Creative thinking ability, cognitive type and R&D performance

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The purpose of this study was to investigate the contributions of creative thinking ability and cognitive type to research and development (R&D) performance. One hundred and six researchers in an R&D institute of a petroleum company in Taiwan were given the *Circle Test of the Torrance Test of Creative Thinking and Myers-Briggs Type Indicator*. Their R&D performance was measured in terms of assigned technical reports, completed service projects, published papers, and a supervisor's performance rating. Results showed that there was a low but positive correlation between creativity and the first-authored paper and the technical report. The cognitive type was on the other hand associated with the performance rating and the first-authored service project assignment. Implications for R&D management are discussed.

Introduction

Creativity

Creativity has been found to be related to productivity, positive mental health, and originality (Golann, 1963). It is commonly held that creativity leads to discovery in science, creative performance in fine arts, or breakthrough in new thoughts. Nystrom (1979) states that successful innovations depend on creativity, and he sees creativity as a cause and innovation as an effect. Harmon (1958) studied creativity through the products it produced and found a correlation ranging from 0.61 to 0.76 between rated creativity and number of publications.

In today's extremely competitive business environment resulting from fierce globalization, enterprises are under constant pressures to innovate. A company wishing to continuously enhance its competitiveness on a global scale must innovate more effectively than its competitors. As Humble and Jones (1989) pointed out that the driving force for innovation is either the technological or the personal curiosity of individuals rather than markets. This clearly calls for the mastery of innovation skills in research and development (R&D) workers. R&D professionals are important human resources. How to select creative individuals and inspire their creative spirits under a supportive corporate context is an inevitable challenge for management.

However, creative thinking ability is an intellectual function that differs from abilities defined by intelligence. Although creativity requires a threshold level of intelligence, there is negligible correlation between creativity and intelligence when one's intelligence is beyond this threshold (Guilford and Christensen, 1973). Manifestos of intelligence, such as school achievements, or educational level, provide no promise to one's creative potentials. Hence, it is important to investigate R&D workers' creative thinking ability and see how it relates to R&D performance.

Cognitive types

Cognitive types are thought to influence information search and the selection of alternative courses of action (Mason and Mitrof, 1973; Carlyn, 1977). Cognitive types have been found to be related to occupational choice (Hellriegel *et al*., 1992) and decision making (Henderson and Nutt, 1980). The concept was first proposed by Carl Jung (1926). From his theoretical analysis and empirical observations, Jung classified people's cognitive preferences along three dimensions:

(1) The orientation of their attention to either abstract ideas (introvert type), or to objects and things in the environment (extrovert type) (I-E):

- Extrovert type persons are usually outgoing and adapt readily to social situations. They prefer variety and action, and communicate well with others.
- Introvert type persons have a more inward orientation and prefers to detach themselves from the outer world.

(2) Their way of perceiving things by means of intuition or sensation (N-S).

- Sensing type individuals focus on perceptual impressions they receive from the environment and prefer to deal with concrete details. They normally dislike working with unstructured problems and uncertain situations.
- Intuitive type individuals, on the contrary, process incoming perceptual stimuli more deeply and prefer to work with abstract ideas, inferred meanings, and hidden possibilities.

(3) Their way of making decisions by feeling or thinking (F-T).

- Thinking type individuals prefer logical structures as a means to clarify and analyse a given situation. They often try to force problems and solutions into a pre-existing formula.
- Feeling type individuals are the exact opposite. These individuals are skilled at understanding other people's feelings, and therefore structure their decisions on personal and subjective impressions. They are sensitive to other people's needs and feelings, and tend to be sympathetic. They usually relate well to people.

The *Myers and Briggs Type Indicator* (Myers and Briggs, 1962; Myers, 1977) is a measure of the above three cognitive types based on Jung's theory. In the scale, a fourth dimension is included to measure:

(4) The degree of selectivity to external stimuli as either perceptive or judging (P-J).

- Judging type individuals are those who are set with certain standards and are relatively more selective in information. They tend to be more organized and systematic.
- Perceptive type individuals tend to be curious and open-minded. They live their lives in a flexible and spontaneous fashion, hoping to understand their environment in order to adapt to it.

Cognitive type is acquired and shaped by one's environment and experiences. It is a rather stable personal characteristic that may influence one's prospect of success in a certain career. Myers and Briggs (1962) have documented many research findings which showed that intuitive type is a salient, common feature among high achieving professionals, feeling-thinking and perceptive-judging types on the other hand, tend to have varied career activities. For example, highly creative architects were found to be introvert, intuitive, and perceptive, with no difference in the thinking-feeling dimension (MacKinnon, 1970). Wheatley *et al.* (1991) proposed that the intuitive way of perceiving things, the extrovert orientation to life, the feeling way of making decisions will make a perceptive individual more positively related to the level of imagination and creativity in the strategic process of management. Therefore, it is interesting to examine the relationship between R&D performance and cognitive type.

Methodology

Subjects

The subjects were all employees of a large petroleum manufacturing company in Taiwan. The company's annual sales were over NT$330 billion in 1995 (equivalent to US$10 billion) and its tasks include the exploration, production, refining, storage, transportation, and sales of petroleum products; and the manufacturing and supply of petrochemical raw materials in Taiwan. It operates two oil refineries that produce a total topping capacity of 770, 000 barrels per day.

The company owns two research institutes: an exploration and production research institute and a refining and manufacturing research institute established in 1977 to meet the R&D needs of the two oil refineries.

The R&D Committee at Headquarters is in charge of the overall planning and coordination of all R&D activities. However, the respective institutes carry out short-term research projects related to individual practice.

One hundred and six R&D researchers (93 male, 13 female) were drawn from a total of 126 professionals in the refining and manufacturing research institute. Each R&D professional belongs to one of 7 departments covering research subjects on petroleum products, refining processes, fuel, lubricants, environmental engineering, industrial materials, and technical service. About 15% of research projects are long-range strategic plans, the remaining 85% are short-term problems raised by the oil refineries. All R&D workers hold at least a masters degree. About two thirds of them have a doctoral degree. Both males and females were included in the study because previous research indicates no gender differences in creative performances (Richardson, 1986). The subjects' ages ranged from 29 to 59 years old with an average of 38.59 ($SD = 5.36$).

Measuring instruments

Torrance Test of Creative Thinking, Circle Test. *The Torrance Test of Creative Thinking, Circle Test* (Torrance, 1974) was used as the measure of creativity in the present study. The Chinese version of the test was revised and validated by Horng and Wang (1994). The test-retest reliability of the test ranged from 0.51 to 0.81. The inter-rater scoring reliability for the present study ranged from 0.97 to 0.99. There is a 10-minute time limit on this test. There are four measures of creative thinking ability, namely, fluency (Flu.), flexibility (Flex.), originality (Orig.) and elaboration (Elab.). These four scores can be summed to yield a total creativity score. The definition of each measure is as follows:

1. Fluency: refers to the number of different ideas one can generate in given time.
2. Flexibility: refers to the number of different categories one may traverse during the search for ideas.
3. Originality: refers to the rarity or uniqueness of an idea. The originality of an idea was determined by statistical infrequency based on the norm.
4. Elaboration: refers to the number of details one adds to an idea when it is conveyed.

Myers-Briggs Type Indicator. *The Myers-Briggs Type Indicator* (Myers, 1977) was used to obtain four continuous scores indicative of cognitive type:

1. introvert vs. extrovert (I-E)
2. intuitive vs. sensing (N-S)
3. feeling vs. thinking (F-T) and
4. perceptive vs. judging (P-J).

The neutral point of a type is set at 100. The higher the score, the more introvert, intuitive, feeling, and perceptive a person is. There is no time limit for the test. In the present study, we found the test-retest reliability ranged from 0.71 to 0.92 for each type. The construct validity of the scale was checked by factor analysis with orthogonal rotation. We obtained four factors that overlapped substantially with Myers' (1977) classification of types (I-E, 67%; N-S, 89%; P-J, 67%; F-T, 54%).

R&D performance measures. The Refining and Manufacturing Research Institute uses four quantitative measures to evaluate an individual's R&D performance: the number of technical reports assigned to them, the number of papers published, the number of service projects completed, and the number of patents received.

However, the task demands are made at the group level. Each department is required to publish about 20 to 25 papers annually and perform about the same number of service projects to the oil refineries. The only demand made at the individual level is to turn in at least one technical report a year. However, there is no constraint that one's research paper, technical report, and service project cannot overlap.

Organizational decisions regarding raise and promotion are determined primarily by tenure and the annual performance rating made by the supervisor.

In our study we obtained subjects' performance records from their personnel files with the permission from the company and the individual him/herself, and defined each performance measure as follows:

1. Service project (Service). Refers to the mean number of service projects assigned to a researcher in the past three years. Service projects are the primary task for our subjects. They are R&D items in response to customer's complaints or technical problems from the oil refineries.
2. Technical report (Report). Refers to the mean number of technical reports a researcher has a claim of authorship in the past three years. They are written research reports which may come from completed service projects or other research projects.
3. Paper published (Paper). Refers to the mean number of papers published in the past three years to which a researcher has a claim of authorship. The difference between paper and technical report is that the latter was not necessarily published. Therefore, there is a certain degree of overlap between these two measures.
4. Performance rating (Rating). Refers to the mean performance rating a researcher received from his/her supervisor in the past three years.

Because most of the R&D works were team projects, the use of a total score can be misleading about an individual's role, we divided the total count of published papers, technical reports, and service projects into either first-author (principal investigator) or co-author (secondary investigator) categories.

The number of patents received was very low (2 in past three years), we did not include it in the present study.

Procedure

All subjects were administered the *Circle Test* and *Myers-Briggs Type Indicators* in groups. The Circle Test was administered first, followed by the Myers-Briggs Type Indicator.

Results

Table 1 reports the descriptive statistics of 106 subjects' test scores on the four measures of creativity, the four cognitive types, and the four R&D performance measures.

When compared to the neutral point of 100, this R&D group tended to be introvert ($M = 108.25$, $SD = 22.19$), sensing ($M = 84.59$, $SD = 22.28$), thinking ($M = 87.43$, $SD = 25.86$), and judging ($M = 81.54$, $SD = 17.86$) in cognitive type. It is somewhat different from our prediction that R&D workers would be more intuitive than sensing type.

Table 1 also shows that the number of the first-authored technical reports ($M = 0.62$, $SD = 0.53$) was about half of the co-authored technical reports ($M = 1.54$, $SD = 1.24$). No such difference was found for the service projects (first-author, $M = 0.69$, $SD = 0.94$; co-author, $M = 0.76$, $SD = 0.76$), or the publications (first-author, $M = 0.69$, $SD = 1.04$; co-author, $M = 0.64$, $SD = 0.78$). However, the variances of these three variables are quite large.

Table 1. Descriptive statistics of all variables.

Variable	*Mean*	*SD*	*N*
Report (Total)	2.15	1.24	106
First-Author	0.62	0.53	106
Co-Author	1.54	1.24	106
Paper (Total)	1.32	1.39	106
First-Author	0.69	1.04	106
Co-Author	0.64	0.78	106
Service (Total)	1.45	1.32	106
First-Author	0.69	0.94	106
Co-Author	0.76	0.76	106
Performance Rating	83.18	2.62	106
Creativity (Total)	48.70	16.32	97
Fluency	17.46	6.38	97
Flexibility	10.26	3.87	97
Originality	8.78	4.33	97
Elaboration	12.20	5.80	97
Introvert-Extrovert	108.25	22.19	97
Intuition-Sensing	84.59	22.28	97
Feeling-Thinking	87.43	25.86	97
Perceptive-Judging	81.54	17.86	97

Legends: Report, technical reports; Paper, paper published; Service, service projects.

Table 2 lists the inter-correlation coefficients of all R&D performance measures. It can be seen that there is moderate, but not high, correlation between total numbers of technical report, paper publication, and service project (r's, $0.21 - 0.50$, p's <0.05). Within each category of R&D performance measures (technical report, paper publication, service project), each subscore has high and positive correlation with its respective total score (r's, $0.68 - 0.91$, p's <0.01) except the correlation between the first-authored technical report and its total score ($r = -0.21$, $p < 0.05$). Nevertheless, the inter-subscore correlation within each R&D performance category tends to be low (r's, $0.16 - 0.22$). The inter-correlations between subscores across R&D performance categories are also relatively low (r's, $0.01 - 0.49$). Performance rating on the other hand appears to have moderate correlation with all nine objective measures of R&D performance (r's, $0.25 - 0.42$, p's<0.05). Psychometrically speaking, we can be relatively sure that these 10 scores are reliable measures of different components of a R&D performance construct.

To obtain a succinct picture of the R&D performance construct under our investigation, all ten R&D measures were factor analysed. The Varimax rotated factor structure (Table 3) suggests that the R&D activities our subjects engaged in can be explained by three factors. The first factor is characterized by three R&D measures, co-authored technical report, total technical report, and co-authored service project. It is labelled 'achievement through collaboration'. This factor alone explains 41% of the total variance of our subjects' R&D performance. The second factor is composed of all three paper publication measures and is thus labelled 'scholarship'. This factor accounts for

Table 2. Inter-correlation between R&D performance measures.

	R_1	R_2	P_t	P_1	P_2	S_t	S_1	S_2	Rating
Report-t	−0.21*	0.91**	0.21*	0.06	0.31**	0.43**	0.27**	0.41**	0.42**
First-Author	—	0.22*	0.10	0.18	−0.06	0.14	0.19	0.01	0.25**
Co-Author		—	0.17	0.02	0.33**	0.37**	0.19	0.41**	0.31**
Paper-t			—	0.83**	0.68**	0.50**	0.37**	0.41**	0.39**
First-Author				—	0.16	0.37**	0.37**	0.18	0.27**
Co-Author					—	0.40**	0.16	0.49**	0.33**
Service-t						—	0.83**	0.71**	0.41**
First-Author							—	0.19	0.31**
Co-Author								—	0.33**

** $p < 0.01$, * $p < 0.05$.
Legends: R, technical report; P, paper published; S, service project; Rating, performance rating.
Subscripts: t, total amount; 1, first-author; 2, co-author.

Table 3. Factor loadings of R&D performance measures on three factors.

Variable\Factor	1	2	3	h^2
Report (co-author)	**0.93**	0.03	0.10	88
Report (total)	**0.90**	0.01	0.25	87
Service (co-author)	**0.58**	0.48	0.00	57
Performance rating	0.43	0.30	0.41	44
Paper (total)	0.10	**0.95**	0.14	93
Paper (first-author)	−0.17	**0.76**	0.36	74
Paper (co-author)	0.41	**0.68**	−0.23	68
Service (total)	0.51	0.54	0.46	76
Report (first-author)	0.08	0.07	**0.79**	64
Service (first-author)	0.24	0.36	**0.65**	61
% total variance explained	41	18	13	72

Legends: Report, technical report; Paper, paper published; Service, service project; h^2, commonality, % of variance of each R&D measure explained by 3 factors.

18% of the total variance of R&D performance. The third factor explains 13% of the total variance and is characterized by the first-authored technical reports and the first-authored service projects. It is labelled 'technical service'. Together these three factors accounted for 72% of the total variance in ten R&D measures. Note that performance rating appears to load on the three factors equally (0.43, 0.30, and 0.41 respectively). However, the commonality (h^2) suggests that these three factors only account for about 44% of the variance in performance rating. Similarly factor loading of the total number of service projects were also equally split among three factors. This pattern of results suggests that (1) there are factors influencing performance rating other than the ten R&D measures, and, (2) the total number of service projects assigned to a worker can in large part be explained by his/her ability in collaborating with others, scholarship, and task demands ($h^2 = 0.76$).

Table 4 reports the correlation coefficients between measures of the creative thinking abilities, cognitive types, and R&D performance measures. It can be seen that R&D performance measured by the number of first authored works, such as technical reports, publications, and service projects, has higher correlation with creativity than the co-authored works. Therefore, we decided not to lump the first-authored works with the second-authored works in the analyses.

As shown in Table 4, some R&D performance measures were correlated significantly with thinking type of cognition. However, since we also observed that although most cognitive types were not related to creativity ($|r\text{'s}| < 0.09$), there was a significant positive correlation between elaboration and thinking type ($r = -0.25^1$, $p < 0.01$). Thus, it is unclear whether the observed correlation was spurious due to the mediation of the elaboration aspect of creativity.

High vs. low R&D performer's differences in creativity and cognitive type

In order to make a more vigorous test of the relation between creativity and R&D performance, we divided subjects into a high performing group and a low performing group and then compared differences in their creativity by the t-test. Subjects who scored in the top 25% of each performance measure served as the high performing group and those who scored in the bottom 25% of each performance measure as the low performing group.

Results of t-tests showed that when R&D performance was evaluated in terms of first-authored technical reports, the high performance group indeed scored significantly higher than the low performance group on

- fluency (hi-R&D, $M = 19.88$, $SD = 5.17$; low-R&D, $M = 14.83$, $SD = 5.51$; $t\ (48) \geqslant 1.97$, p's < 0.05),
- flexibility (hi-R&D, $M = 11.08$, $SD = 3.82$; low-R&D, $M = 9.00$, $SD = 3.62$; $t\ (48) \geqslant 1.97$, p's < 0.05),

Table 4. Correlation between creativity, cognitive type, and R&D measures.

	Flu.	Flex.	Orig.	Elab.	Creat.	I-E	N-S	F-T	P-J
Report (Total)	0.05	0.10	−0.02	0.24*	0.12	−0.01	−0.15	−0.08	−0.14
First-Author	0.32**	0.24*	0.18	0.19	0.30**	−0.01	0.05	−0.03	−0.03
Co-Author	−0.09	−0.01	−0.09	0.16	−0.01	−0.01	−0.17	−0.07	−0.12
Paper (Total)	0.06	−0.04	0.12	0.12	0.09	−0.04	−0.01	−0.24**	−0.10
First-Author	0.11	−0.03	0.20*	0.08	0.12	0.04	0.08	−0.12	0.03
Co-Author	−0.05	−0.03	−0.05	0.11	−0.00	−0.12	−0.12	−0.28**	−0.22*
Service (Total)	0.05	−0.03	0.05	0.17	0.09	−0.07	−0.15	−0.26**	−0.08
First-Author	0.07	0.02	0.07	0.21*	0.13	−0.06	−0.10	−0.22*	−0.03
Co-Author	0.00	−0.07	0.00	−0.03	−0.00	−0.04	−0.13	−0.18	−0.11
Perf. Rating	0.16	0.18	0.05	0.20	0.19	−0.02	−0.09	−0.21*	−0.11

** $p < 0.01$, * $p < 0.05$.
Legends: Report, technical report; Paper, paper published; Service, service project; Perf. Rating, performance rating; Flu., fluency; Flex., flexibility; Orig., originality; Elab., elaboration; Creat., total creativity; I-E, Introvert-Extrovert; N-S, Intuition-Sensing; F-T, Feeling-Thinking; P-J, Perceptive-Judging.

- elaboration (hi-R&D, $M = 13.19$, $SD = 6.79$; low-R&D, $M = 9.75$, $SD = 5.32$; t (48) ≥ 1.97, p's < 0.05), and
- total-creativity (hi-R&D, $M = 53.73$, $SD = 14.20$; low-R&D, $M = 41.42$, $SD = 15.33$; $t(48) \geq 1.97$, p's < 0.05)

Subjects in the high or low group as defined by first-authored service projects also differed significantly in

- elaboration (hi-R&D, $M = 13.84$, $SD = 6.00$; low-R&D, $M = 9.26$, $SD = 5.32$; t (46) = 2.79, $p < 0.01$).

Finally, subjects in the high or low group as defined by performance rating also differed in

- elaboration (hi-R&D, $M = 13.44$, $SD = 5.36$; low-R&D, $M = 9.68$, $SD = 6.38$; t (47) = 2.24), $p < 0.05$).

Most strikingly, the results converged to show that R&D workers with more first-authored works are indeed higher on creative thinking abilities. Co-authored works did not bear the similar relationship to creativity.

The same procedure was used to compare the high vs. low R&D performer's differences in cognitive types.

Results of t-test on cognitive types indicated that subjects high on performance rating tended to be more thinking type ($M = 80.85$, $SD = 22.76$) than their low performance rating counterparts ($M = 97.36$, $SD = 28.50$) (t (47) = 2.24, $p < 0.05$). No difference in other types was found.

Creativity and cognitive type as predictors of R&D performance

The above analyses showed that individual measures of creative thinking ability and cognitive type relate to R&D performance in different ways. Here, stepwise multiple regression was done with four creativity measures and four cognitive types as the predictors and individual performance measure as the criterion. Results (Table 5) showed that fluency of thinking was the single predictor entered into the regression equation when first-authored technical report was concerned ($R^2 = 0.11$, $\beta = 0.03$, $F_{(1, 95)} = 10.86$, $p < 0.01$). About 11 percent of the total variance was explained. The effects of flexibility and elaboration previously observed disappeared completely. Similarly, originality was the only predictor for the first-authored publications. Four percent of the total variance was explained ($R^2 = 0.04$, $\beta = 0.05$, $F_{(1, 95)} = 4.06$, $p < 0.05$).

It is not surprising to find that the feeling-thinking dimension was the only statistically significant predictor of the first-authored service projects and performance rating. However, the variance explained was only 5% ($R^2 = 0.05$, $\beta = -0.01$, $F_{(1, 95)} = 4.85$, $p < 0.05$) and 4% ($R^2 = 0.04$, $\beta = -0.02$, $F_{(1, 95)} = 4.22$, $p < 0.05$) respectively. Note that the contribution of elaboration to first-authored service projects and performance rating disappeared when the effect of thinking type was already accounted for. Because the simple correlation between predictors and criterion variables tends to be low (Table 4), and the number of subjects was not big enough, no further multivariate analysis was warranted.

In summary, the regression analyses showed that although creative thinking ability and cognitive type indeed were significantly related to R&D performance, the magnitude of the influence was not very large. However, assume that the roles played by intelligence and domain knowledge in R&D performance was already explained by subjects' educational level, the 4–11 percent increase in the amount of the total variance explained cannot be taken as trivial.

Conclusion and discussions

Results of the present study indicated that creative thinking ability and cognitive type were related to our subjects' R&D performance. However, the pattern of relationship between creative thinking and R&D performance was quite different from that of between cognitive type and R&D performance. Specifically speaking, fluency and originality of an R&D worker's creative thinking ability were related to his/her productivity on the first-authored technical report and the first-authored paper publication; whereas thinking type of cognition was related to the productivity of the first-authored service project and performance rating. These findings may shed some light on the nature of R&D activities in this R&D institute in particular and the relation among creativity, cognitive type, and R&D performances in general.

Table 5. Results of stepwise regression analysis.

R&D Measure	Predictor	R^2	β	df	F
Report (first-author)	Fluency	0.11	0.03	1, 95	10.86**
Paper (first-author)	Originality	0.04	0.05	1, 95	4.06*
Service (first-author)	Feeling-Thinking	0.05	−0.01	1, 95	4.85*
Performance Rating	Feeling-Thinking	0.04	−0.02	1, 95	4.22*

** $p < 0.01$, * $p < 0.05$.
Legends: Report, technical report; Paper, paper published; Service, service project.

The finding that creative thinking ability was related to the first-authored R&D works is very encouraging in that it points out a way of predicting a researcher's R&D performance. This information is especially invaluable in that generally R&D workers are a group of highly intelligent people with good academic achievement. Given that intelligence is not a sufficient condition for predicting one's creative achievement, the extra information provided by one's creative thinking ability in predicting R&D performance can be helpful in selection and also in designs of skill development programmes for this group of workers.

The finding is nevertheless intriguing in that the company did not weigh the first-authored works differently from the co-authored works in the performance evaluation system. In fact, the company values collaborative achievement more than other factors and the R&D works are structured by teams. Relatively, individual initiation is not encouraged. The R&D tasks are mostly initiated and regulated by problems raised by the oil refineries and by Headquarters, and distributed at group level. Whether this kind of practice is beneficial for the R&D works and the R&D worker's spirit awaits further clarification.

The link between cognitive type and R&D performance in this study was that thinking type individuals tended to receive higher performance ratings and had more opportunities to be the principal investigator in service projects than feeling type individuals. Feeling individuals are more sensitive to other's needs and tend to be sympathetic, relating well to most people. It is a quality important to success in teamwork. We have found in our previous research that middle level managers tended to be skewed toward feeling type (Wang and Horng, 1996). On the contrary, thinking individuals prefer logical structures, and are analytical and insensitive to personal feeling. The results of this study suggest that the nature of R&D works of this company may fit better with the thinking type. As a result, the management decisions, such as performance evaluation and job assignment, which are usually structured mainly upon task demands tend to favour thinking type persons.

Finally, although we did not find any difference in the sensing-intuition dimension between high and low R&D performers, it is still intriguing to observe that our R&D subjects as a group tended to be more sensing than intuitive. Generation of new ideas and deep thoughts requires one to go beyond the surface level in information processing. How can our subjects be exceptions? One conjecture is that the R&D tasks of this research institute do not really demand new or active idea generations from the R&D workers. An examination of the institute's task content seems to confirm this conjecture. Our observations here, therefore, seem to suggest that cognitive type may be sensitive and shaped in accordance with environmental influences.

In summary, results of this study suggest that creative thinking ability, especially fluency and originality, may account not only for R&D performance in terms of quantity but perhaps also scholarly quality. However, our study had a very limited scope because our subjects were drawn from a petroleum manufacturing company only and the performance measures we used were limited to quantity measures. We have no way to determine if the results would generalize to other R&D labs or different R&D measures. Future research is needed to test the generalization of the findings.

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Note

1. Note that high Feeling/Thinking score means low in thinking type.

