Person–project fit and R&D performance: a case study of Industrial Technology Research Institute of Taiwan

Sen-Hao Cheng[1], Yau-De Wang[2], Ruey-Yun Horng[3] and Yung-Chang Huang[3]

[1]Centre for Measurement Standards, Industrial Technology Research Institute, Taiwan, Rm.211, Bldg. 8, 321 sec. 2, Kuang Fu Rd., Hsinchu, Taiwan. buddycheng@itri.org.tw
[2]Department of Management Science, National Chiao Tung University, Taiwan. ydwang@mail.nctu.edu.tw
[3]Department of Industrial Engineering and Management, National Chiao Tung University, Taiwan. ryhorng@cc.nctu.edu.tw, ychuang.iem87g@nctu.edu.tw

This study examined the relation between the research and development (R&D) performance and the fit between a researcher's cognitive type and the task demand of the project that was implied in Wang, Wu & Horng's (1999) study. Three hundred and eighteen research projects completed by 205 project leaders in the 3 years were classified into Unsworth's four creativity types along two dimensions: (1) whether the research addressed an open- or closed-ended problem and (2) whether the project was assigned or actively sought by the researcher. Each researcher's personal traits were assessed using Myers–Briggs Type Indicator (MBTI) and Kirton's Adaptor–Innovator Scale (KAI). Results show that researchers with a conforming, feeling, or judging-type cognition performed better with assigned projects for solving closed problems. Those with an originality and intuitive-type cognition performed better on self-initiated projects for solving open-ended problems. Researchers with sensing-type cognition performed better with assigned projects for solving open-ended questions. Thus, a careful match between a researcher's cognitive type and the task demand of project is important for R&D management.

1. Introduction

Creative ideas spring from individuals. Recognizing individual creativity is therefore important to organizational creativity. But any creative achievement of an individual is the product of a multitude of personal as well as environmental factors (Simonton, 1999). Lack of support from certain developmental and environmental factors can render personal creativity futile (Gove, 1994; Amabile, 1996; Lumsden, 2001). For example, creative achievement of an organization depends not only on the creativity of individual employees but also on organizational factors such as task demands, availability of financial and human resources, and a culture of innovation (West, 2000; Unsworth et al., 2005). Thus, our study aims to investigate the relation between research and development (R&D) performance and the fit between a researcher's

cognitive type and an organizational factor, the task demand of the project.

For R&D work, creative achievement demands that researchers not only be competent in domain knowledge but also possess certain types of cognition (Kennedy and Kennedy, 2004). Studies in literature suggest that an intuitive type of cognition that seeks deeper meanings behind the sense experiences is related to better R&D performance (e.g. Shallcross and Sisk, 1989; Agor, 1991). However, Wang et al. (1999) found that in a group of 106 researchers of a large petroleum company in Taiwan, the intuitive type of cognition was not related to R&D performance when R&D performance was measured by either the mean number of paper published, the mean number of technical service projects completed, or supervisor's mean performance rating in 3 years. But they did find a positive relation between a researcher's paper publication and his/her fluency and originality of thinking. Wang et al. attributed these puzzling findings to the task demands of the company. Namely, the R&D tasks of this company were mostly technical problems raised by its oil refineries and its top managers, which might severely constrain the functions of a researcher's intuition on cognition. As an extension of Wang et al.'s speculation about the relation between a researcher's cognitive type and the task demand, we posit that, other environmental factors being equal, when the task demand of a research project fits with a researcher's cognitive type, the project performance will be enhanced. In the following section, we first discuss both the relations between creativity and cognitive type and the relations between Unsworth's (2001) creativity types of task demand and cognitive type. Next, a set of fitness hypotheses for empirical testing will be proposed.

1.1. Creativity and personality

Creativity, by nature, requires one to respond in a nonconforming, independent, and different way to the world. Individuals who are creative may be disposed toward original ways of responding, and thus display certain patterns of cognition or personality traits (e.g. Torrance and Horng, 1980; VanGundy, 1984; Sternberg, 1999). For example, Torrance (1995) identified the following 10 characteristics to be common among creative individuals in a 30-year longitudinal study: delight in deep thinking, tolerating mistakes, loving their own work, having clear purpose, enjoying their work, feeling comfortable as a minority of one, being different, not being well rounded, having a sense of mission, and having the courage to be creative. Eysenck (1997) even uses the term 'psychoticism' to describe creative persons, which refers to their inability or reluctance to inhibit bizarre free associations. Personal characteristics such as psychoticism or disposition to originality may be determined genetically, making them highly persistent and resistant to change (Eysenck, 1997; Lumsden, 2001). They often exert an important top-down influence on an individual's coping behavior in response to specific, bottom-up, situational demands (Heller et al., 2004; Johnson, Chang, and Lord, 2006).

Cognitive type refers to a person's unique way of processing information imported externally, including how one encodes, transforms, stores, and retrieves information mentally. It is a relatively stable personal trait developed from interactions with one's environment (Jung, 1923). Cognitive type affects one's observation, processing, and organization of information from the environment and consequently affects one's judgment or decision making (Messick, 1976). Building on Jung's theory, Myers and her colleagues (Myers and Briggs, 1962, 1977; Myers et al., 1998) developed the Myers–Briggs Type Indicator (MBTI) scale to measure cognitive type along the following four dimensions: *extroversion vs introversion* (E–I), *sensing vs intuition* (S–N), *thinking vs feeling* (T–F), and *judging vs perceiving* (J–P). Extroverts and introverts differ by the extent to which their attention is focused on external events or internal ideas. Sensing and intuition are associated with the depth of information processing. Sensing-type people pay attention only to information at sensory level while intuitive-type people would process information further to grasp the deeper meaning and implications of their experiences. Thinking or feeling refers to a person's guiding attitude toward evaluating and judging one's own experiences. Thinking-type people evaluate their own experiences through logical analysis while feeling-type people focus on affects such as likes or dislikes aroused by an event. Judging or perceiving refers to how stringently one filters the information from the external sources. Judging-type people use stringent criteria to filter out information that is new or in conflict with their knowledge repertoire. In contrast, perceiving-type people are open-minded and have a low threshold for information filtering.

Studies in the literature suggest that an intuitive type of cognition leads to better R&D

performance (e.g. Shallcross and Sisk, 1989; Agor, 1991). An example is Roberts' (1989) study investigating personality and motivations of technological entrepreneurs. With data from 73 technical entrepreneurs, he found that technical entrepreneurs are more introverted, intuitive, and thinking-oriented than the general population, but with no difference in preference toward judging or perceiving. Within the group of technical entrepreneurs, however, those who were high on entrepreneurship were more extroverted, intuitive, and perceiving than those who were low on entrepreneurship. But they did not differ in preference toward thinking or feeling. Intuitive type of cognition is therefore consistently related to performance in tasks that require creativity.

Another cognitive type that influences performance and group management at the workplace is the preference for originality. Kirton (1976, 2000, 2003) conceptualizes this personal trait along an adaptation-innovation dimension. An innovator is one who brings in new changes and innovative ideas by disrupting the status quo of an organization or discipline. In contrast, an adaptor is one who prefers to stay within the limits of the established practices and ways of thinking. Kirton's studies (e.g. 1980, 2000, 2003) suggest that preference along the adaptation-innovation continuum is a stable cognitive type that people bring into their work context. Even though this trait is not related to a person's ability, skill, or ways of doing things, it will cause difficulties in one's coping with an environmental structure, a task demand, or a co-worker that is in conflict with one's preferred cognitive type. Collaboration and management of people with diverse cognitive abilities and styles are often required for complex tasks. For example, a team of highly innovative R&D workers may need a team leader who is an adaptor to maintain order and efficiency in the daily research routine, and vice versa (Kirton, 2000). R&D tasks may vary in their demand for creativity and are preferred by researchers whose preferences fall at different position along the adpatation-innovation continuum. Thus, fitness between an individual's adaptation-innovation preference and the demand of an R&D task is also important for R&D management.

1.2. Creativity type of R&D task and cognitive type

Work and work environment play a crucial role in determining R&D performance. In a study on the interplay between project environment and project team performance, Thamhain (2004) collected 76 project teams' ratings of their environment from 27 large technology-based multinational companies. Performance was measured by the senior manager's rating of overall team performance, ability to deal with risk, and efforts and commitment to results. Data showed that the most important drivers of high team performance came from factors that satisfied researchers' personal as well as professional needs such as personal interest in work itself, pride, professional work challenge, and accomplishment and recognition. To a slightly lesser extent, environmental supports such as effective communication, mutual trust and respect, cross-functional cooperation and support, and autonomy and freedom also positively affected team performance.

Different R&D endeavors may require different cognitive types and different levels of cognitive capacities. For example, an R&D task may require a researcher to extend the boundaries of the currently accepted theoretical paradigms, or to propose a new paradigm by integrating different, even conflicting, perspectives (Sternberg, 1999). In addition, motivation for creativity may be classified as either intrinsic or extrinsic. Creative acts driven by one's own interest or values tend to persist under unfavorable conditions, whereas those driven by extrinsic factors often discontinue once the contingent rewards diminish (Deci and Ryan, 1985; Amabile, 1996). Unsworth (2001) therefore classified creative acts into four types along two dimensions: the motivation and the problem type. On the motivation dimension, a creative act can be classified as either self-initiated or demanded by others. On the problem type dimension, a creative act can be classified by whether the problem it addresses is open or closed. The *closed-type problem* has readily available answers and yet requires creative effort in formulating alternative solutions. The *open-type problem* requires effort on solving a problem that has not yet been identified. According to Unsworth's classification along the above two dimensions, R&D tasks can be designated as one of the four types as follows:

1. *Proactive creativity*: the creative task is self-initiated and the goal is to define and then solve the problem.
2. *Expected creativity*: the task is demanded by others and there are no known solutions to the problem. The goal is to define the problem clearly and then solve the problem.

3. *Contributory creativity*: the task is self-initiated and the goal is to tailor and apply available solutions to the problem.
4. *Responsive creativity:* the creativity task is demanded by others and solutions to the problem have been proposed previously. The goal is to modify, revise, or adapt the known solutions to fit the current situation.

Creative tasks with dissimilar natures require different ways of information processing, and consequently, different cognitive types (Allinson et al., 1994). Thus, we posit that creative achievement of the above four types of R&D work requires researchers of different cognitive types and cognitive preferences along the adaptation-innovation dimension.

1.3. Predicted relations between creativity type of R&D task and cognitive type

Because individuals with intuitive-type cognition prefer working on fundamental issues and deducing their implications, we predicted that intuitive-type researchers would outperform sensing-type researchers on projects that require proactive creativity. Furthermore, because judging-type individuals like to manage life in a planned, orderly way and prefer working on organized and structured problems, we predicted that they would outperform researchers of other cognition types on responsive and contributory projects. In contrast, perceiving-type individuals who are open, flexible, and unrestrained would perform better on projects that need proactive or expected creativity. In scientific research, thinking-type researchers may fit better with physical science projects that require formal, logical analysis of external, objective experiences. In contrast, feeling-type or introverted researchers may fit better with social science projects that require psychological, affective understanding of the inner needs of human beings. In addition, the extroversion–introversion distinction may only be relevant to whether a researcher's interests are directed toward outer observable phenomena or inner, abstract ideas. We did not expect 'thinking vs feeling' and 'extroversion vs introversion' distinctions to be relevant to research projects in our sample because they were exclusively technology-related.

R&D performance may also be affected by an individual's disposition toward originality (Barron, 1955). Kirton's distinction between innovators and adaptors in a work context ties closely with Unsworth's distinction between the open- vs closed type of problems. Problems that need new perspectives and unconventional thinking may be more appealing to innovators who prefer to work in an original way. In contrast, problems that fall within the constraint of tradition and convention may be more appealing to adaptors. Consequently, we hypothesized that innovator-type researchers would perform better on projects of the proactive-type and the project of expected-type. In contrast, the adaptor-type researchers would perform better on responsive- and contributory-type projects. A summary of the predicted fit between project type and R&D worker's cognitive type is given in Table 1.

1.4. Context of the study

R&D project leaders from the Industrial Technology Research Institute (ITRI) of Taiwan

Table 1. A summary of predicted person–project fit relations and observed findings

Creativity			MBTI predicted	MBTI finding[1]	KAI predicted	KAI finding[1]
Problem	Drive	Type				
Open	Internal	Proactive (OI)	Intuitive	+	Innovator	+ $\text{Originality}_{\text{high}}$
			Perceiving	+		$\text{Conformity}_{\text{low}}$ $\text{Efficiency}_{\text{high}}$
Open	External	Expected (OE)	Perceiving	− Sensing	Innovator	−
Closed	Internal	Contributory (CI)	Judging	−	Adaptor	−
Closed	External	Responsive (CE)	Judging	+ Feeling	Adaptor	+ $\text{Originality}_{\text{low}}$ $\text{Conformity}_{\text{high}}$

[1] +, predictions confirmed by data; −, predictions not confirmed by data. O, open problem; C, closed problem; I, internal drive; E, external drive; MBTI, Myers–Briggs Type Indicator; KAI, Kirton's Adaptor–Innovator Scale.

provided data for empirical testing of our fitness hypotheses. ITRI has played the role of an engine that powers technological innovations in Taiwan since its establishment in 1973. By 2006, ITRI has evolved into a research institute with more than 5,000 researchers conducting R&D in six major areas: information and communications, electronics and optoelectronics, material, chemical, and nanotechnologies, biomedical technology, energy and environment, and mechanical and systems. ITRI is funded by both the public and private sectors with an annual budget exceeding half a billion US dollars. By 2005, it has created near 10,000 patents, established 150 spin-off companies, and contributed an average of annual 500 technology transfers to the industry.

An ITRI project usually involves a team of researchers, often with the project leader as the principal investigator. Upon completing a project, researchers must submit a technical report. Since 2000, ITRI has launched an effort to build a database to document all its project reports. Only some projects, particularly those funded by the government, are subject to an overall evaluation. Otherwise, there is no consistent process using standard criteria for comprehensive evaluation of a project's performance. Researchers receive only an overall individual-based annual performance evaluation from their supervisor.

2. Method

2.1. Sampling of projects and project leaders

ITRI's research projects are classified into four categories based on the source of fundings:

1. *Forward-looking project*s are supported by funds for developing knowledge that will lead to the creation of new products, new technological applications, or new industries. They are characterized by high risks, high initial investment, high uncertainty involved in bridging scientific findings and end applications. Longer lead time is needed in consolidating research results. About 10% of the total annual research budget came from this category.
2. *Key technology projects* are supported by funds for developing core technologies needed for establishing new domestic industries or for producing the innovative components and products needed by established industries. Works include technical research, constructing and testing production facilities, trial run testing, and collecting and analyzing technological, marketing, economic, and legal information. About 45% of the total annual research budget came from this category.
3. *Service projects* are supported by funds for providing technical services to public or private sectors, including consultation, R&D supports, or technological assessment and evaluation. About 43% of the total annual research budget came from this category.
4. *Self-initiated projects* are supported by funds for researches initiated by researchers. Usually, $<2\%$ of the total annual research budget is allotted for this category.

Proposals and project leaders for the first two types of projects are mostly but not exclusively determined by a top-down process, but researchers can refuse the assignment. Proposals for the latter two types are mostly raised by individual researchers.

The participants of this study were drawn from 1,015 ITRI project leaders employed during the years of 2000–2002. A total of 2,178 projects had been completed during these 3 years. Among those projects, service projects accounted for 42.5%; key-technology projects, 33.8%; forward-looking projects, 16.9%; and self-initiated projects, 6.8%. In the 3 years, about 49% of participants directed only one project, 23%, two projects; and 27%, three or more projects. Most participants (66.3%) had directed only one of the above four categories of projects. Some (26.5%) had directed two categories of projects, and a few (6.3%) had directed three categories of projects. Very few (0.9%) had directed projects across all four categories and were excluded from our sample.

Because the distribution of projects across four ITRI categories was uneven and the creativity types of projects were unknown, it was necessary for us to secure enough observations for each type of ITRI project in the sample. To do so, we first included 97 researchers who had directed the self-initiated projects. Then, we retained those researchers who had odd employment numbers from the remaining pool. All those who had conducted forward-looking projects in this retained group were then included ($n=107$). Finally, we randomly selected 99 researchers from the remaining pool of project leaders. The final sample comprised of 299 (275 males and 24 females) project leaders, after excluding four researchers who had already left the ITRI by

the time of this survey. Forty-eight percent of these project leaders had a master's degree and 42% a doctoral degree. Their mean age was 37.37 (range: 25–54). Their average professional experience was 9.28 years, and the total number of projects they directed in 2000–2002 was 475.

Two hundred and five project leaders (68.56%) responded to our questionnaire (188 males and 17 females; mean age, 37.53, SD = 6.47). Forty-six percent of them had a master's degree and 44% a doctoral degree. The total number of projects led by the respondents in 2000–2002 was 318 ($M = 1.56$). The distribution of these projects across ITRI's four categories is listed in Table 2. Most respondents (68.3%) had worked only in one of the four categories of projects, only 28.3% in two categories, and 3.4% in three categories.

2.2. Creativity type of project

On the basis of the answers given by the participants to three questionnaire items regarding the origin of the project (*self-initiated or assigned*), the nature of the problems involved (*original or old problem*), and the availability of ready solutions (*available or unavailable*), we classified each project into one of Unsworth's (2001) four creativity types according to the rules as follows: a project was designated as a *proactive type* if it was self-initiated and the problem involved was original and had no ready solutions. It was designated as an *expected type* if the project was assigned but the problem was original and with no ready solutions. A project was designated as a *contributory type* if it was self-initiated but the problem involved had ready solutions. Finally, a *responsive type* project was assigned and had ready solutions. The distribution of the creativity types of these projects is shown in Table 2. As Table 2 shows, although the self-initiated and the forward-looking projects accounted for a small portion of all ITRI projects, they were more likely of the proactive-type creativity (89%). Our sampling method to retain enough projects in these two categories is thus warrented.

2.3. Measures of cognitive type

The MBTI was used to measure a researcher's cognitive type. Four scores on the scale indicate a person's cognitive orientations on E–I, S–N, T–F, and J–P dimensions. Higher scores indicate stronger orientation towards introversion, intuition, feeling, and perceiving, and vice versa. To test the fitness hypotheses, we selected the top 50 persons (I-, N-, F-, or P-type) and the bottom 50 persons (E-, S-, T-, or J-type) from the 205 participants according to their scores on each of the four dimensions. The top and the bottom group's differences in project performance were then compared.

Participants' responses on the MBTI were factor-analysed. The obtained eight-factor structure corresponds to the four dimensions of MBTI and explains 32% of the total variance. The internal consistency coefficients (Cronbach's α) were 0.76, 0.79, 0.69, and 0.79 for E–I, S–N, T–F, and J–P, respectively. The overall internal consistency of the scale was 0.80.

In addition, Kirton's (1976) Adaptor–Innovator Scale (KAI) was used to measure a researcher's preference for originality. Three subscores representing the degree of preference for originality, efficiency, and conformity, were obtained. Kirton's studies (Kirton, 2000, 2003) suggest that innovators are characterized by high originality, low conformity and low efficiency, and so the degree of one's conformity and efficiency was scored reversely and added to originality score to yield a total KAI score representing the degree of one's preference for innovation. However, we

Table 2. Distribution of creativity types of ITRI's four types of projects

Creativity	ITRI fund type					
	Self-initiated	Forward-looking	Key technology	Service	Total	%
Proactive (OI)	20	20	2	3	45	14.2
Expected (OE)	5	7	4	2	18	5.7
Contributory (CI)	19	32	25	19	95	29.8
Responsive (CE)	27	33	40	60	160	50.3
Total	71	92	71	84	318	
%	22.3	28.9	22.3	26.4		

O, open problem; C, closed problem; I, internal drive; E, external drive; ITRI, Industrial Technology Research Institute.

found a negative correlation ($r = -0.23$, $P < 0.01$) between originality score and the reversed efficiency score, contrary to the previous studies (e.g. Kirton, 1976; Bobic et al., 1999) that found a positive correlation in samples of the general public, college students or business managers. We therefore decided to analyse KAI's three subscores separately. Again, the top 50 participants and the bottom 50 participants on three KAI subscores were selected to represent those with higher and lower originality, efficiency, or conformity, respectively. Note that because of the reverse scoring, a higher efficiency or conformity score corresponds to a lower preference for efficiency or conformity.

Factor analysis on KAI items yielded a three-factor solution that corresponds to originality, efficiency, and conformity constructs and explains 40% of the total variance. The Cronbach's α's were 0.82, 0.79, and 0.78 for these three subscales and 0.79 for the total scale.

2.4. Measure of project performance

Because there was no formal performance evaluation of a project, and the mean number of projects directed by a researcher was only 1.56 in the 3 years, we decided to use the presence (1) or absence (0) of a participant's involvement in a certain creativity type of project as a measure of his/her performance in that type of project. The performance of a certain creativity-type project was further weighted by the participant's rating of that project's accomplishments. Participants were asked to evaluate every project they directed in 2000–2002 separately by the following seven-point Likert scales: (1) the degree of success, (2) the degree of personal involvement, (3) personal satisfaction with the project, (4) personal creative contribution to conceptualization of the problem, (5) the degree of the theoretical contribution of the project, (6) creativity in technical aspects of the project, (7) satisfaction of clients, and (8) capital investment from industries attracted by the findings of the project (the last two items were only for service projects). Finally, participants gave an evaluation of the overall success of project on a nine-point rating scale. The averaged rating from all items (seven or nine items) served as an index of the achievement of a project. Some of these items were derived from Spender's (1996) three criteria for evaluating advanced technology program: the advancement of scientific and technological knowledge, returns on the investment, and spillover socio-economic returns to others in the system. The reliability coefficiency (Cronbach's α) for the project evaluation items is 0.79. A project leader's performance on each of the four creativity types of research was the average performance rating of all projects he/she directed within that type. The absence of project of a certain creativity type was indicated by a score of 0. Consequently, the project performance score derived from the following formula was not only a researcher's self-evaluation but also an objective measure of participation in the project:

$$P_i = \frac{\sum_{j=1}^{n} X_{ij}}{N_i},$$

where i is the creativity type of a project (e.g. 1, active; 2, expected; 3, contributory; 4, responsive), j is the number of i type of project completed by a project leader in 2000–2002, X_{ij} is the averaged performance rating of jth project of i type, and N_i is the total number of i creativity type of project. The performance measure P_i was set to zero when $N_i = 0$.

2.5. Survey process

Questionnaires were mailed to participants. Part 1 included three items for assessing a project's creativity type. Part 2 followed Part 1 and included nine items for assessing a project's performance. Participants were instructed to answer these two parts for each project they completed in 2000–2002 separately. The name of the project was indicated at the beginning of Part 1. The rest of the questionnaire was for the evaluation of the participant's cognitive types and included the MBTI scale and the KAI scale. The order of the MBTI scale and KAI scale was counterbalanced across participants.

3. Results

To examine the relation between person–project fit and R&D performance, performance difference between the top 50 persons and the bottom 50 persons on an MBTI or KAI dimension was compared by a t-test. An unequal variance t-test was used when the assumption of homogeneity of variances was violated. Tables 3 and 4 list the descriptive statistics and the test statistics.

Table 3. Mean (SD) project performance of researchers with different cognitive types

Creativity\ cognition	Extrovert	Introvert	*t*
Proactive (OI)	1.20 (2.43)	0.63 (1.75)	1.34
Expected (OE)	0.67 (1.85)	0.30 (1.19)	1.20
Contributory (CI)	1.38 (2.38)	2.32 (2.48)	−1.94
Responsive (CE)	3.31 (2.48)	2.62 (2.50)	1.39
	Sensing	Intuitive	
Proactive (OI)	0.24 (1.20)	1.79 (2.67)	−3.73***
Expected (OE)	0.71 (1.83)	0.08 (0.59)	2.32*
Contributory (CI)	1.95 (2.68)	1.91 (2.49)	0.07
Responsive (CE)	3.23 (2.44)	2.55 (2.44)	1.40
	Thinking	Feeling	
Proactive (OI)	1.21 (2.32)	1.08 (2.35)	0.28
Expected (OE)	0.52 (1.63)	0.31 (1.26)	0.72
Contributory (CI)	2.29 (2.54)	1.51 (2.36)	1.60
Responsive (CE)	2.02 (2.45)	3.38 (2.32)	−2.84**
	Judging	Perceiving	
Proactive (OI)	1.06 (2.29)	1.31 (2.40)	−0.55
Expected (OE)	0.56 (1.57)	0.42 (1.44)	0.48
Contributory (CI)	1.91 (2.59)	1.76 (2.41)	0.30
Responsive (CE)	2.78 (2.49)	2.26 (2.39)	0.33

*$P<0.05$; **$P<0.01$; ***$P<0.001$.
O, open problem; C, closed problem; I, internal drive; E, external drive.

Table 4. Mean (SD) project performance of high vs low KAI researchers

Creativity type	Group		*t*
	High	Low	
Originality			
Proactive (OI)	1.26 (2.41)	0.30 (1.19)	2.53**
Expected (OE)	0.40 (1.38)	0.49 (1.50)	−0.34
Contributory (CI)	2.78 (2.74)	1.89 (2.48)	1.69
Responsive (CE)	1.90 (2.50)	3.19 (2.21)	−2.74**
Efficiency			
Proactive (OI)	0.77 (1.93)	0.89 (2.09)	−0.30
Expected (OE)	0.79 (1.85)	0.31 (1.24)	1.52
Contributory (CI)	2.23 (2.59)	2.25 (2.53)	−0.03
Responsive (CE)	2.45 (2.62)	2.79 (2.40)	−0.67
Conformity			
Proactive (OI)	0.59 (1.80)	1.18 (2.28)	−1.44
Expected (OE)	0.51 (1.57)	0.19 (0.95)	1.26
Contributory (CI)	1.88 (2.44)	2.26 (2.64)	−0.75
Responsive (CE)	3.25 (2.42)	2.22 (2.48)	2.12*

*$P<0.05$; **$P<001$.
O, open problem; C, closed problem; I, internal drive; E, external drive; KAI, Kirton's Adaptor–Innovator.

3.1. Cognition–project fit and project performance

Consistent with our prediction, intuitive-type researchers outperformed sensing-type ones on proactive-creativity projects. Unexpectedly, we also found that the sensing-type researchers outperformed the intuitive-type researchers on expected-creativity projects. In addition, no significant difference between judging- and perceiving-type researchers was found for all four creatvitity types of projects. This was contrary to our prediction. It might be due to the artefact that only a small proportion of ITRI researchers (15%) were perceiving-type. As a check, we reclassified researchers by the type defined by the judging–perceiving difference score. Result of *t*-test shows, as expected, that judging persons ($n = 174$) outperformed perceiving persons ($n = 31$) on responsive type of projects (judging, $M = 3.01$, $SD = 2.48$; perceiving, $M = 1.94$, $SD = 2.34$), $t_{(203)} = 2.24$, $P < 0.03$. However, we also found unexpectedly that feeling-type researchers outperformed thinking-type researchers on responsive-creativity projects (Table 3). We did not predict beforehand that the thinking–feeling disctinction would matter to ITRI researchers because the ITRI projects are only technology related. As shown in Table 2, about 38% of ITRI's responsive-type projects were service projects responding to the needs for technical assistance from public or private sectors. This type of research may not be very attractive to researchers in general. In addition, about 91% (187/205) of our participants were thinking type, and those 50 persons designated as feeling type were still better described as thinking type, only to a lesser extent. We suspect that even within a group of thinking-type researchers, those who lean more toward feeling end might be more sympathetic and willing to respond to the calls from others in the environement.

3.2. Originality-project fit and project performance

Table 4 shows that researchers who scored higher on the originality score outperformed their lower-originality counterparts on proactive- but not expected-creativity projects. In contrast, the low-originality group outperformed the high-originality group on responsive- but not contributory-creativity projects. In addition, researchers higher on conformity outperformed their low-conformity counterparts on responsive-creativity projects.

3.3. Cluster analysis on personal traits

The above analyses show that there is indeed a relation between the person–project fit and research performance. To gain a more integrated understanding of the relation, we performed a cluster analysis on the seven scores of KAI and MBTI to derive a profile of the personal traits of researchers. Two groups of ITRI researchers were obtained (Table 5). The first group was comprised of 96 researchers characterized by lower originality, lower efficiency, higher conformity, and more sensing and judging type of cognition. The second group was comprised of the other 109 researchers characterized by higher originality, higher efficiency, lower conformity, and more intuitive and perceiving type of cognition. Among the four creativity types of projects, the second group of researchers significantly outperformed the first group on proactive-creativity projects (Table 5). It is clear that researchers with a preference for originality, and a cognitive type that seeks deeper meaning and remains open to experiences fit better with research tasks that demand active intellectual endeavors.

Analyses of demographical data of these two clusters of participants (Table 5) revealed that the two groups did not differ in terms of age, level of education, or supervisory experiences. However, the second cluster, the group higher on originality, comprised more females and younger, junior researchers compared with the first group.

4. Discussions and conclusions

This study examined the relation between the R&D performance and the fit between a researcher's cognitive type and the creativity type of a project. The observed fitness relations are summarized in Table 1. Results of the study show that on the one hand, intuitive-type researchers who are constantly looking for meaning beyond the surface and researchers with preference for originality appear to perform better on self-initiated research with novel problems. In contrast, sensing-type researchers who attend only to sensual, factual experiences perform better on the externally assigned projects with novel problems. On the other hand, researchers who evaluate

Table 5. Results of cluster analysis and tests of difference between means (SD) or proportions

	Cluster 1	Cluster 2	t
KAI			
Originality	44.10 (5.87)	46.72 (5.64)	−3.25***
$\text{Efficiency}_{\text{reversed}}$	26.55 (3.53)	24.87 (3.84)	3.25***
$\text{Conformity}_{\text{reversed}}$	30.18 (4.86)	34.39 (5.17)	−4.00***
MBTI			
E–I	103.85 (22.30)	102.94 (21.68)	0.93
S–N	72.90 (14.76)	108.38 (13.15)	−18.21***
T–F	74.71 (16.16)	75.75 (17.93)	−0.44
J–P	64.42 (11.41)	86.41 (20.91)	9.17***
Project			
Proactive (OI)	0.53 (1.67)	1.32 (2.40)	−2.76**
Expected (OE)	0.64 (1.72)	0.28 (1.16)	1.74
Contributory (CI)	1.85 (2.56)	2.06 (2.51)	−0.58
Responsive (CE)	3.05 (2.57)	2.68 (2.41)	1.10
Age	38.48 (6.35)	36.69 (6.49)	1.99*
Tenure	10.26 (6.29)	8.59 (5.96)	1.95*
Superviory Position	22 (22.9%)	25 (22.9%)	$\chi_1^2 = 0.00$
Gender			
Male	93 (96.9%)	95 (87.2%)	
Female	3 (3.1%)	14 (12.8%)	$\chi_1^2 = 6.34$ **
Education			
Doctoral	41 (42.7%)	50 (45.9%)	
Masters	43 (44.8%)	52 (47.7%)	
Others	12 (12.5%)	7 (6.4%)	$\chi_2^2 = 2.24$

*$P<0.05$; **$P<0.01$; ***$P<0.001$.
O, open problem; C, closed problem; I, internal drive; E, external drive; KAI, Kirton's Adaptor–Innovator Scale; MBTI, Myers–Briggs Type Indicator; S–N, sensing vs intuition; T–F, thinking vs feeling; E–I, extroversion vs introversion; J–P, judging vs perceiving.

experiences by affect, and researchers who are more of the adaptor type perform better on externally assigned closed-type projects. Compared with researchers who are open in perception, judging-type researchers will do better with assigned and closed type projects. Thus, to achieve better R&D performance, it is important in R&D management to provide researchers with opportunity to work on projects that fit with their cognitive types.

Results of this study also reveal an interesting yet straightforward relation between the profile of a researcher's personal traits and the creativity demands of a project. Researchers who are original, efficient, less conforming, intuitive, and perceiving perform better on self-initiated projects with novel problems in comparison with researchers who are conforming, sensing, and judging. Yet, these two groups of researchers perform just as well on researches that place fewer demands on creativity. This simple pattern of fit suggests that whenever a difficult, novel research problem is encountered, researchers with these personal traits must be included in the taskforce in order to enhance project performance. It also suggests that in R&D management, more focus should be placed on identifying and cultivating these personal traits, because proactive-creativity is the ultimate goal of all R&D endeavors.

ITRI is an important research institution in Taiwan. ITRI's researchers are responsible for developing advanced technologies to establish new industries as well as for providing technical services to assist current industries. The projects they undertake vary greatly in creativity demand. It is important for ITRI to carefully match the nature of research project to the cognitive type and the preference for originality of its researcher so as to enhance its R&D performance.

We have found that in ITRI, many research projects require either responsive (50%) or contributory creativity (30%), and only a small number require proactive (14%) or expected creativity (6%). Among those proactive-creativity projects, about 89% of them came from self-initiated projects and forward-looking projects (Table 1). If ITRI wants to become more innovative in technological advancement, it will need to provide sufficient funding to encourage its researchers to initiate studies on open-ended problems or assign these problems to researchers. To further improve innovativeness of proactive-creativity projects, ITRI needs to create an

environment that would nourish the development of personal traits conducive to creativity.

However, the fitness profiles we found with ITRI project leaders are not completely in agreement with our theoretical predictions. One possible reason for this discrepancy is the limit of our empirical data. ITRI is a technology-oriented research institute. Its researchers and research tasks are limited in scope and unable to give a full-span test of the idea of the person–project fit. Owing to the limits of our source of empirical data, the generalization of our findings must proceed with caution. Furthermore, creative achievements are a product of a multitude of personal, organizational, and environmental factors. We must be aware that the promises of person–project fit on project performance are also critically contigent on other factors such as an innovative culture and collaboration from colleagues.

An incidental yet nontrivial finding from this study is that the proactive researchers were higher on both preference for originality and preference for efficiency. This finding challenges Kirton's (1976, 2000, 2003) theoretical conjecture that originality correlates negatively with efficiency. We suspect that the difference between our findings and Kirton's theory may be caused by an artefact of range restriction in our sample. However, we also surmise that a higher preference for originality may not necessarily require a lower preference for efficiency in professional researchers. Future studies are needed to clarify this contradiction.

References

Agor, W.H. (1991) How intuition can be used to enhance creativity in organization. *The Journal of Creative Behavior*, **25**, 11–19.

Allinson, C.W., Hayes, J. and Davis, A. (1994) Matching the cognitive styles of managment students and teachers: a preliminary study. *Perceptual and Motor Skills*, **79**, 125–128.

Amabile, T.M. (1996) *Creativity in Context*. Boulder, CO: Westview Press.

Barron, F. (1955) The disposition toward originality. *Journal of Abnormal and Social Psychology*, **51**, 478–485.

Bobic, M., Davis, E. and Cunningham, R. (1999) The Kirton Adaptation–Innovation Inventory. *Review of Public Personnel Administration; Columbia*, **19**, 18–31.

Deci, E.L. and Ryan, R.M. (1985) *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum.

Eysenck, H.J. (1997) Creativity and personality. In Runco, M.A. (ed.), *The Creativity Handbook*, Vol. 1. New Hampden Press, pp. 41–66.

Gove, W.R. (1994) Why we do what we do: a biopsychological theory of human motivation. *Social Forces*, **73**, 363–394.

Heller, D., Watson, D. and Illies, R. (2004) The role of person versus situation in life satisfaction: a critical examination. *Psychological Bulletin*, **130**, 574–600.

Johnson, R.J., Chang, C-H., and Lord, R.G. (2006) Moving from cognition to behavior: what the research says. *Psychological Bulletin*, **132**, 381–415.

Jung, C.G. (1923) *Psychological Types*. London: Rutledge & Kegan Paul.

Kennedy, R.B. and Kennedy, D.A. (2004) Using the Myers–Briggs Type Indicatior in career counseling. *Journal of Employee Counseling*, **41**, 38–44.

Kirton, M.J. (1976) Adaptors and innovators: a description and measure. *Journal of Applied Psychology*, **61**, 622–629.

Kirton, M.J. (1980) Adaptors and innovators in organizations. *Human Relations*, **3**, 213–214.

Kirton, M.J. (2000) *Adaptors and Innovators: Styles of Creativity and Problem Solving*. London: KAI Distribution Center.

Kirton, M.J. (2003) *Adaptors and Innovators: In the Context of Diversity and Change*. London: Routledge.

Lumsden, C.J. (2001) Genes, culture and creative minds. *Bulletin of Psychology and the Arts*, **2**, 16–20. Available at: http://www.apa.org/divisions/div10/articles/lumsden.html#top.

Messick, S. (1976) *Personality Consistencies in Cognition and Creativity: Individuality in Learning*. CA: Jossey–Bass.

Myers, I.B. and Briggs, K.C. (1962) *Myers-Briggs Type Indicator*. Princeton, NJ: Educational Testing Service.

Myers, I.B. and Briggs, K.C. (1977) *Myers-Briggs Type Indicator-Form G*, Consulting Psychologists Press.

Myers, I.B., McCauley, M.H., Quenk, N.L. and Hammer, A.L. (1998) *Myers-Briggs Type Indicator Manual*. Palo Alto, CA: Consulting Psychologists Press.

Roberts, E.B. (1989) The personality and motivations of technological entrepreneurs. *Journal of Engineering and Technology Management*, **6**, 5–23.

Shallcross, D. J. and Sisk, D.A. (1989) *Intuition: An Inner Way of Knowing*. Buffalo, New York: Bearly Limited.

Simonton, D.K. (1999) Talent and its development: an emergenic and epigenetic model. *Psychological Review*, **106**, 435–457.

Spender, J.C. (1996) The three dimensional model of the advanced technology program. Unpublished

Report of National Institute of Standards and Technology, USA, October.

Sternberg, R.J. (1999) A propulsion model of types of creative contributions. *Review of General Psychology*, **3**, 83–100.

Thamhain, H.J. (2004) Linkages of project environment to performance: lessons for team leadership. *International Journal of Project Management*, **22**, 533–544.

Torrance, E.P., and Horng, R.Y. (1980) Creativity and style of learning and thinking characteristics of adaptors and innovators. *Creative Child and Adult Quarterly*, **5**, 80–85.

Torrance, E.P. (1995) *Why Fly? A Philosophy of Creativity*. Norwood, NJ: Ablex Publishing Company.

Unsworth, K. (2001) Unpacking creativity. *Academy of Management Review*, **26**, 289–297.

Unsworth, K., Wall, T.D. and Carter, A. (2005) Creative requirement: a neglected construct in the study of employee creativity? *Group and Organization Management*, **30**, 541–560.

VanGundy, A. (1984) *Managing Group Creativity: A Modular Approach to Problem Solving*. New York: American Management Association.

Wang, C.W., Wu, J.J. and Horng, R.Y. (1999) Creative thinking ability, cognitive type and R&D performance. *R&D Management*, **29**, 247–254.

West, J.E. (2000) Intelligence + community = creativity. *Research Technology Management*, **43**, 30–32.