behaviours encompassing both the initiation and implementation of ideas.

Dimensions

Much of the work on IWB theoretically distinguishes between various dimensions, which are often linked to different stages of the innovation process. For example, Scott and Bruce (1994) operationalize IWB as a multi-stage process. Drawing on Kanter (1988), they outline three stages relevant to IWB, namely idea generation, coalition building and implementation. However, we notice that idea generation is rather broad, as it is proposed to include behaviours to both explore and generate ideas. Creativity research, however, indicates that these two behaviours rely on distinct cognitive abilities (e.g., Runco & Chand, 1994; Basadur, 2004). Similarly, in the entrepreneurship literature, opportunity exploration is regarded to precede idea generation. Both behaviours also have distinct personality and environmental determinants (e.g., Shane, 2003). Here, we distinguish four dimensions of innovative work behaviour, and label them as idea exploration, idea generation, idea championing, and idea implementation.

The start of an innovation process often has an element of chance: the discovery of an opportunity or some problem arising. The trigger may be a chance to improve conditions or a threat requiring an immediate response. Drucker (1985) identified seven sources of opportunities, including: unexpected successes, failures or events; gaps between 'what is' and 'what should be'; process needs in reaction to identified problems or failure; changes in industrial or market structures; changes in demographics such as labour force composition; changes in perception; and finally, new knowledge. Idea exploration includes looking for ways to improve current products, services or processes or trying to think about them in alternative ways (e.g., Kanter, 1988; Farr & Ford, 1990; Basadur, 2004).

Idea generation is the next proposed element of IWB. The generation of ideas may relate to new products, services or processes, the entry into new markets, improvements in current work processes, or in general terms, solutions to identified problems (e.g., Van de Ven, 1986; Amabile, 1988; Kanter, 1988). The key to idea generation appears to be the combination and reorganization of information and existing concepts to solve problems or to improve performance. Good idea generators approach problems or performance gaps from a different angle. Kanter (1988) speaks of 'kaleidoscopic thinking' as idea generation often involves rearranging already existing pieces into a new whole.

Idea championing becomes relevant once an idea has been generated. Most ideas need to be promoted as they often do not match what is already used in their work group or organization. Even if ideas have legitimacy or appear to fill a performance gap, for most ideas it is uncertain whether their benefits will exceed the cost of developing and implementing them, and resistance to change often occurs (Kanter, 1988). In this respect, the champions of innovation literature focuses on persons in informal roles who push creative ideas beyond roadblocks in their organizations and help realizing innovative ideas (e.g., Shane, 1994). Championing includes finding support and building coalitions by expressing enthusiasm and confidence about the success of the innovation, being persistent, and getting the right people involved (Howell, Shea & Higgins, 2005).

Finally, ideas need to be implemented. Considerable effort and a result-oriented attitude are needed to make ideas happen. Idea implementation also includes making innovations part of regular work processes (Kleysen &

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Street, 2001) and behaviours like developing new products or work processes, and testing and modifying them (e.g., Kanter, 1988).

Previous Measures

Table 1 lists available measures of IWB. The seminal measure of IWB was developed by Scott and Bruce (1994). They developed a one-dimensional six-item scale covering idea generation, coalition building and idea realization, but they did not attempt to empirically separate these dimensions. Since then, others operationalized IWB with similar, one-dimensional measures with limited items (e.g., Bunce & West, 1995; Spreitzer, 1995; Basu & Green, 1997; Scott & Bruce, 1998).

Janssen (2000) was first to try and develop a multi-dimensional measure, using both self and other ratings of IWB. He formulated items specifically tapping idea generation, idea promotion and idea implementation, but found strong correlations, and concluded that his items could best be combined and used as a single additive scale. Next, a similar result was found by Kleysen and Street (2001). In fact, Krause (2004) and Dorenbosch, van Engen and Verhagen (2005) were first to present IWB measures tapping two dimensions, namely idea generation and idea implementation. Both studies can be regarded as further steps in the evolving measurement of IWB. Most recently, however, Reuvers and colleagues (2008) also mentioned idea generation, promotion and realization in their conceptualizing of IWB, but in their empirical work, no attempt was reported to actually distinguish between these dimensions.

Previous measures have some caveats that we try to address here. First, even if they include different behaviours, IWB measures are mostly operationalized as one-dimensional in measurement (e.g., Scott & Bruce, 1994; Reuvers et al., 2008). Second, previous studies were barely concerned with validity – we found only a few cases providing some validity information. For example, Scott and Bruce (1994) correlated their IWB measure with objective innovation outcomes, while Janssen (2000) analysed the correction between leader and subordinate reports of innovativeness. Measures of IWB are rather used as outcome measures in studies where other constructs (e.g., empowerment) were the focal variables and accordingly received full attention. Thirdly, many studies only collected single source data, i.e., employees' self-ratings or by asking supervisors to rate employees' innovativeness. We now elaborate on how we account for these challenges.

Validation Hypotheses

We anticipate that modelling IWB as multi-dimensional better reflects the domain of the construct. A necessary condition in the validation of any multi-dimensional measure is that each of the proposed dimensions contributes to an overall construct of IWB. Simultaneously, however, it is required that, though related, the dimensions of a construct reflect distinct components (Campbell & Fiske, 1959). Thus, we hypothesized:

> *Hypothesis 1A:* Idea exploration, generation, championing and implementation contribute to an overall construct of innovative work behaviour.
>
> *Hypothesis 1B:* Idea exploration, generation, championing and implementation are four distinct dimensions of innovative work behaviour.

In order to demonstrate criterion validity, we empirically relate our proposed IWB measure with various other, but related, constructs. When collecting data we asked supervisors to report on their subordinates' IWB, while subordinates reported their perceptions of our validation constructs, including participative leadership, external work contacts and individuals' innovative output.

Participative leadership involves the use of decision-making procedures that allow subordinates to influence important decisions, and grant them autonomy to design and guide their own tasks. It can take different forms, including consultation, joint decision-making and delegation (Yukl, 2006). Several studies have found empirical evidence for a positive correlation between participative leadership and innovative work behaviour. For example, Krause (2004) investigated whether supervisors could exert influence on the innovation process by granting their employees freedom and autonomy. Among 399 middle managers from German enterprises, she found that freedom and autonomy were positively related to various types of innovative behaviour, including the generation, testing and implementation of ideas. Krause argued that individuals are more likely to engage in innovative behaviours, because freedom and autonomy improves their perceptions of being in control to change their situation and to bring relief to perceived performance gaps. We hypothesized:

> *Hypothesis 2:* Participative leadership is positively related to innovative work behaviour.

External work contacts relate to the frequency of employees' contacts with

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Table 1. Previous Measures of Innovative Work Behaviour

Study	Items and dimensions	Sample and self or other ratings	Reliability and validity
Scott and Bruce (1994)	6 items; one dimension	Managers of 172 engineers, scientists and technicians in an R&D department; other ratings, single source	$\alpha = 0.89$; significant correlation with objective measure of filed invention disclosures ($r = 0.33$)
Bunce and West (1995)	5 items; one dimension	Sample 1 435 employees from a national health service; self-ratings, single source Sample 2 281 employees from a national health service; self-ratings	Sample 1 $\alpha = 0.75$; no validity reported Sample 2 $\alpha = 0.80$; no validity reported
Spreitzer (1995)	4 items; one dimension	Subordinates of 393 managers of an industrial company; other ratings, multiple source	$\alpha = 0.91$; no validity reported
Basu and Green (1997)	4 items; one dimension	Supervisors of 225 employees of a printing manufacturer; other ratings, single source	$\alpha = 0.93$; no validity reported
Scott and Bruce (1998)	4 items; one dimension	Sample 1 Leaders of 110 professionals in an R&D facility; other ratings, multiple source Sample 2 Leaders of R&D engineers working at four locations of a manufacturer of electronic equipment; other ratings, multiple source	Sample 1 $\alpha = 0.86$; significant correlation with objective measure of individual innovation (number of invention disclosures) Sample 2 $\alpha = 0.84$; no validity reported
Janssen (2000)	9 items; one dimension	Self-ratings of 170 employees of a food manufacturer and 110 supervisor (other) ratings of innovative behaviour, multiple source	$\alpha = 0.95$ (self-ratings) and 0.96 (supervisor ratings); significant correlation between both scales ($r = 0.35$)
Kleysen and Street (2001)	14 items; one dimension	225 employees from different organizations; self-rating, single source	$\alpha = 0.97$; no support of validity (inadequate fit of structural equation model)
Krause (2004)	8 items related to two dimensions (5 items on creativity and 3 on implementation)	399 middle managers from different German organizations; self-ratings, single source	α-values of 0.78 and 0.81 are reported; exploratory factor analysis shows the two factors are factorially distinct.
Dorenbosch, van Engen and Verhagen (2005)	16 items related to two dimensions (10 items on creativity and 6 items on implementation)	132 non-managerial employees in a Dutch local government organization; self-ratings, single source	α-values of 0.90 and 0.88 are reported; the additive scale of both dimensions had $\alpha = 0.92$; no validity reported
Reuvers et al. (2008)	4 items; one dimension	335 respondents in four Australian hospitals; self-rating, single source	$\alpha = 0.86$; no validity reported

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individuals or groups outside the organization who may form a relevant source of information, inspiration or innovation resources. Examples include contacts with customers (Kanter, 1988), professionals outside the organization (Kimberly & Evanisko, 1981) and scientists (Kasperson, 1978). Employees with such contacts have better opportunities to engage in innovative work behaviour, as their contacts expose them to more diverse views and ideas that may help spark their creativity. In addition, external contacts may help to find resources for innovation. Perry-Smith and Shalley (2003) developed propositions on the association between social relationships and the related construct of creativity. Drawing on social network theory, they suggested several mechanisms through which the social context influences creativity. Individuals with frequent external work contacts have a more diverse network with many so-called 'weak ties', as external work contacts are usually characterized by little affect or social exchange. The access to non-redundant information and diverse social circles provided by these weak ties facilitates several processes helpful for innovative work behaviour, including options for opportunity exploration, sources of ideas, and support to implement innovations. We expected:

Hypothesis 3: External work contacts are positively related to innovative work behaviour.

Innovative output of employees is used most often in the scarce validity analyses of IWB measures. Scott and Bruce (1994, 1998) reported significant correlations between IWB and independently rated counts of invention disclosures. When tasks of employees are fully focused on innovation, more 'objective' measures of innovative outputs (like patent counts) may exist. However, in firms offering knowledge-intensive services (our population, see below), such objective measures for the innovative output of employees are not available. Therefore, in this study, we followed the approach of Axtell et al. (2000) by using employees' self-ratings of innovative output. Innovative work behaviour is expected to affect different forms of innovative output, for example, more suggestions for innovations and more ideas for change being put forward as well as more realized innovations, such as new products and processes being developed. We anticipated:

Hypothesis 4: Innovative work behaviour is positively related to innovative output.

Pilot Study

A pilot study was carried out among matched dyads of 81 knowledge workers and their supervisors in one organization. This study aimed to develop an initial version of the IWB measure to test the measures of participative leadership, external contacts and innovative outcomes. Next, the main study tested our validation hypotheses.

Method

The pilot study was carried out at a business and policy research institute in the Netherlands. Its customer base includes policy makers from ministries, local governments, the European Commission, industry associations and large enterprises. Data were collected from two sources. All 102 knowledge workers this firm employed were invited to participate. Employees received a packet with the questionnaire, a cover letter (assuring confidentiality and explaining the procedure for the survey) and a return envelope. Employees filled out items on our validation constructs of participative leadership, external work contacts and innovative outputs (see below). A total of 81 employees participated, representing a response rate of 79 per cent. Their mean age was 42 years. Some 86 per cent of the respondents had a university education and 64 per cent were male. Next, we requested all supervisors to rate their subordinates' IWB. All supervisors were willing to participate. They filled out the questionnaire with matched codes for each of their subordinates (an average of seven subordinates per supervisor) and sent these to the researchers.

The Appendix lists all items used to measure our constructs. The item pool for IWB consisted initially of 17 items, inspired by Janssen (2000), Kleysen and Street (2001) and Scott and Bruce (1994). Whenever needed, items were translated in Dutch and reworded or adapted. In the initial version, idea exploration, generation, championing and implementation were measured with five, four, four and four items, respectively. Participative leadership was measured with six items based on Den Hartog (1997). External work contacts were measured using a scale of five items developed by De Jong and Den Hartog (2005). The measure contained statements on the frequency of contacts with customers, people from other companies, knowledge institutions and universities, and visiting conferences. The self-rated innovative output scale consisted of six items on the frequency of employees' suggestions and

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implementation efforts related to new products and services, work practices, knowledge and markets (groups of customers). Axtell and colleagues (2000) used a similar measure. Responses could vary from 1 to 5 (either 'never–always' or 'totally disagree–totally agree').

Results

The pilot study served to examine the factor structure of our initial IWB measure, i.e., to develop an initial version with empirically distinct dimensions as input for the main survey. We also wanted a shorter measure. Given that we had planned a follow-up survey in which leaders would again report on multiple employees, a 17-item measure was expected to be too long, and indeed, some supervisors in the pilot had complained about length. Thus, exploratory factor analysis (EFA) was used to explore the dimensions of the IWB items and to shorten the measure.

Using our 17 IWB items, pre-analysis tests for the suitability of the data for factor analysis were computed as recommended by Hair et al. (2007). The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.93, and the Bartlett test of sphericity was significant at $p < 0.001$, indicating suitability of the data. An initial EFA was computed. Only two factors had eigenvalues larger than 1, yet the scree criterion suggested a four-factor solution. Further analysis with oblique rotation limiting the number of factors to four showed this solution extracted 87 per cent of the variance; however, some factor loadings were ambiguous. Following Hair et al. (2007), factor loadings should preferably be over 0.50, while cross-loadings should not exceed 0.30. An item-selection process applying these criteria induced a ten-item scale, explaining 83 per cent of the variance. Table 2 lists the selected items (see Appendix for the dropped items). The table also shows that each dimension is sufficiently reliable (Cronbach's $\alpha > 0.70$ and mean correlation >0.40).

We note that the third and fourth dimensions explained <10 per cent of the variance, implying that their eigenvalues were still <1. For this reason, in our follow-up survey reported hereafter, we engaged in confirmatory factor analyses to obtain more robust tests of the dimensionality of IWB. The other measures had good reliability, i.e., Cronbach's α was 0.87 for participative leadership, 0.85 for external work contacts and 0.82 for innovative output. Moreover, item-rest correlations exceeded 0.45 and the mean correlations were bigger than 0.40.

Main Study

After our pilot study yielded initial instruments, we performed a large-scale follow-up survey to provide further reliability information, and to test our validation hypotheses.

Method

The sample consisted of knowledge workers and their managers from 94 small knowledge-intensive service firms in the Netherlands. Participating firms were sampled based on NACE (sector) codes, including code 72 (IT services), 7411, 7412 (legal and accounting services), 7413, 7414, 744 (economic services) and 742 (engineering services). Firms' general managers were first invited to participate. To check whether the participating firms were representative, a χ^2 test demonstrated no significant differences with the population distribution of knowledge-intensive services firms ($p = 0.09$). We also asked the general managers to report some basic innovation indicators for their firms, including product and process innovation, and again found no significant differences with the population of knowledge-intensive services firms (as reported by Statistics Netherlands, 2007).

In firms with fewer than 10 employees, managers were asked to provide details on all staff doing knowledge work. Managers of larger firms were asked to draw a random sample of 10 knowledge workers, based on whose date of birth came up first. Participants provided the contact details of 905 employees that we invited to take part in the survey. Data were collected from two sources. The participating managers first received a questionnaire asking them to rate their subordinates' IWB. The 10-item measure developed in the pilot study was applied for this purpose, and we received 879 ratings of subordinates on IWB (97 per cent). One week later we sent out the subordinate questionnaire along with a cover letter assuring confidentiality and explaining the voluntary nature of participation. Subordinates again reported on participative leadership, external work contacts and innovative output (measures identical to those tested in the pilot study).

A total of 703 employees responded (78 per cent). Some 66 per cent of these respondents were males. A total of 32 per cent were employed in engineering services, 14 per cent in IT services, 12 per cent in juridical services, and 42 per cent in consultancy. Using χ^2 tests we compared the distributions of respondents and non-respondents on gender and service type. Both tests revealed no significant

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Table 2. Exploratory Factor Analysis of Innovative Work Behaviour (n = 81)

How often does this employee. . .	Factor 1 (idea generation)	Factor 2 (idea exploration)	Factor 3 (idea championing)	Factor 4 (idea implementation)
(x1). . . pay attention to issues that are not part of his daily work?	0.20	**0.52**	–0.25	–0.10
(x2). . . wonder how things can be improved?	0.19	**0.59**	–0.22	–0.12
(x3). . . search out new working methods, techniques or instruments?	**0.75**	–0.12	–0.18	–0.03
(x4). . . generate original solutions for problems?	**0.85**	0.07	–0.06	0.03
(x5). . . find new approaches to execute tasks?	**0.79**	0.17	0.15	–0.13
(x6). . . make important organizational members enthusiastic for innovative ideas?	0.02	0.03	**–0.92**	–0.06
(x7). . . attempt to convince people to support an innovative idea?	0.05	0.12	**–0.76**	–0.09
(x8). . . systematically introduce innovative ideas into work practices?	0.29	–0.26	–0.18	**–0.56**
(x9). . . contribute to the implementation of new ideas?	–0.01	0.05	0.05	**–0.95**
(x10). . . put effort in the development of new things?	0.02	0.12	–0.22	**–0.69**
Explained variance	49.9%	15.7%	9.8%	7.4%
Cronbach's α (of bold items)	0.90	0.88	0.95	0.93
Mean correlation (of bold items)	0.74	0.78	0.90	0.82

differences ($p = 0.56$ and $p = 0.11$, respectively). After merging both files, the dataset consisted of 693 complete leader–subordinate dyads (77 per cent of all sampled dyads).

Results

We first repeated the reliability analyses, and found similar results as in the pilot study. Reliability was good for all measures ($\alpha > 0.70$, mean correlation >0.40 and IRCs >0.30). We do not report these findings due to space limitations.

Next, confirmatory factor analysis (CFA) was used to test our hypotheses 1A and 1B. As the strongest test of fit is to identify and test competing models that represent different hypothetical relationships (Hair et al., 2007), we identified four models for empirical comparison. First, a model with all items loading onto a single factor was estimated. This model mirrors previous scales that depict IWB as one-dimensional (e.g., Spreitzer, 1995; Basu & Green, 1997). It also provides a test of the large share of variance of the first factor that we found in our exploratory factor analysis, suggesting that IWB may indeed be one-dimensional. Then, a two-factor model was run with items on opportunity exploration and idea generation loading on the first factor and items on championing and application on the second factor. This model reflects the operationalization of Krause (2004) and Doren-

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Table 3. Overall Fit Indices for Innovative Work Behaviour Scales (Threshold Values in Brackets) (n = 879)

Model	Absolute fit		Incremental fit		Parsimonious fit
	GFI (>0.90)	RMSEA (<0.08)	TLI (>0.90)	NFI (>0.90)	χ^2/df (<5.0)
One factor	0.78	0.18	0.81	0.85	30.19
Two factors	0.85	0.15	0.88	0.90	20.49
Three factors	0.96	0.07	0.97	0.97	5.80
Four factors	0.97	0.06	0.98	0.98	4.63

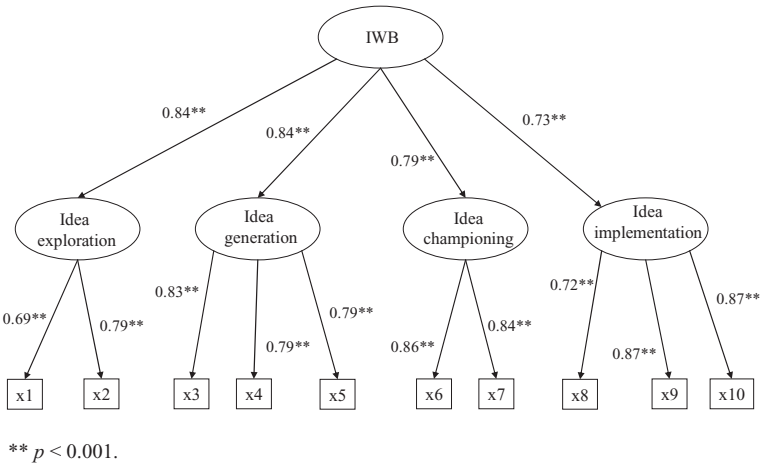


Figure 1. Second Order Confirmatory Factor Analysis of Innovative Work Behaviour (n = 879)

bosch, van Engen and Verhagen (2005). It also builds on our pilot study EFA which yielded only two factors with eigenvalues >1. Next, a three-factor model was estimated. This model reflects the assumptions of Scott and Bruce (1994) and Janssen (2000) in assuming that IWB consists of idea generation (now also including exploration), championing and implementation. Finally, we estimated a four-factor model that specified each item to load on its proposed dimension.

The second, third and fourth model were all specified as second-order CFA models. The factor structure was further specified to account for the relationships among the first-order factors (in this case, the dimensions of IWB) to estimate the proposed contribution of the various dimensions to an overall construct of innovative work behaviour. Table 3 provides the results drawing on maximum likelihood estimates. It reports absolute fit measures (GFI and RMSEA, both indicating recovery of observed correlations between the items), incremental fit measures (TLI and NFI, comparing a proposed model to a baseline one-factor model with all items having unity factor loadings) and a parsimonious fit measure (χ^2/df, indicating whether model fit has been achieved by 'overfitting' data using too many coefficients). Reported threshold values were taken from Hair et al. (2007). The results indicated that the four-factor model provides the best fit. Values of all indices are within acceptable ranges. The three-factor model can also be regarded as acceptable, but less so than the four-factor model. Figure 1 provides the factor loadings of the four-factor CFA model. Each first- and second-order factor loading is statistically significant at $p < 0.001$. Results clearly support hypothesis 1A.

To test hypothesis 1B, a range of alternative four-factor models was run. Rather than modelling a second-order factor of IWB, these models were specified with plain correlations between the four dimensions. We ran six alternative models that subsequently fixed each correlation between a pair of dimensions on

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unity. Sufficient distinctiveness between the proposed dimensions is indicated when each of the constrained models has a deteriorated fit compared to the unconstrained model (Bollen, 1989). For this purpose, we assessed the $\Delta\chi^2$ statistic. In each case a model with a less optimal fit emerged ($\Delta\chi^2 > 38.0$ with one additional degree of freedom).

Although the alternative CFA models provided some support for hypothesis 1B, the correlations between the four dimensions were relatively high. Table 4 provides descriptive statistics and correlations for all relevant measures, including the four separate IWB scales and the overall measure of IWB.

We note that the correlations between the dimensions of IWB are high and significant, ranging from 0.60 to 0.74. Thus, although we found support for their distinctiveness in the CFA, taken as a whole our results do not strongly support hypothesis 1B. In line with Janssen (2000), the dimensions may be best viewed to combine additively to create an overall scale of innovative work behaviour. Accordingly, in the regression analyses to test hypotheses 2–4, we entered only the overall IWB scale and not its separate dimensions.

Table 4 also includes our validation constructs and control variables (firm size, gender and sector) that we used when examining the criterion validity of the IWB measure. To test hypotheses 2–4 we applied hierarchical multilevel regression analysis. As our data have a nested structure (employees within firms), using OLS regression analysis may provide inaccurate standard errors and false significance tests. To investigate this potential caveat, pre-analysis tests were done to examine whether our data required multi-level modelling (as recommended by Snijders & Bosker, 1999). Indeed, we found that our IWB and innovative output measures – the dependent variables in our analyses presented hereafter – had positive intra-class correlation coefficients, indicating that a significant share of variance in employees' IWB and innovative output was due to being part of a specific firm. Drawing on one-way analysis of variance, we also found *F*-values indicating significant differences between employees in different firms. These findings suggest that multi-level modelling is merited (Snijders & Bosker, 1999).

Hierarchical multi-level regression allows the simultaneous examination of the effects of group level and individual level variables on individual level outcomes, while accounting for the non-independence of observations within groups. We here report the estimates of random intercept models, which regard differences between firms as a source of variance in the intercept of the regression equation only (random slope models were also estimated and provided identical results). Hierarchical multilevel regression uses maximum-likelihood estimates and model fit is assessed by comparing deviance measures of subsequent models: a decrease of the deviance measure (Δdev) is related to Δdf (degrees of freedom) and tested against a χ^2 distribution.

To test hypotheses 2 and 3 we estimated three models using IWB as dependent variable. First, we estimated an intercept-only model to provide the initial value of the deviance measure (model 1). Next, we entered the control variables of firm size, gender and sector dummies (model 2). Finally, we estimated the full model, which also includes our measures of participative leadership and external work contacts (model 3) (see Table 5).

The initial deviance measure was 2034.34. The second model enters the control variables of size, gender and industry type. This significantly increased model fit (Δdev = 21.90 with Δdf = 5, $p < 0.001$). *T*-tests revealed this effect was due to size, gender and legal services. In model 3, participative leadership and external work contacts were entered as predictors, again improving model fit (Δdev = 517.01 with Δdf = 2, $p < 0.001$). In line with hypotheses 2 and 3, both predictors had positive and significant effect parameters.

To test hypothesis 4 we followed a similar procedure with innovative output as dependent variable. Again, the analysis consisted of three steps, i.e., estimation of an intercept-only model, entering the control variables, and finally entering the full IWB measure (Table 6). The initial deviance measure was now 1434.11. Entering the control variables as predictors gave a better fit. More importantly, adding IWB in the third model improved the fit even more (Δdev = 131.19 with Δdf = 1, $p < 0.001$). *T*-tests revealed that the positive effect parameter of IWB was highly significant, supporting our hypothesis. Employees higher on innovative work behaviours show more innovative output. In all, these results support the criterion validity of our IWB measure.

Discussion

Employees' IWB is crucial for many of today's organizations. The research presented here aimed to increase both our understanding of IWB and to improve its measurement. Despite an extensive amount of work, attempts to validate IWB measures have been scarce. The field is dominated by single-source studies drawing on self-ratings or supervisor ratings of employees' innovation behaviours. Moreover, available measures usually regard IWB as

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Table 4. Descriptive Statistics and Correlations among Scales (n = 693)*

	Mean	SD	Correlations												
			1	1a	1b	1c	1d	2	3	4	5	6	7	8	9
1. Innovative work behaviour	3.08	0.82													
1a. Opportunity exploration	3.32	0.87	0.86												
1b. Idea generation	2.98	0.88	0.90	0.74											
1c. Championing	2.87	1.03	0.90	0.69	0.74										
1d. Application	3.14	0.94	0.86	0.60	0.70	0.70									
2. Participative leadership	3.48	0.68	0.25	0.18	0.22	0.22	0.24								
3. External work contacts	2.83	0.88	0.27	0.25	0.23	0.27	0.19	0.25							
4. Innovative output	3.23	0.68	0.35	0.30	0.34	0.32	0.27	0.31	0.57						
5. Dummy: Size (>20 empl.)	0.66	0.47	−0.10	−0.03	−0.09	−0.10	−0.13	−0.18	0.00	0.02					
6. Dummy: Gender (males)	0.66	0.47	0.08	0.06	0.14	0.06	0.03	0.01	0.31	0.20	0.18				
7. Sector dummy: legal services	0.12	0.34	−0.21	−0.16	−0.20	−0.20	−0.17	−0.06	−0.12	−0.09	−0.07	−0.16			
8. Sector dummy: consultancy	0.42	0.49	0.13	0.09	0.13	0.12	0.12	0.13	0.12	0.12	−0.26	−0.17	−0.33		
9. Sector dummy: engineering	0.32	0.46	0.00	0.01	−0.02	0.00	0.00	−0.12	0.00	−0.10	0.27	0.19	−0.26	−0.56	
10. Sector dummy: IT services	0.14	0.35	0.02	0.02	0.03	0.02	0.00	0.03	−0.06	0.05	0.07	0.14	−0.16	−0.35	−0.27

* Absolute values $0.07 \leq r < 0.10$ are significant at 5%, with $0.10 \leq r < 0.13$ at 1%, and with $r \geq 0.13$ at 0.1%.

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Table 5. Hierarchical Multilevel Regression of Innovative Work Behaviour (n = 693)

	Model 1	Model 2	Model 3
Standardized effect parameters:			
Size		–0.12∧	–0.06
Gender		0.07∧	–0.01
Sector: legal services		–0.17∧	–0.23*
Sector: consultancy services		0.04	–0.05
Sector: engineering services		–0.01	–0.02
Participative leadership			0.18**
External work contacts			0.23**
Model fit:			
Deviance	2034.34	2012.44	1495.43
Δ deviance		21.90	517.01
Δ df		5	2
Significance		**	**

** $p < 0.001$, * $p < 0.01$, ∧ $p < 0.05$.

Table 6. Hierarchical Multilevel Regression of Innovative Output (n = 693)

	Model 1	Model 2	Model 3
Standardized effect parameters:			
Size		–0.03	0.00
Gender		0.22**	0.19**
Sector: legal services		–0.09	0.01
Sector: consultancy services		0.04	0.02
Sector: engineering services		–0.12	–0.12
Innovative work behavior			0.40**
Model fit:			
Deviance	1434.11	1389.90	1258.71
Δ deviance		44.21	131.19
Δ df		5	1
Significance		**	**

** $p < 0.001$.

being one-dimensional, whereas theory suggests that it may be multi-dimensional.

We proposed that IWB consists of four related dimensions, namely, the exploration, generation, championing and implementation of ideas. We used confirmatory factor analysis (CFA) to examine whether these dimensions contribute to an overall construct of innovative work behaviour, and whether the dimensions are sufficiently distinct to justify a multi-dimensional model. A 10-item measure of the four IWB dimensions derived from a pilot study was tested in a large-scale follow-up study. In terms of absolute, incremental and parsimonious fit, the proposed four-factor model performed better than any competing model. Second-order CFA revealed that each of the four dimensions clearly contributed to an overall construct of IWB.

However, evidence of the distinctiveness of the four dimensions was weak. We found some high intercorrelations, suggesting that IWB may be one-dimensional, and echoing Janssen's (2000) earlier conclusion that the dimensions would combine additively to create an overall measure of IWB. Although authors such as Kanter (1988) and King and Anderson (2002) argued that conditions for

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innovation may theoretically be best understood if one assumes the discovery of ideas and their implementation as discrete stages, real-world innovation processes are reciprocal with overlapping stages. Or, in the words of Scott and Bruce (1994), 'individuals can be expected to be involved in any combination of these behaviours at any one time' (p. 582).

Nonetheless, we recommend that continued work is merited on the measurement of IWB and the distinctiveness of its dimensions. Two routes may be particularly worthwhile. First, while self-ratings of IWB have inherent problems, supervisor ratings may have pitfalls too. Supervisors' ratings might be somewhat biased due to their overall, holistic view of the capabilities and performance level of a particular employee. This might inflate intercorrelations between the dimensions of IWB. Thus, investigating distinctiveness based on ratings of others who closely observe the focal employee's IWB (peers, subordinates, customers) may be of interest. Second, more needs to be done to assess convergent and divergent validity. In order to claim robustness and added value, we need to know how the measure behaves when it is correlated with traditional measures of IWB, as reported in Table 1. We did investigate correlations with employee-rated innovation output, which may actually be regarded as a first indication of convergent validity, but more evidence is needed.

Except for content validity, we also empirically explored the measure's criterion validity by correlating it with related, but distinct, constructs, namely participative leadership, external work contacts and employees' innovation outputs. We found clear evidence that these three constructs correlate with IWB, and accordingly, our new measure seems to have good criterion validity. Participation in decision-making and autonomy encourage employees to generate and implement ideas. Participative leadership likely enhances employees' intrinsic motivation as well as their feelings of responsibility, efficacy and control. This, in turn, is likely to enhance employees' willingness to engage in IWB. External work contacts were also positively and significantly related to IWB. This is in line with Perry-Smith and Shalley's (2003) suggestion that we need to empirically explore the social side of individual innovation in which (external) network contacts seem to be crucial. Apparently, it is tougher to be innovative when one is isolated or surrounded only by people from inside the organization. Finally, in line with previous work, the expected relationship between innovative work behaviour and innovative output was confirmed. This fits with the academic commonsense that IWB helps enhance organizations' innovative ability and results.

Understanding innovative work behaviour is important for the field of individual innovation. Objective measures such as patent counts and technical reports are usually only available for specific tasks (e.g., scientists, R&D workers). Mumford (2003) already indicated that research is most needed in those contexts where innovation and everyday work performance are not the same (in other words, innovative efforts of all employees rather than just those in innovation-oriented jobs). Accordingly, we expect that supervisor and peer ratings of individual innovation and IWB will be increasingly useful; however, this will only hold true if the measures used are reliable and valid. Although some further development and validation is needed, this study has tried to provide a measure that is applicable in different contexts, especially when innovative efforts are needed from all employees. It can be used in further research aimed to enhance our understanding of individual innovation.

Appendix: Measures

* item dropped after pilot survey.

Innovative Work Behaviour (Supervisor Rated)

How often does this employee . . .
. . . pay attention to issues that are not part of his daily work?
. . . look for opportunities to improve things?*
. . . consider innovative opportunities?*
. . . wonder how things can be improved?
. . . explore new products or services?*
. . . search out new working methods, techniques or instruments?
. . . generate original solutions for problems?
. . . create new ideas?*
. . . find new approaches to execute tasks?
. . . mobilize support for innovative ideas?*
. . . acquire approval for innovative ideas?*
. . . make important organizational members enthusiastic for innovative ideas?
. . . attempt to convince people to support an innovative idea?
. . . transform innovative ideas into useful applications?*
. . . systematically introduce innovative ideas into work practices?
. . . contribute to the implementation of new ideas?
. . . put effort in the development of new things?

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Participative Leadership (Employee Rated)

My executive . . .
. . . asks for my opinion.
. . . asks me to suggest how to carry out assignments.
. . . consults me regarding important changes.
. . . lets me influence decisions about long-term plans and directions.
. . . allows me to set my own goals.
. . . gives me considerable opportunities for independence and freedom.

External Work Contacts (Employee Rated)

In my work I visit external customers.
I keep in touch with prospective customers of my firm.
I visit conferences, trade fairs and/or expositions.
I talk to people from other companies in our market.
I keep in touch with people from universities/knowledge institutions.

Innovative Output (Employee Rated)

In your job, how often do you . . .
. . . make suggestions to improve current products or services?
. . . produce ideas to improve work practices?
. . . acquire new knowledge?
. . . actively contribute to the development of new products or services?
. . . acquire new groups of customers?
. . . optimize the organization of work?

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