Journal of Research in Personality **34,** 305–328 (2000)
doi:10.1006/jrpe.1999.2274, available online at http://www.idealibrary.com on IDEAL®

Individual Differences in Need for Cognition and Complex Problem Solving

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This article reports an empirical study investigating the relation between Need for cognition of individuals and their effectiveness in solving complex problems. A complex, long-duration, computer-simulated, multifaceted cognitive task was presented to 45 managers from a very large Indian metal-processing unit. Problem-solving effectiveness was assessed on *success, consistency,* and *crisis-free nature.* Need for cognition was assessed using the 18-item, short-form need-for-cognition scale. Results show that need for cognition of individuals has significant positive association with effectiveness in solving complex problems. Individuals with a higher need for cognition: (a) were more successful in solving the problem, (b) collected information and made decisions on more aspects of the problem, and (c) faced fewer crises during the process. Some curvilinear effects were also observed. Results further indicate that exposure strengthens the development of need for cognition.

Key Words: need for cognition; complex problems; complex problem solving

I think, at a child's birth, if a mother could ask a fairy godmother to endow it with the most useful gift, that gift would be curiosity.

—Eleanor Roosevelt

The work reported in this article was done at the Indian Institute of Management Ahmedabad, by the first author under the guidance of the second author. This study forms part of the doctoral dissertation of the first author at IIM Ahmedabad. Industrial Finance Corporation of India, PD Agarwal Foundation, and the Choudhury-Padmanabhan-Pant-IIMA FPM Alumni Trust gave research awards/grants for it. IIM Calcutta supported the preparation of this article. We thank Sasi B. Misra, Jagdeep S. Chhokar, and R. Srinivasan for useful comments and support and Sanjay Kumar, the participant managers, and the management of the organization where this study was conducted for their cooperation.

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0092-6566/00 $35.00

Viewing human beings as information-processing systems, a number of research studies have generated valuable insights on aspects such as sense making, judgment, decision making, and problem solving of individuals in different contexts and under varying conditions. One stream of literature has sought to inquire into the nature of *differences among individuals* in information gathering, information processing, and how these processes affect outcomes. In this context, *need for cognition* (Cacioppo & Petty, 1982) has attracted considerable research attention in recent years (see Cacioppo, Petty, Feinstein, & Jarvis, 1996, for an elaborate review).

Need for cognition refers to ''a need to structure relevant situations in meaningful, integrated ways. . . [and] a need to understand and make reasonable the experiential world'' (Cohen, Stotland, & Wolfe, 1955, p. 291). When an individual is unable to make sense of the situation in meaningful ways, he/she is likely to experience ''feelings of tension and deprivation'', which, in turn, is likely to cause the individual to initiate ''active efforts to structure the situation and increase understanding'' (Cohen et al., 1955, p. 291). While all individuals would need to make sense of their world, they would have this need in differing degrees, and there would also be differences in the extent of motivation they exhibit and the efforts they put in to do so. According to Cacioppo et al. (1996), individuals with a high need for cognition are likely to ''seek, acquire, think about, and reflect back on information to make sense of stimuli, relationships and events'' as compared to those with a low need for cognition, who are likely to ''rely on others (e.g., celebrities and experts), cognitive heuristics, or social comparison processes to provide this structure'' (p. 198).

Need for cognition has been studied in various settings and its relation with several individual variables has been examined. For instance, it has been found that need for cognition is *negatively* related to dogmatism (Cacioppo & Petty, 1982; Fletcher, Danilovics, Fernandez, Peterson, & Reeder, 1986); need for closure, closed mindedness, and preference for order and predictability (Petty & Jarvis, 1996; Webster & Kruglanski, 1994); need for structure (Neuberg & Newsom, 1993; Petty & Jarvis, 1986); and the tendency to avoid, ignore, or distort new information (Venkatraman, Marlino, Kardes, & Sklar, 1990). On the other hand, need for cognition has been found to be *positively* associated with the tendency to generate complex attributions for human behavior (Fletcher et al., 1986); continuous attention to an ongoing cognitive task (Osberg, 1987); curiosity (Olson, Camp, & Fuller, 1984); objectivism (Leary, Sheppard, McNeil, Jenkins, & Barnes, 1986); desire for new experiences (Venkatraman et al., 1990; Venkatraman & Price, 1990); tendency to seek, evaluate, and use relevant information for decision making and problem solving; and openness to ideas, actions, feelings, and values (Berzonsky & Sullivan, 1992).

The influence of need for cognition on information-processing activities of individuals has also been assessed. Studies show that individuals with a higher need for cognition recall greater amounts of information to which they have been exposed (Cacioppo, Petty, & Morris; 1983; Heslin & Johnson; 1992; Kassin, Reddy, & Tulloch, 1990; Lassiter, Briggs, & Bowman, 1991); pay more attention to the quality of information available (Cacioppo & Petty, 1982; Cacioppo, Petty, Kao, & Rodriguez, 1986; Cacioppo et al., 1983); generate a higher number or proportion of issue/task relevant thoughts (Axsom, Yates, & Chaiken, 1987; Verplanken, 1993; Verplanken, Hazenberg, & Palenewen, 1992); make thoughtful judgments (Verplanken, 1989); possess knowledge on a variety of issues (Ahlering, 1987; Cacioppo et al., 1986; Condra, 1992); and perform better in various cognitive tasks such as arithmetic (Dornic, Ekehammar, & Laaksonen, 1991), anagrams (Baugh & Mason, 1986), and college course work (Leone & Dalton, 1988; Sadowski & Gulgoz, 1992).

However, need for cognition has not been studied in the context of individuals solving complex problems or negotiating ill-structured situations. As our environments become increasingly complex, turbulent, and dynamic, this inquiry has begun to attract serious attention in research. As Herbert Simon and associates (1992) observe, ‘‘Problem solving research today is being extended into the domain of ill-structured problems’’ (p. 52). But, according to VanLehn (1989), ‘‘research is just beginning in this area, so many of the proposed processes are based only on a rational extension of the basic ideas of routine problem solving’’ (p. 549).

This article is based on an empirical study conducted with a sample of managers who worked on a complex, long-duration, computer-simulated problem, and it examines the relation between need for cognition of individuals and the effectiveness with which they solve complex problems. In the article, we begin with a discussion of the nature of complex problems. Propositions for the study are then presented, followed by description of the research design and measures. After presenting the analysis and results, the article concludes with discussion of the findings.

COMPLEX PROBLEMS

Characteristics of Complex Problems

Problems that are mostly nonroutine and for which well-defined solutions do not exist are referred to as complex. They are characterized by the presence of many dimensions (or variables) which are often interlinked, and these variables and their linkages may not be evident to the problem-solver. Problem definition, or the answer to ‘‘what are the central issues here’’, can differ widely among individuals at a particular point in time, and it can be different for the same individual at different points in time. This happens as different individuals may identify different aspects of the problem as being crucial or relevant (e.g., Dearborn & Simon, 1958), and an individual may give different meanings to the same aspect at different points in time. Also, individuals may not be clear as to what they are aiming to achieve by solving the problem, and the preferences or goals may be unclear or ambiguous. Even when the goals are clear, the probabilities of the occurrence of all possible consequences of different courses of action may be unclear (Cohen, March, & Olsen, 1972). In organizational contexts, there tend to be many stakeholders interested in influencing the problem-solving processes and their outcomes, and it is even possible that these stakeholders advocate conflicting goals and positions. Further, the decision-makers may, themselves, change their minds over time and problem solving may be spread over an extended period involving many decision-makers.

Complex problems also have the tendency to ‘‘evolve’’ from one state to another. The state of the problem at any point is a function of the different actions of commission or omission of the individuals involved in problem-solving process. As each succeeding problem-state evolves as a result of the consequences of action taken or not taken by the problem-solver, the pattern of evolution can be quite different for different individuals, even when the initial state is similar. The problem also evolves as a result of the inherent stochastic nature of any natural system and as a result of internal or external shocks.

Researchers have used a variety of terms to describe these kinds of problems. In addition to *complex* (Dearborn & Simon, 1958; Doerner, 1980) and *ill structured* (Simon et al., 1992; Ungson, Braunstein, & Hall, 1981), these problems have been termed *unstructured, wicked,* or *ill behaved* (Mason & Mitroff, 1972, 1981); *unstructured strategic* (Mintzberg, Raisinghani, & Theoret, 1976); *messy* (Ackoff, 1979); *non-programmed* (Simon, 1957), and *ill-defined* (Newell & Simon, 1972).

Solving Complex Problems

The process of solving a complex problem depends on many factors. The definition of the initial state would reflect the individual’s understanding of the nature of the problem at the beginning, and the desired end-state would be described as the goal expected to be achieved by solving the problem. The inherent difficulties in defining the problem are captured by the following description of design problems in architecture (Rittel, 1971, as cited in Mason and Mitroff, 1972):

> They are not well defined; every formulation of the problem is already made in view of some particular solution principle. If the idea of the solution is elaborated or even changed during the design process, new aspects become relevant and new kinds of information will lead to different questions about what is the case in the particular situation and about what is desired or acceptable. Since nobody can anticipate all conceivable design possibilities before design starts, nobody can list all po-

> tentially relevant data in a complete, well-defined problem formulation. (pp. 479–480)

The problem-solver has to then gather the required information and make the necessary decisions to solve the problem and achieve the set goal. Feedback has to be actively sought to monitor how well the process of problem solving is progressing toward goal achievement. This is also necessary for continuous redefinition of the problem state at different points in the problem-solving process. It can lead to redefinition of the desired end-state and modification of the set goal. Further, the problem-solver also needs to be aware of the possible time lag between decision and outcome.

In solving complex problems, it is also important to have a defined closure to the problem-solving process. This is because the desired end-state may continuously get redefined as the problem-solver progresses toward the solution, and there are no widely accepted criteria to decide when and where one should finally stop. In architectural design problems, for example, ‘‘there is no criteria which would determine whether a solution is correct or incorrect. . . no rule which would tell the designer when to stop the search for a better solution. Limitations of time and other resources lead the individual to the decision that now it is good enough’’ (Rittel, 1971, as cited in Mason and Mitroff, 1972, pp. 479–480). The problem-solvers may decide on closure when they feel that the goal has been achieved, or when the goal has not yet been achieved but the newly reached state of the solution is sufficient and acceptable under a new set of criteria. They may also abandon problem solving if they are unable to make any meaningful sense of the problem to solve it effectively or when they find that pursuing the problem does not make much sense in the new situation that has emerged.

RESEARCH PROPOSITIONS

Need for Cognition and Complex Problem Solving

As we can note from the above discussion, complex problems contain elements of complexity, uncertainty, and dynamism, and solving them effectively is not a one-shot process. Continuous sense making and development of multiple perspectives of the problem are crucial for solving such problems effectively. One of the primary requirements for this to happen is that the individual problem-solvers should have an inclination to actively and continuously engage in thinking about the situation and to structure it in ways that are meaningful to them. According to Cacioppo and Petty’s (1982) conceptualization, individuals with a high need for cognition are more likely to think about a complex situation and develop meaningful interpretations, and this in turn is likely to help them decide and act effectively in that situation. Hence we propose that:

> Proposition 1. With increase in need for cognition, individuals are likely to be more effective in solving complex problems.

If individuals with a higher need for cognition are likely to be more effective problem-solvers, what factors could enable this? Cacioppo and Petty (1982) note that individuals with a higher need for cognition are likely to consider a larger number of possibilities and to try out alternative hypotheses to make meaningful sense of situations. To do so, it would be necessary that they seek and acquire more information on the problem. That is, effectiveness of solving the complex problem would be dependent on the nature of the information-gathering behavior of individual problem-solvers, both in terms of *quantity* and *diversity* of information. Quantity refers to the amount or number of units of information that the individual gathers in the problem context to solve it, and diversity refers to the different types of information gathered. In addition, unless the problem-solvers get an overall grasp of the different dimensions of the complex problem and their interrelationships, they may not be able to solve the problem effectively. Hence, gathering more information can lead to effective problem solving only if they also gather them on more aspects of the problem. In other words, both the quantity and the diversity of information sought on the problem need to be higher for solving it effectively. Hence we propose that:

> Proposition 2. With increase in need for cognition, individuals are likely to gather greater amounts of information while solving complex problems.
>
> Proposition 3. With increase in need for cognition, individuals are likely to gather information on more aspects of the problem while solving complex problems.

RESEARCH DESIGN

The data collection was done in an interactive setup involving a computer-simulated complex problem. Each individual participating in the study was assigned the task of managing a small garment unit for 24 months in a real time of 2½ h. The simulation was run by one of the authors, who also functioned as the interface between the participants and the garment unit being simulated on the computer. The problem-solvers could seek information on any aspect of the problem from the facilitator and instruct him to implement their decision on the computer. Problem solving was followed by a feedback discussion session. A need-for-cognition scale was administered before the simulation.

Sample Size and Characteristics

Forty-five managers from seven hierarchy levels [E2 (Assistant Manager) to E8 (General Manager)] and six functional areas (Production and Operations, Purchase and Materials Management, Maintenance, Marketing, Finance, and Personnel and Human Resources Development) from a large metal-processing unit of an Indian public-sector company formed the sample. At the time of the study, the unit had over 50,000 employees and 4,000 managers at its location. In addition to statistical considerations (Levin & Rubin, 1994) and allowance for data losses/defects, the sample size was influenced by the time needed for data collection and consequent organizational constraints—each manager was required to spend about 4 to 5 h with the facilitator and so was not available for regular work for most part of the day. The sample represented 21 of the 82 departments in the organization, including most of its core shops. Average age of the participants in the sample was 41 years (range: 26 to 55 years).

Seven managers were MBAs, 13 had postgraduate qualifications, and 24 of them had training in foreign countries on advanced technical and managerial aspects. There was one female manager in the sample.

Data Collection

Administering the need-for-cognition scale. The manager taking part in the study normally reported to the facilitator's room between 9:00 and 11:00 AM depending on work contingencies to be dealt with in the morning. After initial familiarization and a brief introduction of the study, the individual was requested to complete the 18-item, short-form version of the need-for-cognition scale (Cacioppo, Petty, & Kao, 1984; Cacioppo et al, 1996, p. 253). The responses to each item had to be given on a scale of ''1'' (*not at all characteristic of me*) to ''5'' (*very characteristic of me*). Of the 18 items in the scale, 9 were reverse coded. Some of the typical items were: ''I would prefer complex to simple problems,'' ''I like to have the responsibility of handling a situation that requires a lot of thinking,'' and ''Thinking is not my idea of fun.'' Computer simulation of the complex problem followed administration of the questionnaire.

Presenting the complex problem as a management game: Computer simulation of an organization. The complex problem to be solved in this study was presented to the individual as a computer-simulated management game. Management games have been used for research in group-behavior, decision-making, leadership, decision-support-systems, strategic-management, and organization studies. They are used to create experiential environments within which learning and behavioral change can occur and can be studied (Keys & Wolfe, 1990). Management games provide a reliable alternative to field experiments by providing a high degree of control of the context and at the same time avoid many of the generalization problems of laboratory experiments (Brehmer & Doerner, 1993).

The computer-simulated complex problem presented in this study—*Manutex* (Schaub, 1988)—was a total-enterprise or top-management game (Keys & Wolfe, 1990) or a microworld (Brehmer & Doerner, 1993; Senge, 1990). Total-enterprise or top-management games are simulations of the whole organization which incorporate a large number of decision variables from many areas such as marketing, production, personnel, and finance and thus require their integration for solving it successfully (Keys & Wolfe, 1990, p. 308). Manutex has been used in previous studies on complex problem solving (e.g., Doerner, 1991, 1996; Ramnarayan, Strohschneider, & Schaub, 1997; Ramnarayan & Strohschneider, 1997). A model of Manutex is given in Fig. 1 (arrows indicate influences among variables, flow of products, etc.).

A case description of the the Manutex simulation was given to the individual for reading. It describes Manutex as a small-scale, ready-made-garment-manufacturing unit situated in Malaysia, employing 37 people in three levels and five departments and capable of making seven products using three raw materials. The case also gives a brief history of the unit, current work methods, personnel relations, product market position, inventory level, financial position, and so on. The individual was instructed to manage all the affairs of the Manutex firm as its CEO for 2 years (24 simulated months), starting from January of a year, within a real time of 2½ h.

The Manutex simulation is a complex one, comprising a large range of built-in information. It also allows for a wide range of interventions or decisions to be implemented. For instance, the individual could seek information on as many as 53 aspects of Manutex. This information was grouped in seven categories such as *products* (past production, current target, product quality, scheduling priority, stock, raw material required, etc.), *personnel* (salaries, satisfaction levels, recruitment, etc.), *machine* (working conditions, maintenance needs, power, accessories, etc.), and *money* (details of income, expenditure, bank balance, etc.). The individual had to specifically ask for any necessary information. They could also make decisions on many

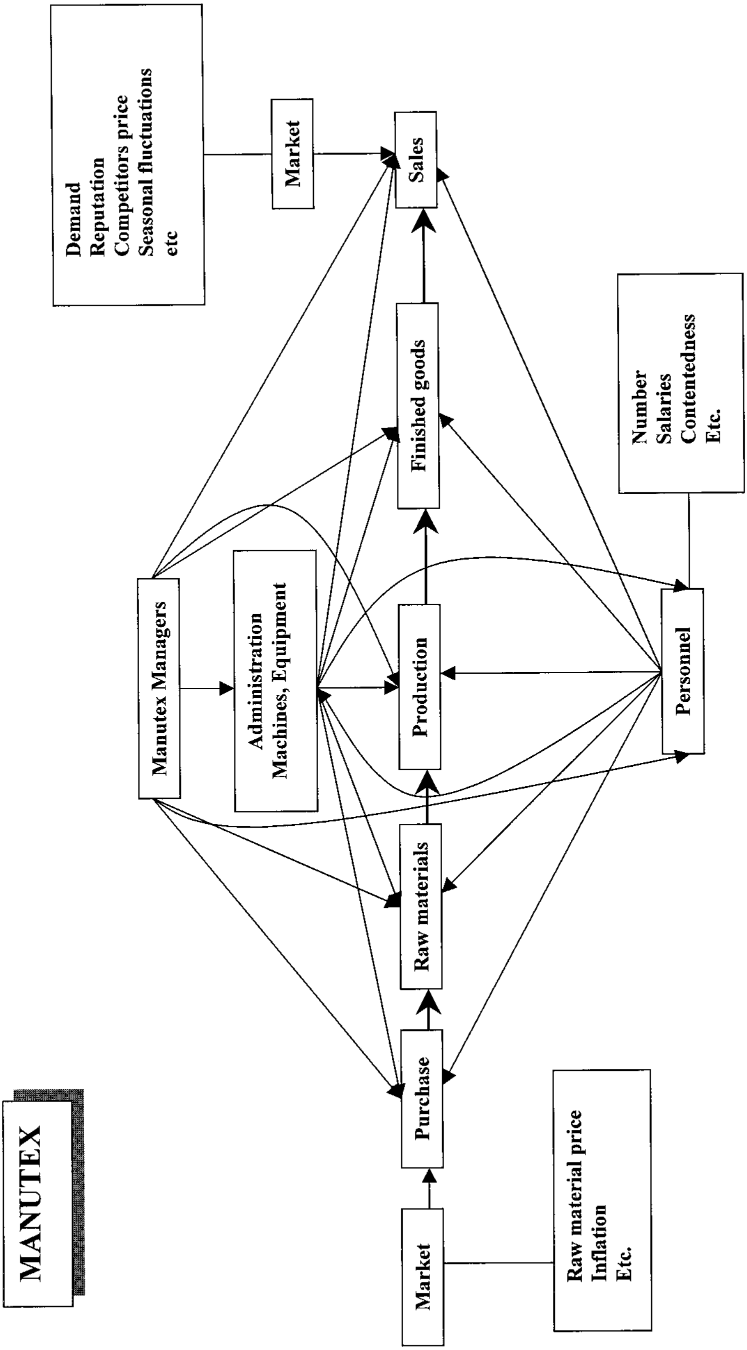

FIG. 1 Simplified model of the Manutex system. Copyright by H. Schaub (1988). Reprinted with permission.

of these aspects during each time interval. One of the authors acted as an intermediary between the individual and the computer for conveying the information that was asked for and implementing decisions. The simulation was followed by a feedback discussion, lasting 30 to 40 min. Of the 45 managers in the sample, the simulation could be conducted only with 42. Of these, 5 managers opted out in the early stages and one manager failed to complete the need-for-cognition scale. The simulation data of the remaining 36 managers, including the female manager, who completed 12 time intervals (one year) or more were used for analysis of complex problem-solving behavior.

Measures

Effectiveness of Complex Problem Solving: Measures of the Dependent Variable

Evaluating the effectiveness of individuals in solving a complex problem is also complex since there is no one measure which can exhaustively and uniquely capture it. This is because different individuals give varying importance to different aspects and outcomes of the problem and accordingly end up with different solutions which may be satisfying to them in terms of meeting their objectives. Hence we need to use multiple measures. In the Manutex simulation, solving the problem effectively meant managing the simulated organization effectively. Three dimensions were identified to define problem-solving effectiveness: *success, consistency,* and *crises-free nature* of problem solving.

''Success'' in complex problem solving. Success in problem solving refers to the problem-solver's achievement as measured by different favorable outcomes. Individuals who solve the problem effectively should show relatively higher levels of achievement as compared to others who are not so effective. Success was measured by the following parameters of Manutex: (a) cash balance (profit) of the firm at the end of the session, (b) total production and sales during the session, and (c) average values of cash balance, production, and sales during the session (all in Malaysian Dollars, M$).

''Consistency'' in complex problem solving. In terms of organizational effectiveness, some stability is necessary in the operations of any organization, even while attempting change, growth, or expansion (Srivastva & Fry, 1992). Extreme fluctuations in production, sales, cash flow, or any other important aspect of organizational functioning can adversely affect factors such as employee morale, machine conditions, public image, and shareholder faith in the company. The performance fluctuations should not, therefore, be extreme and drastic; they should be manageable and within the absorptive capacity of the organization. The extent of fluctuations of different aspects of Manutex such as cash balance, production, and sales during the session was assessed with the statistical measure of ''coefficient of variation'' (ratio of standard deviation to mean). It was expected that the coefficient of variation of these aspects would be lower for individuals who pursue the problem more effectively as compared to those who do not.

''Crises-free nature'' of complex problem solving. Many problem-solvers tend to deviate from courses of action that are the most desirable for effectively solving the problem. They may implement faulty planning and decision making by not gathering all relevant information or by not having complete and sufficient understanding of the complexity of the problem, which leads to what are termed as *errors* (Doerner, 1990; Frese & Zapf, 1994). Errors result when the problem-solver uses unplanned actions, inadequate interventions, or inaction or overlooks important factors. In the Manutex simulation, errors result in unanticipated crises for the firm (termed as ''alarms''). Some of the alarms that may appear in this simulation are the *store* (running out of raw materials or accessories, leading to production stoppage), *account* (cash balance becoming negative, necessitating bank borrowing), and *dismissals* (personnel resigning due to low salaries, unsatisfactory social benefits, poor performance of the firm,

etc.). An individual who pursues the problem effectively may be expected to face fewer crises as compared to those who are not so effective. Low scores on the following two measures indicate a crises-free nature of problem solving: (a) the number of simulated months during which individuals faced alarms (termed as ‘‘alarm months’’) and (b) the total number of different alarms which they actually faced.

ANALYSIS AND FINDINGS

Reliability of the Need-for-Cognition Scale

Forty-four out the 45 managers in the sample completed the need-for-cognition scale. Internal consistency of the scale as measured by Cronbach’s α was found to be 0.744 ($n = 44$, number of items $= 18$). According to Nunnally (1967), for research of this nature, this value of alpha is acceptable. It is also comparable to the values reported in other studies with the need-for-cognition scale (see Cacioppo et al., 1996, pp. 200–203). With respect to split-half reliability, the Guttman coefficient was found to be 0.728, and the Spearman–Brown coefficient, 0.738 ($n = 44$, number of items 18). The Spearman–Brown coefficient indicates the reliability of the 18-item scale if it was made up of two equal halves, while the Guttman coefficient is an estimate of reliability that does not assume that the two parts of the scale are equally reliable or have the same variance (Norusis/SPSS Inc., 1994, pp. 149–150). These values of Cronbach’s alpha and split-half reliability measures are moderately high, indicating that the short version of the need-for-cognition scale was reliable.

Need-for-Cognition Profile of Sample of Individuals in the Study

The need-for-cognition scores of the 44 managers in the sample varied between 49 and 84 with a mean of 65.75 and $SD = 8.92$ (kurtosis $= -0.63$, skewness $= -0.034$). The need-for-cognition scores of the 36 managers whose simulation data were analyzed for complex problem-solving behavior also varied between 49 and 84, but showed a mean of 64.75 and $SD = 9.27$ (kurtosis: -0.72, skewness: 0.14). In the short form version of the need-for-cognition scale used here (Likert type, 18 items on 1 to 5), 90 being the highest score possible, 18 the lowest, with a midpoint of 54, the mean need-for-cognition score of the sample of individuals in this study can be considered as being on the high side. We now discuss the effectiveness of complex problem solving of individuals in relation to their need for cognition.

Data Analysis

Correlation analysis was used to relate need for cognition with each of the problem-solving effectiveness measures (Table 1). However, when the scatter plots of some dependent variables indicated curvilinear effects, we also did *regression curve fitting*. This procedure follows simple linear regression, but instead of only finding the best linear fit, it also estimates if a statisti-

TABLE 1
Relationship between Measures of Effectiveness of Managers in Solving the Simulated Complex Problem and Their Need for Cognition: Linear Effects

Measures of problem solving (PS) effectiveness	Correlation with need for cognition
Success measures[a]	
Cash balance at end of PS[b]	0.45***
Total production at end of PS[c]	0.24
Total sales at end of PS[c]	0.33*
Average cash balance during PS[b]	0.47****
Average production during PS[c]	0.32*
Average sales during PS[c]	0.41**
Consistency measures	
Coefficient of variation of cash balance during PS[d]	−0.12
Coefficient of variation of production during PS[c]	−0.25
Coefficient of variation of sales during PS[b]	−0.23
Crises-free nature measures	
Number of intervals with crises during PS[b]	−0.45***
Total number of crises faced during PS[b]	−0.48****

[a] In Malaysian Dollars.
[b] $n = 36$, two-tailed significance.
[c] $n = 33$, two-tailed significance.
[d] $n = 35$, two-tailed significance.
* $p < .1$.
** $p < .05$.
*** $p < .01$.
**** $p < .005$.

cally significant new model (quadratic, logarithmic, or exponential) adds any further insight (Norusis/SPSS Inc., 1993). Here we abided by the principles of ‘‘statistical simplicity’’ and ‘‘theoretical meaningfulness’’ (Harman, 1967) and preferred the linear model whenever it became significant. We went one step further and examined a more complex model, the quadratic, when it was found to explain relatively higher portion of variance of the data. The quadratic effects observed are presented in Table 2. Assumptions of regression like multicollinearity and normality of error were taken into account using residual analysis.

Need for Cognition of Individuals and Their Problem-Solving Effectiveness

‘‘Success’’ in complex problem solving. As noted earlier, higher values of measures such as cash balance at the end of the simulation; total sales and average values of cash balance; and production and sales during the simulation would reflect greater success in problem solving. These measures

TABLE 2
Relationship between Measures of Effectiveness of Managers in Solving the Simulated Complex Problem and Their Need for Cognition (NC): Quadratic Effects

Measures of problem solving (PS) effectiveness[a]	R^2	$F(2, 32)$	t ratio of coefficients	Significance of t ratios
Cash balance at end of PS (M$)[b]	0.24	5.24*	NC: 3.119	0.1268
			NC$^{2:}$ −2.681	0.1875
Average cash balance during PS (M$)	0.27	5.99**	NC: 1.643	0.1099
			NC$^{2:}$ −1.406	0.169
Number of intervals with crises during PS	0.34	8.57***	NC: −2.907	0.0065
			NC$^{2:}$ 2.674	0.0116
Total number of crises faced during PS	0.35	8.89****	NC: −2.692	0.0111
			NC$^{2:}$ 2.437	0.0204

[a] $n = 36$.
[b] Malaysian Dollars.
* $p < .05$.
** $p < .01$.
*** $p < .005$.
**** $p < .001$.

showed a significant, positive, linear variation with need for cognition of individuals (Table 1, Figs. 2 and 3). In other words, success of individuals in solving the complex problem increased with increase in their need for cognition. With increasing need for cognition, the problem-solvers produced a larger quantity of products, were able to sell more of those in the market,

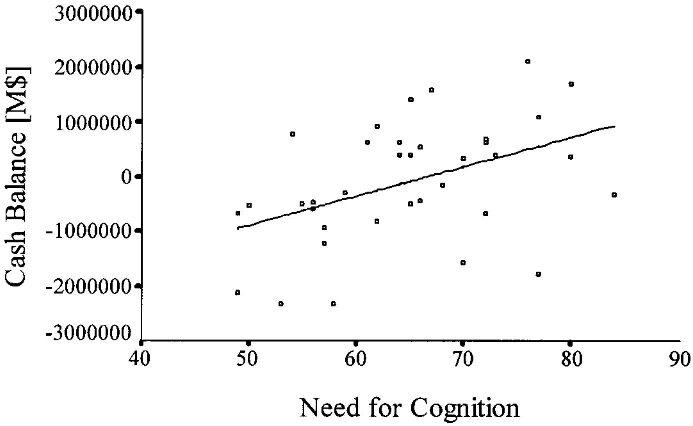

FIG. 2 Cash balance (in Malaysian Dollars; M$) at the end of the session with need for cognition ($R^2 = 0.2$, $F = 8.46$, $p < .01$, $n = 36$).

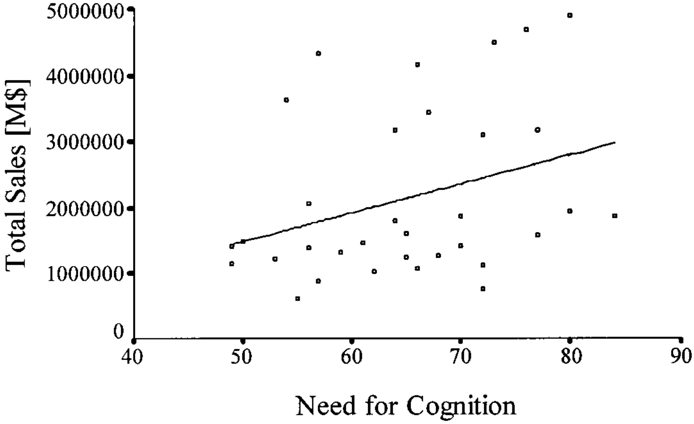

FIG. 3 Total sales (in Malaysian Dollars; M$) during the session with need for cognition ($R^2 = 0.11$, $F = 3.77$, $p < .1$, $n = 33$).

and ended up with a higher cash balance (or profit) by managing the simulated organization Manutex successfully. It may also be noted from Table 2 that some quadratic effects were observed, indicating that though success in problem solving increased with increasing need for cognition, beyond a certain point at the higher end of need for cognition, it tended to decline.

''Consistency'' in complex problem solving. Consistency with which individuals solved the complex problem was measured by the coefficient of variation of production, sales, and cash balance during problem solving. This yielded very weak results (Table 1). With increasing need for cognition, the coefficient of variation of production ($r = -.25$, $p = .166$), sales ($r = -.23$, $p = .176$), and cash balance ($r = -.12$, $p = .479$) decreased linearly. Hence it would not be possible to confidently state that with increasing need for cognition, individuals achieved more consistent performance.

''Crises-free nature'' of problem solving. We had used two measures to assess the crises-free nature of problem solving of individuals: the number of time intervals when they faced crises (alarm months) and the actual number of crises they faced while solving the problem. Both these measures showed a statistically significant, linearly decreasing trend ($r = -.45$, $p < .01$ and $r = -.48$, $p < .005$ respectively; Table 1), implying that problem solving became increasingly crises free with increasing need for cognition. We also observed statistically significant quadratic effects of a ''U'' form for both these variables (Table 2, Figs. 4 and 5). That is, as need for cognition of individuals increased, the number of time intervals in which they faced crises as well as the actual number of crises they faced declined, reached a low value, and then began to increase.

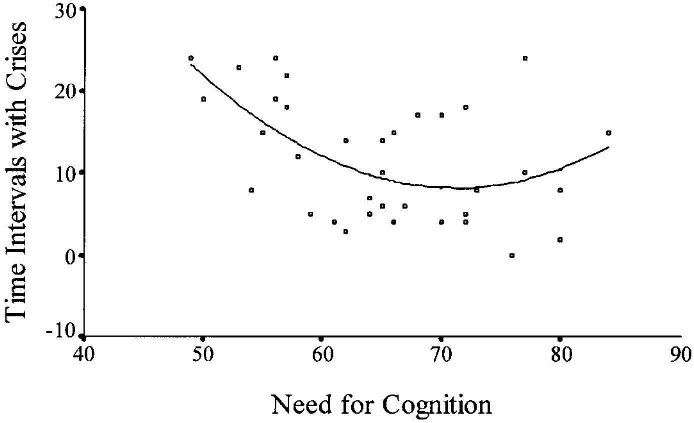

FIG. 4 Number of time intervals during the session when individuals faced crises with need for cognition ($R^2 = 0.34$, $F = 8.57$, $p < .005$, $n = 36$).

Information Gathering and Decision-Making Behavior during Complex Problem Solving

As described earlier, the information gathered by individuals while solving the complex problem was analyzed on two dimensions: quantity and diversity. While quantity refers to the amount of information gathered while solving the problem, diversity refers to the variety of aspects of the problem on which individuals gathered information. For instance, in the Manutex problem, the individuals may choose to understand how the production activity

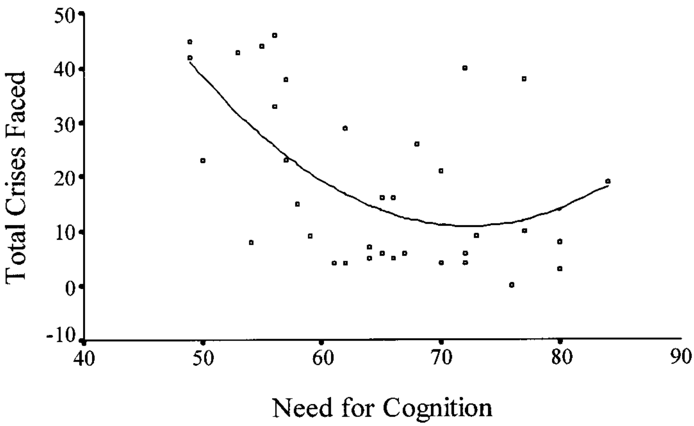

FIG. 5 Total number of crises faced by individuals during the session with need for cognition ($R^2 = 0.35$, $F = 8.89$, $p < .001$, $n = 36$).

TABLE 3
Correlation between Need for Cognition of Managers and Their Information-Gathering and Decision-Making Behavior while Solving the Simulated Complex Problem

	NC_Score[a]	A_s[b]	B_s[c]	Uniq_A[d]	Uniq_B[e]
NC_Score	—				
A_s	.25[f]	—			
B_s	−.02[g]	.09[f]	—		
Uniq_A	.42[f]**	.52[f]****	−.04[f]	—	
Uniq_B	.30[f]*	.20[h]	−.01[f]	.69[h]*****	—

[a] Need for cognition score of managers.
[b] Number of units of information gathered.
[c] Number of units of decisions made.
[d] Unique units of information gathered.
[e] Unique units of decisions made.
[f] $n = 35$, two-tailed significance.
[g] $n = 36$, two-tailed significance.
[h] $n = 34$, two-tailed significance.
* $p < .1$.
** $p < .05$.
*** $p < .01$.
**** $p < .005$.
***** $p < .0001$.

needs to be organized. They may then gather information on, say, the nature of constraints and considerations for planning production, actual production achieved during the earlier months, quality of products, raw materials required for meeting production target, lead times, machine capacity, number of workers required, and so on. Each of these aspects on which the problem-solver gathered information was considered as a unique unit. The number of such unique bits of information gathered gave an indication of the breadth of the problem-solvers' sense making and the extent of their coverage of the problem space. Table 3 summarizes the findings.

It was found that the quantity of information gathered, measured by the total units of information collected by individuals while solving the problem, showed a weak, positive relation with need for cognition ($r = .25$, $p = .14$). However, the diversity of aspects which individuals covered through information seeking was found to be significantly positively related to need for cognition ($r = .42$, $p < .05$). This means that with increasing need for cognition, the unique units of information gathered by problem-solvers increased—they dealt with more aspects of the problem for effectively making sense of it.

The number of decisions made by individuals while solving the problem did not show any significant relation with need for cognition. However, the diversity of decisions made by them increased with increase in need for cognition ($r = .3$, $p < .1$). This means that with increasing need for cognition, problem-solvers paid attention to more aspects of the problem by making decisions and acting on them. We also checked for mediation effects[1] of information gathering and decision-making behavior on the outcome measures of problem solving. The effects were not significant and need for cognition still emerged as the significant variable in explaining the outcomes. Specifically, the effect of need for cognition on outcome measures of problem solving such as cash balance and crises faced were not eliminated when information gathering and decision making were controlled.

DISCUSSION

In this study, we examined the relationship between need for cognition of individuals and their effectiveness in solving complex problems. We had a sample of managers working on a complex, long-duration, computer-simulated problem. It was proposed that with increase in need for cognition of individuals: (1) their effectiveness of solving complex problems would increase and that they would gather (2) more amount of information and (3) information on more aspects/dimensions of the problem during problem solving.

Results show that the effectiveness of solving the simulated complex problem increased with problem solvers' increased need for cognition. Specifically, with a higher need for cognition, individuals were more successful in solving the complex problem as measured by various favorable outcomes. For individuals with a greater need for cognition, problem solving also became easier. They were more successful in avoiding the crises that tend to be created by actions that are insufficient or excessive for solving the problem. A surprising finding was that as values of need for cognition increased beyond a certain point, the crises increased. There was weak support for the proposition that the individuals demonstrated more consistent performance with enhanced need for cognition. While the need for cognition had a weak, positive relationship with the amount of information gathered, there was practically no relationship with the number of decisions taken. Finally, as need for cognition increased, individuals exhibited a greater breadth of coverage in dealing with the problem by collecting information and taking decisions on more aspects of the complex problem.

An explanation for the increasing effectiveness of individuals in solving the simulated complex problem with increase in need for cognition comes from their information-gathering behavior during problem solving. Effective complex problem solving requires a continuous and repetitive process of sense making of the many variables and their linkages, awareness of evolving

[1] This was suggested by one of the anonymous reviewers.

multiple perspectives, formulating working hypotheses, testing ‘‘experimental’’ decisions, monitoring the consequences of those decisions by actively seeking feedback, and appropriately modifying the decisions. The process of experimentation and learning has to go on for some time until the individual gains a reasonable grasp of the problem. As Simon and Hays (1976, p. 277) point out, complex problems are ‘‘those problems in which the problem solver contributes to the definition and resolution, using information generated from initial unsuccessful attempts at a solution.’’ The success of this process of problem solving is rooted in gathering adequate and relevant information on various problem dimensions so that the individual gains a grasp of the complexity, uncertainty, and dynamic nature of the problem.

The study indicates that individuals with higher need for cognition tend to examine more dimensions of the problem, as seen in the higher diversity of information sought. There is also some indication that such individuals gather a greater quantity of information. These two aspects of information gathering may have enabled individuals with higher need for cognition to gain a broad and deep understanding of the complexity of the problem, as well as to keep continuous track of its evolution from one time interval to the next.

Mere sense making through information gathering, however complete it may be, is not sufficient to deal successfully with the complex problem. Individuals also have to process this information, make suitable decisions, and act on them. The decision-making behavior of individuals during problem solving in this study reveals on one hand no significant relation between the total number of decisions made and need for cognition. Individuals with high and low scores on need for cognition make nearly the same number of decisions in this problem-solving simulation. But individuals with higher need for cognition were found to be more effective in solving the complex problem. Two other aspects of effective problem solving may explain this: the diversity and the intensity of decisions made.

In this study, individuals with a higher need for cognition did exhibit a larger diversity or variety in their decision making—they made decisions concerning more dimensions of the problem. Considering the intensity aspect, effective decision making requires not only correctly identifying the relevant variables and their relations, but also assessing the exact nature of those relationships in terms of both magnitude and direction. Individuals may understand that variable A is related to B and that, say, the relationship between them is positive, but may not grasp its magnitude. In other words, the understanding that an attempt at increasing A would result in an increase in B is incomplete if individuals do not grasp the magnitude of change to be made in A to achieve the desired change in B. Incomplete understanding of the magnitude of a relationship can lead to inadequate or excessive interventions.

An example from the Manutex problem illustrates this well. Many problem-solvers realized that ‘‘advertising’’ their products had a positive bearing on ‘‘sales’’ in the market and, accordingly, decided to advertise. But many of them could not grasp the magnitude of the relationship between advertising and sales, as designed in this problem. Some of them asked the facilitator for the default advertising budget (which was M$1,500), then increased it to, say, M$2,500 or M$3,000 and expected sales to pick up. But this increase was inadequate to bring about any appreciable change in the sales of their products in the market. Consequently, a number of them concluded incorrectly that the advertising intervention did not hold much potential or promise. On the other hand, some other individuals related the advertising budget to other factors such as nature of industry, volume of operations, and projected demand figures and increased the advertising budget to, say, M$15,000 or M$20,000 and reached a different conclusion about the impact of advertising. Thus two persons may have made the same number of decisions while solving the problem, but may have differed in the crucial aspect of making decisions of adequate magnitude to bring about the desired outcomes. Our findings suggest that individuals with a lower need for cognition tended to make inadequate decisions.

The advertising–sales relationship also highlights another interesting aspect of problem-solving behavior—the tendency of individuals to be limited by the available information. In our postsimulation interviews, many individuals reported that the initial advertising budget constrained their thinking and prevented them from exploring alternative options. They tended to consider this aspect in isolation and therefore found any amount over M$3000 too radical. On the other hand, a few others who related advertising budget to the nature of the industry and the overall sales budget felt free to initiate a discontinuous change.

As we have noted, the study shows that some of the measures of problem solving effectiveness hold significant quadratic relationships with need for cognition. For instance, crises faced by individuals during problem solving decreased with an increasing need for cognition and then again increased. This is possibly due to the following reasons. Individuals with a higher need for cognition tended to examine more aspects of the problem. They gathered a variety of details and tried to incorporate them in their decisions. It is possible that at the higher end of need for cognition, individuals were going into too many aspects of the problem, not all of which were important and relevant for effectively solving it. Perhaps their awareness of a variety of issues and their perception of fine-grained details of what was going on in different spheres interfered with their ability to stay focused on key issues within the time constraints.

It may also be argued that with increased need for cognition, individuals were not really making more effective sense of the problem. We have seen that with increased need for cognition individuals attended to more aspects of the problem through information gathering and decision making, but they did not gather an adequate amount of information. From the definition of need for cognition one would expect individuals with a higher need for cognition to gather more information, but this has not been supported strongly in this study. This could imply that with increased need for cognition individuals examined the different dimensions of the problem as would be expected of them, but they had not explored these in sufficient detail to be able to integrate the different pieces into a meaningful whole. In other words, the ability to see multiple aspects of the problem is alone not sufficient unless this ability is supplemented by the ability to make coherent sense of the situation by taking an overview. In dealing with complex problems, unless the awareness of all the details is balanced by the ability to identify the strategic issues and concerns, there is a strong likelihood that individuals would be unable to decide and act with a sense of confidence.

As presented earlier, other studies on need for cognition provide supporting evidence for the finding that effectiveness of individuals in solving complex problems increases with an increase in their need for cognition. These studies reveal that need for cognition is positively related to aspects such as the ability of individuals to pay exclusive attention to ongoing cognitive tasks, longing for new experiences that stimulate thinking, desire for higher control over one's environment, and tendency to seek out and elaborate relevant information under problem-solving conditions. Studies have also found that need for cognition is negatively related to dogmatism, need for closure, and procrastination.

What we can infer from these studies which relate need for cognition to certain aspects of personality, disposition, or behavior is that need for cognition, which is essentially a personality variable (Cacioppo et al., 1996), does not stand in isolation in the personality of an individual. As illustrated above, a somewhat coherent pattern of positive and negative associations exists. These diverse facets of the personality of individuals collectively influence and enable them to be open to new situations, gain understanding, make integrated and holistic sense of the issues to be able to decide and act, and also enjoy the process of problem solving. Can an individual's need for cognition be developed or augmented? Cacioppo et al. (1996) believe that it is possible: ''need for cognition, at least in theory, should result from a person's values and the competence feedback and feelings of personal satisfaction and mastery derived from cognitive challenges. . . . The development of need for cognition, therefore, may benefit from the construction of contingencies (e.g., in educational settings) that foster both cognitive development and feelings of enjoyment, competence, and mastery in thinking'' (p. 246).

This point assumes importance when we consider that the need for cognition of managers in this study showed a ''U'' variation with their age (R^2 =

.2, $F = 4.1$, $p < .05$, $n = 36$). In the initial stages of their career, the young managers are new to their organizational and work contexts. They have been well educated and selected from reputable graduate schools or through a national-level examination. They exhibit keenness, interest, and initiative to learn the systems, processes, and tasks in the job. But as they move up to middle management positions, as reported during the feedback discussions, their designations change, but the nature of responsibilities essentially remains the same. There was little or no job enrichment associated with a rise to middle levels. Opportunities for learning either decrease or do not exist. It is possible that these factors are reflected in a relatively lower need for cognition. But as they move up to senior levels of management, they show an increased need for cognition, probably due to a substantial change in the nature of their tasks. At higher levels, their tasks become varied and they are entrusted with general management responsibilities which need a wider, holistic, and macro perspective or outlook. There is higher task diversity and increased challenges of an unstructured nature. Perhaps this explains the increased need for cognition at the higher levels of management.

This implies that the context plays an important role in shaping and/or influencing an individual's cognitive motivation. It also raises another question—does cognitive motivation lie dormant in individuals because the context is not favorable at a given point? The sample of managers who participated in this study had lifelong careers with their organization. Young people who joined as management trainees grew through middle management levels to senior levels. So, if we find that the need for cognition of middle-level managers is relatively lower compared to the other levels in the organization, it could mean dormancy during that period. We need further research to explore these aspects.

CONCLUSION

We studied the effectiveness of complex problem solving of individuals in relation to their need for cognition with a managerial sample from a very large organization. The findings show that need for cognition of individuals holds a significant positive relationship with effectiveness of solving complex problems. Individuals with a higher need for cognition were more successful in solving the complex problem simulated for this study—their levels of achievement were higher and they faced fewer crises during problem solving, as they considered a wider variety of issues and aspects of the problem as compared to individuals with a lower need for cognition. This indicates that individuals with a higher need for cognition are likely to be more effective in those contexts, tasks, or roles that are generally ill structured.

Considering that virtually all earlier studies on need for cognition have looked for linear effects, either due to dichotomization of the variable or due to the use of linear regression procedures, this study is significant with the identification of quadratic effects as well.[2] The study also points to the influence that the broader context in which individuals function has on the manner in which they develop, sustain, and enhance their cognitive motivation to deal with problems. This highlights the importance of factors such as job design and job contexts and training schemes for managers in organizations to help them keep their cognitive motivation keen and active. Middle-level managers need special attention in this regard—this study found them to be relatively lower on need for cognition as compared to managers at junior or senior levels. As managers in our sample had lifelong careers with the organization, this might also indicate that cognitive motivation of individuals lies dormant when the context is not nurturant and favorable. Further research is necessary to gain greater understanding of the nature of influence of contextual, organizational, and other background variables on the need for cognition of individuals.

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