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Cognitive Style and intelligence interaction in Gifted Problem – Soning Performance

Dr. Usama Mohamed Abdel-Maged
Sohag Faculty of Education

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COGNITIVE STYLE AND INTELLIGENCE INTERACTION IN GIFTED PROBLEM-SOLVING PERFORMANCE

Dr. Usama Mohamed Abdel-Magid
Educational Psychology Department, Sohag Faculty of Education
South Valley University

SUMMARY: The aim of this study was to investigate the way in which both cognitive style and intelligence affect gifted students' performance on unconventional problem-solving tasks. The sample comprised 200 15-16.5-year-old gifted secondary school students. The students were given Cognitive Styles Analysis (CSA), Raven's Standardised Progressive Matrices (RSPM), Sternberg's Triarchic Abilities Test (STAT) and four problem-solving tasks. The main findings were that intelligence has affected the problem-solving performance positively, in that the differences between the high and low intelligence students were always in favour of the highly intelligent students. However, the effects of the two dimensions of cognitive style were either positive or negative, depending on the nature of each problem. The findings generally suggested that cognitive style represents a potentially very important variable of individual differences in problem solving.

INTRODUCTION

Separate literatures have developed in the areas of intelligence, problem solving and cognitive style. In the present study, the individual differences of the three variables and the overlaps between them in relation to gifted problem-solving performance were examined.

Problem solving is an extremely complex activity which not only involves intellectual skills and knowledge but also cognitive style and cognitive strategies. Maker (1993) has reviewed problem solving as a central concept in many definitions of intelligence (conventional problems), creativity (unconventional problems) and giftedness. Standardised tests of fluid intelligence have often been shown to be significant predictors of academic performance and other indices of problem solving (e.g., Guttman, 1969; Jensen, 1970, Snow, 1980; 1981; Tucker and Warr, 1996) in part because the same types of information-processing are present in both sets of activities.

Over the last century, a great deal of research on human problem solving has been conducted. Most of this research has focused on problems characterised as *well-defined* (Greeno, 1978). Another type of research in the field of problem solving has been conducted focusing on what the researchers call *ill-defined* problems. These latter problems were generally dealt with through creativity in the earlier Gestalt theories (Hoover & Feldhusen, 1990: 838).

Despite the broad range of variables investigated in the field of problem solving, little attention has been paid to the effects of cognitive style. The previous research focused on the effect of the prior experience on problem-solving performance. The present researcher believes that part of solving this kind of problem may exist outside the limits of prior experience. It is probable that an individual's cognitive style is a main factor in solving these problems.

THE CONCEPT OF COGNITIVE STYLE

People are continually bombarded by a variety of stimuli from their environment. They probably attend to only a small range of stimuli at any one time but try to make sense of it through a coding process of categories. "*Cognitive style theorists consider that there is an identifiable consistency about the way in which each of us carries out this coding process*" (Fontana, 1981). These theorists suggest that people do not drastically change their methods of solving problems, whether they are academic or social, and therefore cognitive style is considered as an integral part of our personality. Cognitive style is neither ability nor a personality trait but rather it has been considered as a subtle mediator between cognition and personality (Grigorenko & Sternberg, 1995; Kogan, 1983; Messick, 1984; 1993; 1994; Witkin & Goodenough, 1981). It has become clear that cognitive style deeply affects a wide range of learning performance (see Abdel-Magid, 2004; Riding, 2002; Riding & Rayner, 1998).

In answering the question "what is style?" there is a need to clarify the differences between what is 'style' and what is 'ability'. Three characteristics identified by Guilford (1980) as clarifying these differences are:

1. Ability is more concerned with *level* of performance, while style focuses on the *manner* of performance.
2. Ability is *unipolar*, whilst style is *bipolar*.
3. Ability has values attached to it such that one end of an ability dimension is valued and the other is not, while for a style dimension neither end is considered better overall.

Riding and Rayner (1998: 11) comment, "*Both style and ability will affect performance on a given task. The basic distinction between them is that performance in all tasks will improve as ability increases, whereas the effect of style on* *performance for an individual will be either positive or negative, depending on the nature of the task."*

Riding and Rayner (1998) define four areas of psychology from which a contemporary theory of style appears to stem. Those areas are: (1) perception, (2) cognitive controls and cognitive process, (3) mental imagery and (4) personality constructs. The large number of construct labels which emerged led to a great deal of conceptual confusion, since the same labels have been used for indicating behaviours which are qualitatively different, and conversely similar behaviours have been given different labels. Hence, some researchers have endeavoured to conceptualise the different cognitive styles into a number of schemes (Curry, 1987; Grigorenko & Sternberg, 1995; Kogan, 1983; Miller, 1987; Riding & Cheema, 1991).

Reviewing 30 models identified by the researchers in the cognition-centred tradition, Riding and Cheema (1991) concluded that they could be organised into two *orthogonal* cognitive style families or dimensions; a Wholist-Analytic dimension (WA) and a Verbal-Imagery dimension (VI) (Fig. 1).

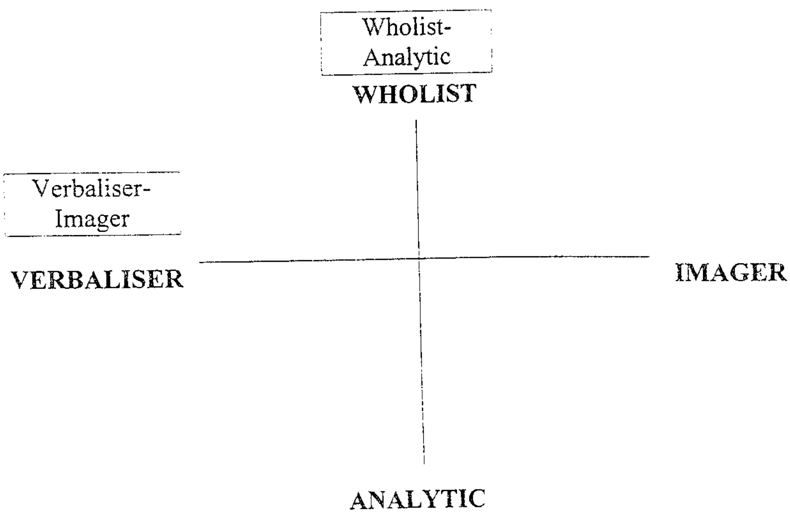

Figure 1 The Cognitive Style Dimensions

Source: Riding and Cheema (1991)

The WA dimension describes whether an individual tends to *organise* information into wholes or parts. The VI describes whether an individual during thinking is inclined to represent information verbally or in mental images. Further reviews by

Rayner and Riding (1997) have supported this conclusion. These styles have been found to be unrelated to intelligence, while both styles and intelligence affected performance on problem solving tasks (Riding & Pearson, 1994). They have also been found to influence learning processes and outcomes (Riding & Sadler-Smith, 1992; Riding & Caine, 1993; Riding & Douglas, 1993; Riding & Read, 1996). Many studies made by Riding and his co-workers have supported the existence of the two dimensions of cognitive style (see Riding, 2000; 2001; Riding & Cheema, 1991; Riding and Rayner 1998; Rayner & Riding, 1997).

The identification of distinct families of cognitive style, the WA and VI, led to the need for a satisfactory and efficient means of assessing both dimensions of style. The attempts resulted in the Cognitive Styles Analysis (CSA) developed by Riding (1991).

INTELLIGENCE

The concept of intelligence is very broad. Some researchers see it as a single factor, while others see it as encompassing multiple abilities (e.g., Gardner, 1983; Sternberg, 1985). Intelligence tests have been under debate since the last century (Sternberg & Kaufman, 1997). Dissatisfaction with the existing psychological concepts of the nature of intelligence and intellectual giftedness was the first factor leading researchers to recognise a need for an innovative approach to intelligence testing (Shavinina, 2001; Shavinina & Kholodnaya, 1996).

There has been an increasing interest in the identification of students who are intelligent in ways which go beyond IQ. The reason is in part that IQ tests do not explain much of the variance in students' performance (Sternberg, 1995: 2). The shortcomings of traditional theories of intelligence have been discussed frequently in the literature (e.g., Neisser, 1998; Neisser, et al., 1996; Sternberg, 1985; 1990). In general, the traditional psychometric approach has regarded intelligence as synonymous with IQ. However, many contemporary theorists, such as Carroll (1993), have recognised that there is probably more to intelligence than merely the general factor and they suggest some kind of hierarchical theory. Sternberg (1999: 437) argues that the problem with theorists who support the existence of a general factor is that they tend to restrict the range of participants, tasks and situational context in which they have studied intelligence. He argues that when the range of such variables is expanded, the claim that a general factor of intelligence characterises *all* of cognitive functioning becomes more doubtful.

Recently, theorists in the field of intelligence have been interested more in theory-based assessments whereby they can explain and predict intelligent performance in school as well as other settings. Sternberg (1991) has proposed a new approach to the psychological assessment of intellectual abilities which is based on his triarchic theory of successful intelligence and intellectual giftedness. The triarchic theory of intellectual giftedness is a special case of a more general triarchic theory of human intelligence. According to the theory of human intelligence (Sternberg, 1985; 1986; 1988a; 1997a; 1997b; 1997c), there are three main kinds of intellectual giftedness (or three kinds of intelligence):

Analytic Giftedness: Giftedness in analytic skills involves being able to dissect a problem and understand its parts. It is involves when the components of intelligence are applied to analyse, evaluate, judge or compare and contrast. It is typically involved when components are applied to relatively familiar kinds of problems where the judgements to be made are of an abstract nature. People who are strong in this area of intellectual functioning tend to do well on conventional tests of intelligence, which place a premium on analytical reasoning. Sternberg (1998a: 20) believes that children develop in ways beyond merely what is tested by conventional psychometric intelligence tests. Creative intelligence seems to be one source of variation in intelligence, a source which is almost wholly untapped by conventional tests.

Synthetic giftedness: Synthetic giftedness is seen in people who are insightful, intuitive, creative or simply adept at coping with relatively novel situations. People who are synthetically gifted may not earn the highest IQ scores on conventional measures of intelligence, but they may be the ones who ultimately make the greatest contributions to such pursuits as science, literature, art, drama, and the like. Sternberg (1998a) argues that when the range of tasks and situational contexts of the conventional tests are expanded, one starts to tap sources of individual differences which these tests measure poorly or not at all. Sternberg (1997c) believes that to be successful in life requires the use of creative and practical skills, but because these skills have not been actively encouraged or selected for, students tend not to develop them. The emphasis on analysis is not wrong, just unbalanced.

Practical giftedness: Practical giftedness involves applying the analytic and/or synthetic abilities which individuals may have to the kinds of problems which confront them in daily life. It involves applying the components of intelligence to experience so as to (a) adapt to, (b) shape and (c) select environments. Adaptation is involved when one changes oneself to suit the environment. Shaping is involved when one changes the environment to suit oneself. In addition, selection is involved when one decides to seek out another environment which is a better match with one's needs, abilities and desires.

Combining Analytic, Synthetic and Practical Giftedness: It is probable that people do not possess only one of these kinds of skills. Rather, they represent some blend of the three different kinds, and this blend can change over time. According to Sternberg (1997a) the central part of giftedness is co-ordinating the three skills and knowing when to use which one. Giftedness is viewed as a well-managed balance of the three abilities, and a gifted person is a good "mental self-manager."

PROBLEM SOLVING

Problem solving has been defined as "*cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver*" (Mayer & Wittrock, 1996: 47). Problems may be classified as well-defined or ill-defined. Sternberg (1982) made several distinctions between well-and ill-defined problems (problem spaces):

1. Ill-defined problem spaces seem to rely upon a single major insight whereas well-defined problem spaces are a sequence of relatively minor insights;
2. In well-defined problems you can represent the problem space as a sequence of discrete and well-articulated states, but you cannot do this with ill-defined problems;
3. In well-defined problem spaces the end, or goal, state is similar or identical to the starting state: however, in ill-defined problem spaces the end state is different from the starting state.

Regardless of the nature of the problem, an individual needs to go through certain steps which Sternberg (1998b: 8-12) calls a *problem-solving cycle*. These steps need not be in a fixed order. Generally, the individual needs: (1) to recognise that there is a problem; (2) to define what exactly the problem is; (3) to devise a strategy to solve the problem: (4) to represent information, both externally and internally; (5) to decide what kind of resources to allocate to a problem and to decide how many resources to devote to the problem; (6) to keep track of how the well problem solving is going; and (7) to check after the problem solving is completed. The greatest difficulty for the problem solvers could be how to represent the problem.

Some researchers believe that creativity is a special form of problem solving. Guilford (1956) linked creativity directly with problem solving. He concluded that the creative process has four stages: recognising the existence of a problem, producing a variety of relevant ideas, evaluating the various possibilities produced and finally drawing appropriate conclusions which may lead to the solution of the problem. Getzels and Csikszentmihalyi (1976) also demonstrated that creators are distinguished as much by their ability to find and pose new problems as by their capacity to solve problems posed by others. Brophy (1998) also concluded that finding, identifying and clarifying a problem are the aspects of problem solving which lead to creativity. However, the present researcher believes that creative abilities are more likely to be apparent when the problem solving calls for a kind of divergent thinking or productive thinking.

COGNITIVE STYLE, INTELLIGENCE AND PROBLEM SOLVING

Although cognitive style affects the ways in which individuals view problems, process information of different types and arrive at solutions (Riding & Powell, 1993: 221), the relationship between cognitive style and problem-solving performance is not the same as intelligence. While the performance on all tasks improves as intelligence increases, the effect of style on performance for an individual will be either positive or negative, depending on the nature of the task (Riding & Rayner, 1998). Kantowski (1981) asserted that problem-solving processes depend as much on the type of problem as on the individual information-processing style of the solver.

Antonietti and Gioletta (1995) carried out five studies to investigate whether Analogical Problem Solving (APS) is associated with individual differences in reasoning ability and cognitive styles. In study 1, they applied Dunker's retardation problem and Raven Progressive Matrices on 43 undergraduates aged between 19-27 years old. Results showed a lack of relation between Raven's Standard Progressive matrices (RSPM) and analogical problem solving.

In study 2, they investigated how the Field Dependence/Independence (FD/I) can predict analogical transfer in a problem-solving context. They applied Dunker's retardation problem and the Group Embedded Figure Test (GEFT) on 75 19-27 yr-old undergraduate students. The results showed that the FI students were more likely to be analogical solvers than FD students were.

In study 3, they investigated the effects of two other cognitive styles on APS: the left-right mode of thinking and the verbalisation-visualisation tendency. Fifty 19-27-yr-old undergraduate students completed the Dunker's retardation problem, a self-report questionnaire *Your Style of Learning and Thinking* SOLAT (Torrance, 1988) to assess the left-right style of thinking, and the *Visual-Verbal Strategy Questionnaire* (VVSQ) (Antoniette & Giorgetta, 1993). The VVSQ consists of items concerning everyday-life activities in which persons may think in propositions or in pictures. For each item students estimate how frequently they employ the mental strategy described in such an item. In this instrument, students were classified as verbaliser, mixed or visualiser. The results showed a lack of relationships between both VVSQ and SOLAT.

Study four investigated the possible relationship between the APS and the Adaptor-Innovation style. In this study, 52 undergraduates (aged 19-27 yr) carried out Dunker's retardation problem and the Kirton *Adaptor-Innovation Inventory* (KAI) (Kirton, 1976). The results showed that there was a marginally significant effect, where the analogical solution of the retardation problem tended to be more frequently among adaptors than innovators ($P < 0.07$). Generally, the results suggested that cognitive styles, rather than abilities, are involved in APS.

Tucker and Warr (1996) investigated information processing of fluid intelligence, elementary cognitive components (processing speed, measured inversely as time and working memory) and cognitive styles (cognitive tempo, planfulness and complexity) as predictors of performance in a relatively complex task. Eighty participants from the institute's research panel took part in the study. They completed the AH4 test of general intelligence (Heim, Watts & Simmonds, 1975), a questionnaire containing items for self-reports of the three cognitive styles and the stimulated tele-shopping task. This instrument was used as a complex task and administered through an Apple Macintosh LCII computer linked to a B4-size monochrome visual display unit.

Processing time and working memory were also assessed through that system, in terms of a four-choice reaction-time task and a measure of backward digit-span respectively. The results showed that fluid intelligence scores were more closely associated with measures of speed rather than accurate task performance and differences in cognitive tempo co-vary with speed of problem solving but not with speed of routine activity. However, generally the cognitive style variable did not increase the predictive power of intelligence and the elementary cognitive components. Tucker and Warr (1996: 91) concluded: "*cognitive style will be most reflected in task performance when the activities involved permit considerable variation in the style under investigation.*"

Particular styles that appear potentially important in solving problem tasks are WA and VI (Riding & Cheema, 1991). Variations in these styles are expected to be of particular potential relevance to problem solving performance. So far, cognitive style, in its relation to problem solving, has not been as thoroughly explored as different cognitive abilities and almost nothing has been done using the two dimensions of cognitive style mentioned above. The present study sought to shed some light on how individuals' cognitive style affects the solution of an ill-defined problem.

THE AIM OF THE STUDY

Despite the broad range of issues investigated in the field of problem solving, little attention has been paid to the effects of cognitive style. The present study examined the way in which both cognitive style and intelligence affect gifted problem-solving performance. Of particular interest in this study were ill-defined problems, which may call for creative thinking.

The main hypothesis was that both intelligence and cognitive style affect problem-solving performance but in different ways. Because of the wide-ranging content of intelligence tests, intelligence scores are expected to be closely related to problem solving performance. Cognitive styles are also expected to interact with each other and/or with intelligence more than to have major effects on problem solving performance.

METHOD

Sample

Eight secondary schools (four for boys and four for girls) were asked to submit nominations of gifted students to participate in this study. The schools were urban public schools located in Sohag City, Egypt. The gifted students were identified based on teacher nominations using Purdue Academic Rating Scales (PARS) (Feldhusen, Hoover, and Saylor, 1990), achievement scores (at least among the top 10% of his or her grade peers), consistent high performance in the last two years and scoring 120 or above on RSPM. Overall, the sample consisted of 200 students between the ages of 15 and 16.5. There were 105 boys and 95 girls in the 2^{nd} and 3^{rd} grades of secondary education. Numbers were nearly equal (2^{nd} grade = 97, 3^{rd} grade = 103).

Instruments

Cognitive Styles Analysis (CSA)

The computer-presented Cognitive Styles Analysis (CSA) (Riding, 1991) was used to determine the students' position on the two fundamental cognitive styles, The Wholist-Analytic (WA) and Verbal-Imagery (VI). The CSA instrument comprises three subtests. The first consists of a set of 48 verbal questions which assess the VI dimension. The second two subtests consist of 40 diagrammatic problems which assess the WA dimension. Each of the cognitive style dimensions is a continuum and independent of the other (Riding & Rayner, 1998: 44-45). Simply pressing one of two designated keys on the keyboard to indicate 'True' or 'False' to each question activates the response mode. The ratios of response times is calculated by the software to indicate to the subject whether they tend to be 'Wholist' or 'Analytic', 'Verbaliser' or 'Imager' or somewhere in between.

The questions related to the verbal aspect on the VI dimension are straightforward statements which sample a subject's capacity to recognise category, similarity or difference between pairs of concepts. The statements are in the form, '**(X)** and **(Y)** are the same type' to which the response is either true or false, indicated by pressing the appropriate key. The set of questions related the imagery style is based primarily on whether a subject can visualise the colour similarity or difference between two named objects. The questions of this type are written in the form '**(X)** and **(Y)** are the same colour'. Similarly, the response is either true or false.

The background to the development of the CSA is given in Riding and Cheema (1991) and its mode of operations is fully described in Riding (1997). The CSA has several advantages (Riding, 2000: 318-319) in that it is an objective test because it positively assesses both ends of each style dimension and hence measures style rather than ability. It can be used with a wide range of ages from children to adults. It is context free and can be used in a wide range of situations. Moreover, it is available in various languages: versions in English, Arabic, French, Dutch, German, Malay and Spanish. It is a direct measure of cognitive processing and hence is less susceptible to the effects of social desirability.

Sternberg's Triarchic Abilities Test (STAT)

The STAT (Sternberg, 1993b) is based on the triarchic theory of intelligence and constitutes one theory-based alternative to traditional intelligence tests. As mentioned above, the triarchic theory views intelligence as comprising three aspects: an analytical aspect, a creative aspect and a practical aspect. The test has a set of nine multiple-choice subtests, each consisting of two sample items and four test items (total=36 items). The nine subtests are as follows:

1. Analytical-Verbal: Figuring out meanings of neologisms (artificial words) from natural contexts. Students see a novel word embedded in a paragraph, and have to infer its meaning from the context.
2. Analytical-Quantitative: Number series. Students have to say what number should come next in a series of numbers.
3. Analytical Figural: Matrices. Students see a figural matrix with the lower right entry missing. They have to say which of the options fits into the missing place.
4. Practical-Verbal: Everyday reasoning. Students are presented with a set of everyday problems in the life of an adolescent (who might be themselves or someone else), and have to solve the problems.
5. Practical Quantitative: Everyday Maths. Students are presented with scenarios requiring the use of maths in everyday life, and have to solve problems based on the scenarios.
6. Practical-Figural: Route planning. Students are presented with a map of an area (e.g., an entertainment park), and have to answer questions about navigating effectively through the area depicted by the map.

7. Creative Verbal: Novel Analogies. Students are presented with verbal analogies preceded by counterfactual premises (e.g., money falls off trees). They have to solve the analogies as through the counterfactual premises were true.
8. Creative Quantitative: Novel Number Operations. Students are presented with rules for novel number operations. Students have to use the novel number operations to solve the presented maths problems.
9. Creative-Figural: Students are first presented with a figural series which involves one or more transformations; they then have to apply the rule of the series to the new figure with a different appearance in order to complete the new series (Sternberg, 1998).

Sternberg (1994: 45) mentions that the abilities as well as tests measuring them are viewed as potentially correlated. They are not independent, as in psychometric theories with orthogonal factors (e.g., Guilford, 1967) or in Gardner's (1983) theory of multiple intelligences.

Preliminary validation of the STAT (Sternberg & Clinkenbeard, 1995) has shown it to be appropriate for the intended purposes and correlated with but not identical to other tests. In 1996, the psychometric properties of the test were computed on a sample consisting of 326 high school students. The internal-consistency reliabilities of the subtests were computed for the multiple-choice items. These reliabilities were .63 for the analytical items, .62 for the creative items, and .48 for the practical items. The consistency of these internal reliabilities was reviewed as satisfactory (Sternberg et al., 1996). In 2001, Sternberg and others used techniques of hierarchical confirmatory factor analysis of STAT in three international samples. The results provide some support for the structural validity of the STAT. However, this result should be understood in the light of the limitations of the current version of STAT. First: it is difficult to measure the creative and practical aspect of intelligence in a paper-and-pencil format, especially via multiple-choice items. Moreover, the subtests were kept short to minimise testing time and the test is not standardised. Also, the test has not been shown to work at all ages or levels of ability. The current version of the STAT is still in progress and not final (Sternberg, 1995:15).

Abdel-Magid (2002) translated the STAT into the Arabic language with the permission of the author. The Arabic version of STAT was revised by some researchers in the Educational Psychology department of Sohag, South Valley University (Egypt). Then, the STAT was translated back into English to ensure adequate translation and reviewed by some Arabic speaking research students in the School of Education, the University of Birmingham, UK. Some of the original items which did not apply to the Arabic context were changed. In order to establish its factorial structure, a principal components analysis with Varimax rotation was performed with 852 secondary school students from Sohag City on the subtests of STAT (9 subtests). The factor analysis showed that the STAT measures three abilities which it is supposed to measure. The Alpha Cronbach reliabilities of the subtests were computed for the multiple-choice items. These reliabilities were .69 for the analytical items, .65 for the creative items, and .60 for the practical items. However, it should be borne in mind that this test has been constructed particularly to identify gifted students, so it seems that it is difficult for normal students.

Raven's Standard Progressive Matrices (RSPM)

The RSPM is known as one of the most widely used intelligence tests in the world. It is commonly reviewed as a *culture-free* intelligence test. The RSPM may be described as consisting of 60 visual analogy problems, each having the form of a two-way Serial Analogies Test. In each set the first problem is as nearly as possible self-evident. Each item consists of a matrix of geometric designs which are presented as the problem with one design removed from the sequence. The individual's task is to educe the theme of relations expressed among the designs and choose the missing figure from among the options set. The items on the RSPM are divided among five sets (A through E). Items in a given set share a common theme of relations; however, the nature of the relations increases in complexity within a set as well as across the sets (i.e., set E is the most difficult set).

The items of the first set, set A, consist of "continuous patterns" (as Raven calls them). In the sets B-E each item consists of four (set B) or nine figures (set C-E) in which one figure is missing. At the bottom of the page, six (set B) or eight (set C-E) numbered figures (the response categories) are arranged in two rows. In all of these, only one completes the missing figure above it. Everyone, whatever his age, is given exactly the same series of problems in the same order and is asked to work at his/her own speed, without interruption, from the beginning to the end of the scale. As the order of the problems provides the standard training in the method of working, the scale can be given either as an individual, a self-administered or as a group test.

Problem-Solving Tasks

The researcher applied four problems adapted from the literature of thinking. To allow for variations in processing, some problems were chosen to be more dependent on verbal processing while others were more dependent on imagery processing. All the problems were modified to be paper-and-pencil tests. A brief description of each problem is given below.

The First Problem

This problem was adopted from Maier's work (1968). In this problem, two cords were hung from the ceiling, one hung near the wall, the other from the centre of the room. The task of the subject was to tie the ends of these two cords together using any objects available (such as poles, clamps, pliers or extension cords). The problem is that if the subject holds either cord in his or her hand he or she cannot reach the other.

The Second Problem

This problem was adopted from Saugstad and Raaheim's work (1960). In this problem, the task of the subject was to transfer a number of steel balls from a glass into a metal cylinder. The glass containing the steel balls was placed on a movable wooden frame and the metal cylinder was to the side of it. The subject had to keep behind a wooden table, or a chalk line, 260 cm. away from the wooden frame. At his disposal for the solution of the problem the subject had four newspapers of a certain size, a length of string, a pair of pliers, five elastic bands and one iron nail.

The Third and Fourth Problems

These problems tested insight. These problems were simple in structure. In the third problem, the subjects were given a triangle pointing upwards consisting of ten circles. They were asked to show how to make the triangle to point downwards by moving only three circles. In the fourth problem, the subjects were asked to arrange 10 coins so as to give 5 rows (lines) with 4 coins in each row.

Procedure

All participants undertook the four problem-solving tasks. RSPM, STAT and CSA. The RSPM was applied first, and then the STAT. The four problems were given later at three different times. There was no limited time for solving these problems. However, students averaged 15 minutes for solving each one. The responses from the four problems were scored as follows: correct = 1, incorrect = 0. Participants carried out each instrument in the same order in their class groups (there were 16 classes in all). Under the supervision of the present researcher, students did the Arabic version of computer-presented Cognitive Styles Analysis (CSA) in the computer lab of the schools which contained 15 computers.

RESULTS

For the purposes of the analysis, the sample was divided in terms of their cognitive style ratio into two categories based on the medians to give four cognitive style groups of similar size as follows:

(a) Wholist-Analytic dimension: Wholists, 1.38 or less; Analytics, 1.39 or more.

(b) Verbal-Imager: Verbalisers, 1.15 or less; Imagers, 1.16 or more.

In terms of RSPM scores, the sample was divided into two groups: the first group was 50 or below, and the second was 51 to 60. The analytical, practical and creative abilities were also divided into two levels. The results were divided into four main sections (a problem in each section), each section including analysis of four parts as follows:

1. RSPM, gender and cognitive style.
2. Analytical ability, gender and cognitive style.
3. Practical ability, gender and cognitive style, and
4. Creative ability, gender and cognitive style.

The Hiloglinear model was used to analyse the data. The Hiloglinear was called for because the data were highly skewed in their distribution. The Hiloglinear model is a way of summarizing and highlighting the association in a complex crosstabulation table. It allows us to compare a number of models to see which best fit the data. The design is called hierarchical, in that it assumes that if there are interactions in the model then the main effects will also be present (Clark-Carter, 1999: 364). In HiLoglinear models, all the variables which are used for classification are independent variables, and the dependent variable is the number of cases in a cell of the crosstabulation. Since backward elimination appears to be the better procedure for model selection (Norusis, 1993, 162), it is the only procedure used here. Only significant interactions will be mentioned.

Problem 1.

A series of Hiloglinear analyses was done on the students' performance on problem (2), including RSPM (2), STAT (analytical (2), practical (2) and creative ability (2), WA style (2), VI style (2) and gender (2).

TABLE 1. Output of Hiloglinear: The Backward Elimination of Problem 1

	DF	L.R. Chisq Change	Prob.	Iteration
Problem solving*RSPM	1	7.747	.0054	2
Problem solving*WA	1	6.787	.0092	2

There were two significant interactions. The first interaction was between problem solving performance and RSPM (P = .005). As expected, the students of high intelligence were more superior to those of low intelligence. The second interaction was between problem and WA style (P = 0.009). The Analytics were superior to Wholists in solving this problem.

Problem 2

The backward Elimination with generating class problem (2) by RSPM (2) by gender (2) by WA (2) by VI (2) indicated that there was a significant interaction between problem-solving performance and RSPM (Table 2), with the most intelligent students being superior to the lowest.

TABLE 2. Output of Hiloglinear: The Backward Elimination 0f Problem 2

	DF	L.R. Chisq Change	Prob.	Iteration
Problem*RSPM	1	12.227	.0005	2
Problem*Analytical Ability	1	8.153	.0043	2
Problem*practical ability* Gender* VI	1	4.723	.0298	4

There was a significant interaction between problem solving and analytical ability. The students of high analytical ability were superior to the students of low analytical ability. In addition, there was a significant four-way interaction between problem by practical ability by gender and VI style, and this is shown in Figure 2.

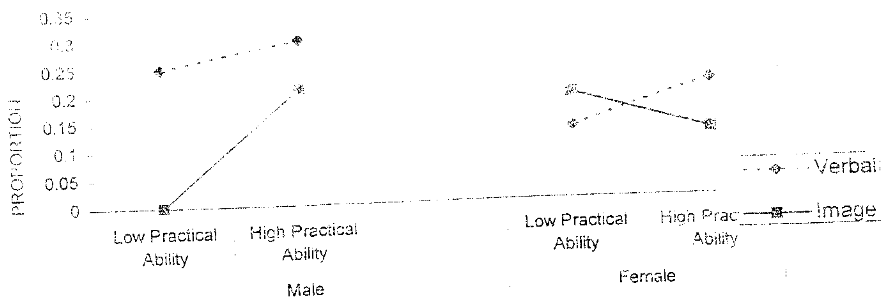

FIG. 2 The Effect of Practical Ability and VI Style on Problem 2

Inspection of Figure 2 shows that in the low practical ability group, the male Verbalisers were the highest, while the male Imagers were the lowest. In the high practical ability group, the male Verbalisers were the highest while the female Imagers were the lowest.

Problem 3

The results indicated that there was a significant three-way interaction between the problem, RSPM and VI style, and this is shown in Figure 3. It is clear from Figure 3 that the means of the Verbalisers are roughly equal, and the major difference is between the Imager groups.

TABLE 3. Output of Hiloglinear: The Backward Elimination of Problem 3

	DF	L.R. Chisq Change	Prob.	Iteration
Problem*RSPM*VI	1	5.432	.0198	3
Problem*Analytical Ability	1	8.153	.0043	2
Problem*Creative ability*WA	1	5.900	.0151	3

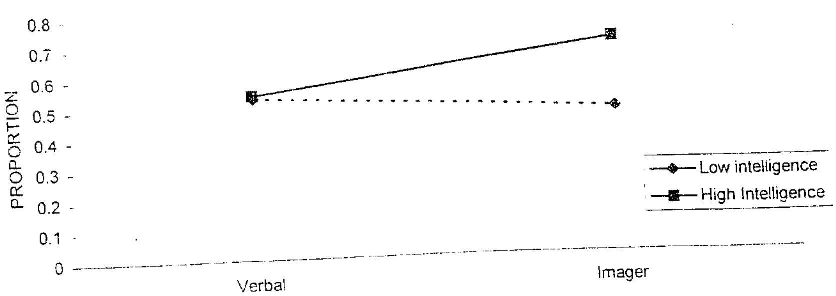

FIG. 3 The Effect of RSPM and VI on Problem 3

There was a significant interaction between the problem and analytical ability, with those of the highest intelligence being superior to the lowest in problem solving performance. There was a significant three-way interaction between problem, practical ability and gender. In the low practical ability group, the females were superior to the males, while in the high practical ability group the reverse was the case. There was also a significant interaction between problem solving, creative ability and WA style. This is shown in Figure 4.

FIG. 4 The Effect of Creative Ability and WA style on Problem 3

Inspection of Figure 4 shows that the performance on problem 3 was little affected by Wholist style but it was greatly affected by Analytic style. The Analytics of high creative ability were the highest while Analytics of low creative ability were the lowest.

Problem

The Backward Elimination with generating class problem (2) by RSPM (2) by gender (2) by WA (2) by VI (2) indicated that there was a significant three-way interaction between problem, RSPM and WA style (P = 0.036). This is shown in Figure 5.

TABLE 4. Output of Hiloglinear: The Backward Elimination of Problem 4

	DF	L.R. Chisq Change	Prob.	Iteration
PROBLEM*RSPM*WA	1	4.374	.0365	4

Inspection of Figure 5 shows that the performance on problem 4 was little affected by the Wholist style but it was greatly affected by Analytic style. Again, the Analytics of high intelligence were the highest while Analytics of low intelligence were the lowest.

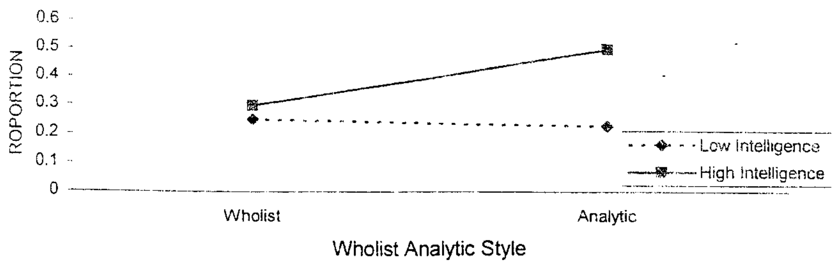

FIG. 5 The Effect of RSPM and WA Style on Problem 4

DISCUSSION

The aim of this study was to investigate the way in which both cognitive style and intelligence affect problem-solving performance of gifted students. The main interest was in studying unconventional problems which require a more creative approach than is the case with conventional or well-defined problems. The hypothesis was that both intelligence and cognitive style affect problem-solving performance but in different ways.

The findings of this study supported this hypothesis. Intelligence has almost always affected the problem-solving performance positively, in that the differences between the students of high and low intelligence were always in favour of the highly intelligent students. However, the effect of cognitive style on problem-solving performance could be either positive or negative, depending on the nature of each problem. This difference between the way in which both intelligence and cognitive style affect problem-solving performance will become clearer as the results are discussed.

Intelligence and Problem solving

It was expected that intelligence would be correlated to problem-solving performance, because of the wide-ranging content of intelligence tests and also because of the same types of information processing which are present in both sets of activities.

There were significant effects of RSPM on the performance of problems 1 and 2 but not on that of 3 or 4. This may be because problems 3 and 4 are insight problems and this kind of problem calls for problem finding, in which the operators needed to transform the given state of the problem, which is not clearly defined into the goal state, as must be elaborated by the problem solver (Jausoves, 1994: 82) and this is not the case with RSPM's items. In problems 1 and 2, there were significant effects of RSPM in favour of the highly intelligent students. This result can be understood in terms of the relationship between intelligence and creativity. It is believed that "*highly intelligent people are more likely to be creative than are people with lower intelligence, but that high intelligence is neither a necessary nor a sufficient condition for creativity*" (Nickerson, 1999: 396).

Although the conventional theory of creativity supposes that intelligence and creativity are separate constructs, later theory emphasises that the two work together (e.g., C..rpley, 1994). A combination of the two is needed for higher levels of creative behaviour (Renzulli, 1986). An early conceptualisation of the way in which they combine is the *threshold model*, according to which a minimum level of intelligence (about 120-130 IQ) is necessary before creativity is possible (Runco & Albert, 1986).

Cognitive Style, Intelligence and Problem Solving

The findings suggest that both individuals' abilities and cognitive styles influence problem-solving performance and mediate the relationship between the person and eventual achievement. In problem 1, both WA style and RSPM affected the problem-solving performance. There was a significant interaction between problem and WA style. The Analytics were superior to the Wholists in solving this problem. It is worth mentioning that whereas there was a significant effect of WA, there was no significant effect of analytical ability. It appears that the way in which a person organises information was a main point in solving this problem.

In problem 2, there was a significant four-way interaction between problem, practical ability, gender and VI style. For the practical low ability group, the male Verbalisers were the best, while the male Imagers were the worst. For the practical high ability group, the male Verbalisers were the best, while the female Imagers were the worst. It is worth mentioning here that with low practical ability, none of the male Imagers managed to solve this problem while the male Verbalisers of low practical ability did better than both the male Imagers and the female Imagers of high practical ability. The researcher noted that during the test, many students commented that could not solve the problem verbally and they wanted to draw the solution instead of writing it.

All these students were Imagers. This observation reveals the effect of the verbal context of this problem on the Imagers especially those who had low practical ability. This may show that visual strategies were not useful for solving this problem.

A significant three-way interaction was found between problem 3, RSPM and VI style. For the low intelligence group, the Verbalisers were superior to the Imagers in problem solving performance, while for the high intelligence group the Imagers were superior to the Verbalisers. The result showed that the means of the Verbalisers were equal, while the major difference was between the Imager groups. The problem is agreed to be a nonverbal problem, and, to solve it, one should visualize the 'coins' in different ways and this may explain why the Imagers were superior in solving this problem.

There was also a significant interaction between problem solving, creative ability and WA style in problem 3. The Wholists of low creative ability were superior to the Analytics, while the Analytics of high creative ability were superior to the Wholists in problem-solving performance. There was no difference between the performance of the Wholists of low creativity and the Wholists of high creativity. However, the main difference was between the Analytic groups, where the Analytics of high creativity were superior to the Analytics of low creativity. However, it seems necessary to interpret this result cautiously, since this interaction appeared only with this problem. Further research is needed to clarify the relationship between the two dimensions and creativity using different measures to assess creativity.

There was also a significant three-way interaction between the problem, RSPM and the WA style on problem 4, with the Analytics of high intelligence being the superior group. The performance on problem 5 was little affected by the Wholist style but it was greatly affected by the Analytic style. Again, the analytics of high intelligence performed best while the Analytics of low Intelligence performed least well.

The findings demonstrate that it is not only individuals' abilities which influence problem-solving performance, but also the individuals' cognitive style which mediates the relationship between the person and eventual achievement. The results also suggest that future studies of problem solving should take into account the effects of individuals' cognitive style on their performance.

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