NONABSOLUTE/ RELATIVISTIC (N/R) THINKING: A POSSIBLE UNIFYING COMMONALITY UNDERLYING MODELS OF POSTFORMAL REASONING

by

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A THESIS SUMMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE STUDIES

(Department of Educational Psychology and Special Education)

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

March 1995

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Date March 21, 1995

ABSTRACT

This dissertation identified and addressed four of the unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected models of postformal reasoning, namely Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment.

A total of 254 participants aged 10 to 48 and attending Grade 5 to doctoral studies were involved. Each participant was administered eight tests in pencil-and-paper format to measure eight different constructs of thinking. Different specific hypotheses were evaluated through different statistical approaches.

The four identified issues were addressed as follows:

Firstly, nonabsolute/ relativistic thinking was reconceptualized and operationally defined as a multidimensional and multilevel construct. Two dimensions were proposed: the basic form and the epistemic view. Within the basic form dimension, two levels were proposed: the formal and the postformal forms.

Secondly, a battery of three tests was specifically designed by Arlin and the author to measure the different dimensions and levels of nonabsolute/ relativistic thinking.

Thirdly, strong empirical evidence was obtained supporting the general hypothesis that nonabsolute/ relativistic thinking is a possible unifying commonality underlying the four selected postformal models. Within the construct of nonabsolute/ relativistic thinking, two dimensions, the basic form and the epistemic view, can be differentiated as hypothesized.

Fourthly, empirical evidence was also obtained supporting the general hypothesis that nonabsolute/ relativistic thinking is an instance of both formal and postformal reasoning. Specifically within the basic form dimension, two qualitatively different forms, the formal and the postformal, can be differentiated as hypothesized. Findings

also suggested that the development of a nonabsolute epistemic view might play a crucial role in the development of the postformal form. Therefore, the emergence of the postformal form can be explained by a paradigm shift from an absolute to a nonabsolute epistemic view. Performances in the tests of the postformal form and of the epistemic view in combination were found to be good predictors of performances in the selected postformal tests.

Significant implications of the findings are that nonabsolute/ relativistic thinking represents a form of metamorphosis from closed-system to open-system thinking and it might serve as a potential springboard in the development of higher order thinking.

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ACKNOWLEDGEMENTS

First of all, I would like to thank the three advisors on my dissertation advisory committee. My gratitude goes to Dr. Patricia K. Arlin who is the major inspiration for this dissertation. Her support throughout the study from inception to fruition is appreciated beyond words. My sincere thanks also go to Dr. Marion Porath for her stimulating ideas and fresh perspectives. I am also extremely grateful to Dr. Nand Kishor for his expert advice in all the statistical analyses of my study, particularly in confirmatory factor analysis.

I would like to express my gratitude to the following persons for their special permission to cite or use their work:

Dr. Patricia K. Arlin for her permission to use her Problem Finding Task, to adapt the Arlin Test of Formal Reasoning, and to use her adaptation of the scoring criteria of the tests of Dialectical Reasoning and of Reflective Judgment. Her joint authorship in the designing of the battery of the three tests of nonabsolute/ relativistic thinking is also much appreciated.

Dr. Karen Kitchener and her colleagues for the permission to use and adapt the test of Reflective Judgment Interview copyrighted by King and Kitchener in 1978.

Dr. Deirdre A. Kramer for all the information she had generously shared with me.

Dr. Jan Sinnott for her permission to use her test of Relativistic Operations and for her advice on the scoring criteria.

Dr. Marylou F. Worthen for sharing with me her unpublished papers and her Preformal, Formal, Postformal-Relativistic Test (PFPR Test) of Cognitive Development.

I would like to thank the following persons for their generous help in the recruitment of participants: Dr. Patricia K. Arlin, Heesoon Bai, Dr. Elizabeth Jordan, Ophelia Kan, Dr. Nand Kishor, Dr. William McKee, Joyce Poon, Dr. Marion Porath, and Barbara Turnboll. I am equally thankful to all the participants without whose participation, this study would not be realized.

I would like to express my appreciation to the principal of Selkirk Secondary School, Mr. J.P. Harrington, and his staff and the principal of Killarney Secondary School, Mr. G. May, and his staff who had been very helpful in the process of recruitment of participants.

My gratitude also goes to Ophelia Kan for her very professional and indispensable help in serving as the second rater in the scoring of all the test protocols and in editing the manuscript.

My appreciation goes to the faculty, staff and fellow students of the Department of Educational Psychology and Special Education who have been extremely supportive in many ways. My appreciation also goes to the staff of the Education Computing Services for their invaluable assistance.

As my study spans a period of time throughout which innumerable persons have given me their support, I am unable to list all of them but my thanks go to each and every one of them.

Last but not least, my deepest gratitude goes to my mother for her patience and standing by me all these years.

DEDICATION

This dissertation is dedicated to my parents and all my teachers with deep gratitude.

CHAPTER I: INTRODUCTION

The purpose of this study is to explore nonabsolute/ relativistic (N/R) thinking as one of the possible unifying commonalities underlying the models of postformal reasoning. There has been speculation that nonabsolute/ relativistic (N/R) thinking might be required for the performance of higher order thinking, specifically in postformal reasoning (see Arlin, 1974, 1975/6; Basseches, 1980; King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981; Kramer, 1983a; Riegel, 1973; Sinnott, 1981, 1989). In this light, better understanding about nonabsolute/ relativistic (N/R) thinking could be of benefit to the field of cognitive development and education, be it formal or informal. However, the specific nature of nonabsolute/ relativistic (N/R) thinking is still an open question if not a question unexplored. Thus in this study, an attempt is made to explore nonabsolute/ relativistic (N/R) thinking in the context of both formal and postformal reasoning from a developmental perspective.

A. BACKGROUND OF THE STUDY

Piaget's interdisciplinary research was historically the dominant theory of cognitive development for several decades. However, in the past decade or so, Piaget's theory of cognitive development, particularly his structural stage model has been seriously questioned or even dismissed by some researchers (e.g. Brainerd, 1978; Broughton, 1984; Siegler, 1981).

Particularly as a reaction to Piaget's claim that formal reasoning/ operations represent the final stage of cognitive development, a number of models of postformal reasoning and adult cognition has been proposed. Most of these proposed models share the conviction that, by ending the stages of cognitive development in adolescence, Piaget

truncated developmental concepts of both adulthood and cognition (Arlin, 1975; Commons, Armon, Kohlberg, Richards, Grotzer & Sinnott, 1990; Commons, Richards & Armon, 1984; Commons, Sinnott, Richards & Armon, 1989; Mines & Kitchener, 1986).

During the first decade of research on postformal reasoning/ operations, researchers focused on creating models and developing measures. Thus postformal reasoning has grown to become a collective label for a wide range of models describing late adolescent and adult thinking. Some of these models might be considered as continuations or extensions of the formal stage, and as such they represent one facet of the neo-Piagetian movement. On the other hand, other models represent entirely different forms or views of adult cognition. The models of postformal reasoning extended into very diverse domains and were formulated through very different approaches.

Recently, there seems to be a growing interest in unifying models and organizing data across domains and measures. In the attempt to unify the diversity in the field, one approach is to interrelate empirically the different postformal sequences through "cross measures" and "cross domains" studies (e.g. Cavanaugh & Stafford, 1989; Commons et al., 1984; Commons et al., 1989; Hoyer et al., 1989; Kitchener & King, 1985). As revealed in these studies, the line of transition from formal to postformal thinking is by no means clear cut. For example, Cavanaugh and Stafford (1989) found that a person may be identified as functioning at the postformal level using a test developed by Labouvie-Vief and colleagues (Labouvie-Vief, Adams, Hakim-Larson & Hayden, 1983), but not necessarily so using a test developed by Commons and colleagues (Commons, Richards & Kuhn, 1982). Such kind of intra-individual discrepancies might reflect problems associated with measurement, or level of task difficulty , or domain specificity, or a combination of these factors.

However, before entertaining the above mentioned possibilities which might be an explanation for the intra-individual discrepancies regarding the performances with

postformal reasoning tests, I would argue that a more fundamental issue needs to be addressed, that is, do the postformal reasoning tests in question share any basic commonalities at all? This fundamental issue is precisely the concern of another approach by which attempts were made to unify the field of postformal research through theoretically analyzing the forms or structures of certain postformal models in order to identify their commonalities (Kramer, 1983; Kitchener, 1983; Arlin, 1984; Commons & Richards, 1984).

There has been speculation that nonabsolute/ relativistic (N/R) thinking may be one of the possible unifying commonalities underlying a cluster of postformal models and measures. A number of researchers has independently suggested that nonabsolute/ relativistic (N/R) thinking is required for postformal reasoning (e.g. Arlin, 1975, 1975/6; Basseches, 1980; King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981; Riegel, 1973; Sinnott, 1981, 1989). In a similar vein, Kramer (1983a) proposed that nonabsolute/ relativistic (N/R) thinking may be one of the core features underlying the models of postformal reasoning. However, I would argue that the proposition that nonabsolute/ relativistic (N/R) thinking as one of the commonalities underlying the models of postformal reasoning contains unresolved issues. Research is needed to explore and possibly resolve these issues.

B. PROBLEM STATEMENTS

Four of the unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the models of postformal reasoning are identified and addressed in this study.

The first unresolved issue concerns the lack of empirical evidence in support of the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible

unifying commonalities underlying the models of postformal reasoning. It appears that such a proposition has yet to be tested empirically. However, before submitting such a proposition to empirical testing, there are other basic issues to be addressed.

The second unresolved issue is whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature. An implicit assumption held by some of the researchers is that in order for nonabsolute/ relativistic (N/R) thinking to be qualified as a common feature of postformal reasoning, it is necessary to demonstrate that it possesses a form or structure that is postformal in nature (Cavanaugh, Kramer, Sinnott, Camp & Markley, 1985; Kramer, 1983b). While some researchers suggested that some kind of relativistic thinking is required for postformal reasoning (e.g. Arlin, 1984, 1990; Kramer, 1983a; Sinnott, 1981, 1989), other researchers questioned whether nonabsolute/ relativistic (N/R) thinking is really postformal (Cavanaugh et al., 1985; Kramer, 1983b). The counter-argument as primarily advanced by Kramer (1983b, 1986) contended that the awareness of relativity, contrary to prediction, was found to be necessary but not sufficient for formal operations. Therefore, it is debatable whether nonabsolute/ relativistic (N/R) thinking is an instance of formal or postformal reasoning.

The discussion of both the first and second unresolved issues would necessarily extend to the third and the fourth unresolved issues. The third unresolved issue concerns the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. The fourth unresolved issue concerns the need for the design of a measure of this very construct. As suggested in the relevant literature, there is really no consensus among the researchers regarding the specific nature of nonabsolute/ relativistic (N/R) thinking, let alone the definition and measurement of such a construct (Arlin, 1974, 1975/6; Basseches, 1980; Cavanaugh et al., 1985; Kitchener, 1986; Kitchener & King, 1981; Kramer, 1983a; Riegel, 1973; Sinnott, 1981). I would argue that both the first and second unresolved issues are hinged upon and eventually have to be related to the third and the fourth unresolved issues. The reason is that without an operational definition and

measurement of the construct of nonabsolute/ relativistic (N/R) thinking, there is really no basis for 1) testing empirically the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the selected models of postformal reasoning, and for 2) determining the structural stage status of nonabsolute/ relativistic (N/R) thinking.

The focus of this study is to address these four unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the several models of postformal reasoning.

C. RESEARCH QUESTIONS

Research Question 1:

How can nonabsolute/ relativistic (N/R) thinking be operationally defined?

This research question is designed to address the third unresolved issue concerning the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. To address this question, nonabsolute/ relativistic (N/R) thinking would be defined as a multidimensional and multilevel construct. Two of the dimensions to be explored are the basic form dimension and the epistemic view dimension associated with nonabsolute/ relativistic (N/R) thinking. Within the dimension of basic form, nonabsolute/ relativistic (N/R) thinking would be defined at both the formal and postformal level.

Research Question 2:

How can nonabsolute/ relativistic (N/R) thinking be measured?

This research question is designed to address the fourth unresolved issue concerning the need for the design of a measure of nonabsolute/ relativistic (N/R) thinking. To address

this question, nonabsolute/ relativistic (N/R) thinking would be measured as a multidimensional and multilevel construct. A battery of three tests of nonabsolute/ relativistic (N/R) thinking are proposed in this study to measure 1) the formal form, 2) the postformal form, and 3) the epistemic view of nonabsolute/ relativistic (N/R) thinking.

Research Question 3:

Is nonabsolute/ relativistic (N/R) thinking a common factor underlying the selected models of postformal reasoning?

This research question is designed to address the first unresolved issue concerning the lack of empirical evidence in support of the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the models of postformal reasoning. To address this question, the inter-relationships among the tests of postformal reasoning and of nonabsolute/ relativistic (N/R) thinking would be explored.

Research Question 4:

Is nonabsolute/ relativistic (N/R) thinking an instance of formal or postformal reasoning or of both?

This research question is designed to address the second unresolved issue concerning whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature. To address this question, the relationship among nonabsolute/ relativistic (N/R) thinking, formal reasoning and the selected models of postformal reasoning would be empirically explored. The different dimensions and levels of nonabsolute/ relativistic (N/R) thinking would also be employed for prediction purposes.

D. SIGNIFICANCE OF THE STUDY

The focus of this study is the exploration of whether nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the models of postformal reasoning. The search for commonalities underlying the selected postformal models would serve two purposes: 1) to unify the diversity in the field of postformal research; and 2) to differentiate some of the qualities of postformal reasoning from those of formal reasoning.

From a theoretical perspective, this study deals with a specific segment within a broader context of problems, namely the search for possible connections among the different models of postformal reasoning and between formal and postformal reasoning.

As Arlin (1989) pointed out, the logic and mechanism of the transition between formal and postformal operations have yet to be discovered. Thus I would argue that a better understanding about the possible commonalities underlying a specific cluster of postformal models might help shed some light on the transition from formal to postformal reasoning in specific, and from lower to higher order thinking in general.

At an empirical level, attempts are made to define operationally, and to measure quantitatively the construct of nonabsolute/ relativistic (N/R) thinking, as well as to relate empirically such a construct with formal and postformal reasoning. Thus such attempts might represent an alternative approach to the work done on relativistic thinking by Sinnott (1981, 1989) and Kramer (Cavanaugh et al., 1985; Kramer, 1983a) among others.

From an applications perspective, I would argue that the framework of nonabsolute/ relativistic (N/R) thinking could be applied to operate on a wide variety of domains such as issues in science, humanities, laws, politics, religion, and morality of today as well as real life problems of everyday living. In a clinical and educational sense, the framework of nonabsolute/ relativistic (N/R) thinking could be used to

diagnose the presence or absence of the basic forms and the epistemic views associated with such types of thinking. The framework of nonabsolute/ relativistic (N/R) thinking could also provide suggestions for the development of more powerful forms of data manipulation so as to facilitate more effective means of problem finding and problem solving.

As findings of this study support the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected models of postformal reasoning, further research is called for to investigate both the theoretical and applied implications of such findings. Since one of the prime concerns of education is the development of cognitive potentials, the findings of this study could be of particular interest. Future research would be desirable to explore possible ways of promoting and facilitating the development of nonabsolute/ relativistic (N/R) thinking which in turn might serve as a springboard for the development of higher order thinking within and across domains.

E. DEFINITION OF TERMS

Formal reasoning:

Formal reasoning or formal operations are postulated by Piaget to represent the final stage of cognitive development (Inhelder & Piaget, 1958). The major characteristic of formal reasoning is the ability to engage in "abstract thinking" which permits the reversibility between reality and possibility. Its essential features include hypothetical-deductive reasoning, propositional thinking and construction of all possible combinations (see Arlin, 1975; Byrnes, 1988; King, 1986; Neimark, 1975, 1979, 1982).

Nonabsolute/ relativistic (N/R) thinking:

Nonabsolute/ relativistic (N/R) thinking has been proposed to be one of the possible unifying commonalities underlying the models of postformal reasoning. This type of thinking is often contrasted with the kind of relatively more absolute and rigid thinking associated with formal reasoning. There is no consensus among researchers regarding the specific nature of nonabsolute/ relativistic (N/R) thinking. The terms "nonabsolute" and "relativistic" are often used interchangeably. The connotation of such terms is often vague and open for interpretation.

According to the classical definition of relativity by Inhelder and Piaget (1958), a simple form of relativity can be defined as the coordination of two or more frames or systems of reference, which is one of the eight formal operational schemata or concepts. Arlin (1984a) argued that this schema might represent the pivotal concept that marks the transition from high-formal to postformal reasoning.

Taking Arlin's (1984a) argument one step further, it is proposed in this study that nonabsolute/ relativistic (N/R) thinking can be defined as a multidimensional and multilevel construct.

Postformal reasoning:

Postformal reasoning or postformal operations are defined through a wide range of models which have been designed to describe late adolescent and adult thinking, specifically thinking beyond formal reasoning (see Commons et al., 1984). The proposal of postformal reasoning can be viewed as the result of dissatisfactions regarding the claim made by Inhelder and Piaget (1985) that formal reasoning represents the final stage of cognitive development. Researchers in the field of postformal reasoning generally claim that adult thinking contains the framework of formal reasoning and other frameworks as well. This kind of development results in multiple frameworks under

which formal operations are used within a higher-stage system of operations. These frameworks provide the means to transcend the limitations of formal reasoning.

Models of postformal reasoning associated with nonabsolute/ relativistic (N/R) thinking:

The models of postformal reasoning postulated to be associated with nonabsolute/ relativistic (N/R) thinking include: problem finding (Arlin, 1974, 1975/6), dialectical reasoning (Basseches, 1980), relativistic operations (Sinnott, 1981, 1989), and reflective judgment (King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981).

More detailed discussion on the terms mentioned above is presented in the literature review in chapter II.

CHAPTER II. LITERATURE REVIEW

A review of the pertinent theoretical and empirical literature related to postformal reasoning is provided in this chapter. This chapter is composed of four parts: A) Formal reasoning--a final stage?; B) Postformal reasoning--beyond formal reasoning; C) Nonabsolute/ relativistic (N/R) thinking--a proposed unifying commonality underlying postformal models; D) Summary and discussion.

Part A (Formal reasoning) serves as a background for the discussion of part B (Postformal reasoning) which in turn provides a context for the discussion of part C (Nonabsolute/ relativistic (N/R) thinking). Finally, a summary of the literature review is provided that leads to the development of research questions.

A. FORMAL REASONING--A FINAL STAGE?

1. Overview

Piaget described cognitive development as a process of acquisitions of general structures that are related to each other in a logical and hierarchical sequence. Within this framework of the developmental process, he posited four structural stages: 1) sensorimotor (0-2 years), 2) pre-operational (2-7 years), 3) concrete operational (7-11 years), and 4) formal operational (11 years and above).

The focus of part A is to provide a brief introduction to the formal operational stage (see Inhelder & Piaget, 1958). The formal operational stage as considered by Inhelder and Piaget (1958) is unique. It is the "final equilibrium" in cognitive development. This claim was made despite the fact that the oldest subject's protocol reported was 16 years 10 months (Inhelder & Piaget, 1958, p.60).

The major characteristic of formal reasoning/ operations is the ability to engage in "abstract thinking" which contrasts with concrete thinking of the previous stage and which permits the reversibility between reality and possibility. Associated with this major characteristic of formal reasoning are several essential features that include: 1) hypothetic-deductive reasoning which involves the ability to generate hypotheses and subject them to empirical investigation; 2) propositional thinking which involves the ability to think in terms of propositions and to make logical inferences and 3) construction of all possible combinations which involves the ability to generate all possible combinations of variables systematically. This strategy ensures a complete listing of "the possible" from which "the real" may be identified. (see Arlin, 1975; Byrnes, 1988; King, 1986; Neimark, 1975, 1979, 1982).

According to Piaget (Inhelder & Piaget, 1958, 1969), formal operations are associated with two logical-mathematical models, namely 1) the combinatorial system, and 2) the INRC group of transformation. The first model, the combinatorial system, is also known as the 16 binary combinations. Through this model one can generate the listing of possibilities of elements and their relations. The second model, the INRC group, is a representation of the Klein 4-group which is borrowed intact from abstract algebra (Brainerd, 1978a, 1978b). The four groups of transformation are: Identity (I), Negation (N), Reciprocity (R), and Correlative (C). In this model the relationships among sets of propositions are described. (see Brainerd, 1978a, 1978b; Brynes, 1988; Inhelder & Piaget, 1958, 1969; King, 1986 for more detailed discussion on the two logical-mathematical models.)

Inhelder and Piaget (1958) identified eight formal operational schemata or concepts which are dependent not only upon the logical-mathematical operations but also on "appropriate data" and "experience" (see p.308). These eight concepts are: 1) multiplicative compensations, 2) correlations, 3) probability, 4) combinations, 5) proportions, 6) forms of conservation beyond direct verification, 7) mechanical

equilibrium, and 8) co-ordination of two or more frames or systems of reference which is said to require a simple type of relativistic thinking (Arlin, 1980, 1984a, 1984b, 1986a; Inhelder & Piaget, 1958).

2. Criticisms

Piaget's model of formal operations has been the subject of much criticism. The more common types of criticism are as follows and they are by no means mutually exclusive:

1) The first criticism is that the model lacks parsimony (cf. Brainerd, 1978) and empirical fit (cf. Bynum, Thomas & Weitz, 1972). It has been pointed out that the logical competency as described by Piaget's model of formal operations cannot be detected in the performance of adolescent subjects. Thus, a less elaborate model would already be sufficient to explain adolescent thinking (see Commons, Richards & Armon, 1984).

2) The second criticism represents a radical rejection of the stage model in general and of the model of formal operations in particular (cf. Broughton, 1984; Riegel, 1973). This type of criticism challenges the entire theoretical foundation of the model. It argues that the centrality of logic in the model of formal operations precludes all other dimensions of cognition, and has taken cognitive development completely out of the context of reality. Broughton (1984), in his criticism of Piaget's theory, argued that there are at least 15 major problems with the formal operational model. Each is taken as a refutation of Piaget's assumptions. All are taken to comprise a critical mass necessitating a replacement of Piaget's theory. According to Broughton (1984), "the issue is not one of the stage 'beyond formal operations', it is one of the stages 'beyond Piaget'" (p.411).

I would argue that this type of criticism might be right in that the model of formal operations cannot adequately represent the multidimensional character of cognitive development. However, this does not necessarily mean that the study of cognitive development should exclude the dimension of formal operations completely. Rather the study of cognitive development might be expanded to include other dimensions besides those associated with formal operations.

3) The third criticism is a challenge to the universality of Piaget's theory, especially the stage of formal operations (Broughton, 1984; Buck-Morss, 1975; Laboratory of Comparative Human Cognition (LCHC), 1982). Piaget's theory has been criticized as being ethnocentric and socioeconomically biased because formal thinking is found to be absent in many world cultures, and is not even universally present in the population of Western cultures (Buck-Morss, 1975). Piaget (1972) revised his position regarding the stage of formal operations even within Western culture. He recognized that the first results had been "based on a somewhat privileged population". Nevertheless, he maintained that all individuals reach the stage of formal operations, if not between 11 and 15 years, at least between 15 and 20. Piaget (1972) suggested that they reach this stage in different domains according to their professional specializations. Dasen (1977) referred to this limitation as a source of paradox: the formal operations, which were supposed to be context-free, are in fact context-bound or at least domain-specific.

According to Chapman (1988), what seems necessary is a model of development-in-context that would do justice to two intuitions: a) that variation in forms of cognition exists as a function of socio-cultural context, but b) that some forms of cognition may nevertheless be judged as more "advanced" than others in some restricted sense. Chapman pointed out that Piaget's stage theory is limited in the sense that it is unidirectional (with only one stage sequence) and teleological (with a fixed end point). He proposed to reconceptualize cognitive development as being multi-directional and non-teleological. The notion of multidirectional development implies that there could be

more than one developmental pathway. That means that there could well be other developmental sequences other than that proposed by Piaget. The notion of non-teleological development implies that it is not exactly necessary to establish a fixed end point of development. Developmental progress do not have to be measured in terms of the decreasing distance towards the end point, but can be traced in terms of the increasing distance away from the identified source of error.

4) The fourth criticism is that the model of formal operations is too limited to capture the richness and complexity of adolescent and adult thinking. It is suggested that there are other forms of thinking which might develop parallel to formal thinking and supplement it (e.g. Riegel, 1973). These other forms of thinking might also develop after formal thinking and might even replace it (cf. Arlin, 1975; Commons, Richards et al. 1984). In fact I would argue that this type of criticism is not incompatible with Chapman's (1988) proposal that cognitive development can be reconceptualized as being multi-directional and non-teleological.

This fourth criticism provides the basis to explore potential development beyond formal reasoning. As a result, more sophisticated types of thinking have been proposed and they are generally grouped under the collective label of "postformal" reasoning (see Commons, Richards et al, 1984).

B. POSTFORMAL REASONING--BEYOND FORMAL REASONING

1. Overview

Postformal reasoning is a collective label for a wide range of models of adult thinking, specifically thinking beyond formal operations.

As mentioned in the previous section, some researchers in the mid-1970's began to challenge Piaget's claim about formal operations being the final stage of cognitive development. Riegel (1973) proposed dialectical operations to be the final period of cognitive development. Arlin (1975) was among the first to point out that formal operational thinking is not necessarily the final equilibrium and suggested a possible fifth stage or postformal stage of cognitive development.

In general, the researchers espousing this perspective considered that formal reasoning cannot capture the richness, complexity and creative power of the mature human mind as exemplified by achievements in arts, humanities, contemporary sciences, spiritual traditions and everyday living (cf. Commons, Armon, Kohlberg et al., 1990; Commons, Armon, Richards et al., 1989; Commons, Richards & Armon, 1984; Mines & Kitchener, 1986; Sinnott, 1989). Most of these researchers shared the conviction that by ending the stages of cognitive development in adolescence, Piaget truncated developmental concepts of both adulthood and cognition. As a result there is a growing interest in the study of adolescent and adult cognitive development. More specifically, in this type of research, attempts are made to explore the potential development beyond formal reasoning. More sophisticated types of thinking have been proposed. They are grouped under the collective label of "postformal reasoning" though not all of these characterizations of postformal reasoning presuppose formal operations.

2. Diversity

Under the collective label of "postformal" reasoning is a wide range of models of adult thinking extended into very diverse domains such as problem finding and problem solving (Arlin, 1975, 1989), moral reasoning (Armon, 1984, 1989; Erdynast, 1990; Tappan, 1990), social reasoning (Benack, 1984; Blanchard-Fields, 1989; Powell, 1980,

1984; Sinnott, 1984), life-span psychology (Labouvie-Vief, 1984, 1990; Smith, Dix & Baltes, 1989), and epistemic cognition (Kitchener & King, 1978).

According to Commons, Richards et al. (1984), there are two general approaches to the formulation of postformal reasoning.

1) One approach is to locate limitations in formal operations and then to describe a kind of thinking that enables the individual to transcend those limitations. Researchers borrow examples of thinking already developed in other contexts such as dialectical traditions (Basseches, 1980), philosophy of science (Linn & Siegel, 1984), general system theory and Buddhism (Koplowitz, 1984), relativity theory (Sinnott, 1981), and moral philosophy (Armon, 1984) as models for postformal reasoning. In these models, the proposition that formal operations are sufficient for adults to solve all problems is questioned. For other models, an argument is made as to whether formal operations are even necessary.

2) Another approach is to analyze the nature of cognitive developmental processes rather than the limitations inherent in formal operations. Instead of focusing on a demonstration that change does occur, this approach attempts to show how change occurs. For example, Fischer, Hand and Russell (1984) relate postformal reasoning to the development of abstractions; Sternberg (1982, 1984) to higher-order relational thinking; Commons and Richards (1984) to the increase in levels of complexity; and Pascual-Leone (1984) to the development of attentional capacity.

Researchers from either of the above two approaches generally claim that adult thinking contains the formal operational framework but encompasses other frameworks as well. This kind of development results in multiple frameworks under which formal operations are used within a higher-stage system of operations and transcend the limitations of formal operations. There may well be other approaches in which the formal operational framework is simply ignored and alternate models of cognitive

development are proposed. An example of these approaches would be Vedic psychology (see Alexander, Davies et al., 1990).

3. In Search of Unifying Commonalities

During the first decade of research on postformal reasoning, the tasks that occupied most researchers were those of developing models and validating measures. Recently, there appears to be an increasing interest in organizing or unifying the diversity in the field of postformal research. According to Benack and Basseches (1989), there are two approaches in the attempt to organize or unify the field of postformal research. One approach is to interrelate empirically the different postformal sequences through "cross domains" and "cross measures" studies (e.g.Cavanaugh & Stafford, 1989; Commons & Richards, 1984; Commons, Sinnott et al., 1989; Hoyer et al. 1989; Kitchener & King, 1985; Schrader et al., 1989). These studies showed that the line of transition from formal to postformal reasoning is by no means clear cut. For example, Cavanaugh and Stafford (1989) found that a person may be identified as functioning at the postformal level using a test developed by Labouvie-Vief and colleagues (Labouvie-Vief, Adams, Hakim-Larson & Hayden, 1983), but not necessarily so using the test developed by Commons and colleagues (Commons, Richards & Kuhn, 1982). Such kind of intra-individual discrepancies might reflect problems associated with measurement, level of task difficulty and/or domain specificity. However, before entertaining these possibilities, I would argue that a more fundamental issue needs to be addressed, namely, do these postformal models in question share any basic commonalities at all? This fundamental issue is precisely the concern of another approach which attempts to unify the diversity in the field of postformal reasoning. In this approach, the forms or structures of certain postformal models would be analyzed theoretically in order to identify their common

features (e.g. Arlin, 1984; Commons & Richards, 1984; Kitchener, 1983; Kramer, 1983a). The aim of such theoretical work is to reduce the conceptual complexity of the field by making clear the logical relationships among the various models of postformal reasoning. One of the proposed unifying commonalities underlying the models of postformal reasoning is nonabsolute/ relativistic (N/R) thinking which is the main topic of this study (see Kramer, 1983a).

C. NONABSOLUTE/RELATIVISTIC (N/R) THINKING-- A PROPOSED COMMONALITY UNDERLYING POSTFORMAL MODELS

1. Overview

There has been speculation that nonabsolute/ relativistic (N/R) thinking might be one of the possible unifying commonalities underlying a cluster of postformal models. A number of researchers has independently suggested that nonabsolute/ relativistic (N/R) thinking is required for the operations of postformal reasoning (e.g. Arlin, 1974, 1975/6; Basseches, 1980; Cavanaugh, Kramer, Sinnott, Camp & Markley, 1985; King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981; Riegel, 1973; Sinnott, 1981, 1989).

In a similar vein, Kramer (1983a) proposed that nonabsolute/ relativistic (N/R) thinking might be one of the core features of postformal reasoning. Kramer (1983a, p.91) identified three "core" features shared by most of the postformal models: 1) the realization of the nonabsolute, relativistic nature of knowledge; 2) an acceptance of contradiction; and 3) the integration of contraction into an overriding whole. (The second and third features are characteristics of dialectical thinking as well.) However, in the literature there is no consensus regarding the specific nature of nonabsolute/

relativistic (N/R) thinking (feature 1). The terms "nonabsolute" thinking and "relativistic" thinking are often used interchangeably. The connotation of such terms is often vague and open to interpretation. I would suggest that, in order to be more explicit, the term "nonabsolute" thinking can be used to imply the general construct whereas the term "relativistic" thinking can be used to imply a specific type of "nonabsolute" thinking though there could well be other types of "nonabsolute" thinking besides that of "relativistic" thinking. According to Inhelder and Piaget (1958, p.317), a simple form of relativity can be defined as the coordination of two or more frames or systems of reference, which is one of the eight concepts or schemata of formal operations. Arlin (1984a) argued that this schema might represent the pivotal concept that marks the transition from high-formal to postformal operations.

Based on Inhelder and Piaget's (1958) definition that a simple form of relativity can be defined as the coordination of two or more frames or systems of reference, I would further argue that nonabsolute/ relativistic (N/R) thinking (feature 1) is a general case of features 2 and 3 mentioned in the above in that feature 2 (i.e. the acceptance of contradiction) can be considered as the acceptance of the specific nature of the relationship among the parts or frames to be coordinated and similarly, feature 3 (i.e. integration of contradiction) can be considered as the specific type of coordination that relates and synthesizes the parts or frames into a dialectical whole. Thus features 2 and 3, which are characteristics of dialectical thinking, can be regarded as specific cases of feature 1, that is, nonabsolute/ relativistic (N/R) thinking.

In this light, nonabsolute/ relativistic (N/R) thinking indeed seems to represent a basic common feature among postformal models. However, the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the models of postformal reasoning is yet to be empirically tested. There are a number of unresolved issues pertaining to such a proposition. They are discussed in the next section.

2. Unresolved Issues

Four of the unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected postformal models are identified and addressed in this study.

The first unresolved issue concerns the lack of empirical evidence to support the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected postformal models. These postformal models include : problem finding (Arlin, 1974, 1975/6), dialectical reasoning (Basseches, 1980; Benack & Basseches, 1989), relativistic operations (Cavanaugh et al., 1985; Sinnott, 1981, 1989), and reflective judgment (King et al., 1983; Kitchener, 1986; Kitchener & King, 1981). It is important to point out that empirical work has yet to be done to test this proposition. However, before submitting such a proposition to empirical testing, there are several other issues to be examined.

The second unresolved issue is whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature. An implicit assumption held by some of the postformal researchers is that in order for nonabsolute/ relativistic (N/R) thinking to be qualified as a common feature underlying the models of postformal reasoning, it is necessary to demonstrate that it possesses a form or structure that is postformal in nature (Cavanaugh et al., 1985; Kramer, 1983b). While a number of researchers (e.g. Arlin, 1984, 1990; Kramer, 1983a; Sinnott, 1981, 1989) have suggested that some kind of relativistic thinking is required for postformal operations, others have questioned whether the awareness of relativity is really postformal at all (Cavanaugh et al., 1985). Thus it is debatable whether nonabsolute/ relativistic (N/R) thinking is an instance of formal or postformal reasoning.

Although Kramer (1983a) proposed in her earlier work that nonabsolute/ relativistic (N/R) thinking is one of the core features of postformal operations, later she,

as well as others, queried the postformal status of relativistic thinking (Cavanaugh et al., 1985; Kramer, 1983b, 1986). Their query was based on the findings that the awareness of relativity was necessary but not sufficient for formal thinking, and formal thinking was in turn found to be necessary but not sufficient for "acceptance of contradiction" and "integration of contradiction" into the dialectical whole. Such findings seem to cast doubt on the proposition that awareness of relativity itself is postformal. However, I would argue that such findings were contingent upon the definition of relativistic thinking as well as the nature of the specific tasks used in Kramer's work and their level of difficulty.

Firstly, I would relate to Kramer's definition of relativity. In Kramer's studies (1983b, 1986), relativistic and dialectical reasoning were assessed by two tasks both presenting a dilemma. The tasks were coded for the following four categories: a) formism-mechanism, b) awareness of relativity, c) acceptance of contradiction, and d) integration of contradiction into the dialectical whole. Pepper's (1942) synthetic world views were used to guide the coding process. Under this coding system, relativity was defined as the awareness of the relativistic nature of knowledge. Four subcategories were used for coding the presence of relativity: a) pragmatism, b) change as basic to reality, c) contextualism, and d) uniqueness-indeterminacy. I would argue that the above definition of relativity represents only a rudimentary notion of the relativistic nature of knowledge.

Secondly, I would relate to Kramer's definition of formal reasoning. In Kramer's (1983b, 1986) studies, formal reasoning was defined by four tasks: a) the Plant Task which measures the ability to separate variables; b) the Snail Task which measures the ability to coordinate two frames of reference, a simple form of relativity (Arlin (1984) suggested that such form might represent a pivotal concept that marks the transition from high formal to postformal reasoning.); and c) the Grade Inflation Task and d) the Political Climate Task which were designed by Kramer to measure the ability to

coordinate multiple frames of reference. In fact three of the four formal tasks measure a certain form of relativity but with varying degrees of difficulty. In this light, Kramer's finding that the awareness of relativity was necessary but not sufficient for formal reasoning could in fact be re-interpreted as that the awareness of relativity was necessary but not sufficient for the operations of relativity at the high-formal level. At this juncture, I would argue further that Kramer's findings do not necessarily preclude the possibility that relativity could operate at both the formal and postformal levels. Therefore, the definition and measurement of relativistic thinking operating at both the formal and postformal levels are yet to be reconceptualized.

The discussion of both the first and second unresolved issues would necessarily extend to the third and the fourth unresolved issues. The third unresolved issue concerns the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. The fourth unresolved issue concerns the need for the design of a measure of such a construct. Although a number of researchers have suggested that nonabsolute/ relativistic (N/R) thinking seems to be required for the operations of postformal reasoning, there is really no consensus regarding the specific nature of nonabsolute/ relativistic (N/R) thinking, let alone the definition and measurement of the construct (Arlin, 1974, 1975/6; Basseches, 1980; Kitchener, 1986; Kitchener & King, 1981; Kramer, 1983a; Riegel, 1973; Sinnott, 1981, 1989).

I would argue that both the first and the second unresolved issues in fact are hinged upon and eventually have to be related to the third and the fourth unresolved issues. The reason for this argument is that without an operational definition and measurement of the construct of nonabsolute/ relativistic (N/R) thinking, there is really no basis for 1) testing empirically the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the selected postformal models, and for 2) determining the structural stage status of nonabsolute/ relativistic (N/R) thinking.

Thus it seems that, in order to address the above stated unresolved issues, the formulation of a definition of nonabsolute/ relativistic (N/R) thinking would be of utmost importance. However, before formulating a definition of such a construct, it would seem logical to examine some of the postformal models which have been postulated to require nonabsolute/ relativistic (N/R) thinking.

3. Models associated with Nonabsolute/ relativistic (N/R) Thinking

The models of postformal reasoning which have been postulated to require nonabsolute/ relativistic (N/R) thinking include:

a) Problem Finding (Arlin, 1974, 1975/76);

b) Dialectical Reasoning (Riegel, 1973; Basseches, 1980);

c) Relativistic Operations (Cavanaugh, Kramer, Sinnott, Camp & Markley, 1985; Sinnott, 1981, 1989) and

d) Reflective Judgement (King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981).

The above four models of postformal reasoning are selected for discussion for two reasons: 1) the authors of these models have independently suggested that nonabsolute/ relativistic (N/R) thinking is required for their respective models of reasoning; and 2) the nature of postformal reasoning could be considered as best characterized by the kind of reasoning described by these four models (Arlin, 1990).

Through examining these selected models of postformal reasoning, one might be able to extract from them some common essentials which could provide ingredients for the conceptualization and definition of nonabsolute/ relativistic (N/R) thinking.

In order to provide an advance organizer to the following review of the postformal models, I would point out that there are different aspects of nonabsolute/ relativistic (N/R) thinking embedded in these selected models of postformal reasoning. These different aspects of nonabsolute/ relativistic (N/R) thinking could be viewed as the different dimensions of the very construct. Two of the more important dimensions of nonabsolute/ relativistic (N/R) thinking proposed to be explored are: 1) the basic form dimension and 2) the epistemic view dimension.

Regarding the basic form dimension, I would argue that a basic form of nonabsolute/ relativistic (N/R) thinking could in fact be identified throughout the selected postformal models and therefore, propose that such a "postformal" form of nonabsolute/ relativistic (N/R) thinking could be defined as "multiple-frame operations on ill-defined problems". The definition proposed will be expanded in the later part of this chapter. However, at this point, this proposed definition could serve as a frame of reference for the review of these models.

Regarding the epistemic view dimension, I would argue that the epistemic view associated with nonabsolute/ relativistic (N/R) thinking could be reflected primarily in one of the postformal models, namely the Reflective Judgment model, although the epistemic view has also been mentioned sporadically in the rest of the selected models.

In the following, the selected models of postformal reasoning will be briefly introduced and discussed in terms of their relationship with nonabsolute/ relativistic (N/R) thinking.

a) Problem Finding

The concept of problem-finding (cf. Arlin, 1975, 1989) can be traced back to studies concerning creative thought vis-a-vis "discovered problems" (Getzels, 1964; Getzels & Csikszentimihalyi, 1970); the formulation of generic problems (Taylor, 1972);

the raising of general questions from ill-defined problems (Mackworth, 1965); and the slow cognitive growth represented in the development of significant scientific thought (Gruber, 1973). Mackworth's (1965) work on the development of scientific breakthroughs characterized the work of the technician as problem-solving and that of the scientist as problem-finding. He used information processing terms to describe the "outcome" of problem-finding as "the generation of many general (or generic) questions from many ill-defined problems". Mackworth considered that the ability to engage in problem-finding is precisely what distinguished the scientist from the highly competent technician. A similar view is contained in Einstein's (Infeld & Einstein, 1938) observation that "the formulation of a problem is often more essential than its solution, which may be merely a function of mathematical or experimental skill. To raise new questions, new possibilities, to regard old questions from a new angle requires creative imagination and marks real advance in science" (p. 92).

In relation to postformal reasoning, problem-finding (Arlin, 1975) was initially hypothesized to be the fifth stage of cognitive development. Later it was reconceptualized as one of the important forms of reasoning associated with postformal/fifth stage thinking. The model of problem-finding has been subjected to continuous revision (Arlin, 1984, 1986, 1989). Findings (Arlin, 1975, 1989) revealed that problem-finding and problem-solving are two distinct processes and suggested that one has to be a good problem solver before one can be a good problem finder. Such an idea corresponds with Smilansky's (1985) argument. The logic for such a proposition is as follows. Formal operations involve problem-solving processes associated with well-defined problems. By definition, each well-defined problem has one or a limited number of correct solutions. In contrast, problem-finding processes are associated with ill-defined problems. By definition, ill-defined problems have no known method of solution and no criteria for judging the correctness of the solution(s). Thus Arlin (1975, 1989) argued that formal thinking, being problem-solving in nature, is a necessary but not

sufficient condition for problem-finding. Problem-finding was found to be highly correlated with other postformal measures including dialectical and relativistic thinking.

In the context of this review, problem-finding, as a specialized form of postformal reasoning, can be viewed as operating at a metacognitive level providing orientation to problem-formulation and problem-solving processes. As Arlin (1975) pointed out, the situation of problem finding is typically ill-defined in nature. I would further argue that the ill-defined nature of problem finding requires a person to generate different frames of reference which can then be developed into different ways of organizing the data and asking questions about the situation presented. In addition, such processes of problem finding would also allow a person to question or challenge assumptions upon which knowledge is based. In this light, I would argue that problem finding would necessarily involve "multiple-frame operations on ill-defined problems", which is proposed to be the postformal form of nonabsolute/ relativistic (N/R) thinking. Such a form is argued to be one of the commonalities underlying the selected postformal models.

b) Dialectical Thinking

The dialectical philosophical perspective comprises a family of world views about the nature of existence and knowledge. These world views while differing from each other in many aspects, share three common features: the common emphasis on change, wholeness, and internal relations. A dialectical world view can be contrasted with a static world view.

> From the dialectical perspective, what might otherwise be viewed as fundamental elements of existence are instead viewed as temporary forms which existence takes, and what might otherwise be viewed as interactions

> of fundamental elements are instead viewed as fundamental processes of change through which these forms of existence emerge. (Basseches, 1980, p. 404)

Both Riegel (1973) and Basseches (1980) proposed dialectical thinking as forms of thinking beyond formal operations. However, Riegel's model and Basseches' model differ considerably from each other. Riegel's model did not assume formal operations. He emphasized the dialectical nature of non-alienated thought at all ages (primitive dialectics as differentiated from scientific dialectics). Riegel did use Piaget's notion of formal operations as "final equilibrium" as a springboard for his own theory.

Basseches describes dialectical thinking as a metasystemic form of cognitive organization operating at a postformal stage of cognitive development. Dialectical thinking, according to this model, is organized by the concept of dialectic, in which the process of transformation of forms is understood in terms of interactive and constitutive relationships. Dialectical thinking is operationalized in the Dialectical Schemata Framework. The framework consists of 24 schemata or "moves in thought" that dialectical thinkers tend to make. The schemata represent motion, relations, forms, and integration of motion, relations and forms in a model of dialectical evolution. Each of these schemata is not necessarily dialectical thinking in itself. Rather, dialectical thinking is an organization of these schemata into a structure equilibrated by the idea of dialectic. Thus one may use many of these schemata or "moves of thought" without engaging any organized structures of dialectical thinking.

In the context of this review, I would suggest that dialectical thinking can be regarded as a metasystemic form of cognitive organization in a qualitative sense as differentiated from a quantitative sense. Thus dialectical thinking as such could be said to require the coordination and/or integration of multiple frames or systems in the context of ill-defined problems. In this light, I would argue that dialectical thinking would

necessarily involve "multiple-frame operations on ill-defined problems" which is proposed to be the postformal form of nonabsolute/ relativistic (N/R) thinking. Such a form is argued to be one of the commonalities underlying the selected postformal models.

c) Relativistic Operations

A number of researchers have suggested that some kind of relativistic logic is required for postformal thinking (e.g. Arlin, 1984, 1990; Kramer, 1983a; Sinnott, 1981, 1989).

According to Sinnott (1989), relativistic thought can come into play only when the problem is seen as ill-structured. Relativistic operations may be defined as logical operations which can be used as a system to relate, order and select the more useful of many mutually contradictory but 'true' formal-operational systems (Cavanaugh, Kramer, Sinnott, Camp & Markley, 1985).

In Sinnott's model (1989), there are two main characteristics of relativistic postformal operations: 1) self-reference and 2) the ordering of formal operations. The essential notions of self-reference are that all knowledge has a subjective component and so is, of necessity, incomplete. Thus any logic one uses is self-referential. As for the ordering of formal operations, the postformal system of self-referential truth orders formal truth systems, one of which is somewhat subjectively chosen and imposed on data. These two characteristics are considered to be qualitatively different from characteristics of other developmental stages and are not part of any other postformal systems proposed thus far.

These two characteristics can in fact be viewed as special features of nonabsolute/ relativistic (N/R) thinking in the context of this review. I would suggest that the first characteristic of 'self-reference' is meant to emphasize the subjectivity which might be

involved in the coordination of thoughts; and that the second characteristic of 'the ordering of formal operations' is meant to emphasize the form of thinking which involves multiple-frame operations. In this light, I would argue that relativistic operations would also necessarily involve "multiple-frame operations on ill-defined problems", which is proposed to be the postformal form of nonabsolute/ relativistic (N/R) thinking. Such a form is argued to be one of the commonalities underlying the selected postformal models.

d) Reflective Judgment

In the model of reflective judgment, seven stages or levels of epistemic cognition are postulated (Kitchener, 1986; Kitchener & King, 1981). The model is used to describe "an individual's assumptions about what can be known and what cannot (e.g. our knowledge of some things is ultimately uncertain), how we can know (e.g. by observing events directly, via authority), and how certain we can be in our knowing (e.g. absolutely, probabilistically). Corresponding to each stage of knowing is a description of how beliefs are justified in light of the certainty or lack of certainty of knowledge. Each stage of justification appears to be a logical outgrowth of a set of epistemic assumptions (p.219)."

The seven stages of epistemic cognition postulated in this model are ordered in sequence. For example, an individual who uses Stage 7 reasoning would typically have shown evidence of the other six stages of epistemic cognition at earlier ages. The epistemic assumptions of the early stages (i.e. Stages 1-3) do not acknowledge that real uncertainty exists. Rather, they assume that, ultimately, uncertainty can be translated to certainty, for example, by consulting an authority or by waiting until the truth is known sometime in the future. Stages 4-7 acknowledge the uncertainty of knowing although

there are subtle differences in the understanding of the causes of uncertainty. What appears to mature in the later stages is the understanding of how judgments can be made in the face of this uncertainty.

The main concern of the model of reflective judgment is the detection of the changes in epistemic view from an absolute to a nonabsolute/ relativistic view of the knowledge of reality. Although Kitchener and Kitchener (1981) considered that logic and epistemology are different domains, I would still argue that these two domains are related because it is probable that a certain form of thinking or logic could be contingent upon certain types of epistemic view. Formal operations, according to Kitchener and Brenner (1990), when defined as the ability to operate on propositions inductively and deductively, do not account for differences in epistemic assumptions. However, I would argue that this might in fact suggest that some kind of postformal logic is associated with a more sophisticated epistemic view.

The tasks of reflective judgment basically involve dialectical thinking, a specialized form of postformal operations. Again, I would argue that the form of thinking required for reflective judgment is also compatible with "multiple-frame operations on ill-defined problems", which is proposed to be the postformal form of nonabsolute/ relativistic (N/R) thinking. Such a form is argued to be one of the commonalities underlying the selected postformal models.

4. Reconceptualizing the Construct of Nonabsolute/ relativistic (N/R) Thinking

Based on the above review of the postformal models, I would argue that the "formal" form of relativity, which was defined by Inhelder and Piaget (1958) as the

coordination of two or more frames or systems of reference, cannot adequately represent the kind of nonabsolute/ relativistic (N/R) thinking underlying these selected postformal models. In order to formulate a definition of nonabsolute/ relativistic (N/R) thinking that could characterize both its formal and postformal qualities, I would argue that a reconceptualization of the construct of nonabsolute/ relativistic (N/R) thinking would be necessary.

In this context, I would argue that nonabsolute/ relativistic (N/R) thinking could be conceptualized and defined as a multidimensional and multilevel construct. Two of the more important dimensions of nonabsolute/ relativistic (N/R) thinking are proposed: 1) the basic form dimension, and 2) the epistemic view dimension. Within the basic form dimension, two levels are proposed: 1) the formal form, and 2) the postformal form. (See Figure 1.)

Figure 1
Dimensions and Levels of Nonabsolute/ Relativistic (N/R) Thinking

		DIMENSIONS	
		Basic Form	Epistemic View
L E V E L S	Formal	Formal Form	
	Post-formal	Postformal Form	Epistemic View

The conception of nonabsolute/ relativistic (N/R) thinking being multidimensional is in fact compatible with Kitchener's (1983) three-level model of cognitive processing which represents an account of the complex monitoring done by

individuals when faced with ill-defined problems. In Kitchener's three-level model of cognitive processing, the first level is "cognition". Individuals, at this level, compute, memorize, perceive, solve problems, etc.. The second level is "metacognition". Individuals, at this level, monitor their own cognitive processes when they are engaged in the first level tasks. The third level is "epistemic cognition". Individuals, at this level, reflect on the limits of knowing, the certainty of knowing, and the criteria of knowing. According to Kitchener (1983), epistemic assumptions influence how individuals understand the nature of problems and the strategies they use for problem solving. Current research suggests that, while cognitive and metacognitive processes appear to develop in childhood and are used throughout the life span, epistemic cognition develops in the late adolescent and adult years.

With reference to Kitchener's (1983) model of cognitive processing, I would argue that each dimension of nonabsolute/ relativistic (N/R) thinking corresponds to a specific aspect of a particular level in Kitchener's model. Specifically, the basic form dimension of nonabsolute/ relativistic (N/R) thinking can be viewed as a specific aspect of the second level or the metacognitive level processing in Kitchener's model. Similarly, the epistemic view dimension of nonabsolute/ relativistic (N/R) thinking can be considered as a specific aspect of the third level or the epistemic level of processing in Kitchener's model.

a) The Basic Form Dimension of Nonabsolute/ relativistic (N/R) Thinking

The basic form of nonabsolute/ relativistic (N/R) thinking can be construed as a certain form of knowing or thinking associated with a nonabsolute/ relativistic representation of reality. Within the basic form dimension of nonabsolute/ relativistic (N/R) thinking, two levels are proposed: 1) the formal form, and 2) the postformal form.

I have argued earlier in this chapter that "relativistic" thinking can be regarded as a specific type of "nonabsolute" thinking. Within this type of "nonabsolute" thinking, it is crucial to distinguish between two forms of relativity, namely the formal form and the postformal form (Kramer, 1983a). If such forms can be distinguished, it is also important to explain why the formal and the postformal forms are structurally and/or qualitatively different. Here, a similar if not parallel case can be made with the transition from the concept of compensation in concrete operations to the concept of multiplicative compensations and mechanical equilibrium in formal operations (see Arlin,1984b, 1986a).

In the concrete operational stage, the conception of compensation would generally involve two dimensions as exemplified in the conservation tasks. (e.g. The conservation of liquid would involve compensation between the height of water levels and the width of the containers. Similarly, the conservation of substance would involve compensation between the length and the thickness of the clay dough.)

However, in the formal operational stage, the concept of compensation is expanded to become that of multiplicative compensations in which multiple dimensions would be involved. (e.g. The conservation of volume would involve compensations among the dimensions of length, height and width.)

In the high-formal operational stage, the concept of compensation is further expanded to become that of mechanical equilibrium in which multiple sets of compensation would be involved, so that a balance or equilibrium would be maintained (e.g. the piston task).

I would argue that the example of the development of the concept of compensation could be used to demonstrate how a certain concept can evolve across stages through its structural elaboration and transformation.

In the case of relativistic thinking, at the formal level, Inhelder and Piaget (1958) defined a simple form of relativity as the coordination of two or more frames or systems

of reference. This is one of the eight concepts of formal operations. Arlin (1984) argued that the coordination of two or more frames or systems of reference might represent a pivotal concept that marks the transition from high-formal to postformal reasoning. The question is whether such a form can adequately represent the common form of nonabsolute/ relativistic (N/R) thinking underlying the models of postformal reasoning. In relation to this issue, Arlin (1980) suggested that the coordination of multiple frames or abstract frames might represent a basis for the postformal form of relativity. Based on the concept of multiple-frame coordination, Kramer (1984) designed a task (called "political climate") to assess the ability to coordinate three frames of reference. However, Kramer (1985) reported that the coordination of two frames of reference was not found to be a "necessary but not sufficient" condition for the coordination of three frames of reference. Thus Kramer argued against the coordination of multiple frames of reference as well as against relativistic thinking as postformal reasoning. Thus whether relativity is formal or postformal in nature remains an open question.

I would argue that Arlin's (1980) suggestion of "coordination of multiple frames" represents a major step towards the conceptualization and definition of relativistic thinking. Following this line of argument, I propose to take Arlin's suggestion one step further. That is, I propose to define the forms of nonabsolute/ relativistic (N/R) thinking in terms of two criteria: 1) the quantity of the frames of reference, and 2) the quality of the task involved. (See Figure 2.)

From such a perspective, the formal tasks, regardless of the number of frames of reference involved, are well-defined problems. This also applies to the task assessing the coordination of three frames of reference designed by Kramer (1984). On the contrary, the postformal tasks are life-like tasks involving not only multiple frames of reference but also ill-defined problems. In this light, I would argue that one of the major differences between formal and postformal forms is that between well-defined and ill-defined problems.

Figure 2
Definition Criteria for the Two Forms of Nonabsolute/ Relativistic (N/R) Thinking

			QUANTITY OF FRAMES OF REFERENCE	
			Single	Multiple
QUALITY OF PROBLEMS		Well-defined	Not Postformal	Formal
		Ill-defined	Not Postformal	Postformal

A brief contrast between well-defined and ill-defined problems is as follows. For well-defined problems all the information necessary to produce a solution is given, thus it is possible to derive objective answers to the problems. For ill-defined problems, the information given is not complete, thus it is not possible to derive any objective answers. (For discussion on similar concepts of well-structured problems and ill-structured problems, see Wood, 1990; Brabeck & Wood, 1990).

Following this line of argument, I propose to define the basic forms of nonabsolute/ relativistic (N/R) thinking at two levels namely, the formal form and the postformal form:

1) The formal form of nonabsolute/ relativistic (N/R) thinking can be defined as "multiple-frame operations on well-defined problems".

2) The postformal form of nonabsolute/ relativistic (N/R) thinking can be defined as "multiple-frame operations on ill-defined problems".

Moreover, I would argue that these two forms of nonabsolute/ relativistic (N/R) thinking are qualitatively different though structurally similar.

Structurally speaking, both forms involve multiple-frame operations. In this context, a "frame" can be defined as a system or organization of relationships among elements. For example, in the Piagetian task of "Co-ordination of two or more frames or systems of reference", the relationship between the turtle and the paper strip would constitute one frame or system of reference, and the relationship between the paper strip and the desk would constitute another frame or system of reference. In this sense, multiple-frame operations refer to the operations on or the co-ordinations of multiple systems or organizations of relationships among elements.

Qualitatively speaking, I would argue that the kinds of problem involved with the two forms of nonabsolute/ relativistic (N/R) thinking are different in nature.

The formal form operates on well-defined problems which can be represented by closed systems. For well-defined problems, all the information necessary to produce a solution is given or can be derived from what is given. In this case, it is possible to derive one or a few solutions.

By contrast, the postformal form operates on ill-defined problems which can be represented by self-constructed as well as open systems (see Koplowitz, 1984). For ill-defined problems, the information given is not complete. Thus it is crucial to point out that, for ill-defined problems, because the systems for operations have yet to be constructed and defined, one is often required to generate information beyond that which is given or known. That is to say, a person's knowledge or experience about the content and context of the problems concerned would be called for. Such quality of postformal form would be in contrast with that of the formal form which is content/context-free according to Inhelder and Piaget (1958). Another crucial difference is that, since the postformal form typically deals with self-constructed and open systems, it is not possible to expect any absolute or objective solutions. Thus I would further argue that postformal operations would necessarily imply uncertainty, indeterminacy, subjectivity and perhaps even creativity.

With reference to the above mentioned qualitative differences, it is possible to suggest that the formal form of relativity is confined to solving arbitrary or contrived problems, whereas the postformal form of relativity is meant to deal with life-like problems in a more flexible and creative manner. In this study, it is hypothesized that a shift from an absolute to a nonabsolute epistemic view might have a crucial role to play in the development of the postformal form.

b) The Epistemic View Dimension of Nonabsolute/ relativistic (N/R) Thinking

The epistemic view of nonabsolute/ relativistic (N/R) thinking can be construed as certain theories of knowing or theories of knowledge of reality associated with a nonabsolute/ relativistic world view. The epistemic view dimension of nonabsolute/ relativistic (N/R) thinking is theoretically hypothesized to be associated with the "postformal" form of nonabsolute/ relativistic (N/R) thinking. However, this hypothesis is yet to be empirically tested. In a similar vein, Kitchener (1983) considered epistemic cognition as the highest level of cognitive processing in her three-level model of cognition.

During the course of cognitive development, individuals do tend to shift from an absolute to a nonabsolute/ relativistic view about the nature of knowledge of reality. I would propose that several specific aspects pertinent to the nature of knowledge of reality can be identified. The following are four of these specific aspects which are extracted and modified from the work of Kitchener and colleagues (Kitchener, 1981; Kitchener & Brenner, 1990; Kitchener & King, 1986). They concern:

1) The means of knowledge: a nonabsolute/ relativistic view would be implied by the recognition that all means involved in the construction of knowledge are ultimately subjective.

2) The limits of knowledge: a nonabsolute/ relativistic view would be implied by the recognition that the ultimate nature of reality can only be approximated but can never be completely in grasp. Thus the limits of knowledge are ever unfolding but never reached.

3) The criteria of knowledge: a nonabsolute/ relativistic view would be implied by the recognition that there is no absolute criterion for judging any solution, because all criteria are always relative to certain sets of assumptions.

4) The nature of reality: a nonabsolute/ relativistic view would be implied by the recognition that reality is in constant flux (i.e. the notion of a dynamic world view versus a static world view).

These four specific aspects are by no means exhaustive, but are argued to be vital points for tapping a person's epistemic view. It is hypothesized that a shift from an absolute to a nonabsolute epistemic view could be crucial to the development of the postformal form of nonabsolute/ relativistic (N/R) thinking. This would be analogous to Kuhn's (1970/72) "paradigm shift" in the revolution of scientific reasoning. The relationship between one's epistemic view and one's form(s) of thinking is explored in one of the specific research questions in chapter III.

The above mentioned characteristics of nonabsolute/ relativistic (N/R) thinking are used in chapter III as a basis for formulating an operational definition as well as for designing a battery of tests of nonabsolute/ relativistic (N/R) thinking.

E. SUMMARY & DISCUSSION

One of the attempts to unify the diversity in the field of postformal research is to search for commonalities underlying the models of postformal reasoning. Nonabsolute/

relativistic (N/R) thinking has been proposed to be one of the possible unifying commonalities underlying the postformal models (Kramer, 1983a). However, such a proposition is inconclusive. Four of the unresolved issues pertaining to such a proposition are identified and addressed in this study.

Briefly speaking, the first unresolved issue concerns the lack of empirical evidence to support the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the selected models of postformal reasoning. An empirical testing of this proposition is called for. However, before submitting such a proposition to empirical testing, there are other basic issues to be addressed.

The second unresolved issue is whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature. An implicit assumption held by some of the postformal researchers is that in order for nonabsolute/ relativistic (N/R) thinking to be qualified as a common feature underlying the postformal models, it is necessary to demonstrate that it possesses a form or structure that is postformal in nature (Cavanaugh et al., 1985; Kramer, 1983b). While a number of researchers (e.g. Arlin, 1984, 1990; Kramer, 1983a; Sinnott, 1981) suggested that some kind of relativistic thinking is required for postformal operations, others questioned the postformal stage status of relativistic thinking (Cavanaugh et al., 1985). Thus the postformal stage status of relativistic thinking has been a debatable issue.

The discussion of both the first and the second issues would necessarily extend to the third and the fourth issues. The third unresolved issue concerns the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. The fourth unresolved issue concerns the need for the design of a measure of such a construct. As revealed in relevant literature, there is really no consensus regarding the specific nature of nonabsolute/ relativistic (N/R) thinking, let alone the definition and measurement of such a construct.

I would argue that both the first and second unresolved issues actually are hinged upon and eventually have to be related to the third and the fourth unresolved issues. The reason is that without the definition and measurement of nonabsolute/ relativistic (N/R) thinking, there is no basis for 1) testing empirically the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the selected postformal models; and for 2) determining the structural stage status of nonabsolute/ relativistic (N/R) thinking. In order to address the above stated unresolved issues, the formulation of a definition of nonabsolute/ relativistic (N/R) thinking would seem to be of utmost importance.

In order to define nonabsolute/ relativistic (N/R) thinking, four selected postformal models which are postulated to require nonabsolute/ relativistic (N/R) thinking are reviewed in this study. They are: 1) Problem Finding (Arlin, 1974, 1975/76, 1989); 2) Dialectical Reasoning (Basseches, 1980; Benack & Basseches, 1989); 3) Relativistic Operations (Sinnott, 1981, 1989); and 4) Reflective Judgment (Kitchener, 1986; Kitchener & King, 1981). The aim of reviewing these models is to extract from them some common essentials which could provide ingredients for the conceptualization and definition of nonabsolute/ relativistic (N/R) thinking.

Based on the review of the selected postformal models, I would argue that the "formal" form of relativity, defined by Inhelder and Piaget (1985) as the coordination of two or more frames or systems of reference, cannot adequately represent the kind of nonabsolute/ relativistic (N/R) thinking underlying the selected postformal models. In order to formulate a definition of nonabsolute/ relativistic (N/R) thinking that could characterize both its formal and postformal qualities, a reconceptualization of the construct of nonabsolute/ relativistic (N/R) thinking would be necessary.

In this context, I propose that nonabsolute/ relativistic (N/R) thinking could be conceptualized and defined as a multidimensional and multilevel construct. Two of the

more important dimensions of nonabsolute/ relativistic (N/R) thinking proposed are: 1) the basic form dimension and 2) the epistemic view dimension.

Within the basic form dimension of nonabsolute/ relativistic (N/R) thinking, two levels are proposed: 1) the formal form, and 2) the postformal form. I propose that these two forms can be defined according to two criteria: 1) the quantity of the frames of reference and 2) the quality of the tasks involved.

Regarding the epistemic view dimension of nonabsolute/ relativistic (N/R) thinking, I would argue that four specific aspects pertinent to the nature of knowledge of reality can be identified. They concern: 1) the means of knowledge, 2) the limits of knowledge, 3) the criteria of knowledge, and 4) the nature of reality.

The above characteristics are used as a basis for the formulation of an operational definition and the design of a battery of tests of nonabsolute/ relativistic (N/R) thinking which are described in chapter III.

To conclude, the main focus of this study is to address four of the unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected models of postformal reasoning. In order to address the four unresolved issues presented above, four general research questions as well as some related specific questions are raised. These questions are discussed and addressed in the next chapter.

CHAPTER III: RESEARCH QUESTIONS & METHODOLOGY

In this chapter, there are two parts. Part A contains research questions and part B contains methodology. Under part A, four general research questions are listed. Under part B are four sections: 1) Operational definitions of nonabsolute/ relativistic (N/R) thinking (addressing Research Question 1), 2) Tests of nonabsolute/ relativistic (N/R) thinking (addressing Research Question 2), 3) Pilot study (initially exploring the relationships among the 3 tests of nonabsolute/ relativistic (N/R) thinking), and 4) Design and proposed analyses (addressing Research Questions 3 and 4).

A. RESEARCH QUESTIONS

Four of the unresolved issues pertaining to the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying certain selected models of postformal reasoning were identified in chapter II. To recapitulate, the first issue concerns the lack of empirical evidence to support such a proposition. The second issue concerns whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature. The third issue concerns the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. The fourth issue concerns the need for a design of a measure of nonabsolute/ relativistic (N/R) thinking. I would argue that both the first and second issues are hinged upon and would eventually have to be related to the third and the fourth issues. In order to address these four unresolved issues, four general research questions are raised and are addressed in this chapter. These four general research questions are as follows:

1. How can nonabsolute/ relativistic (N/R) thinking be operationally defined?

(This research question is designed to address the third unresolved issue concerning the need for an operational definition of nonabsolute/ relativistic (N/R) thinking.)

2. How can nonabsolute/ relativistic (N/R) thinking be measured?

(This research question is designed to address the fourth unresolved issue concerning the need for a design of a measure of nonabsolute/relativistic (N/R) thinking.)

3. Is nonabsolute/ relativistic (N/R) thinking a common factor underlying the selected models of postformal reasoning?

(This research question is designed to address the first unresolved issue concerning the lack of empirical evidence in support of the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the models of postformal reasoning.)

4. Is nonabsolute/ relativistic (N/R) thinking an instance of formal or postformal reasoning or of both?

(This research question is designed to address the second unresolved issue concerning whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature.)

B. METHODOLOGY

1. Operational Definition of Nonabsolute/ relativistic (N/R) Thinking

In this section, the first research question namely, **"How can nonabsolute/ relativistic (N/R) thinking be operationally defined?"** is addressed.

I propose to use the term **"nonabsolute thinking"** to imply the general construct and the term **"relativistic thinking"** to imply a specific type of nonabsolute thinking, though there could well be other types of nonabsolute thinking besides relativistic thinking. In this light, the whole term **"nonabsolute/ relativistic (N/R) thinking"** refers to a specific type of nonabsolute thinking that involves the use of relativistic thinking as a form of cognitive operations.

As proposed in the previous chapter, nonabsolute/ relativistic (N/R) thinking could be conceptualized and defined as a multidimensional and multilevel construct (see figure 1). Two of the more important dimensions of nonabsolute/ relativistic (N/R) thinking proposed are: a) the basic form dimension and b) the epistemic view dimension. Within the dimension of the basic form, two levels are proposed: 1) the formal form, and 2) the postformal form.

a) The operational definition of the **basic form dimension** of nonabsolute/ relativistic (N/R) thinking is as follows:

1) The **formal form** of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on well-defined problems" which require the ability to coordinate two or more frames or systems of reference within a well-defined and closed system as a whole. For well-defined problems, all information necessary to

produce a solution is given or can be derived from what is given. Thus it is possible to derive one or a few objective solutions.

2) The **postformal form** of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on ill-defined problems" which require the ability to think flexibly in terms of multiple frames within self-constructed as well as open systems. For ill-defined problems, the information given is not complete. The systems for operations have yet to be constructed and defined, and are open to interactions. The person is often required to generate information beyond that which is given or known. Thus it is not possible to expect any absolute or objective solutions. Such operations would necessarily imply uncertainty and indeterminacy.

b) The operational definition of the **epistemic view dimension** of nonabsolute/ relativistic (N/R) thinking is as follows:

The epistemic view associated with nonabsolute/ relativistic (N/R) thinking is operationally defined in terms of four specific aspects pertinent to the nature of knowledge of reality. These four specific aspects are extracted and modified from the information derived from the Reflective Judgment model which concerns the changes in epistemic view from an absolute to a nonabsolute view of the knowledge of reality (Kitchener, 1986; Kitchener & King, 1981). These four specific aspects concern:

1) **The means of knowledge**: a nonabsolute/ relativistic view would be implied by the recognition that all means involved in the construction of knowledge are ultimately subjective.

2) **The limits of knowledge**: a nonabsolute/ relativistic view would be implied by the recognition that the ultimate nature of reality can only be approximated but can never be completely in grasp. Thus the limits of knowledge are ever unfolding but never reached.

3) **The criteria of knowledge**: a nonabsolute/ relativistic view would be implied by the recognition that there is no absolute criterion for judging any solution, because all criteria are always relative to certain sets of assumptions.

4) **The nature of reality**: a nonabsolute/ relativistic view would be implied by the recogntion that reality is in constant flux (i.e. the notion of a dynamic world view versus a static world view).

The above definition of nonabsolute/ relativistic (N/R) thinking was used as a basis for the design of a battery of 3 tests of nonabsolute/ relativistic (N/R) thinking.

2. Tests of Nonabsolute/ relativistic (N/R) Thinking

In this section, the second research question namely, **"How can nonabsolute/ relativistic (N/R) thinking be measured?"** is addressed. A battery of 3 tests of nonabsolute/ relativistic (N/R) thinking was specifically designed to measure the construct of nonabsolute/ relativistic (N/R) thinking. These 3 tests of nonabsolute/ relativistic (N/R) thinking are: 1) The test of the formal form of N/R thinking (N/R-F), 2) The test of the postformal form of N/R thinking (N/R-PF), and 3) The test of the epistemic view of N/R thinking (N/R-EV). The first 2 tests were designed to measure the 2 levels of the basic form dimension and the last test was designed to measure the epistemic view dimension of nonabsolute/ relativistic (N/R) thinking.

a) The Test of the Formal Form of N/R Thinking (N/R-F)

Test Description

The purpose of this test is to assess the presence of the formal form of nonabsolute/ relativistic (N/R) thinking. Such form of thinking is operationally defined as "multiple-frame operations on well-defined problems". This test adopts a subtest of the Arlin Test of Formal Reasoning (ATFR) (Arlin, 1984b), specifically the subtest of the coordination of two or more frames or systems of reference which makes up part of the third (or the highest) tier of the ATFR. This subtest is designed to test the ability to coordinate two or more frames or systems of reference. Inhelder and Piaget (1958) demonstrated that a simple form of relativity can be defined as the coordination of two or more frames or systems of reference, which is one of the eight concepts or schemata of formal operations. Arlin (1984) argued that this schema might represent a pivotal concept that marks the transition from high-formal to postformal operations.

This test is a pencil-and-paper test made up of 4 multiple-choice questions. The 4 questions are organized into 2 pairs. Each pair of questions is related to a problem which is accompanied with a drawing (see Appendix A). The test items are as follows.

Test items

> A small toy wind-up turtle is placed on a shaded strip of paper. The paper strip is lined up along the edge of a board as shown in the picture. The turtle can be moved along the paper strip. The paper strip can also be moved along the board. Both the toy and the paper strip can be moved forward or backward. The toy, the end of the paper strip, and the starting point on the board are all lined up as shown.

1. If the turtle moves forward at the same speed that the paper strip moves backward, how far will the turtle be from the starting point after a short time (as long as the turtle is still on the strip of paper)?

   A. It would be at the starting point.

   B. One-fourth the distance of the paper strip from the starting point.

   C. Double the distance of the paper strip from the starting point.

   D. It would be behind the starting point.

2. If the turtle moves forward at 1/3 the speed that the paper strip moves backward, where would the turtle be after a short period of time (as long as the turtle is still on the strip of paper)?

   A. Three times as far forward as the paper strip is backward from the starting point.

   B. One-third the distance in front of the starting point as the paper strip is behind the starting point.

   C. It would be behind the starting point.

   D. As far in front of the starting point as the end of the paper strip is in back of it.

Two people are sitting on this train as it passes through a long tunnel in the side of a mountain. Mr. Red (R) is sitting at the front of the train and Mr. Blue (B) is sitting at the back of the train. For the following two situations, decide whether Mr. R and Mr. B will stay in the tunnel for the same amount of time.

3. SITUATION 1: After the train enters the tunnel, Mr. R gets up from his seat in the front, and walks back to sit with Mr. B. How much time altogether will Mr. R spend in the tunnel?

A. Less time in the tunnel than Mr. B.

B. Twice the time in the tunnel as Mr. B.

C. The same amount of time in the tunnel as Mr. B.

D. More time in the tunnel than Mr. B.

4. SITUATION 2: After the train has entered the tunnel, Mr. B gets up from his seat in the back. He walks forward to sit with Mr. R. Halfway on his trip forward, he decides to go back to his seat for his paper. He gets his paper and then goes forward again and joins Mr. R while the train is still in the tunnel. How much time did Mr. B spend in the tunnel?

A. Less time in the tunnel than Mr. R.

B. More time in the tunnel than Mr. R.

C. One-and-one-half as much time in the tunnel as Mr.R.

D. The same amount of time in the tunnel as Mr. R.

Scoring Criteria

The correct answers for the test items are follows.

1. A 2. C 3. D 4. A

Score 1 point for each correct answer to an item. An individual test score is the sum of the 4 item scores.

Interpretation

A score of 0 to 1 would be interpreted as the absence of the formal form of nonabsolute/ relativistic (N/R) thinking. A score of 2 represents a transitional development of such a form. A score of 3 represents the presence of a partially developed formal form of nonabsolute/ relativistic (N/R) thinking. A score of 4 represents the presence of a fully developed formal form of nonabsolute/ relativistic (N/R) thinking.

Technical information about ATFR:

In a multi-trait, multi-method validity study of the ATFR, the test-retest reliabilities yielded were of the order of .76 to .89 (Arlin, 1982). For the total test the Hoyt estimates of reliability ranged from .71 to .89. The Cronbach Alphas for the total test composites ranged from .60 to .73. (Arlin, 1984b)

b) The Test of the Postformal Form of N/R Thinking (N/R-PF)

Test description

This test is specifically designed by Arlin and the author for this study to assess the presence of the postformal form of nonabsolute/ relativistic (N/R) thinking. This form of thinking is operationally defined as "multiple-frame operations on ill-defined problems" which require the ability to think flexibly in terms of multiple frames within self-constructed as well as open systems. This test differs from N/R-F (formal form) in that it involves ill-defined problems for which examinees are required to generate information beyond that which is given including relevant frames of reference. Also this test does not require accuracy in mental computation. Since absolute answers cannot be

expected for this test, the recognition of uncertainty and indeterminacy is necessarily implied.

This test is a pencil-and-paper test made up of 4 open-ended questions. The 4 test items are presented in the following.

Test Items

1. "A" grows 1 cm per month. "B" grows 2 cm per month.

   Who is taller?

   ANSWER:_____

   Why? Explain your answer.

2. City "A" is 12^0 C. City "B" is 10^0 C.

   Which city is warmer?

   ANSWER:_____

   Why? Explain your answer.

3. "A" can run at 15 k.p.h. "B" can run at 12 k.p.h.

   Who would arrive earlier?

   ANSWER:_____

   Why? Explain your answer.

4. "A" weighed 8 kg. "B" weighed 9 kg.

   Which one is heavier?

   ANSWER:_____

   Why? Explain your answer.

Scoring Criteria

A typical absolute answer would be a forced choice between A and B. A typical nonabsolute answer would be exemplified by not choosing between A and B. However, there could be exceptions to the above definitions of an absolute and a nonabsolute answer. Scoring would be based primarily on the quality of the reasons given rather than merely on the choices made. A general guideline is as follows.

Score 1 for an absolute answer in which there was only one frame or system of reference involved in the explanation. (e.g. A is taller than B because A grows faster.)

Score 2 for a nonabsolute answer without relevant explanation. (e.g. Don't know. Unable to decide.).

Score 3 for a nonabsolute answer with a partially relevant explanation. The examinee showed partial awareness of the multiple-frame operations. (e.g. Unable to decide because of insufficient information. There is no information on how tall A and B are in the first place.)

Score 4 for a nonabsolute answer with a general and/or comprehensive explanation. The examinee showed full awareness of the multiple-frame operations in addition to the ability to generate the relevant frames of reference. Ideally, the examinee could point out the problematic assumptions underlying the questions. (e.g. Unable to decide because faster growth rate does not necessarily imply greater height/length. There is other information to be considered such as...).

An individual test score is the average of the 4 item scores. If there is more than one rater, the final test score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of N/R-PF, the postformal form of nonabsolute/ relativistic (N/R) thinking. A score of 2 to less than 3

represents the transitional development of such a form. A score of 3 to less than 4 represents the presence of a partially developed postformal form of nonabsolute/ relativistic (N/R) thinking. A score of 4 represents the presence of a fully developed formal form of nonabsolute/ relativistic (N/R) thinking.

c) The Test of the Epistemic View of N/R Thinking (N/R-EV)

Test description

This test is specifically designed by Arlin and the author for this study to assess the level of the epistemic view (or the theories of knowledge of reality) associated with nonabsolute/ relativistic (N/R) thinking. The epistemic view of nonabsolute/ relativistic (N/R) thinking is operationally defined in terms of four specific aspects pertinent to the nature of knowledge of reality. These four specific aspects concern: 1) the means of knowledge, 2) the limits of knowledge, 3) the criteria of knowledge, and 4) the nature of reality. They are modified extractions from the Reflective Judgment model which concerns the detection of the changes in epistemic view from an absolute to a nonabsolute view of the knowledge of reality (Kitchener, 1986, Kitchener & King, 1981).

This test is a pencil-and-paper test made up of 4 items, each of which contains both a multiple-choice and an open-ended question. Each item corresponds to one of the four specific aspects of the epistemic view. The 4 test items are presented in the following.

Test Items

1. How do you know about the world around you?

   a. through your senses (eyes, ears, nose, etc.)

   b. through your own interpretation (thinking).

   c. others

   Why? Explain your chosen answer.

2. It is possible for you to understand something completely without doubt.

   a. agree

   b. disagree

   c. others

   Why? Explain your chosen answer.

3. When three persons have three different solutions to the same problem, at least one of them must be wrong.

   a. agree

   b. disagree

   c. others

   Why? Explain your chosen answer.

4. Some things will never change.

   a. agree (What are they?_____)

   b. disagree

   c. others

   Why? Explain your chosen answer.

Scoring Criteria

First of all, the rater would have to determine whether an answer is an absolute or nonabsolute one. A general guideline for determining the absolute or nonabsolute nature of an answer for each of the four items are provided in the following.

Item 1 examines the epistemic view concerning the means of knowledge. A nonabsolute/ relativistic view would be implied by the recognition that all means involved in the construction of knowledge are ultimately subjective.

A typical absolute answer would exclude answer (b).

A typical nonabsolute answer would include answer (b).

If answer (c) was chosen, scoring would be based on the quality of the explanation as to whether the answer is absolute or nonabsolute according to the above guideline in relation to a nonabsolute/ relativistic view.

Item 2 examines the epistemic view concerning the limits of knowledge. A nonabsolute/ relativistic view would be implied by the recognition that the ultimate nature of reality can only be approximated but can never be completely in grasp. Thus the limits of knowledge are ever unfolding but never reached.

A typical absolute answer would be answer (a).

A typical nonabsolute answer would be answer (b).

If answer (c) was chosen, scoring would be based on the quality of the explanation as to whether the answer is absolute or nonabsolute according to the above guideline in relation to a nonabsolute/ relativisitic view.

Item 3 examines the epistemic view concerning the criteria of knowledge. A nonabsolute/ relativistic view would be implied by the recognition that there is no absolute criterion for judging any solution, because all criteria are always relative to certain sets of assumptions.

A typical absolute answer would be answer (a).

A typical nonabsolute answer would be answer (b).

If answer (c) was chosen, scoring would be based on the quality of the explanation as to whether the answer is absolute or nonabsolute according to the above guideline in relation to a nonabsolute/ relativistic view.

Item 4 examines the epistemic view concerning the nature of reality. A nonabsolute/ relativistic view would be implied by the recognition that reality is a constant flux of existence (i.e. the notion of a dynamic world view versus a static world view).

A typical absolute answer would be answer (a).

A typical nonabsolute answer would be answer (b).

If answer (c) was chosen, scoring would be based on the quality of the explanation as to whether the answer is absolute or nonabsolute according to the above guideline in relation to a nonabsolute/ relativistic view.

All in all, scoring would be based primarily on the quality of the explanation given rather than merely on the choices made. Once the absolute or nonabsolute nature of an answer is determined, each item can then be scored according to the following criteria:

Score 1 for an absolute answer with an explanation adhering to an absolute view with regard to the content of the test item. (e.g. Item 4: The fact that I am a human being will never change.)

Score 2 for a nonabsolute answer without relevant explanation.

Score 3 for a nonabsolute answer with a partially relevant explanation. (e.g. Item 4: Life is a cycle of birth and death.)

Score 4 for a nonabsolute answer with a general or comprehensive explanation relevant to the test item. (e.g. Item 4: Change is the only "constant" in the world.)

An individual test score is the average of the 4 item scores. If there is more than one rater, the final test score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of the epistemic view associated with nonabsolute/ relativistic (N/R) thinking. A score of 2 to less than 3 represents a transitional development of such kind of epistemic view. A score of 3 to less than 4 represents the presence of a partially developed epistemic view of nonabsolute/ relativistic (N/R) thinking. A score of 4 represents the presence of a fully developed epistemic view of nonabsolute/ relativistic (N/R) thinking.

3. Pilot Study

Objective

The objective of this pilot study was to explore initially the relationships among the 3 tests of nonabsolute/ relativistic (N/R) thinking which are specifically designed for this study: 1) the test of the formal form of N/R thinking (N/R-F), 2) the test of the postformal form of N/R thinking (N/R-PF), and 3) the test of the epistemic view of N/R thinking (N/R-EV).

Related questions include:

a. What, if any, commonalities exist among the item scores of the 3 tests of nonabsolute/ relativistic (N/R) thinking?

b. What, if any, commonalities exist among the individual test scores of the 3 tests of nonabsolute/ relativistic (N/R) thinking?

c. Is the mastery of N/R-F (formal form) a necessary but not sufficient condition for the mastery of N/R-PF (postformal form) and N/R-EV (epistemic view)?

d. Is the mastery of N/R-EV (epistemic view) a necessary but not sufficient condition for the mastery of N/R-PF (postformal form)?

e. How internally consistent are the item scores of the tests of N/R-PF (postformal form) and of N/R-EV (epistemic view) (i.e. the two tests designed by Arlin and the author for this study)?

Participants

The participants were 22 volunteers comprising 14 males and 8 females ranging from age 7 years to 44 years and above. They were residents of Vancouver, B.C. and had been recruited through friends and through faculty members and students of University of British Columbia. Of the 22 participants, only the scores of 17 participants (aged 12 and above) were entered for data analysis, because the other 5 participants were all aged below 12 and were only administered one test, namely N/R-PF (postformal form).

Procedures & Measures

The 3 N/R tests -- N/R-F (formal form), N/R-PF (postformal form), and N/R-EV (epistemic view) -- were in pencil-and-paper format. The N/R-F (formal form) was administered in its original form of four items; the N/R-PF (postformal form) was revised for administration by dropping two redundant items from the original form of six items; and the N/R-EV (epistemic view) was revised for administration by dropping one redundant item from the original form of five items.

All three tests were administered to 14 of the 22 participants. Due to situational constraints, other 3 participants were not administered the N/R-F (formal form). Their missing scores for N/R-F (formal form) were replaced by the variable means. The remaining 5 participants (aged 7 to 12) were administered only the N/R-PF (postformal form). Thus their scores were not used for data analysis, but for reference only.

Two testers were involved in the test administration and data collection. Clarification of vague answers and feedback on the participants' opinions about the tests were elicited whenever a follow-up discussion was possible.

Analysis, Results & Interpretation

To address Questions (a) and (b), exploratory factor analyses using SPSS:X computer programme were conducted to see if the scores of the 3 N/R tests share any commonalities. The method of factor extraction was principal axis factoring (PAF).

For Question (a), an exploratory factor analysis was conducted based on the correlations among the item scores of the 3 N/R tests obtained from the 17 participants. In the revised version of the 3 N/R tests, there were 4 items in each test. Therefore, a total of 12 items were involved. (The correlation matrix is presented in Table 1.)

Table 1
Pilot Study: Correlation Matrix of Item Scores of the 3 N/R Tests

	F1	F2	F3	F4	P1	P2	P3	P4	E1	E2	E3	E4
F1	1											
F2	.09	1										
F3	.35	.26	1									
F4	.04	.47	.12	1								
P1	.51	.11	.44	-.07	1							
P2	.32	.32	.27	-.08	.86	1						
P3	.49	.11	.42	-.07	.98	.86	1					
P4	.33	.48	.15	.28	.74	.81	.75	1				
E1	.44	.25	.26	.27	.76	.68	.79	.89	1			
E2	.28	.36	.21	.17	.75	.80	.80	.94	.91	1		
E3	.41	.22	.35	.16	.74	.74	.78	.87	.82	.84	1	
E4	.24	.65	.20	.42	.48	.54	.49	.79	.75	.73	.57	1

Note. F1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. P1-4 = items of Test of Postformal Form of N/R Thinking. E1-4 = items of Test of Epistemic View of N/R Thinking.

Results indicate that three eigenvalues greater than 1.0 were obtained (eigenvalues = 6.90, 1.82, 1.15). However, extraction was terminated in 2 iterations due to communality exceeding 1.

As an alternative, another exploratory factor analysis was conducted based on the item scores of only the 2 postformal level N/R tests -- N/R-PF (postformal form) and N/R-EV (epistemic view). A total of 8 variables (4 items x 2 tests) were involved. One eigenvalue greater than 1.0 was obtained. The eigenvalue was 6.40, accounting for 80% of the variance. One factor was extracted. Items of both tests yielded high loadings on one factor. For N/R-PF (postformal form), the loadings ranged from 0.86 to 0.95. For N/R-EV (epistemic view), the loadings ranged from 0.69 to 0.95.

For Question (b), an exploratory factor analysis was conducted based on the correlations among the individual test scores of the 3 tests obtained from the 17 participants. (See Table 2 for the correlation matrix.)

Table 2
Pilot study: Correlation Matrix of Test Scores of the 3 N/R Tests

	N/R-F	N/R-PF	N/R-EV
N/R-F	1		
N/R-PF	.41	1	
N/R-EV	.52	.87	1

Note. N/R-F=Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking.

A total of 3 sets of test scores were involved in the analysis. One eigenvalue greater than 1.0 was obtained (eigenvalue=2.23). Similar to the analysis conducted on the items of all 3 tests of nonabsolute/ relativistic (N/R) thinking, extraction was terminated in 7 iterations due to communality exceeding 1.

Again as an alternative, another exploratory factor analysis was conducted on the test scores of only the 2 postformal level N/R tests -- N/R-PF (postformal form) and N/R-EV (epistemic view). A total of 2 variables (2 sets of test scores) were involved. One eigenvalue greater 1.0 was obtained. The eigenvalue was 1.87, accounting for 93.7% of the variance. One factor was extracted. Both tests yielded equally high loadings (0.93) on this factor.

Results of the above exploratory factor analyses seem to suggest that the scores of the 2 postformal level N/R tests -- N/R-PF (postformal form) and N/R-EV (epistemic view) -- tended to load on a common factor. However, when the scores of all 3 N/R tests were analyzed together, they did not converge on a common factor. This seem to suggest that the formal form of nonabsolute/ relativistic (N/R) thinking is indeed qualitatively distinct from the postformal form and the epistemic view of nonabsolute/ relativistic (N/R) thinking as hypothesized in this study. However, such preliminary results which were based on a very small sample need to be validated with a full data set based on a larger sample in the main study.

To address Questions (c) and (d), contingency tables were constructed to evaluate the certain specific relationships among the 3 N/R tests as to the primacy of one test over the other (that is the mastery of one test is a necessary but not sufficient condition for that of the other). The contingency tables of the forms: N/R-F (formal form) x N/R-PF (postformal form), N/R-F (formal form) x N/R-EV (epistemic view), and N/R-EV (epistemic view) x N/R-PF (postformal form) are displayed in Figure 3.

To establish that mastery of one test is a necessary but not sufficient condition for that of another, logically the contingency table involved should contain one empty cell

Figure 3
Pilot Study: Contingency Tables

N/R-F (formal form) x N/R-PF (postformal form)

		N/R-PF (postformal form) non-mastery (1,2)	mastery (3,4)
N/R-F	non-mastery (1,2)	8	0
	mastery (3,4)	4	2

N/R-F (formal form) x N/R-EV (epistemic view)

		N/R-EV (epistemic view) non-mastery (1,2)	mastery (3,4)
N/R-F	non-mastery (1,2)	7	1
	mastery (3,4)	4	2

N/R-EV (epistemic view) x N/R-PF (postformal form)

		N/R-PF (postformal form) non-mastery (1,2)	mastery (3,4)
N/R-EV	non-mastery (1,2)	11	0
	mastery (3,4)	2	4

(target cell). This target cell is the intersection of the non-mastery of an easier test and the mastery of a more difficult test and therefore, there should be no entry for the target cell. Therefore, there should be no entries for cell N/R-F (1,2) by N/R-PF (3,4); cell N/R-F (1,2) by N/R-EV (3,4); and cell N/R-EV (1,2) by N/R-PF (3,4). However, exceptional cases would not be unexpected. If these exceptional cases are few in number, the model would not be threatened.

Tentatively, the results of the contingency tables appear to support the hypotheses that the mastery of N/R-F (formal form) is a necessary but not sufficient condition for that of N/R-PF (postformal form) and N/R-EV (epistemic view), and that the mastery of N/R-EV (epistemic view) is a necessary but not sufficient condition for that of N/R-PF (postformal form). Again, these results need to be validated with a full data set in the main study.

To address Question (e), the internal consistency among the test items of the 2 postformal level N/R tests -- N/R-PF (postformal form) and N/R-EV (epistemic view) -- was explored. The Cronbach Alphas obtained for N/R-PF (postformal form) was 0.95 and for N/R-EV was 0.93. These results suggest that the item scores of both tests were quite internally consistent though not necessarily implying unidimensionality within the tests.

Other observations

In the data obtained from the scores of all 22 participants, it was observed that the transitional development of the postformal form of nonabsolute/ relativistic (N/R) thinking does not appear until the approximate age of 13 years. Regarding the 5 participants who were administered only the N/R-PF (postformal form), their ages ranged from 7 years to 12 years. Their scores did not contradict the above observation in that the transitional development of the postformal form of nonabsolute/ relativistic (N/R) thinking also did not appear in all 5 participants.

Follow up

Information obtained from this pilot study in conjunction with participant feedback on the tests were used as input for item revision. Some items on both tests were rephrased for clarity and simplicity. For the N/R-PF (postformal form), 2 items were deleted from the original 6 items, and for the N/R-EV (epistemic view), 1 item was deleted from the original 5 items because of redundancy. Only the items selected for the revised version of the tests were used for analyses in this pilot study.

Different item orders were tried for the presentation of N/R-PF (postformal form) and N/R-EV (epistemic view) and did not seem to yield significant differences in the response patterns. Tester bias had not been observed.

4. Design and Proposed Analysis

This is the last section of part B (Methodology). To recapitulate, in sections 1 and 2, Research Question 1 (How can nonabsolute/ relativistic (N/R) thinking be operationally defined?) and Research Question 2 (How can nonabsolute/ relativistic (N/R) thinking be measured?) were addressed respectively. In section 3, a pilot study was conducted to explore initially the relationships among the 3 tests of nonabsolute/ relativistic (N/R) thinking which are specifically designed for this study. In this section, Research Questions 3 and 4 which are related to the main study are addressed. The research questions to be addressed are as follows:

Research Question 3:

Is nonabsolute/ relativistic (N/R) thinking a possible unifying commonality underlying the selected models of postformal reasoning?

Research Question 4:

Is nonabsolute/ relativistc (N/R) thinking an instance of formal or postformal reasoning or both?

The design and proposed analysis for the main study are discussed in the subsections: 1) Participants; 2) Procedures; 3) Instruments; and 4) Research questions, hypotheses, and statistics.

Participants

The participants would be about 250 persons with ages ranging from 10 to above 40. The participants would be categorized into 3 age groups: 1) 10 to 15; 2) 16 to 20; and 3) 21 and above. The participants would be recruited on an individual basis as well

as from the public schools in Vancouver, B.C. and outlying areas and University of British Columbia.

The reasons for deciding on the sample size of about 250 are as follows. Firstly, the major method of statistical analysis employed in this study would be confirmatory factor analysis. According to Comrey (1992), a sample size of 200 would be considered as fair, and 300 as good, for factor analysis in general. Thus a sample of about 250 would be adequate to demonstrate the general patterns of relationships among variables if there are any. Secondly, from a statistical standpoint, when factors are strong and distinct and the number of variables is not too large, a relatively small sample size would be acceptable. As a general rule of thumb, a minimum of 5 cases for each observed variable would be considered adequate (Tabachnich & Fidell, 1989). In this study, a maximum of 12 variables (a maximum of 8 individual test scores or 12 item scores) would be involved in each analysis. Thus about 250 cases would more than satisfy the minimum requirement.

The rationale for selecting the age range of 10 to above 40 years is that this age range would probably identify the onsets of minimal formal reasoning, nonabsolute/relativistic (N/R) thinking and minimal postformal reasoning as well as their maturing phases.

According to Piaget (1972), all individuals reach the stage of formal operations, if not between 11 and 15 years, at least between 15 and 20, though some researchers suggested that up to 50 percent of adults never reach the formal reasoning stage (see King, 1986). Correspondingly, as revealed in the tentative findings of the pilot study, the age of onset of nonabsolute/ relativistic (N/R) thinking is around 15. Thus group 1 (ages 10 to 15) is set up to identify the onsets of both minimal formal reasoning and nonabsolute/ relativistic (N/R) thinking.

It is speculated that the development of postformal reasoning begins in late adolescence and early adulthood (see Commons, Richards & Armon, 1984). Thus group 2 (ages 16 to 20) is set up to identify the onset of the minimal postformal reasoning.

Finally, group 3 (ages 21 and above) is set up to identify the maturing phases of all three types of thinking (formal reasoning, nonabsolute/ relativistc (N/R) thinking and postformal reasoning).

Students currently enrolled in English as a Second Language (ESL) Program and special programs would be screened out so as not to confound the findings.

Procedures

The participants would be administered a battery of tests in pencil-and-paper format. The tests would be administered individually or in groups. These tests were either designed or adapted to measure three types of thinking, namely nonabsolute/ relativistic (N/R) thinking, minimal formal reasoning and the minimal postformal reasoning specific to the selected postformal models. A table containing the constructs being measured and the list of corresponding tests is presented in the next section under the topic of Instruments.

All the tests would be scored by two raters. The final test scores for each test entered for statistical analyses would be based on inter-rater agreement which was the average of the individual test scores provided by the two raters.

To minimize intra-rater bias in the scoring of any age group or educational level, all the protocols would be shuffled before scoring. Also, to minimize intra-rater bias in the scoring of any individual protocol, the raters would score the protocols of all the participants on one test before proceeding to the next test in the battery.

Instruments

The constructs being measured and the tests which measure them are contained in Table 3.

Table 3
List of Constructs and Corresponding Tests

Construct being measured	Test	Source
1. Formal Form of N/R Thinking (N/R-F)	N/R-F (ATFR subtest: Coordination of 2 or more frames of reference)	Arlin (1984b)
2. Postformal Form of N/R Thinking (N/R-PF)	N/R-PF	Designed by Arlin & the author (1993)
3. Epistemic View of N/R Thinking (N/R-EV)	N/R-EV	Designed by Arlin & the author (1993)
4. Minimal Formal Reasoning	FR (ATFR subtests: Multiplicative compensations; probabilities; correlations.)	Arlin (1984b)
5. Problem Finding (minimal presence)	PF (Cognitive Problem Finding)	Arlin (1974)
6. Dialectical Reasoning (minimal presence)	DR (Structured questions)	Adapted by Arlin & the author from Basseches(1980)
7. Relativistic Operations (Minimal presence)	RO (Bedroom problem)	Adapted by the author from Sinnott (1984)
8. Reflective Judgment (minimal presence)	RJ (Food Additives)	Adapted by Arlin & the author from King et al. (1983)

Note. N/R=Nonabsolute/ relativistic.

Eight tests are selected for use in this study. They can be divided into 3 groups of tests. These tests were either designed or adapted to measure 3 types of thinking, namely nonabsolute/ relativistic (N/R) thinking, minimal formal reasoning and minimal postformal reasoning. Below is a brief overview of these groups of tests.

The first group of tests includes the 3 tests of nonabsolute/ relativistic (N/R) thinking:

1) The Test of the Formal Form of N/R Thinking (N/R-F) which aims at measuring the basic form of nonabsolute/ relativistic (N/R) thinking operating at the formal level. In this test, a subtest of the Arlin Test of Formal Reasoning (ATFR) (1984) was adopted to assess the presence of a simple form of relativistic thinking.
2) The Test of the Postformal Form of N/R Thinking (N/R-PF) which aims at measuring the basic form of nonabsolute/ relativistic (N/R) thinking operating at the postformal level.
3) The Test of the Epistemic View of N/R Thinking (N/R-EV) which aims at measuring the level of epistemic beliefs associated with nonabsolute/ relativistic (N/R) thinking. (Both the N/R-PF and the N/R-EV are specifically designed by Arlin and the author for this study to measure nonabsolute/ relativistic (N/R) thinking operating at the postformal level.)

The second group of test(s) includes:

4) The test of Minimal Formal Reasoning (FR) which aims at measuring the minimal level of ability for the performance of formal operations. Three subtests of the ATFR (1984) are used representing the first tier of the ATFR which is originally composed of three tiers.

The third group of tests includes the 4 postformal tests:

5) The test of Problem Finding (PF),
6) The test of Dialectical Reasoning (DR),
7) The test of Relativistic Operations (RO), and

8) The test of Reflective Judgment (RJ).

For both Relativistic Operations and Reflective Judgment, one subtest was adopted from the original tests. The rationale for the selection of the particular subtests is stated in their respective test descriptions (see Appendixes B - F). For this study, the scoring criteria of the 4 postformal tests are adapted to tap the minimal presence of postformal reasoning specific to each model.

The descriptions of the 3 tests of nonabsolute/ relativistic (N/R) thinking (tests 1 - 3) were already presented in section 3 of this chapter. The descriptions of the rest of the tests (Tests 4 - 8) as well as their relevant statistical information are provided in the Appendixes.

A summary of the interpretation of test scores of these 8 tests is presented in Table 4.

A sample of the complete set of tests to be administered to the participants is provided in Appendix G. The set of tests is presented in two forms (A and B). The purpose of having two forms of the same set of tests is to counterbalance the test order effect of 1) multiple choice questions (of well-defined problems) and 2) open-ended questions (of ill-defined problems). In Form A, the multiple choice questions -- Minimal Formal Reasoning (FR) and N/R-F (formal form) precede the open-ended questions -- N/R-PF (postformal form), N/R-EV (epistemic view), Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ) -- in the order as stated. In Form B, the open-ended questions (N/R-PF, N/R-EV, PF, DR, RO and RJ) precede the multiple choice questions (FR and N/R-F) in the order as stated. Each participant would be assigned either Form A or Form B on a random basis.

Table 4
Summary of Interpretation of Test Scores

Tests	Scores			
	1	2	3	4
N/R-F (formal form)	Absence	Transitional development	Partial development	Full development
N/R-PF (postformal form)	Absence	Transitional development	Partial development	Full development
N/R-EV (epistemic view)	Absence	Transitional development	Partial development	Full development
FR (Minimal Formal Reasoning)	Absence	Transitional development	Partial Mastery	Full Mastery
	1	2	3	
PF (Problem Finding)	Absence	Transitional development	Minimal presence of postformal reasoning specific to PF	
DR (Dialectical Reasoning)	Absence	Transitional development	Minimal presence of postformal reasoning specific to DR	
RO (Relativistic Operations)	Absence	Transitional development	Minimal presence of postformal reasoning specific to RO	
RJ (Reflective Judgment)	Absence	Transitional development	Minimal presence of postformal reasoning specific to RJ	

Note. N/R=Nonabsolute/ relativistic.

Research Questions, Hypotheses & Statistics

This is the last subsection in section 4 (Design and Proposed Analysis). In this subsection, research questions of the main study, namely Research Questions 3 and 4, are stated together with the proposed statistics and with the hypotheses to be tested. Analyses and results of these two research questions are presented in the next chapter (chapter IV).

Research Question 3:

Is nonabsolute/ relativistic (N/R) thinking a common factor underlying the selected models of postformal reasoning?

Specific questions, proposed statistics and hypotheses related to Research Question 3 are stated below:

3a. What, if any, commonalities exist among the items of the 3 tests of nonabsolute/ relativistic (N/R) thinking --N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view)?

The purpose of this question is to explore the nature of and the relationships among the items of the 3 N/R tests using confirmatory factor analysis.

From a measurement perspective, the application of factor analysis on item scores represents one approach of internal structure analysis in the context of construct validation (Pedhazur & Schmelkin, 1991). Both internal and external structure analyses contribute to part of the ever-ongoing process of construct validation. Although construct validation is not the main focus of this study, the results of the confirmatory factor analyses conducted on the test items could serve as a foundation for the analyses to

be conducted at the next level using test scores instead of item scores of the three N/R tests.

The proposed statistics would involve confirmatory factor analysis using the LISREL 8 computer program. The method of estimation would be Maximum Likelihood (ML). The analysis would be based on the covariances rather than the correlations among the item scores of the 3 N/R tests. The rationale is that the analysis of correlation matrices is problematic in several ways. Such an analysis may a) modify the model being analyzed, b) produce incorrect Chi-square and other goodness-of-fit measures, and c) give incorrect standard errors (Cudeck, 1989; Joreskog & Sorbom, 1993). Therefore, all the subsequent confirmatory factor analyses in this study would be based on covariance matrices.

Two models (Models A1 and A2) would be constructed and tested.

Model A1 would evaluate the following hypotheses:

Hypothesis 3a(1): Three test factors, namely N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view), would underlie the 12 test items.

Hypothesis 3a(2): The 3 test factors would be correlated. (The implication of this hypothesis is that these 3 test factors tap three different aspects of the same construct, hypothesized to be the nonabsolute/ relativistic thinking (N/R) test factor.)

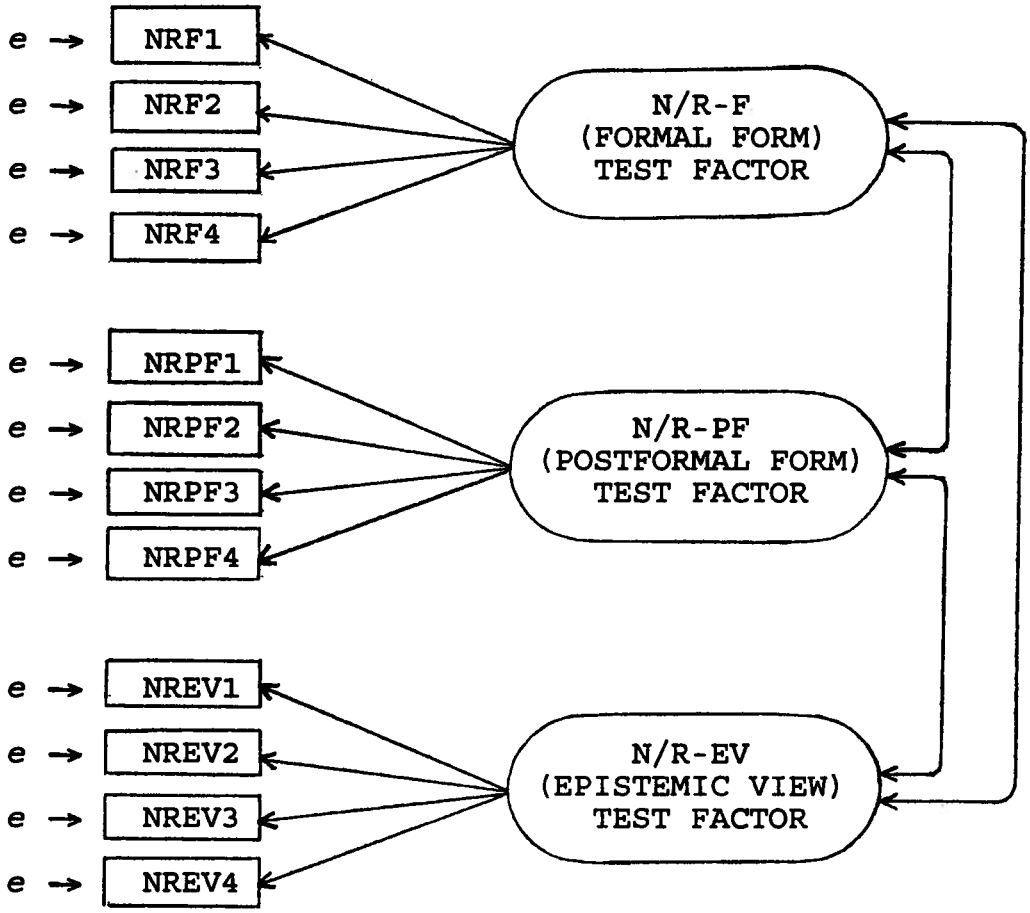
(For specifications of Model A1, see Figure 4.)

Model A2 would evaluate the following hypothesis:

Hypothesis 3a(3): A second order factor, hypothesized to be the nonabsolute/ relativistic thinking (N/R) test factor, would underlie the 3 test factors.

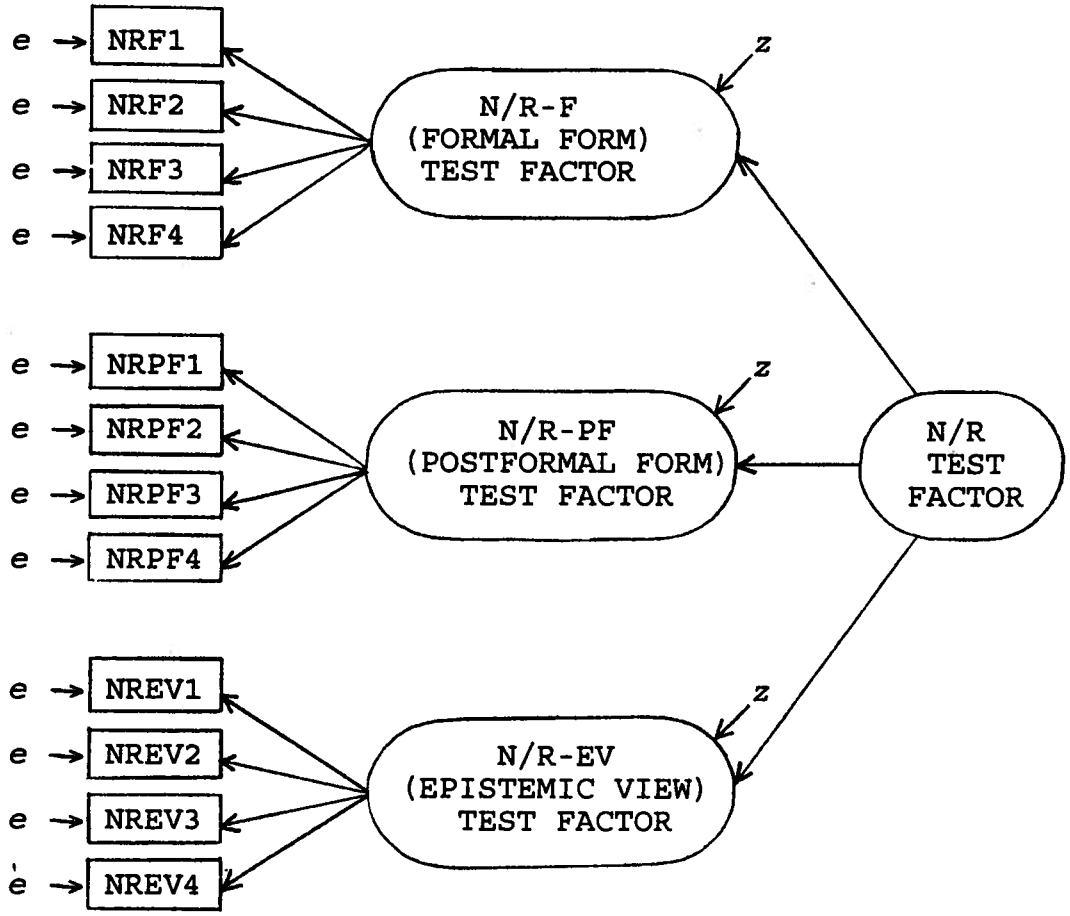
(For specifications of Model A2, see Figure 5.)

Figure 4
Model A1 of Confirmatory Factor Analysis



Note. NRF1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. NRPF1-4 = items of Test of Postformal Form of N/R Thinking. NREV1-4 = items of Test of Epistemic View of N/R Thinking. *e* = error/ unique variance.

Figure 5
Model A2 of Confirmatory Factor Analysis



Note. NRF1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. NRPF1-4 = items of Test of Postformal Form of N/R Thinking. NREV1-4 = items of Test of Epistemic View of N/R Thinking. *e* = first order error/ unique variance. *z* = second order error/ unique variance.

3b. What, if any, commonalities exist among the 3 tests of nonabsolute/ relativistic (N/R) thinking and the 4 tests of postformal reasoning (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ))?

The purpose of this question is to explore nonabsolute/relativistic (N/R) thinking as a possible unifying commonality underlying the selected models of postformal reasoning.

The proposed statistics would involve confirmatory factor analysis using the LISREL 8 computer program. The method of estimation would be Maximum Likelihood (ML). The analysis would be based on the covariances among the test scores of the 3 N/R tests and the 4 postformal tests.

Four models (Models B1 to B4) would be constructed and tested.

Model B1 would evaluate the following hypotheses:

Hypothesis 3b(1): A common factor, namely the nonabsolute/ relativistic thinking (N/R) test factor, would underlie the 3 N/R tests.

Hypothesis 3b(2): A common factor, namely the postformal test factor, would underlie the 4 postformal tests.

Hypothesis 3b(3): The nonabsolute/ relativistic thinking (N/R) test factor and the postformal test factor would be correlated. (The implication of this hypothesis is that the two test factors would represent two different aspects of the same construct, hypothesized to be nonabsolute/ relativistic (N/R) thinking.)

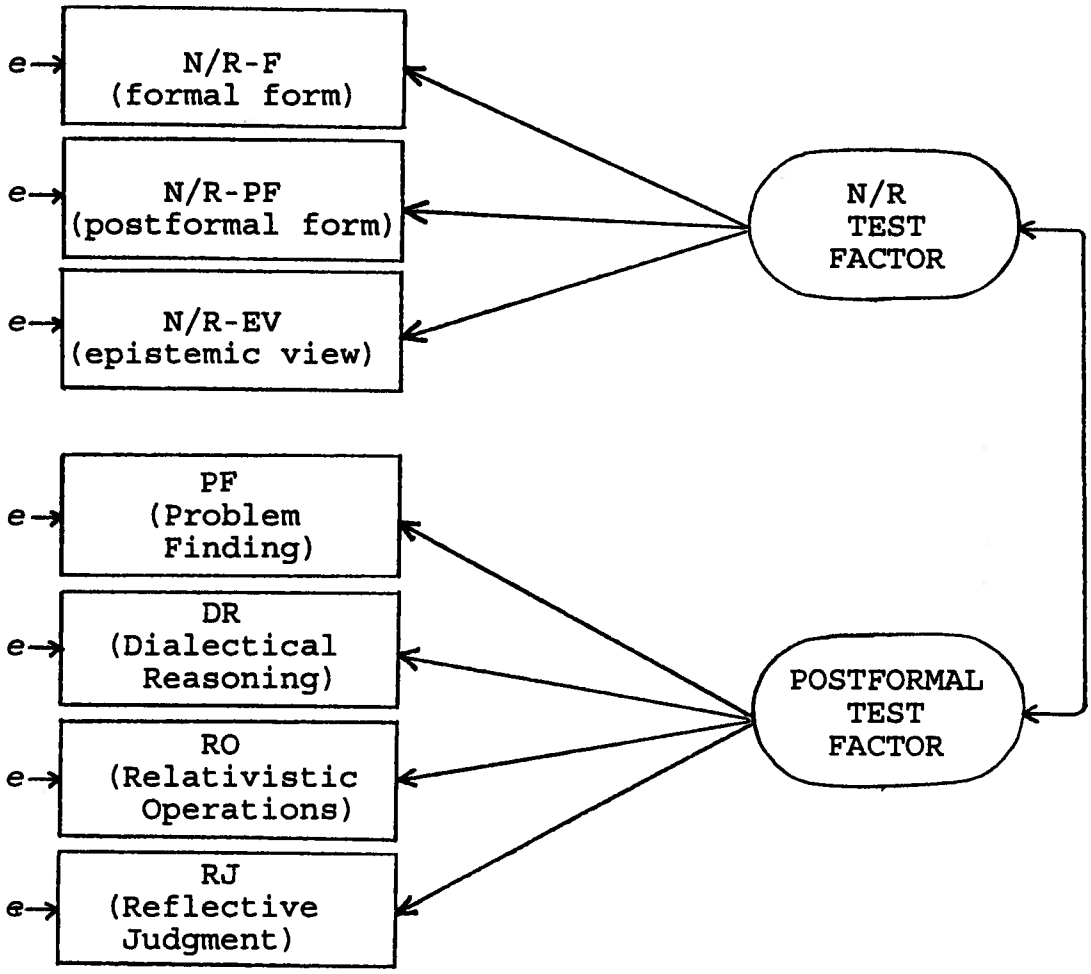
(For specifications of Model B1, see Figure 6.)

Models B2 and **B3** would evaluate the following hypothesis:

Hypothesis 3b(4): nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the 3 N/R tests and the 4 postformal tests.

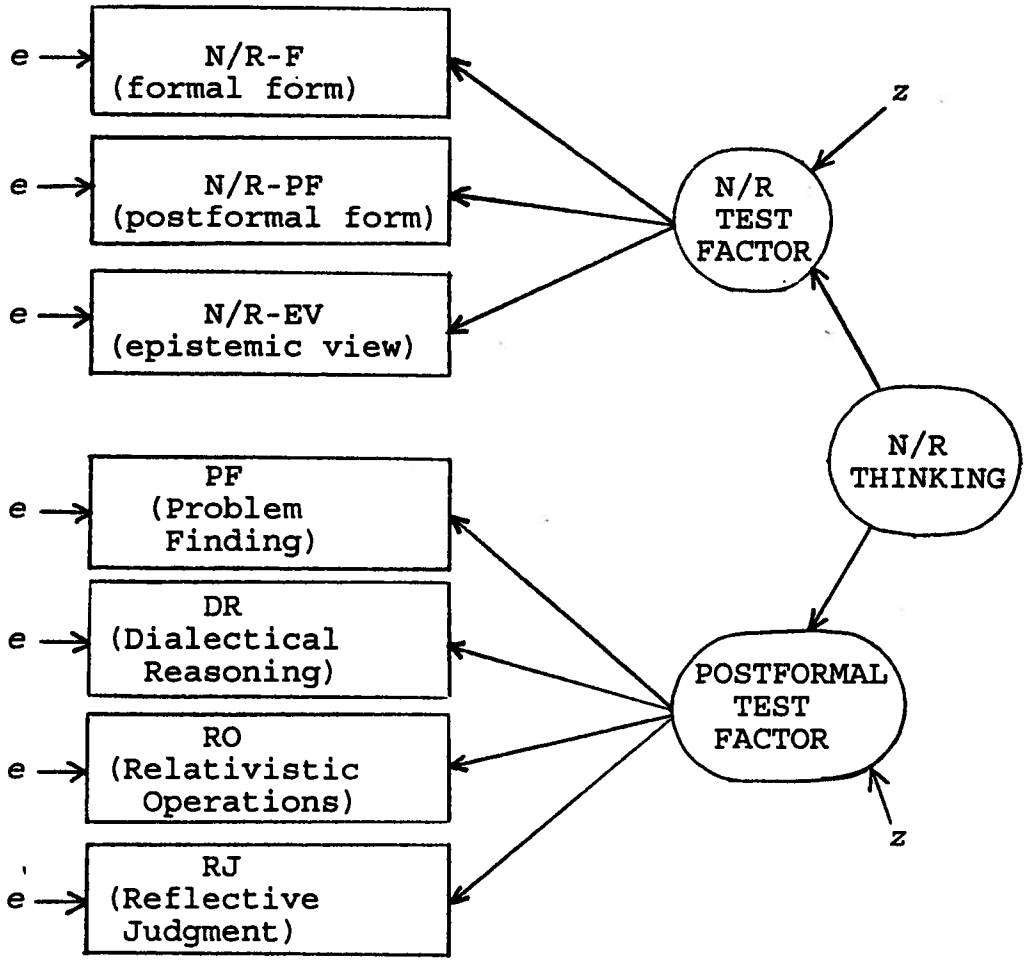
(For specifications of Models B2 and B3, see Figures 7 and 8.)

Figure 6
Model B1 of Confirmatory Factor Analysis



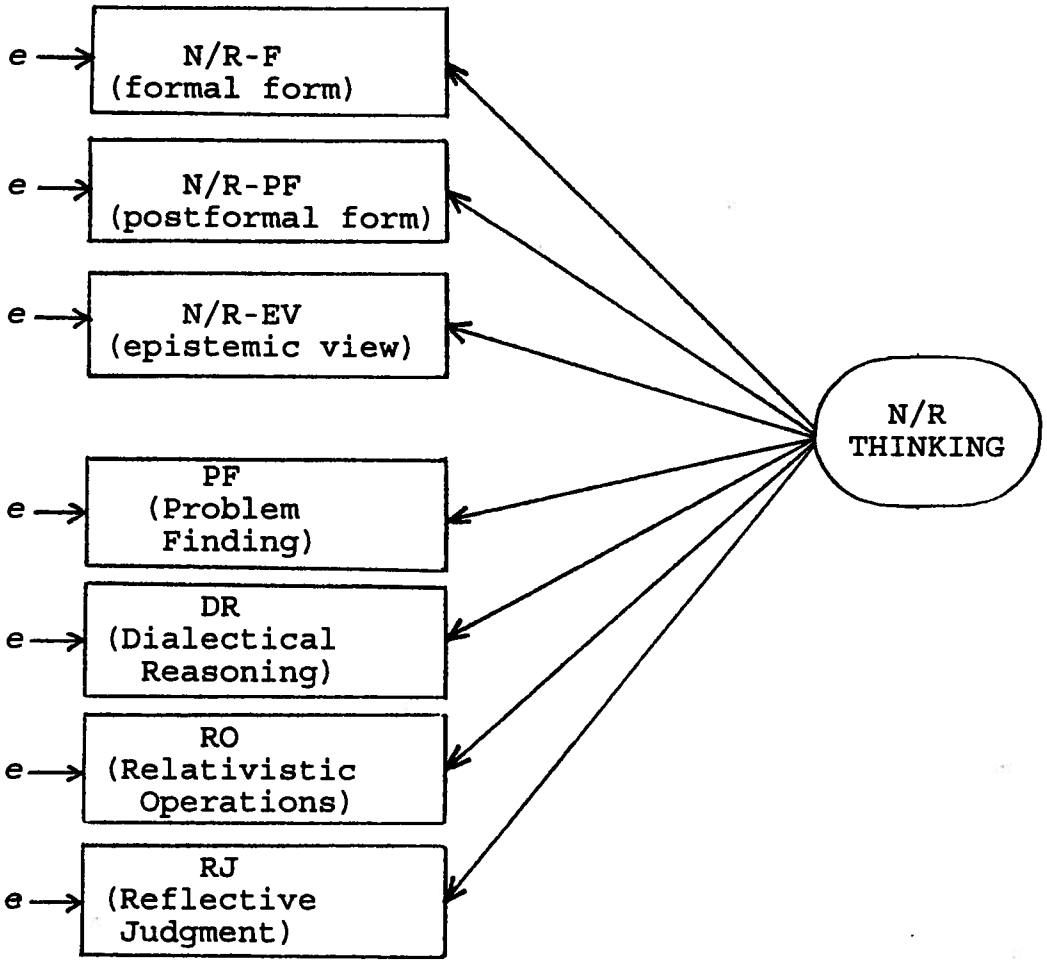
Note. N/R=Nonabsolute/ relativistic. *e* = error/ unique variance.

Figure 7
Model B2 of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic. *e* = first order error/ unique variance. *z* = second order error/ unique variance.

Figure 8
Model B3 of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic. *e* = error/ unique variance.

Model B4 would evaluate the following hypotheses:

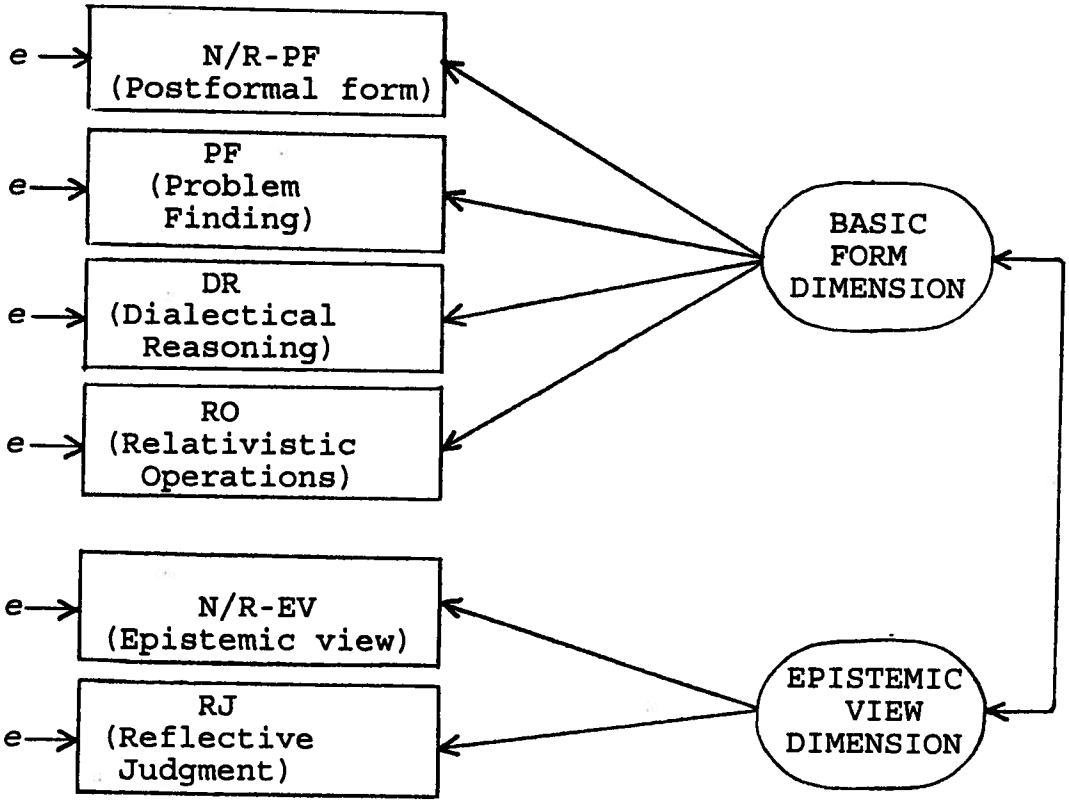
Hypothesis 3b(5): A common factor, namely the basic form dimension, would underlie the 4 tests -- N/R-PF (postformal form), PF (Problem Finding), DR (Dialectical Reasoning), and RO (Relativistic Operations).

Hypothesis 3b(6): A common factor, namely the epistemic view dimension, would underlie the 2 tests -- N/R-EV (epistemic view) and RJ (Reflective Judgment).

Hypothesis 3b(7): The two factors, namely the basic form dimension and the epistemic view dimension, would be correlated. (The implication of this hypothesis is that two dimensions could be differentiated within the same construct, hypothesized to be the postformal level of nonabsolute/ relativistic (N/R) thinking.)

(For specifications of Model B4, see Figure 9.)

Figure 9
Model B4 of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic. *e* = error/ unique variance.

Research Question 4:

Is nonabsolute/ relativistic (N/R) thinking an instance of formal or postformal reasoning or of both?

Specific questions, proposed statistics and hypotheses related to Research Question 4 are stated below:

4a. What is the order of difficulty among the 8 tests -- Minimal Formal Reasoning (FR), N/R-F (formal form), N/R-PF (postformal form), N/R-EV (epistemic view), Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO), and Reflective Judgment (RJ))?

The first approach to this question would be to rank order the 8 tests according to the percentage of task mastery.

The following hypothesis would be evaluated.

Hypothesis 4a(1): The hypothesized order of task difficulty from the least to the most difficult would be as follows -- the test of Minimal Formal Reasoning (FR); the N/R test at the formal level (N/R-F (formal form)); the 2 N/R tests at the postformal level (N/R-PF (postformal form) and N/R-EV (epistemic view)); and the 4 postformal tests (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ)).

The rationale for this hypothesized rank order is that N/R-F (formal form) is closer to formal reasoning whereas N/R-PF (postformal form) and N/R-EV (epistemic view) are closer to postformal reasoning. This hypothesis is based on the assumption that the relationships among the tests can be described in a linear model.

The second approach to this question would be to construct contingency tables to evaluate the certain specific relationships among the 8 tests as to the primacy of one test

over the other (that is the mastery of one test is a necessary but not sufficient condition for that of the other).

The following hypotheses would be evaluated.

Hypothesis 4a(2): Minimal Formal Reasoning (FR) << (is a necessary but not sufficient condition for) each of the 3 N/R tests.

Hypothesis 4a(3): N/R-F (formal form) << each of the 2 postformal N/R tests (N/R-PF (postformal form) and N/R-EV (epistemic view)).

Hypothesis 4a(4): N/R-EV (epistemic view) << N/R-PF (postformal form).

Hypothesis 4a(5): N/R-PF (postformal form) << each of the 4 postformal tests.

Hypothesis 4a(6): N/R-EV (epistemic view) << each of the 4 postformal tests.

Hypothesis 4a(7): The transitional development of N/R-PF (postformal form) << each of the 4 postformal tests.

Hypothesis 4a(8): The transitional development of N/R-EV (epistemic view) << each of the 4 postformal tests.

4b. What is the order of the 8 tests according to their ages of onset of task mastery?

To address this question, the 8 tests were rank ordered according to the age of onset at which the task of each test is mastered. The age of onset is defined as the basal age at and above which age level there is a minimum of at least one incidence of task mastery. For example, in a particular test, if at least one incidence of task mastery appeared at ages 10, 11, 12 and so forth, age 10 would be taken as the age of onset; but if at least one incidence of task mastery of the test appeared at ages 10, 12, 13, 14 and so forth, then age 12 rather than age 10 would be taken as the age of onset. It is not necessary for all the participants of the age of onset thus defined to master the test in question. However, the definition is conditional on an adequate representation of participants at each different age level.

The following hypothesis would be evaluated.

Hypothesis 4b(1): The hypothesized order of the 8 tests according to their ages of onset of task mastery would be as follows -- the test of Minimal Formal Reasoning (FR); the N/R test at the formal level (N/R-F (formal form)); the 2 N/R tests at the postformal level (N/R-PF (postformal form) and N/R-EV (epistemic view)); and the 4 postformal tests (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ)).

The rationale for this hypothesized rank order is that N/R-F (formal form) is closer to formal reasoning whereas N/R-PF (postformal form) and N/R-EV (epistemic view) are closer to postformal reasoning. This hypothesis is based on the assumption that the relationships among the tests can be described in a linear model.

4c. How do the 3 N/R tests correlate with the factors of formal level reasoning and of postformal level reasoning?

The following hypotheses would be evaluated.

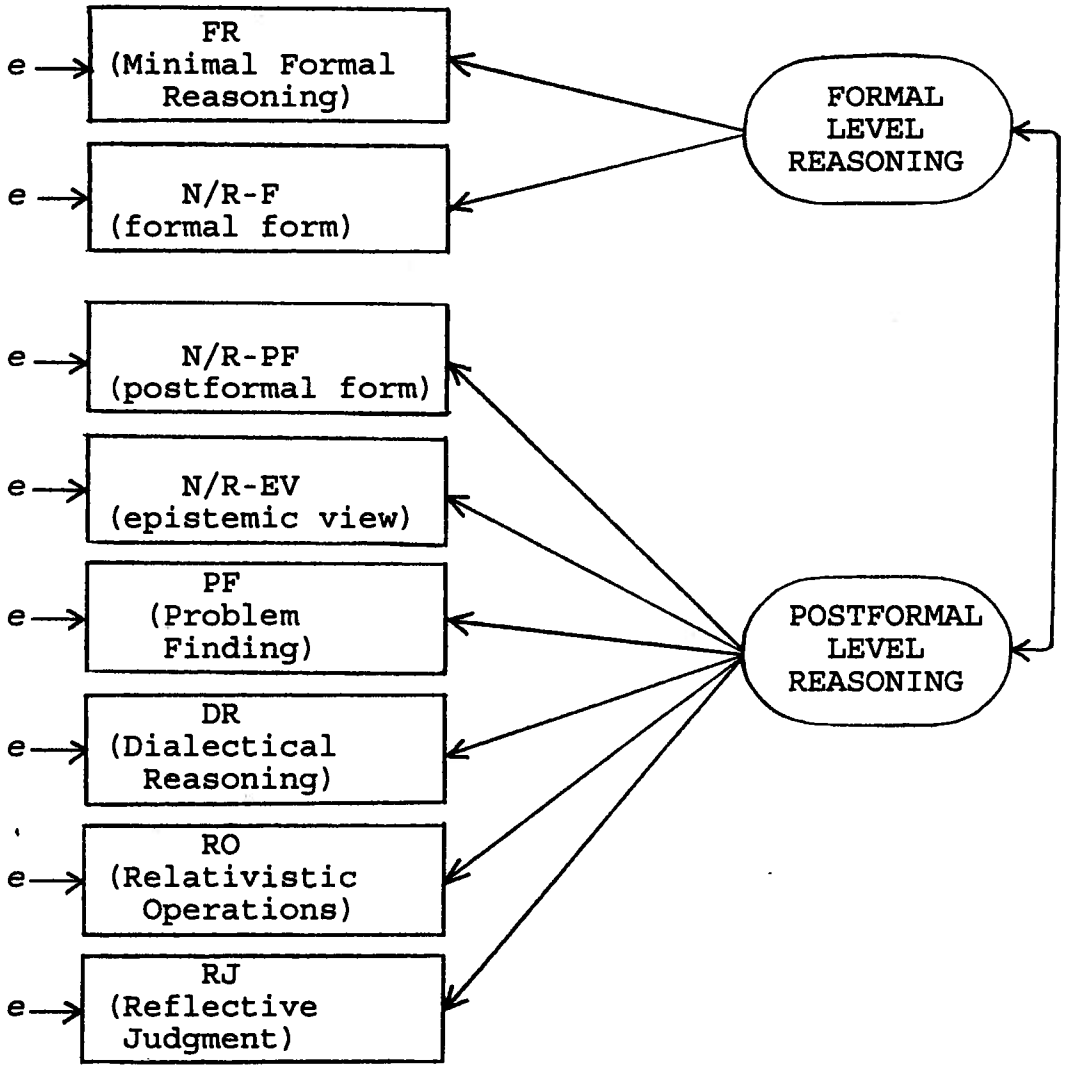
Hypothesis 4c(1): N/R-F (formal form)would load primarily on the factor of formal level reasoning.

Hypothesis 4c(2): N/R-PF (postformal form) and N/R-EV (epistemic view) would load primarily on the factor of postformal level reasoning.

The first approach to this question would involve exploratory factor analysis using SPSS:X computer programme. The analysis would be based on the correlations among the scores of the 8 tests, namely the 3 N/R tests, the 4 postformal test and the test of Minimal Formal Reasoning (FR). The method of factor extraction would be Principal Axis Factoring (PAF).

The second approach to this question would involve confirmatory factor analysis using LISREL 8 computer programme. The method of estimation would be Maximum Likelihood (ML). The analysis would be based on the covariances among the scores of the 8 tests. (For specifications of Model C1, see Figure 10.)

Figure 10
Model C1 of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic. *e* = error/ unique variance.

4d. Which of the performances in the 3 N/R tests would singly or in combination best predict the performances in each of the 4 postformal tests?

To address this question, the following hypothesis would be evaluated.

Hypothesis 4d(1): Performances in N/R-PF (postformal form) and in N/R-EV (epistemic view) rather than that in N/R-F (formal form) would be better predictors of the performances in the 4 postformal tests.

Proposed statistics would involve four separate multiple regression analyses. The predictors in each of the 4 analyses would be the performances in the 3 N/R tests. The criterion variable in each analysis would be the performance in Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ) respectively.

The analyses and results are presented in chapter IV.

4e. Between the performances in N/R-F (formal form) and in N/R-PF (postformal form), which would be better predicted by the performance in N/R-EV (epistemic view)?

To address this question, the following hypothesis would be evaluated.

Hypothesis 4e(1): Performance in N/R-PF (postformal form) rather than that in N/R-F (formal form) would be better predicted by performance in N/R-EV (epistemic view).

The rationale of this hypothesis is that the performances in both N/R-PF (postformal form) and N/R-EV (epistemic view) are hypothesized to represent the postformal level of nonabsolute/ relativistic (N/R) thinking, and that a shift from an absolute to a non-absolute epistemic view is crucial to the development of the postformal form of nonabsolute/ relativistic (N/R) thinking.

Proposed statistics would involve 2 separate simple regression analyses. The predictor in each analysis would be the performance in N/R-EV (epistemic view). The

criterion variable in each analysis would be the performance in N/R-F (formal form) and in N/R-PF (postformal form) respectively.

The analyses and results are presented in chapter IV.

CHAPTER IV: ANALYSES AND RESULTS

In this chapter the analyses and results of the main study are presented. There are three parts in this chapter. Part A contains the information on data collection. Part B contains the preliminary statistics pertinent to the main analyses. Part C contains the analyses and results of the main study which is specifically designed to address Research Questions 3 and 4 of this study.

In order to evaluate the different research hypotheses of this study, different statistical approaches were applied. The computer software LISREL 8 (Joreskog & Sorbom, 1993) was used for the confirmatory factor analyses conducted in this study. The computer programme SPSS:X was used for the rest of the statistical analyses.

For a glossary of the abbreviations and symbols used in this chapter, see Appendix H.

A. DATA COLLECTION

A total of 254 participants who had completed the paper-and-pencil task were involved in this study. There were 25 participants who did not complete the pencil-and-paper task, and their protocols were excluded from the analysis. The participants were encouraged to attempt and complete all the test items; but they were also given the freedom to discontinue at any point. Upon examining the 25 incomplete protocols, it was revealed that based on the performance on other test items, the unanswered questions reflected the participants' test attitude rather than their inability to understand or answer the questions.

Of the 254 participants whose protocols were analyzed, their ages ranged from 10 to 48. They were categorized into 3 general groups. Group 1 comprising participants

aged 10 to 15 was meant to identify the onsets of both formal reasoning and nonabsolute/ relativistic (N/R) thinking. This group made up 44.1% of the sample. Group 2 comprising participants aged 16 to 20 was meant to identify the onsets of postformal reasoning. This group made up 33.9% of the sample. Group 3 comprising participants aged 21 and above was meant to identify the maturing phases of all 3 types of thinking, namely formal reasoning, nonabsolute/ relativistic (N/R) thinking and postformal reasoning. This group made up the remaining 22% of the sample.

Of the sample, 38.6% was male and 61.4% was female.

The educational levels of the participants ranged from Grade 5 to the doctoral level.

The primary school students were recruited on an individual basis. The pencil-and-paper task was administered in small group sessions with the help of a volunteer research assistant. In view of the students' age and educational levels, special efforts were taken to ensure that they understood all the test questions. Forty completed protocols (15.7% of the total sample) were obtained from students of Grades 5 to 7.

The secondary school students were recruited from two sources. Students of Grades 9 to 12 were contacted through the school authorities of Selkirk Secondary School, Kimberly, British Columbia. The pencil-and-paper task was administered in class sessions through the help of the principal advisor of this study. Fifty-three completed protocols (20.9% of the total sample) were obtained from these students. Another group of secondary school students residing in Vancouver, British Columbia was contacted on an individual basis. The pencil-and-paper task was given as a take-home assignment. Eighty-five completed protocols (33.5% of the total sample) were obtained from students of Grades 8 to 12.

Participants of post-secondary levels were recruited on an individual basis as well as through the help of course instructors at the University of British Columbia. The pencil-and-paper task was given as a take-home assignment. Seventy-six completed

protocols (29.9% of the total sample) were thus obtained from individuals, and undergraduate and graduate students of the University of British Columbia. The educational levels of these 76 participants ranged from first year university to doctoral level. Their major fields of study encompassed Arts, Commerce, Education, Science and Social Sciences.

These 254 participants were administered a pencil-and-paper task either in group sessions or as individual take-home assignments. There are two forms, Form A and Form B, to the pencil-and-paper task, and each participant was assigned one of either form on a random basis. The pencil-and-paper task was composed of 8 tests each measuring a construct of reasoning. A brief overview of these tests was presented in chapter III. For quick reference, these 8 tests are listed below:

1) Test of the Formal Form of N/R thinking (N/R-F)

2) Test of the Postformal Form of N/R thinking (N/R-PF)

3) Test of the Epistemic View of N/R thinking (N/R-EV)

4) Test of Minimal Formal Reasoning (FR)

5) Test of Problem Finding (PF)

6) Test of Dialectical Reasoning (DR)

7) Test of Relativistic Operations (RO)

8) Test of Reflective Judgment (RJ)

A summary of the interpretation of test scores of the 8 tests was presented in Table 4.

For the 3 N/R tests -- N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view) -- and the test of Minimal Formal Reasoning (FR), the maximum score of each test is 4. For the 4 postformal tests (Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment), the maximum score of each test is 3. It is important to note that the scoring criteria of the 4 postformal tests were adapted from their original scoring criteria in order to tap the minimal presence

rather than the fully developed forms of postformal reasoning specific to the selected postformal models.

B. PRELIMINARY STATISTICS

In part B, the preliminary statistics pertinent to the main analysis of this study are presented. There are 4 sections. Section 1 contains the inter-rater reliability indices; section 2 the means and standard deviations; section 3 the correlation matrices; and section 4 the covariance matrices.

1. Inter-rater Reliability Indices

All the test protocols were scored by two raters. The final test scores entered for statistical analyses in part B were based on inter-rater agreement which was the average of the individual test scores provided by the two raters.

The inter-rater reliabilities of the test scores except for those in the multiple choice tests of Minimal Formal Reasoning (FR) and of N/R-F (formal form) are presented in Table 5. Also presented in this table are the reliability indices of the item scores of two N/R tests, namely N/R-PF (postformal form) and N/R-EV (epistemic view), which were specifically designed for this study.

The inter-rater reliabilities for the scores of each test and of each item of the two N/R tests were computed by Pearson Product-moment Correlations on the two sets of scores provided by the two raters. The inter-rater reliabilities of the test scores ranged from 0.82 to 0.99, and those of the item scores ranged from 0.93 to 0.99. Based on the conventional criterion of 0.80 as an indication of high correlation, these reliability indices would be considered very high.

Table 5
Inter-rater Reliability Indices

Tests	r
N/R-PF (postformal form)	0.99
N/R-EV (epistemic view)	0.98
PF (Problem Finding)	0.90
DR (Dialectical Reasoning)	0.82
RO (Relativistic Operations)	0.98
RJ (Reflective Judgment)	0.92
Items of N/R-PF (postformal form)	**r**
NRPF1	0.99
NRPF2	0.99
NRPF3	0.99
NRPF4	0.99
Items of N/R-EV (epistemic view)	**r**
NREV1	0.98
NREV2	0.96
NREV4	0.93
NREV4	0.96

Note. **r** = Pearson Product-moment Correlations.

2. Means and Standard Deviations

The means and standard deviations of all the 12 item scores of the 3 N/R tests -- N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view) -- are presented in Table 6.

As items of N/R-F (formal form) are in multiple choice format, the item scores yielded are either 1 or 0. The means of the item scores of this test range from 0.28 to 0.59. The standard deviations of the items scores of this test range from 0.45 to 0.50.

Table 6
Means and Standard Deviations of Item Scores of the 3 N/R Tests

Items	Means	Standard Deviations
N/R-F (formal form)		
NRF1	0.54	0.50
NRF2	0.28	0.45
NRF3	0.59	0.49
NRF4	0.30	0.46
N/R-PF (postformal form)		
NRPF1	1.87	0.94
NRPF2	1.24	0.59
NRPF3	1.84	0.93
NRPF4	1.37	0.75
N/R-EV (epistemic view)		
NREV1	1.92	1.04
NREV2	1.63	0.82
NREV3	2.68	0.78
NREV4	2.13	1.05

As items of both N/R-PF (postformal form) and N/R-EV (epistemic view) are in open-ended questions format, the item scores yielded range from 1 to 4. For the item scores of N/R-PF (postformal form), the means range from 1.24 to 1.87 and the standard deviations range from 0.59 to 0.94. For the item scores of N/R-EV (epistemic view), the means range from 1.63 to 2.68 and the standard deviations range from 0.78 to 1.05. In comparison, the means of N/R-EV (epistemic view) fall within a higher range and the standard deviations of N/R-EV (epistemic view) are shown to have a wider spread.

The means and standard deviations of the individual test scores of the 8 tests -- Minimal Formal Reasoning (FR), N/R-F (formal form), N/R-PF (postformal form), N/R-EV (epistemic view), Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO)and Reflective Judgment (RJ) -- are presented in Table 7.

The means of the individual test scores of FR (Minimal Formal Reasoning), N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view) range from 1.57 to 2.77 out of a maximum score of 4 with the test scores of FR (Minimal Formal Reasoning) yielding the highest means. The standard deviations of the individual test scores of these 4 tests range from 0.61 to 1.00 with the test scores of N/R-F (formal form) showing the widest spread.

Table 7
Means and Standard Deviations of Test Scores of the 8 Tests

Test	Means	Standard Deviations
FR (Minimal Formal Reasoning)	2.77	0.84
N/R-F (formal form)	1.70	1.00
N/R-PF (postformal form)	1.57	0.64
N/R-EV (epistemic view)	2.09	0.61
PF (Problem Finding)	1.52	0.66
DR (Dialectical Reasoning)	1.60	0.85
RO (Relativistic Operations)	1.97	0.80
RJ (Reflective Judgment)	1.51	0.67

The means of the individual test scores of PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment) range from 1.51

to 1.97 out of a maximum of 3 with the test scores of RO (Relativistic Operations) yielding the highest means. The standard deviations of the individual test scores of these 4 tests range from 0.66 to 0.85 with the test scores of DR (Dialectical Reasoning) showing the widest spread.

3. Correlation Matrices

The correlation matrix of all the 12 item scores of the 3 N/R tests is presented in Table 8.

Table 8
Correlation Matrix of Item Scores of the 3 N/R Tests

	F1	F2	F3	F4	P1	P2	P3	P4	E1	E2	E3	E4
F1	1											
F2	-.25	1										
F3	.19	-.08	1									
F4	.11	-.06	.26	1								
P1	.08	-.03	.27	.26	1							
P2	.07	-.06	.05	.03	.33	1						
P3	.08	-.07	.30	.25	.79	.39	1					
P4	.09	-.05	.15	.12	.44	.40	.51	1				
E1	.15	-.02	.33	.05	.46	.24	.45	.36	1			
E2	-.03	-.01	.05	.11	.26	.21	.27	.18	.23	1		
E3	.14	-.10	.27	.07	.42	.24	.42	.32	.46	.22	1	
E4	.14	.01	.05	-.05	.04	.00	.12	.11	.13	.19	.11	1

Note. F1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. P1-4 = items of Test of Postformal Form of N/R Thinking. E1-4 = items of Test of Epistemic View of N/R Thinking.

The correlations among all the 12 item scores range from -0.25 to 0.79.

The correlations among the item scores of N/R-F (formal form) range from -0.25 to 0.26.

The correlations among the item scores of the 2 postformal level N/R tests, namely N/R-PF (postformal form) and of N/R-EV (epistemic view), range from 0 to 0.79.

The correlations among the item scores of N/R-F (formal form) and of the 2 postformal level N/R tests which range from -0.10 to 0.33 are relatively low. As two different levels of test are involved, such a pattern of correlations is not unexpected.

As suggested in some literature on statistics, (see Tabachnich & Fidell, 1989, p.604), a matrix that is factorable should include several sizable correlations. The expected size depends, to some extent, on the sample size. Larger sample sizes tend to produce smaller correlations. If none of the correlations in the matrix exceeds 0.3, the use of factor analysis is questionable because there is probably nothing to factor analyze. In view of this criterion of factorability, the correlation matrix presented in Table 8 could be considered as factorable because it includes several sizable correlations exceeding 0.3. However, instead of subjecting this correlation matrix to confirmatory factor analysis, its associated variance-covariance matrix presented in Table 10 is used in order to avoid problems related to the application of confirmatory factor analysis on correlations as stated in chapter III.

The correlation matrix of the individual test scores of the 8 tests are presented in Table 9.

The correlations among the individual test scores of all the 8 tests range from 0.12 to 0.64.

The correlation between the individual tests scores of the 2 formal level tests, namely FR (Minimal Formal Reasoning) and N/R-F (formal form), is 0.28.

The correlations among the individual test scores of the 6 postformal level tests, namely N/R-PF (postformal form), N/R-EV (epistemic view), PF (Problem Finding), DR

(Dialectical Reasoning), RO (Relativistic Operations), and RJ (Reflective Judgment), range from 0.33 to 0.64.

Table 9
Correlation Matrix of Test Scores of the 8 Tests

	FR	NRF	NRPF	NREV	PF	DR	RO	RJ
FR	1							
NRF	.28	1						
NRPF	.36	.25	1					
NREV	.29	.23	.51	1				
PF	.15	.12	.39	.42	1			
DR	.28	.22	.50	.55	.45	1		
RO	.27	.24	.44	.45	.33	.42	1	
RJ	.36	.26	.61	.62	.47	.64	.48	1

Note. FR=Test of Minimal Formal Reasoning. N/R-F=Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking. PF=Test of Problem Finding. DR=Test of Dialectical Reasoning. RO=Test of Relativistic Operations. RJ=Test of Reflective Judgment.

The correlations among the individual test scores of the 2 formal level tests and those of 6 postformal level tests range from 0.12 to 0.36. As two different levels of test are involved, such a pattern of correlations is not unexpected.

Except for 3 N/R tests, namely N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic form), which are specifically designed for this study, the other tests have been adapted in terms of their scoring criteria to tap the minimal presence of the forms of thinking specific to the tests adapted. Therefore, the pattern of the correlations might differ from that generated from the scores obtained by using the unadapted scoring criteria.

On the whole, this correlation matrix could be considered as factorable because it includes several sizable correlations exceeding 0.3.

4. Variance-Covariance Matrices

The variance-covariance matrix of all the 12 item scores of the 3 N/R tests is presented in Table 10.

The covariances among all the 12 item scores range from -0.06 to 0.69.

The covariances among the item scores of N/R-F (formal form) range from -0.06 to 0.06.

The covariances among the item scores of the 2 postformal level N/R tests, namely N/R-PF (postformal form) and N/R-EV (epistemic view), range from 0 to 0.69.

The covariances among the item scores of N/R-F (formal form) and of the 2 postformal level N/R tests which range from -0.04 to 0.17 are relatively low. As two different levels of test are involved, such a pattern of covariances is not unexpected.

Table 10
Variance-Covariance Matrix of Item Scores of the 3 N/R Tests

	F1	F2	F3	F4	P1	P2	P3	P4	E1	E2	E3	E4
F1	.25											
F2	-.06	.20										
F3	.05	-.02	.24									
F4	.03	-.01	.06	.21								
P1	.04	-.01	.12	.11	.88							
P2	.02	-.02	.01	.01	.19	.35						
P3	.04	-.03	.13	.11	.69	.21	.86					
P4	.03	-.02	.05	.04	.31	.18	.36	.56				
E1	.08	-.01	.17	.03	.45	.15	.44	.28	1.08			
E2	-.01	-.00	.02	.04	.20	.10	.21	.11	.19	.67		
E3	.05	-.04	.10	.03	.31	.11	.30	.19	.37	.14	.61	
E4	.08	.00	.02	-.02	.04	.00	.12	.09	.14	.16	.09	1.1

Note. F1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. P1-4 = items of Test of Postformal Form of N/R Thinking. E1-4 = items of Test of Epistemic View of N/R Thinking.

Interpretation of a variance-covariance matrix is more complicated than that of a correlation matrix because the magnitude of the variances and covariances are affected by the units of measurement. However, based on its associated correlation matrix presented in Table 8 which includes several sizable correlations exceeding 0.3, this variance-covariance matrix could be considered factorable and could be subjected to confirmatory factor analysis.

The variance-covariance matrix of the individual test scores of the 8 tests are presented in Table 11.

Table 11
Variance-Covariance Matrix of Test Scores of the 8 Tests

	FR	NRF	NRPF	NREV	PF	DR	RO	RJ
FR	.71							
NRF	.24	1.00						
NRPF	.20	.16	.41					
NREV	.15	.14	.20	.37				
PF	.08	.08	.17	.17	.44			
DR	.20	.19	.27	.28	.25	.72		
RO	.18	.19	.23	.22	.18	.28	.64	
RJ	.20	.17	.26	.25	.21	.37	.25	.45

Note. FR=Test of Minimal Formal Reasoning. N/R-F=Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking. PF=Test of Problem Finding. DR=Test of Dialectical Reasoning. RO=Test of Relativistic Operations. RJ=Test of Reflective Judgment.

The covariances among the individual test scores of all the 8 tests range from 0.08 to 0.37.

The covariance between the individual tests scores of the 2 formal level tests, namely FR (Minimal Formal Reasoning) and N/R-F (formal form), is 0.24.

The covariances among the individual test scores of the 6 postformal level tests, namely N/R-PF (postformal form), N/R-EV (epistemic view), PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations), and RJ (Reflective Judgment), range from 0.17 to 0.37.

The covariances among the individual test scores of the 2 formal level tests and those of 6 postformal level tests range from 0.08 to 0.20. As two different levels of test are involved, such a pattern of covariances is not unexpected.

Similarly, as some of the tests are adapted in terms of their scoring criteria, the pattern of the correlations might differ from that generated from the scores obtained by using the unadapted scoring criteria.

Based on its associated correlation matrix presented in Table 9 which includes several sizable correlations exceeding 0.3, this variance-covariance matrix could be considered factorable and could be subjected to confirmatory factor analysis.

C. ANALYSES & RESULTS OF THE MAIN STUDY

Part C contains the analyses and results of the main study which is specifically designed to address Research Questions 3 and 4. For reference, a chart containing the specific research questions and the corresponding methods of analysis is presented in Table 12.

Table 12
Summary of Research Questions and Corresponding Methods of Analysis

Research Questions	Methods of Analysis
3. Is N/R thinking a possible unifying commonality underlying the selected models of postformal reasoning?	
3a. What, if any, commonalities exist among the items of the 3 tests of N/R thinking (N/R-F, N/R-PF & N/R-EV)?	- Confirmatory factor analysis (CFA): Models A1 & A2 (see Figs. 11 & 12)
3b. What, if any, commonalities exist among the 3 tests of N/R thinking and the 4 tests of postformal reasoning (PF, DR, RO & RJ)?	- CFA: (Set 1) Models B1-B3 (see Figs. 13-15) - CFA: (Set 2) Model B4 (see Fig. 16)
4. Is N/R thinking an instance of formal or postformal reasoning or of both?	
4a. What is the order of difficulty among the 8 tests (FR, N/R-F, N/R-PF, N/R-EV, PF, DR, RO & RJ)?	- Rank ordering according to percentage of task mastery (see Fig. 17) - Contingency tables (see Figs. 18-24)
4b. What is the order of the 8 tests according to their ages of onset of task mastery?	- Rank ordering according to ages of onset of task mastery (see Fig. 25)
4c. How do the 3 N/R tests correlate with the factors of formal level reasoning and of postformal level reasoning?	- EFA - CFA: Model C1 (see Fig. 26)
4d. Which of the performances in the 3 N/R tests would singly or in combination best predict the performances in the 4 postformal tests?	- Multiple regression analyses
4e. Between the performances in N/R-F and N/R-PF, which would be better predicted by the performance in N/R-EV?	- Simple regression analyses

Research Question 3:

Is nonabsolute/ relativistic (N/R) thinking a common factor underlying the selected models of postformal reasoning?

Related to this research question are 2 specific questions, Questions 3a and 3b. The analyses and results of Question 3a are presented in the following.

3a. What, if any, commonalities exist among the items of the 3 tests of nonabsolute/ relativistic (N/R) thinking -- N/R-F (formal form), N/R-PF (postformal form), N/R-EV (epistemic view)?

The purpose of this question is to explore the nature of and the relationships among the items of the 3 N/R tests using confirmatory factor analysis on the item scores. The results could serve as a foundation for the analyses to be conducted at the next level using test scores instead of item scores of the 3 N/R tests.

To address Question 3a, confirmatory factor analysis was conducted using LISREL 8. The method of estimation was Maximum Likelihood (ML). The analyses were based on the covariances among the item scores of the 3 N/R tests and the results reported were based on completely standardized solutions.

Two models were constructed and tested and they are presented below.

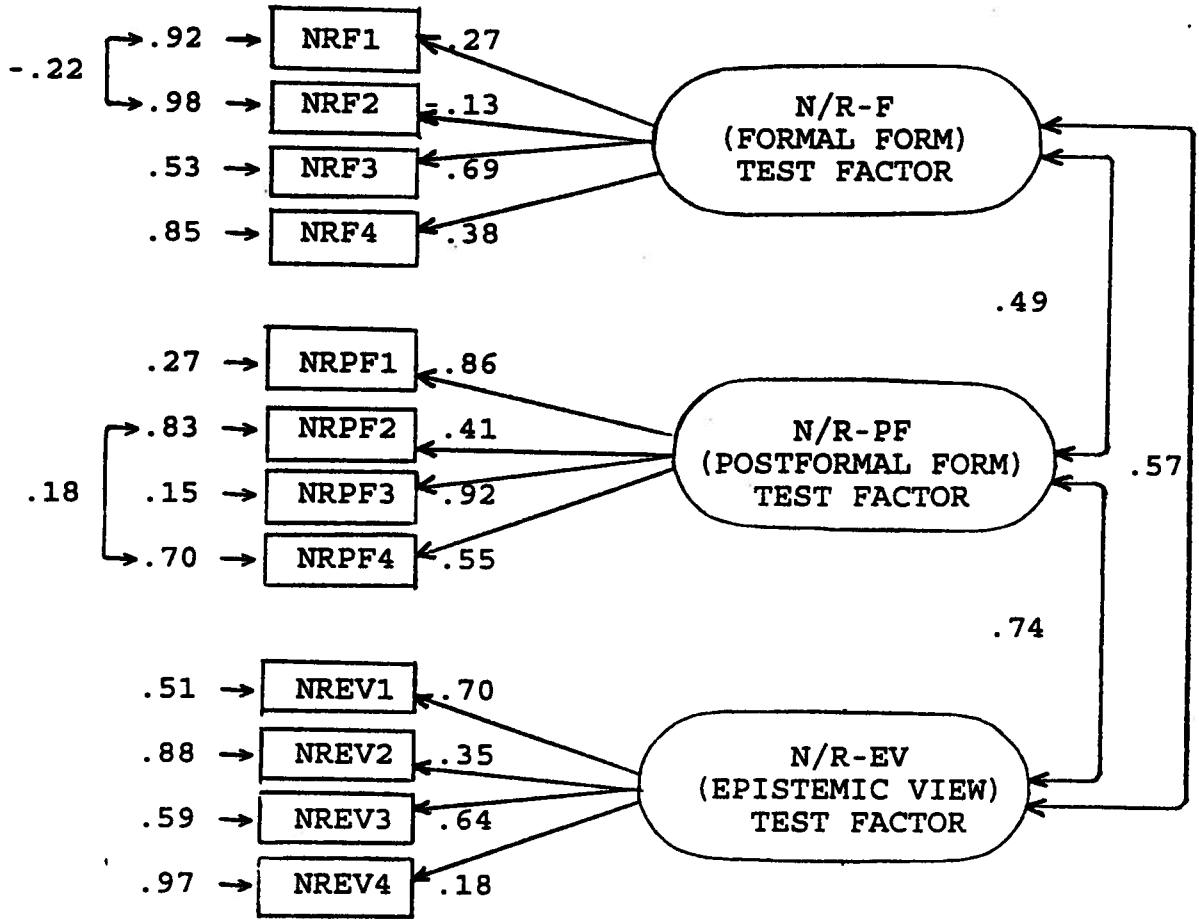
Model A1 (see Figure 11)

The purpose of testing this model is to evaluate the following two hypotheses:

Hypothesis 3a(1): Three test factors, namely N/R-F (formal form), N/R-PF (postformal form), and N/R-EV (epistemic view) would underlie the 12 test items.

Hypothesis 3a(2): The 3 test factors would be correlated. (The implication of this hypothesis is that these 3 test factors tap three different aspects of the same construct, hypothesized to be the nonabsolute/ relativistic thinking (N/R) test factor).

Figure 11
Model A1: Results of Confirmatory Factor Analysis



Note. NRF1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. NRPF1-4 = items of Test of Postformal Form of N/R Thinking. NREV1-4 = items of Test of Epistemic View of N/R Thinking.
Fit-indices: X^2=64.87, df=49, p=.064, Q=1.32, RMR=.025, SRMR=.045, GFI=.96, AGFI=.94, NFI=.91, NNFI=.97 (see Appendix I for explanation of fit-indices).

In this model, the variables were all 12 items of the 3 N/R tests. The 4 items of each test were specified to load on their corresponding test factor. The 3 test factors were: N/R-F (formal form), N/R-PF (postformal form), and N/R-EV (epistemic view). They were specified to correlate with each other. Furthermore, the error/ unique variances of two pairs of items (NRF1 & 2 and NRPF2 & 4) were respecified to correlate with each other, because of the following reasons. NRF1 and NRF2, which belonged to the same subtest, yielded the highest negative covariance (-0.06) and the highest negative correlation (-0.25) among all the test items; and NRPF2 and NRPF4 represented the two most difficult items in the respective tests as reflected in the relatively low percentage of task mastery.

The following fit-indices are obtained:

The Chi-Square is 64.87 with 49 Degrees of Freedom (df) and a probability (p) of 0.064. The Chi-Square/df Ratio (Q) is 1.32. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.025 and 0.045 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.96 and 0.94 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.91 and 0.97 respectively.

(For a brief explanation of the fit indices, see Appendix I. In confirmatory factor analysis, contrary to conventional interpretation of Chi-square statistics, a small Chi-square value and high probability (p) level would indicate a good fit. The degrees of freedom (df) serve as a standard for judging the size of a Chi-Square value. Some researchers proposed a Chi-Square/df ratio (Q) of below 2 or 3 as a criterion of fit (Carmines & McIver, 1981). In this study, a significance level of p=0.05 is used. A Chi-square value associated with a probability level greater than 0.05 would be considered significant.)

As shown in the above results, the model provides an acceptable fit to the data. The results could, therefore, lend support to Hypothesis 3a(1).

Furthermore, the fact that the 3 test factors were shown to be correlated could also lend support to Hypothesis 3a(2). The correlations between N/R-F (formal form) test factor and the other two postformal level test factors --N/R-PF (postformal form) and N/R-EV (epistemic view) -- being 0.49 and 0.57 respectively, were only moderate. The correlation between the two postformal level test factors which was 0.74 was relatively higher. Such a pattern of correlations among test factors is due to the fact that, at the item level, correlations/ covariances between the items of N/R-F (formal form) and the 2 postformal level N/R tests were relatively low (correlations ranging from -0.10 to 0.33 and covariances ranging from 0 to 0.17); whereas correlations/ covariance between the items of the 2 postformal level N/R tests were relatively higher (correlations ranging from 0 to 0.79 and covariances ranging from 0 to 0.69).

The conventional cut-off point for the acceptability of a factor loading is set at 0.30 (Tabachnick & Fidell, 1989). Factor loadings of 0.30 or above would be considered acceptable for completely standardized solutions. Except for 3 test items, namely NRF1, NRF2 and NREV4, which yielded low factor loadings of 0.27, -0.13 and 0.18 respectively, all the other test items which yielded higher factor loadings ranging from 0.35 to 0.92 could be considered as fairly valid indicators of their corresponding constructs (test factors).

For completely standardized solutions, the error or unique variance of each indicator (test item) is derived from the formula of one minus the variance which is the squared factor loading of that particular indicator. As the conventional cut-off point for the acceptability of a factor loading is 0.30, the conventional cut-off point for an error or unique variance is automatically 0.91 as derived from $(1 - 0.3^2)$. Error or unique variances of 0.91 or below would be considered acceptable.

Except for 3 test items, namely NRF1, NRF2 and NREV4, which yielded high error or unique variances of 0.92, 0.98 and 0.97 respectively, all the other test items

which yielded lower error or unique variances ranging from 0.88 to 0.15 fell within the acceptable range.

As specified in the model, the unique variances of the two pairs of items (NRF1 & 2 and NRPF2 & 4) were relaxed to correlate with each other. The correlation between the unique variances of NRF1 & 2 was -0.22 and that between the unique variances of NRPF2 & 4 was 0.18.

In conclusion, findings of Model A1 tend to support Hypotheses 3a(1) and (2).

Model A2 (see Figure 12)

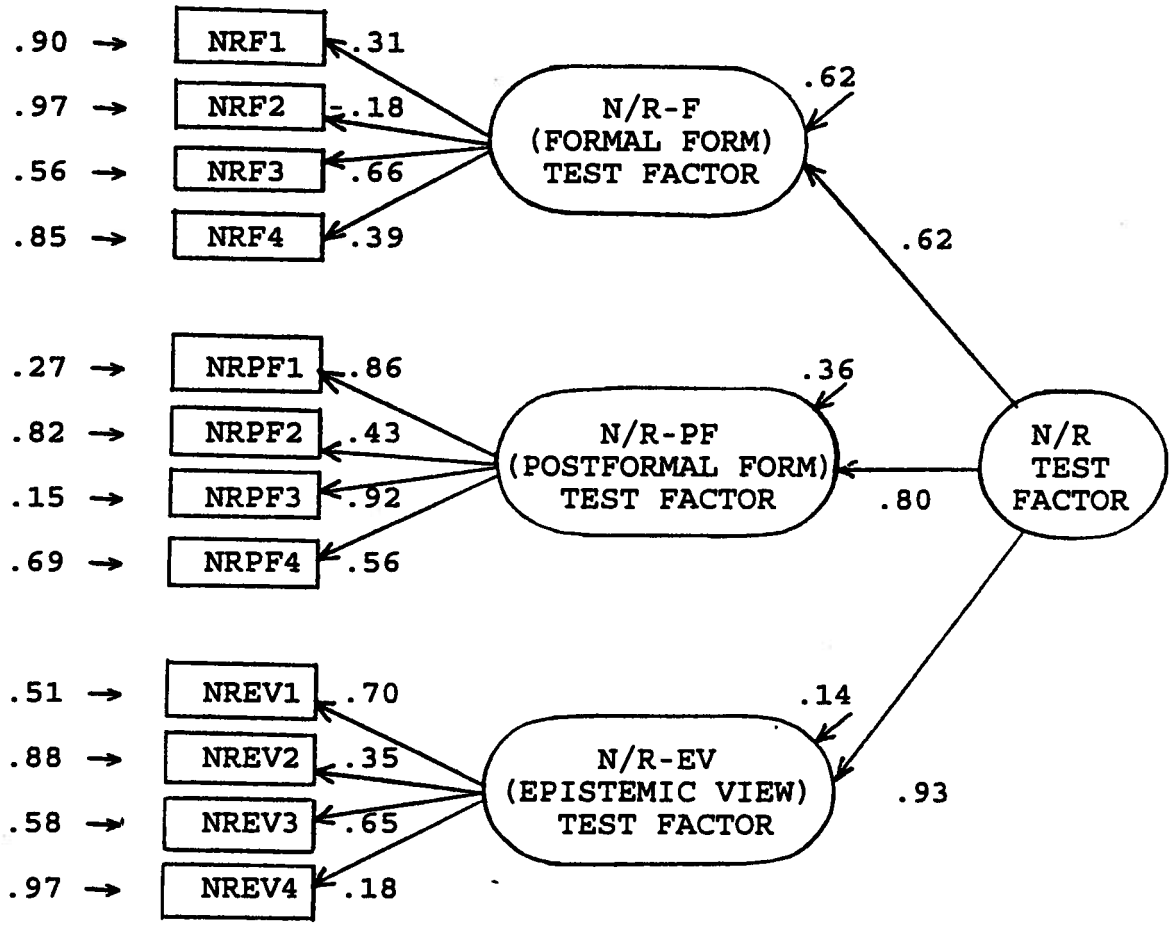
The purpose of testing this model is to evaluate **Hypothesis 3a(3)**: A second order factor hypothesized to be the nonabsolute/ relativistic thinking (N/R) test factor would underlie the 3 test factors.

In this model all the 12 items were specified to load on their corresponding test factors. The 3 test factors were further specified to load on a second order factor which was hypothesized to be the nonabsolute/ relativistic thinking (N/R) test factor. In order to standardize the test factors, a value of 1 was assigned to one of the loadings on the second order factor.

The following fit indices are obtained:

The Chi-Square is 31.41 with 51 Degrees of Freedom (df) and a probability (p) of 0.99. The Chi-Square/df Ratio (Q) is 0.62. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.032 and 0.10 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.89 and 0.83 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.99 and 1.0 respectively.

Figure 12
Model A2: Results of Confirmatory Factor Analysis



Note. NRF1-4 = items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. NRPF1-4 = items of Test of Postformal Form of N/R Thinking. NREV1-4 = items of Test of Epistemic View of N/R Thinking.
Fit-indices: X^2=31.41, df=51, p=.99, Q=.62, RMR=.032, SRMR=.100, GFI=.89, AGFI=.83, NFI=.99, NNFI=1.0 (see Appendix I for explanation of fit-indices).

As shown in the above results, the small Q ratio of 0.62 and the high NFI and NNFI of 0.99 and 1.0 respectively indicate a good fit; but the GFI of 0.89 and the AGFI of 0.83 which are slightly below the suggested threshold of 0.9 do not indicate a particularly good fit. When the overall fit-indices are considered, Model A2 could represent a plausible model. The results would, therefore, still lend support to Hypothesis 3a(3) and further support to the implication of Hypothesis 3a(2).

Based on the conventional criterion of 0.30 and above for the acceptability of a factor loading, except for 2 test items, namely NRF2 and NREV4, which yielded low factor loadings of -0.18 and 0.18 respectively, all the other test items which yielded higher factor loadings ranging from 0.31 to 0.92 could be considered as fairly valid indicators of their corresponding test factors.

As stated earlier, the criterion of 0.91 and below for the acceptability of an error or unique variance is automatically derived from the conventional criterion of 0.3 and above for the acceptability of a factor loading. Based on this criterion, except for 2 test items, namely NRF2 and NREV4, both of which yielded a high error or unique variance of 0.97, all the other test items which yielded lower error or unique variances ranging from 0.90 to 0.15 fell within the acceptable range.

Based on the same criterion mentioned above, the 3 factor loadings on the second order factor (N/R test factor) ranging from 0.62 to 0.93 fell within acceptable range. Correspondingly, the second order error or unique variances ranging from 0.14 to 0.62 also fell within the acceptable range.

The two test items, NRF2 and NREV4, despite their low factor loadings, were retained in the test due to their uniqueness. Subsequently, the item scores of each test could be combined into a single composite score to reflect the corresponding test factor.

A summary of the fit indices of both Models A1 and A2 is presented in Table 13.

Table 13
Summary of Fit Indices of Models A1 and A2

Model	X^2	df	p	Q	RMR	SRMR	GFI	AGFI	NFI	NNFI
A1	64.87	49	.06	1.32	.025	.045	.96	.94	.91	.97
A2	31.41	51	.99	.62	.032	.100	.89	.83	.99	1.0

Note. X^2=Chi-Square, df=degree of freedom, p=probability level, Q=X^2/df ratio, RMR=Root Mean Square Residual, SRMS= Standardized RMR, GFI=Goodness of Fit Index, AGFI=Adjusted Goodness of Fit Index, NFI=Normed Fit Index, NNFI=Non-normed Fit Index.

To conclude, hypotheses 3a(1) through (4) were generally supported by findings of Question 3a.

Hypothesis 3a(1) -- 3 test factors, namely N/R-F (formal form), N/R-PF (postformal form), and N/R-EV (epistemic view) would underlie the 12 items -- was supported by findings in Model A1. The implication of such findings is that the test items could be considered as fairly valid indicators of their corresponding test factors.

Hypothesis 3a(2) -- the 3 test factors would be correlated -- was also supported by findings in Model A1. The implication of such findings is that the 3 N/R tests measure three different aspects of the same construct, namely nonabsolute/ relativistic thinking (N/R) test factor.

Hypothesis 3a(3) -- a second order factor would underlie the 3 test factors -- was supported by findings in Model A2. Such findings also supported the implications of Hypothesis 3a(2).

Here ends the analyses and results of Question 3a.

The analyses and results of Question 3b are presented in the following.

3b. What, if any, commonalities exist among the 3 tests of nonabsolute/ relativistic (N/R) thinking and the 4 tests of postformal reasoning (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO), Reflective Judgment (RJ))?

The purpose of this question is to explore nonabsolute/ relativistc (N/R) thinking as a possible unifying commonality underlying the selected models of postformal reasoning.

To address Question 3b, several confirmatory factor analyses were conducted using LISREL 8. The method of estimation was Maximum Likelihood (ML). The analyses were based on the covariances among test scores of the 3 N/R tests and the 4 postformal tests. The results reported were based on completely standardized solutions.

Two sets of models were constructed and tested. The first set (Models B1 to B3) was designed to explore if nonabsolute/ relativistic (N/R) thinking would underlie the 3 N/R tests and the 4 postformal tests. The second set (Model B4) was designed to explore if the 2 dimensions (the basic form and the epistemic view) could be differentiated within the postformal level of nonabsolute/ relativistic (N/R) thinking. These models are presented below.

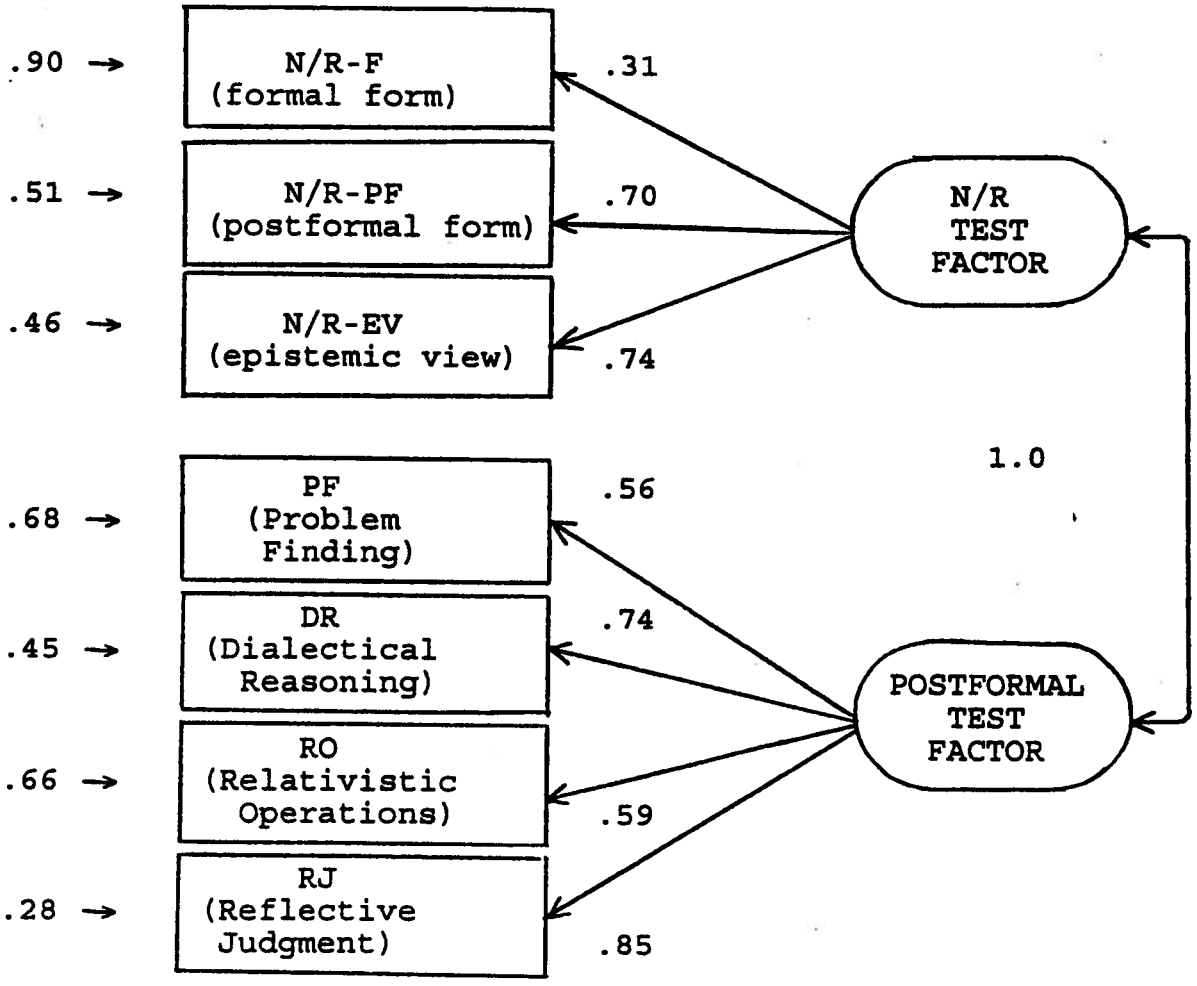
Model B1 (see Figure 13)

The purpose of testing this model is to evaluate the following hypotheses.

Hypothesis 3b(1): A common factor, namely the nonabsolute/ relativistic thinking (N/R) test factor would underlie the 3 N/R tests.

Hypothesis 3b(2): A common factor, namely the postformal test factor would underlie the 4 postformal tests.

Figure 13
Model B1: Results of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic.
Fit-indices: X^2=7.75, df=13, p=.86, Q=.60, RMR=.014, SRMR=.021, GFI=.99, AGFI=.98, NFI=.99, NNFI=1.0 (see Appendix I for explanation of fit-indices).

Hypothesis 3b(3): The N/R test factor and the postformal test factor would be correlated. (The implication of this hypothesis is that the two test factors would represent two different aspects of the same construct, hypothesized to be nonabsolute/ relativistic (N/R) thinking.)

In this model, the 3 N/R tests were specified to load on the N/R test factor; the 4 postformal tests were specified to load on the postformal test factor; and these 2 test factors were specified to correlate with each other.

The following fit indices are obtained:

The Chi-Square is 7.75 with 13 Degrees of Freedom (df) and a probability (p) of 0.86. The Chi-Square/df Ratio (Q) is 0.60. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.014 and 0.021 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.99 and 0.98 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.99 and 1.0 respectively.

As shown in the above results, the model provides an extremely good fit to the data. The good fit is evidenced in the small Q ratio, the high p level, the small RMR and SRMR, and the high GFI, AGFI, NFI and NNFI. Thus the results lend support to Hypotheses 3b(1) to (3).

Based on the conventional criterion of 0.30 and above for the acceptability of a factor loading, the factor loadings of all the tests which ranged from 0.31 to 0.85 fell within the acceptable range.

Based on the conventional criterion of 0.91 and below for the acceptability of an error or unique variance, the unique variances of all the tests which ranged from 0.90 to 0.28 fell within the acceptable range.

The difference in magnitude of factor loadings on the N/R test factor suggested that the formal and the postformal levels of nonabsolute/ relativistic (N/R) thinking could be differentiated. The relatively low factor loading of 0.31 for N/R-F (formal form)

could be interpreted to reflect the formal level of nonabsolute/ relativistic (N/R) thinking. On the other hand, the relatively high factor loadings of 0.70 for N/R-PF (postformal form) and 0.74 for N/R-EV (epistemic view) could be interpreted to reflect the postformal level of nonabsolute/ relativistic (N/R) thinking.

The difference in magnitude of factor loadings on the postformal test factor ranging from 0.56 to 0.85 could be interpreted to reflect differences in the level of task difficulty among the 4 postformal tests.

Two tests yielded relatively low factor loadings. PF (Problem Finding) which yielded a factor loading of 0.56 represents the most difficult (8.2% of task mastery) among the 4 postformal tests whereas RO (Relativistic Operations) which yielded a factor loading of 0.59 represents the least difficult (29.5% of task mastery). Therefore, low factor loadings in this model seem to reflect both extremes in the level of task difficulty.

Of the other two tests, DR (Dialectical Reasoning) and RJ (Reflective Judgment) yielded relatively high factor loadings of 0.74 and 0.85 respectively. They represent the moderately difficult among the 4 postformal tests, with DR yielding 23.6% of task mastery and RJ yielding 9.4% of task mastery.

As revealed in the findings, the N/R test factor and the postformal test factor were shown to be perfectly correlated (r=1.0). (The exact value obtained for this correlation was 1.01 which had been rounded to 1.0 as advised by the technical consultant of LISREL 8 in a personal communication.) This correlation could be interpreted to suggest that a commonality would probably underlie the two test factors.

In order to explore further the relationships among the constructs described in Model B1, another two models were respecified to evaluate Hypothesis 3b(4) -- nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the 3 N/R tests and the 4 postformal tests. In one model, Model B2, the two test factors

were specified to load on a second order factor. In the other model, Model B3, the two test factors were replaced by one first order factor. These models are presented below.

Model B2 (see Figure 14)

The purpose of testing this model is to evaluate **Hypothesis 3b(4)**: nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the 3 N/R tests and the 4 postformal tests.

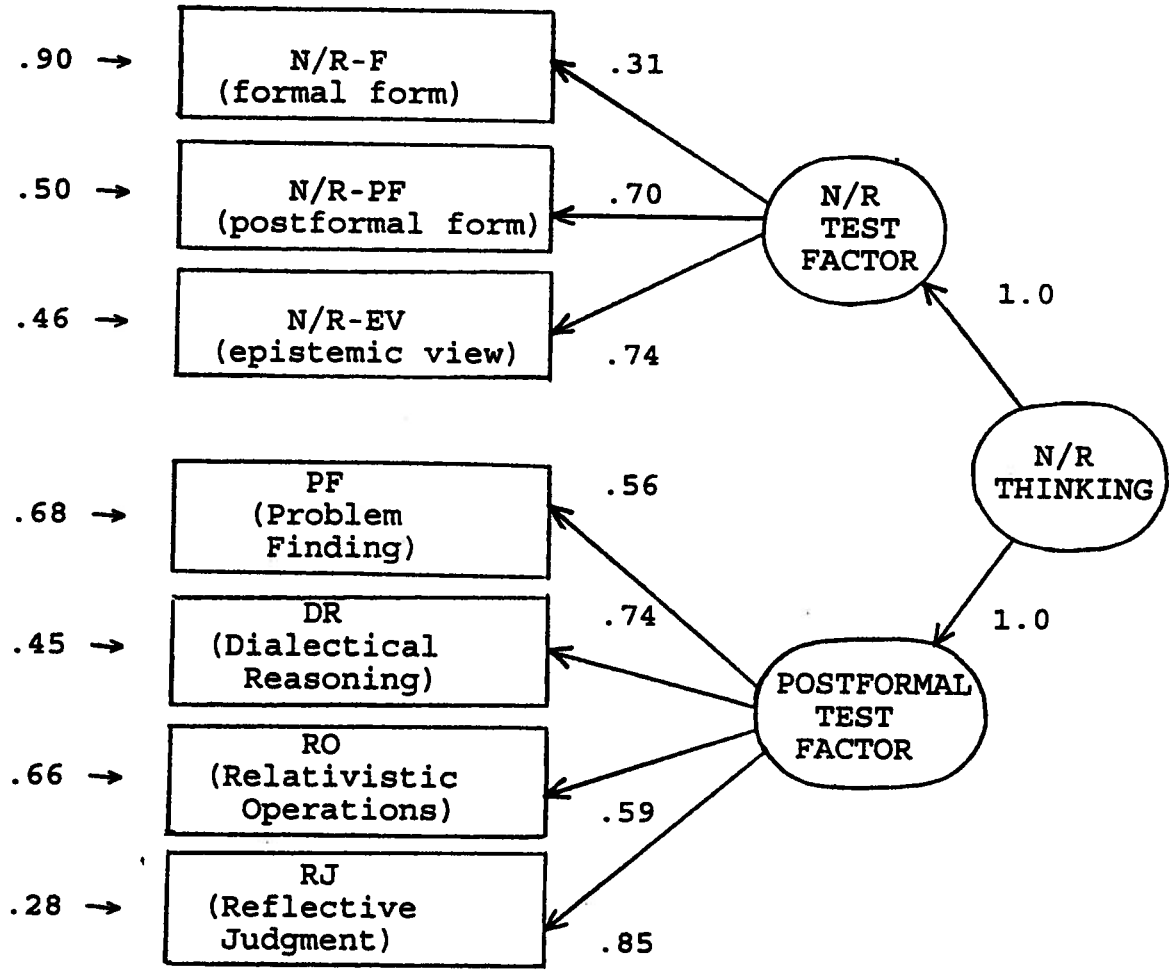
In this model, the 3 N/R tests were specified to load on the N/R test factor; the 4 postformal tests were specified to load on the postformal test factor; and the two test factors were specified to further load on a second order factor, namely nonabsolute/ relativistic (N/R) thinking.

The following fit indices are obtained:

The Chi-Square is 7.80 with 12 Degrees of Freedom (df) and a probability (p) of 0.80. The Chi-Square/df Ratio (Q) is 0.65. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.014 and 0.021 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.99 and 0.98 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.99 and 1.0 respectively.

As shown in the above results, the model provides an extremely good fit to the data. In the comparison of Models B1 and B2, it was shown that their corresponding fit indices yielded the same values except for an insignificant increase in the Chi-square value by 0.05 and in the Q ratio by 0.05 in Model B2. Although Model B2 did not provide an improved fit over Model B1 which already provides an extremely good fit to the data, Model B2 is still a plausible model. Therefore, the findings could still lend support to Hypothesis 3b(4).

Figure 14
Model B2: Results of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic.
Fit-indices: X^2=7.80, df=12, p=.80, Q=.65, RMR=.014, SRMR=.021, GFI=.99, AGFI=.98, NFI=.99, NNFI=1.0 (see Appendix I for explanation of fit-indices).

The factor loadings of this model ranging from 0.31 to 0.85 are identical to those of Model B1. Similarly both the factor loadings and the error or unique variances fell within the acceptable range.

The 2 factor loadings on the second order factor are both 1.0. Correspondingly, the second order error or unique variances would both be 0. Such results are reflective of the perfect correlation (r=1.0) between the 2 test factors.

The alternative model, Model B3, which is more parsimonious, is presented in the following.

Model B3 (See Figure 15)

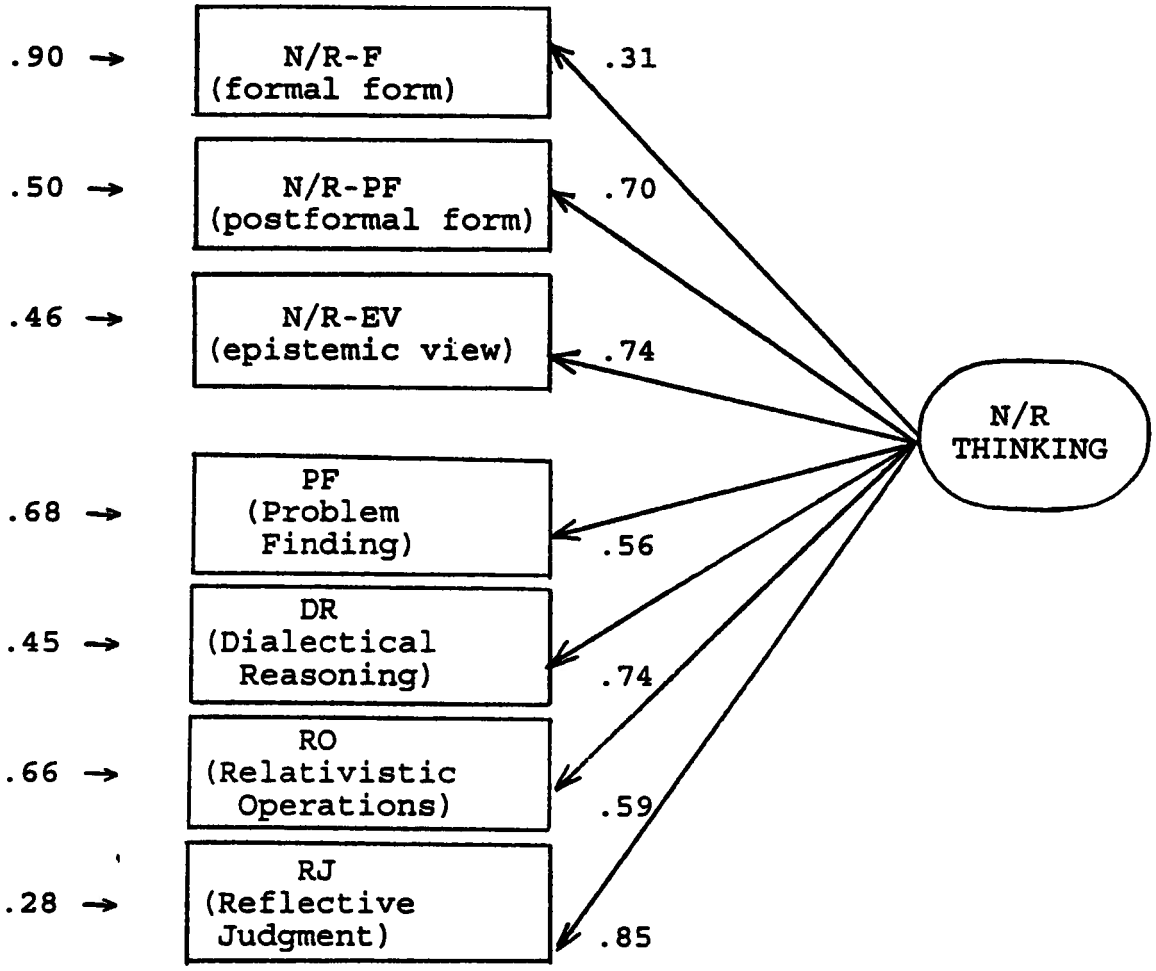
The purpose of testing this model is also to evaluate **Hypothesis 3b(4)**: nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the 3 N/R tests and the 4 postformal tests.

In this model, the 3 N/R tests and the 4 postformal tests were specified to load on only one first order factor.

The following fit indices are obtained:

The Chi-Square is 7.80 with 14 Degrees of Freedom (df) and a probability (p) of 0.90. The Chi-Square/df Ratio (Q) is 0.56. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.014 and 0.021 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.99 and 0.98 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.99 and 1.0 respectively.

Figure 15
Model B3: Results of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic.
Fit-indices: X^2=7.80, df=14, p=.90, Q=.56, RMR=.014, SRMR=.021, GFI=.99, AGFI=.98, NFI=.99, NNFI=1.0 (see Appendix I for explanation of fit-indices).

As shown in the above results, the model also provides an extremely good fit to the data. In the comparison of Models B1 and B3, it was also shown that their corresponding fit indices yielded the same values except for an insignificant decrease in the Chi-square value by 0.05 and in the Q ratio by 0.04 in Model B3, suggesting that Model B3 represents a slightly improved fit over Model B1. Therefore, findings also lend support to Hypothesis 3b(4).

The factor loadings of this model ranging from 0.31 to 0.85 are also identical to those of Models B1 and B2. Similarly both the factor loadings and the error or unique variances fell within the acceptable range.

A summary of the fit indices of Models B1 to B3 is presented in Table 14.

Table 14
Summary of Fit Indices of Models B1 - B3

Model	X^2	df	p	Q	RMR	SRMR	GFI	AGFI	NFI	NNFI
B1	7.75	13	.86	.60	.014	.021	.99	.98	.99	1.0
B2	7.80	12	.80	.65	.014	.021	.99	.98	.99	1.0
B3	7.80	14	.90	.56	.014	.021	.99	.98	.99	1.0

Note. X^2=Chi-Square, df=degree of freedom, p=probability level, Q=X^2/df ratio, RMR=Root Mean Square Residual, SRMS= Standardized RMR, GFI=Goodness of Fit Index, AGFI=Adjusted Goodness of Fit Index, NFI=Normed Fit Index, NNFI=Non-normed Fit Index.

In comparing these three models, it was found that the differences among them were insignificant. Of the two models (Models B2 and B3) both designed to explore further the relationships among the constructs described in Model B1, for parsimony, Model B3 (one first order factor model) would be the model of choice and for a more elaborate description of the relationships among the constructs, Model B2 (second order

factor model) would be the model of choice. However, since all 3 models (B1 to B3) implied nonabsolute/ relativistic (N/R) thinking as a possible unifying commonality underlying the 3 N/R tests and the 4 postformal tests and since all of them provided an extremely good fit to the data, any one of the 3 models could be used to lend support to the general hypothesis that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the selected models of postformal reasoning.

The model of the second set (Model B4) was designed to explore if the two dimensions (the basic form dimension and the epistemic view dimension) could be differentiated within the postformal level of nonabsolute/ relativistic (N/R) thinking. This model is presented below.

Model B4 (see Figure 16)

The purpose of testing this model is to evaluate the following hypotheses.

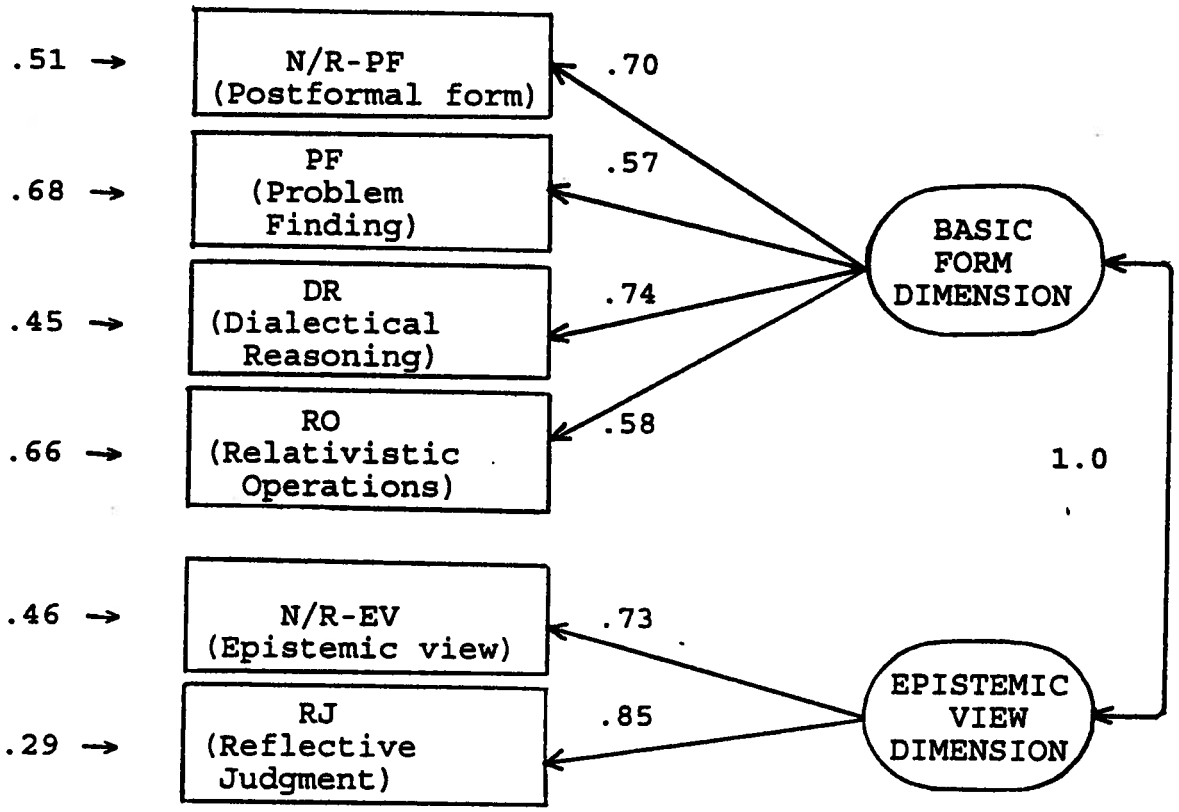
Hypothesis 3b(5): A common factor, namely the basic form dimension, would underlie the 4 tests -- N/R-PF (postformal form), PF (Problem Finding), DR (Dialectical Reasoning), and RO (Relativistic Operations).

Hypothesis 3b(6): A common factor, namely the epistemic view dimension, would underlie the 2 tests -- N/R-EV (epistemic view) and RJ (Reflective Judgment).

Hypothesis 3b(7): The two factors, namely the basic form dimension and the epistemic view dimension, would be correlated. (The implication of this hypothesis is that two dimensions could be differentiated within the same construct, hypothesized to be the postformal level of nonabsolute/ relativistic (N/R) thinking.)

In this model, N/R-PF (postformal form), Problem Finding, Dialectical Reasoning and Relativistic Operations were specified to load on the factor of the basic form dimension; N/R-EV (epistemic view) and Reflective Judgment were specified to load on the factor of the epistemic view dimension; and the two factors were specified to correlate with each other.

Figure 16
Model B4: Results of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic.
Fit-indices: X^2=4.43, df=8, p=.82, Q=.55, RMR=.008, SRMR=.015, GFI=.99, AGFI=.98, NFI=.99, NNFI=1.0 (see Appendix I for explanation of fit-indices).

The following fit indices are obtained:

The Chi-Square is 4.43 with 8 Degrees of Freedom (df) and a probability (p) of 0.82. The Chi-Square/df Ratio (Q) is 0.55. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.008 and 0.015 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.99 and 0.98 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.99 and 1.0 respectively.

As shown in the above results, the model provides an extremely good fit to the data. The good fit is evidenced in the small Q ratio, the high p level, the small RMR and SRMR, and the high GFI, AGFI, NFI and NNFI. Thus the results lend support to Hypotheses 3b(5) to (7).

As revealed in the findings, the factors of the basic form dimension and of the epistemic view dimension were shown to be perfectly correlated (r=1.0). (The exact value obtained for this correlation was 1.01 which had been rounded to 1.0 as advised by the technical consultant of LISREL 8 in a personal communication.) This correlation could be interpreted to suggest that these two factors represent two dimensions of the same construct, hypothesized to be the postformal level of nonabsolute/ relativistic (N/R) thinking.

Based on the conventional criterion of 0.30 and above for the acceptability of a factor loading, the factor loadings of this model which ranged from 0.57 to 0.85 fell within the acceptable range.

Based on the conventional criterion of 0.91 and below for the acceptability of an error or unique variance, the unique variances of this model which ranged from 0.68 to 0.29 fell within the acceptable range.

For the factor of "basic form dimension", the factor loadings of the 4 tests ranged from 0.57 to 0.74. For the factor of "epistemic view dimension", the factor loadings of

the 2 tests were 0.73 and 0.85. Therefore, all the tests could be considered as quite good indicators of their corresponding factors.

To conclude findings of question 3b, Hypotheses 3b(1) through (7) were supported by findings of the above analyses.

Hypothesis 3b(1) -- a common factor, namely the nonabsolute/ relativistic thinking (N/R) test factor would underlie the 3 N/R tests -- was supported by findings of Model B1. The implication of such findings is that the 3 N/R tests measure three different aspects of the same construct, namely nonabsolute/ relativistic (N/R) thinking. The formal and the postformal levels of nonabsolute/ relativistic (N/R) thinking could also be differentiated as suggested in the difference in magnitude of factor loadings.

Hypothesis 3b(2) -- a common factor, namely the postformal test factor would underlie the 4 postformal tests -- was also supported by findings of Model B1. The implication of such findings is that commonality exists among the 4 selected models of postformal reasoning as hypothesized in this study.

Hypothesis 3b(3) -- the nonabsolute/ relativistic thinking (N/R) test factor and the postformal test factor would be correlated -- was also supported by findings of Model B1. The implication of such findings is that a commonality, which is hypothesized to be nonabsolute/ relativistic (N/R) thinking, would probably underlie these two test factors.

Hypothesis 3b(4) -- a common factor, namely nonabsolute/ relativistic (N/R) thinking, would underlie the 3 N/R tests and the 4 postformal tests -- was supported by findings of both Models B2 and B3. The implication of such findings is that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the selected models of postformal reasoning.

Hypothesis 3b(5) -- a common factor, namely the factor of the basic form dimension, would underlie the 4 tests: N/R-PF (postformal form), Problem Finding, Dialectical Reasoning and Relativistic Operations -- was supported by findings of Model B4.

Hypothesis 3b(6) -- a common factor, namely the factor of the epistemic view dimension, would underlie the 2 tests: N/R-EV (epistemic view)and Reflective Judgment -- was also supported by findings of Model B4.

Hypothesis 3b(7) -- the factors of the two dimensions, namely the basic form and the epistemic view, would be correlated -- was also supported by findings of Model B4. The implication of the findings of Model B4 is that two dimensions, namely the basic form and the epistemic view, could be differentiated within the postformal level of nonabsolute/ relativistic (N/R) thinking.

In the context of construct validation, the analysis in Model B1 could serve as an example of the internal structure analysis of the nonabsolute/ relativistic thinking (N/R) test factor. The analyses in Models B2, B3 and B4 could also serve as examples of the external structure analyses of the N/R tests using four other postformal tests as external references.

Here ends the analyses and results of Question 3b.

All in all, all the above findings related to Research Question 3 could lend support to the general hypothesis that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the models of postformal reasoning.

Research Question 4:

Is nonabsolute/ relativistic (N/R) thinking an instance of formal or postformal reasoning or of both?

Related to this research question are 5 specific questions, 4a to 4e.

The analyses and results of Question 4a are presented below.

4a. What is the order of difficulty among the 8 tests -- FR (Minimal Formal Reasoning), N/R-F (formal form), N/R-PF (postformal form), N/R-EV (epistemic view), PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations), and RJ (Reflective Judgment)?

The first approach to this question was to rank order the 8 tests according to the percentage of task mastery. The following hypothesis was evaluated.

Hypothesis 4a(1): The hypothesized order of task difficulty from the least to the most difficult would be as follows -- the test of Minimal Formal Reasoning (FR); the N/R test at the formal level (N/R-F (formal form); the 2 N/R tests at the postformal level (N/R-PF (postformal form) and N/R-EV (epistemic view)); and the 4 postformal tests (Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment).

The rationale for this rank ordering is that N/R-F (formal form) is closer to formal reasoning whereas N/R-PF (postformal form) and N/R-EV (epistemic view) are closer to postformal reasoning. This hypothesis is based on the assumption that the relationships among tasks can be described in a linear model. That is to say that the order of the tests could be presented one after another in a straight line.

The results are presented in Figure 17.

From the perspective of a linear model, the tests can be classified into 3 levels. Level 1 which is the least difficult includes Minimal Formal Reasoning (yielding 50.8% of task mastery). Level 2 which is the moderately difficult includes Relativistic Operations, Dialectical Reasoning, and N/R-F (formal form) (yielding 29.5%, 23.6% and 23.2% of task mastery respectively). Level 3 which is the most difficult includes N/R-EV (epistemic view), Reflective Judgment, Problem Finding, and N/R-PF (postformal form) (yielding 9.4%, 9.4%, 8.2% and 3.5% of task mastery respectively).

Figure 17
Order of Task Difficulty according to Percentage of Task Mastery

	LINEAR MODEL		**NON-LINEAR MODEL**		
			Category 1		Category 2
	Percentage		Percentage		
Least Difficult	50.8	FR	50.8	FR	
Moderately Difficult	29.5	RO	29.5		RO
	23.6	DR	23.6		DR
	23.2	N/R-F	23.2	N/R-F	
Most Difficult	9.4	N/R-EV, RJ	9.4	N/R-EV	RJ
	8.2	PF	8.2		PF
	3.5	N/R-PF	3.5	N/R-PF	

Note. FR=Test of Minimal Formal Reasoning. N/R-F=Test of Formal Form of Nonabsolulte/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking. PF=Test of Problem Finding. DR=Test of Dialectical Reasoning. RO=Test of Relativistic Operations. RJ=Test of Reflective Judgment.

The above results, however, do not correspond strictly to the hypothesized order. As the order of the tests could not be presented one after another in a straight line, they would rather suggest that a non-linear model might be more appropriate in describing the relationships among these tests. (see Figure 17).

From the perspective of a non-linear model, the tests could be rearranged into two categories. Under category 1 are Minimal Formal Reasoning and the 3 N/R tests yielding the following percentage of task mastery: Minimal Formal Reasoning (50.8%), N/R-F (formal form) (23.2%), N/R-EV (epistemic view) (9.4%), and N/R-PF (postformal form) (3.5%). The results for category 1 correspond precisely with the hypothesized order of task difficulty.

Under category 2 are the 4 postformal tests yielding the following percentage of task mastery: Relativistic Operations (29.5%), Dialectical Reasoning (23.6%), Reflective Judgment (9.4%), and PF (8.2%). When the two categories were cross-referenced to compare their relative levels of difficulty, Relativistic Operations and Dialectical Reasoning were shown to be closely associated with N/R-F (formal form); and N/R-F (formal form) was hypothesized to represent a transition from high formal to postformal reasoning (Arlin, 1984). On the other hand, Reflective Judgment and Problem Finding were shown to be closely associated with N/R-EV (epistemic view) and N/R-PF (postformal form); N/R-EV (epistemic view) and N/R-PF (postformal form) were hypothesized in this study to represent the postformal level of nonabsolute/ relativistic (N/R) thinking.

This pattern suggested that the relationships among the 3 N/R tests and the 4 postformal tests were not linear but non-linear. When only Minimal Formal Reasoning and the 3 N/R tests were considered, the assumption of a linear model could still be applied. However, when the 4 postformal tests were also taken into consideration, the assumption of a non-linear model would be more appropriate in describing the relationships among the 8 tests.

All in all, the findings that the 2 postformal level N/R tests (N/R-PF (postformal form) and N/R-EV (epistemic view)) were more difficult than N/R-F (formal form) suggested that the formal and the postformal level could be differentiated within nonabsolute/ relativistic (N/R) thinking.

The second approach to Question 4a was to construct contingency tables to evaluate the certain specific relationships among the 8 tests as to the primacy of one test over the other (that is the mastery of one test is a necessary but not sufficient condition for that of the other). The primacy of one test over the other is based on the assumption that the relationships among these tests could be described in a linear model.

To establish that mastery of one test is a necessary but not sufficient condition for that of another, logically the contingency table involved should contain one empty cell (target cell). This target cell is the intersection of the non-mastery of an easier test and the mastery of a more difficult test and therefore, there should be no entry for the target cell. However, a few exceptional cases would not be unexpected. If these exceptional cases are few in number, the model would not be threatened. For this study, an arbitrary cut-off point was set at 5% which is roughly 13 out of the total of 254 participants.

For evaluation of **Hypothesis 4a(2)** -- Minimal Formal reasoning (FR) << (is a necessary but not sufficient condition for) each of the 3 N/R tests -- contingency tables are presented in Figure 18.

For the contingency table Minimal Formal Reasoning (FR) x N/R-F (formal form), the entry in the target cell was 16 (6.3% of 254, the total number of participants) which would not lend a strong support the hypothesis that FR is a necessary but not sufficient condition for N/R-F. However, this result was not unexpected, because both FR and N/R-F fall within formal reasoning though with N/R-F being more difficult as shown in the entry of 86 (33.9%) in cell FR (mastery) by N/R-F (non-mastery).

Figure 18
Contingency Tables: FR (Minimal Formal Reasoning) x 3 N/R Tests

		N/R-F (formal form) non-mastery (1,2)	mastery (3,4)
FR	non-mastery (1,2)	109 42%	16 6.3%
	mastery (3,4)	86 33.9%	43 16.9%

		N/R-PF (postformal form) non-mastery (<3)	mastery (3,4)
FR	non-mastery (1,2)	123 48.4%	2 0.8%
	mastery (3,4)	122 48%	7 2.8%

		N/R-EV (epistemic view) non-mastery (<3)	mastery (3,4)
FR	non-mastery (1,2)	121 47.6%	4 1.6%
	mastery (3,4)	109 42.9%	20 7.9%

For the contingency table Minimal Formal Reasoning (FR) x N/R-EV (epistemic view), the entry in the target cell was 4 (1.6%) which could be considered as exceptional cases and should not, therefore, threaten the model. Thus the results could support the hypothesis that FR is a necessary but not sufficient condition for N/R-EV.

For the contingency table Minimal Formal Reasoning (FR) x N/R-PF (postformal form), the entry in the target cell was 2 (0.8%) which could also be considered as

exceptional cases. Thus the results could support the hypothesis that FR is a necessary but not sufficient condition for N/R-PF.

For evaluation of **Hypothesis 4a(3)** -- N/R-F (formal form) << each of the 2 postformal N/R tests (N/R-PF (postformal form) and N/R-EV (epistemic view)) -- contingency tables are presented in Figure 19.

Figure 19
Contingency Tables: N/R-F (formal form) x 2 postformal level N/R Tests

		N/R-PF (postformal form) non-mastery (<3)	mastery (3,4)
N/R-F	non-mastery (1,2)	191 75.2%	4 1.6%
	mastery (3,4)	54 21.3%	5 2%

		N/R-EV (epistemic view) non-mastery (<3)	mastery (3,4)
N/R-F	non-mastery (1,2)	180 70.9%	15 5.9%
	mastery (3,4)	50 19.7%	9 3.5%

For the contingency table N/R-F (formal form) x N/R-EV (epistemic view), the entry in the target cell was 15 (5.9%). According to the arbitrary cut-off point of 13 (5%), this result would not support the hypothesis that N/R-F is a necessary but not sufficient condition for N/R-EV. Nevertheless, as the entry is only an excess of 2 cases (0.9%) over the arbitrary cut-off point, the hypothesis could still be considered plausible.

For the contingency table N/R-F (formal form) x N/F-PF (postformal form), the entry in the target cell was 4 (1.6%) which could be considered as exceptional cases. Thus the results could support the hypothesis that N/R-F is a necessary but not sufficient condition for N/R-PF.

For evaluation of **Hypothesis 4a(4)** -- N/R-EV (epistemic view) << N/R-PF (postformal form) -- the contingency table is presented in Figure 20.

Figure 20
Contingency Table: N/R-EV (epistemic view) x N/R-PF (postformal form)

		N/R-PF non-mastery (<3)	mastery (3,4)
N/R-EV	non-mastery (<3)	223 87.8%	7 2.8%
	mastery (3,4)	22 8.7%	2 0.8%

For the contingency table N/R-EV (epistemic view) x N/R-PF (postformal form), the entry in the target cell was 7 (2.8%) which could be considered as exceptional cases. Thus the results could support the hypothesis that N/R-EV is a necessary but not sufficient condition for N/R-PF.

For evaluation of **Hypothesis 4a(5)** -- N/R-PF (postformal form) << each of the 4 postformal tests (PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment)) -- contingency tables are presented in Figure 21.

Figure 21
Contingency Tables: N/R-PF (postformal form) x 4 Postformal Tests

PF (Problem Finding)

N/R-PF	non-mastery (<3)	mastery (3)
non-mastery (<3)	228 89.8%	17 6.7%
mastery (3,4)	5 2%	4 1.6%

DR (Dialectical Reasoning)

N/R-PF	non-mastery (<3)	mastery (3)
non-mastery (<3)	189 74.4%	56 22%
mastery (3,4)	5 2%	4 1.6%

RO (Relativistic Operations)

N/R-PF	non-mastery (<3)	mastery (3)
non-mastery (<3)	174 68.5%	71 28%
mastery (3,4)	5 2%	4 1.6%

RJ (Reflective Judgment)

N/R-PF	non-mastery (<3)	mastery (3)
non-mastery (<3)	224 88.2%	21 8.3%
mastery (3,4)	6 2.4%	3 1.2%

The entries in the target cell for the contingency tables N/R-PF x the 4 postformal tests are as follows:

N/R-PF x PF: 17 (6.7%)

N/R-PF x DR: 56 (22%)

N/R-PF x RO: 71 (28%)

N/R-PF x RJ: 21 (8.3%)

All the above entries in the target cell were too high to support the hypothesis that N/R-PF is a necessary but not sufficient condition for the 4 postformal tests.

When the hypothesis was reversed to state that each of the 4 postformal tests is a necessary but not sufficient condition for N/R-PF, the entries in the new target cell suggested that each of the 4 postformal tests is a necessary but not sufficient condition for N/R-PF. The entries in the new target cell for the contingency tables are as follows:

N/R-PF x PF: 5 (2%)

N/R-PF x DR: 5 (2%)

N/R-PF x RO: 5 (2%)

N/R-PF x RJ: 6 (2.4%)

These results were in fact in line with the findings concerning the order of task difficulty in which N/R-PF was shown to be the most difficult among all 8 tests.

For evaluation of **Hypothesis 4a(6)** -- N/R-EV (epistemic view) << each of the 4 postformal tests (PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment)) -- contingency tables are presented in Figure 22.

The entries in the target cell for the contingency tables N/R-EV x the 4 postformal tests are as follows:

N/R-EV x PF: 14 (5.5%)

N/R-EV x DR: 42 (16.5%)

N/R-EV x RO: 58 (22.8%)

Figure 22
Contingency Tables: N/R-EV (epistemic view) x 4 Postformal Tests

PF (Problem Finding)

		non-mastery (<3)	mastery (3)
N/R-EV	non-mastery (<3)	216 85%	14 5.5%
	mastery (3,4)	17 6.7%	7 2.8%

DR (Dialectical Reasoning)

		non-mastery (<3)	mastery (3)
N/R-EV	non-mastery (<3)	188 74%	42 16.5%
	mastery (3,4)	6 2.4%	18 7.1%

RO (Relativistic Operations)

		non-mastery (<3)	mastery (3)
N/R-EV	non-mastery (<3)	172 67.7%	58 22.8%
	mastery (3,4)	7 2.8%	17 6.7%

RJ (Reflective Judgment)

		non-mastery (<3)	mastery (3)
N/R-EV	non-mastery (<3)	218 85.8%	12 4.7%
	mastery (3,4)	12 4.7%	12 4.7%

N/R-EV x RJ: 12 (4.7%)

All the above entries in the target cell were too high to support the hypothesis that N/R-EV is a necessary but not sufficient condition for the 4 postformal tests.

When the hypothesis was reversed to state that each of the 4 postformal tests is a necessary but not sufficient condition for N/R-EV, the entries in the new target cell suggested that only DR and RO are necessary but not sufficient conditions for N/R-EV. The entries in the new target cell for the contingency tables N/R-EV x DR and N/R-EV x RO are 6 (2.4%) and 7 (2.8%) respectively.

That Hypotheses 4a(5) and 4a(6) were not supported was not unexpected in light of the fact that the 4 postformal tests were adapted to tap the minimal presence of postformal reasoning specific to the selected postformal models. In view of the non-linear relationships among N/R-PF (postformal form) and N/R-EV (epistemic view) and the 4 postformal tests in terms of level of difficulty, two additional sets of contingency tables were constructed.

The first set of contingency tables which was constructed to evaluate **Hypothesis 4a(7)** -- the transitional development of N/R-PF (postformal form) << each of the 4 postformal tests (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ)) -- is presented in Figure 23.

For this set of contingency tables, the "non-mastery of N/R-PF (postformal form)" was changed to "pre-transitional development of N/R-PF (postformal form)", defined as below the score of 2 (<2); and "mastery of N/R-PF (postformal form)" was changed to "transitional development of mastery of N/R-PF (postformal form)", defined as the scores from 2 to 4 (2-4).

Figure 23
Contingency Tables: Transitional Development of N/R-PF (postformal form) x 4 Postformal Tests

		PF (Problem Finding) non-mastery (<3)	mastery (3)
N/R-PF	pre-transitional development (<2)	156 61.4%	5 2%
	transitional development to mastery (2-4)	77 30.3%	16 6.3%

		DR (Dialetical Reasoning) non-mastery (<3)	mastery (3)
N/R-PF	pre-transitional development (<2)	145 57.1%	16 6.3%
	transitional development to mastery (2-4)	49 19.3%	44 17.3%

		RO (Relativistic Operations) non-mastery (<3)	mastery (3)
N/R-PF	pre-transitional development (<2)	134 52.8%	27 10.6%
	transitional development to mastery (2-4)	45 17.7%	48 18.9%

		RJ (Reflective Judgement) non-mastery (<3)	mastery (3)
N/R-PF	pre-transitional development (<2)	157 61.8%	4 1.6%
	transitional development to mastery (2-4)	73 28.7%	20 7.9%

The entries in the target cell for this set of contingency tables are as follows:

N/R-PF x PF : 5 (2%)

N/R-PF x DR : 16 (6.3%)

N/R-PF x RO : 27 (10.6%)

N/R-PF x RJ : 4 (1.6%)

The entries in the target cells suggested that only PF (Problem Finding) and RJ (Reflective Judgment) are necessary but not sufficient conditions for the transitional development of N/R-PF (postformal form).

The second set of contingency tables which was constructed to evaluate **Hypothesis 4a(8)** -- the transitional development of N/R-EV (epistemic view) << each of the 4 postformal tests (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ)) -- is presented Figure 24.

For this set of contingency tables, the "non-mastery of N/R-EV (epistemic view)" was changed to "pre-transitional development of N/R-EV (epistemic view)", defined as below the score of 2 (<2); and "mastery of N/R-EV (epistemic view)" was changed to "transitional development of mastery of N/R-EV (epistemic view)", defined as the scores from 2 to 4 (2-4).

The entries in the target cell for this set of contingency tables are as follows:

N/R-EV x PF : 0 (0%)

N/R-EV x DR : 4 (1.6%)

N/R-EV x RO : 10 (3.9%)

N/R-EV x RJ : 0 (0%)

All the above entries in the target cell could lend support to the hypothesis that the transitional development of N/R-EV (epistemic view) is a necessary but not sufficient condition for each of the 4 postformal tests.

Figure 24
Contingency Tables: Transitional Development of N/R-EV (epistemic view) x 4 Postformal Tests

PF (Problem Finding)

	non-mastery (<3)	mastery (3)
N/R-EV pre-transitional development (<2)	102 40.2%	0 0%
transitional development to mastery (2-4)	131 51.6%	21 8.3%

DR (Dialetical Reasoning)

	non-mastery (<3)	mastery (3)
N/R-EV pre-transitional development (<2)	98 38.6%	4 1.6%
transitional development to mastery (2-4)	96 37.8%	56 22%

RO (Relativistic Operations)

	non-mastery (<3)	mastery (3)
N/R-EV pre-transitional development (<2)	92 36.2%	10 3.9%
transitional development to mastery (2-4)	87 34.3%	65 25.6%

RJ (Reflective Judgement)

	non-mastery (<3)	mastery (3)
N/R-EV pre-transitional development (<2)	102 40.2%	0 0%
transitional development to mastery (2-4)	128 50.4%	24 9.4%

A summary of the results of all the contingency tables are presented below.

Hypothesis 4a(2) -- Minimal Formal Reasoning (FR) << each of the 3 N/R tests -- was partly supported, because results suggested that Minimal Formal Reasoning (FR) is a necessary but not sufficient condition for the two postformal N/R tests, namely N/R-EV (epistemic view) and N/R-PF (postformal form) but not for N/R-F (formal form) though N/R-F (formal form) was shown to be more difficult than Minimal Formal Reasoning (FR). The implication of such findings is that N/R-F (formal form) represents the formal level of nonabsolute/ relativistic (N/R) thinking whereas N/R-PF (postformal form) and N/R-EV (epistemic view) represents the postformal level of nonabsolute/ relativistic (N/R) thinking.

Hypothesis 4a(3) -- N/R-F (formal form) << each of the 2 postformal N/R tests -- was partly supported.

The hypothesis that N/R-F (formal form) is a necessary but not sufficient condition for N/R-PF (postformal form) was supported and in turn provided crucial support to the general hypothesis that two qualitatively distinct levels could be differentiated within the dimension of the basic form of nonabsolute/ relativistic (N/R) thinking.

The hypothesis that N/R-F (formal form) is a necessary but not sufficient condition for N/R-EV (epistemic view) was not supported by virtue of the entry in the target cell exceeding the arbitrary cut-off point of 13 (5%). As the excess was only 2 cases (0.9%) over the arbitrary cut-off point, the hypothesis though not supported could still be considered plausible.

Hypothesis 4a(4) -- N/R-EV (epistemic view) << N/R-PF (postformal form) -- was supported. The implication of this result is that the development of the epistemic view of nonabsolute/ relativistic (N/R) thinking is a crucial antecedent to the development of N/R-PF, the postformal form of nonabsolute/ relativistic (N/R) thinking, and this was hypothesized in the study.

Hypothesis 4a(5) -- N/R-PF (postformal form) << each of the 4 postformal tests -- was not supported. Instead, the reverse conditions that each of the 4 postformal tests was a necessary but not sufficient condition for N/R-PF (postformal form) were supported by findings. These results were consistent with findings concerning the order of task difficulty. The implication of such findings is that a non-linear model rather than a linear model would be more appropriate in describing the relationships among the 3 N/R tests and the 4 postformal tests.

Hypothesis 4a(6) -- N/R-EV (epistemic view) << each of the 4 postformal tests -- was also not supported. When the hypothesis was stated in reverse that each of the 4 postformal tests << N/R-EV (epistemic view), Dialectical Reasoning and Relativistic Operations were found to be necessary but not sufficient conditions for N/R-EV (epistemic view). A non-linear model is also implied in such findings.

Hypothesis 4a(7) -- the transitional development of N/R-PF (postformal form) << each of the 4 postformal tests -- was partly supported by findings that the transitional development of N/R-PF (postformal form) was a necessary but not sufficient condition for only Problem Finding and Reflective Judgment.

Hypothesis 4a(8) -- the transitional development of N/R-EV (epistemic view) << each of the 4 postformal tests -- was supported. The implication of such findings is that the transitional development of N/R-EV (epistemic view) also plays a crucial role in the development of postformal reasoning.

To conclude, results derived from all the above contingency tables were consistent with findings concerning the order of task difficulty and suggested a non-linear model for a more appropriate description of the relationships among the 8 tests especially when the 4 postformal tests were also taken in consideration.

All in all, the findings also showed that the 2 postformal N/R tests (N/R-PF (postformal form) and N/R-EV (epistemic view)) were more difficult than N/R-F (formal form). Moreover, the mastery of N/R-F (formal form) was found to be a necessary but

not sufficient condition for the mastery of N/R-PF (postformal form). Therefore, it could be suggested that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking.

The analyses and results of Question 4b are presented in the following.

4b. What is the order of the 8 tests according to their ages of onset of task mastery?

To address this question, the 8 tests were rank ordered according to the age of onset at which the task of each test is mastered. The age of onset is defined as the basal age at and above which age level there is a minimum of at least one incidence of task mastery. It is not necessary for all the participants of the age of onset thus defined to master the test in question. However, the definition is conditional on an adequate representation of participants at each different age level. (Of the participants recruited for this study, the numbers of participants at each consecutive age level from age 10 to age 20 vary from 4 to 36.)

The following hypothesis would be evaluated.

Hypothesis 4b(1): The hypothesized order of the 8 tests according to their ages of onset of task mastery would be as follows -- the test of Minimal Formal Reasoning (FR); the N/R test at the formal level (N/R-F (formal form)); the 2 N/R tests at the postformal level (N/R-PF (postformal form) and N/R-EV (epistemic view)); and the 4 postformal tests (Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ)).

The rationale for this hypothesized rank order is that N/R-F (formal form) is closer to formal reasoning whereas N/R-PF (postformal form) and N/R-EV (epistemic view) are closer to postformal reasoning. This hypothesis is based on the assumption that the relationships among the tests can be described in a linear model.

The rank order derived from the results was as follows:

FR (age 10); RO (age 13); N/R-F (age 14); N/R-EV, N/R-PF, DR and PF (age 15); and RJ (age 17). (See Figure 25.)

Figure 25
Order of the 8 Tests according to Ages of Onset of Task Mastery

	LINEAR MODEL		**NON-LINEAR MODEL**	
			Category 1	Category 2
Age		Age		
10	FR	10	FR	
11		11		
12		12		
13	RO	13		RO
14	N/R-F	14	N/R-F	
15	N/R-EV, N/R-PF DR, PF	15	N/R-EV, N/R-PF	DR, PF
16		16		
17	RJ	17		RJ

Note. N/R-F=Test of Formal Form of Nonabsolulte/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking. FR=Test of Minimal Formal Reasoning. PF=Test of Problem Finding. DR=Test of Dialectical Reasoning. RO=Test of Relativistic Operations. RJ=Test of Reflective Judgment.

From the perspective of a linear model, the above results did not correspond strictly to the hypothesized rank order. Similar to findings in Question 4a, they suggested that a non-linear model would be more appropriate in describing the relationships among the 8 tests (see Figure 25).

From the perspective of a non-linear model, the tests could be re-arranged into 2 categories. Under category 1 are Minimal Formal Reasoning (FR) and the 3 N/R tests, the rank order of which according to the age of onset was as follows: FR (age 10), N/R-F (age 14), N/R-EV and N/R-PF (age 16). The rank order in this category corresponds precisely with the hypothesized order.

Under category 2 are the 4 postformal tests, the rank order of which according to the age of onset was as follows: RO (age 13), DR (age 15), PF (age 15), and RJ (age 17). The rank order in this category approximates to that of task difficulty in category 2 of Question 4a, Hypothesis 4a(1) with a reversal in the order of PF and RJ.

When the categories 1 and 2 are cross referenced to compare the ages of onset, Relativistic Operations (RO) was shown to be more closely associated with N/R-F (formal form) than with N/R-EV (epistemic view) and N/R-PF (formal form); and N/R-F (formal form) was hypothesized to represent a transition from high formal to postformal reasoning (Arlin, 1984). On the other hand, the other 3 postformal tests, namely Dialectical Reasoning (DR), Problem Finding (PF) and Reflective Judgment (RJ), were shown to be more closely associated with N/R-EV (epistemic view) and N/R-PF (postformal form) than with N/R-F (formal form); and N/R-EV (epistemic view) and N/R-PF (postformal form) were hypothesized in this study to represent the postformal level of nonabsolute/ relativistic (N/R) thinking.

Again, this pattern suggested that the relationships among the 8 tests were not linear but non-linear. Similar to findings in Question 4a, the above results seem to suggest that when only Minimal Formal Reasoning (FR) and the 3 N/R tests were considered, the assumption of a linear model could still be applied. However, when the 4 postformal tests were also taken into consideration, the assumption of a non-linear model would be more appropriate in describing the relationships among the 8 tests.

To conclude, the findings that the mastery of N/R-F (formal form) precedes that of the two postformal N/R tests (N/R-PF (postformal form) and N/R-EV (epistemic

view)) suggested that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking.

The analyses and results of Question 4c are presented in the following.

4c. How do the 3 N/R tests correlate with the factors of formal level reasoning and of postformal level reasoning?

Related to this question, the following hypotheses were evaluated.

Hypothesis 4c(1): N/R-F (formal form) would load primarily on the factor of formal level reasoning.

Hypothesis 4c(2): N/R-PF (postformal form) and N/R-EV (epistemic view) would load primarily on the factor of postformal level reasoning.

The first approach to Question 4c was to conduct exploratory factor analysis using SPSS:X computer programme. The analysis was based on the correlations among the test scores of the 8 tests, namely the 3 N/R tests, the 4 postformal tests and the test of Minimal Formal Reasoning (FR). The correlation matrix was presented in Table 9. The method of extraction was Principal Axis Factoring (PAF). The method of rotation was Oblimin due to the assumption that the factors were correlated. Two eigenvalues (3.77 and 1.03) were obtained accounting for 47.1% and 12.8% of the variance respectively, which together total 59.9% of the variance. Two factors were extracted. The first factor was hypothesized to be the factor of postformal level reasoning and the second to be the factor of formal level reasoning. Relevant information concerning the findings are presented in Table 15.

Table 15
Results of Exploratory Factor Analysis

FACTOR MATRIX

	FACTOR 1	FACTOR 2
RJ	0.84	-0.07
DR	0.73	-0.14
N/R-EV	0.73	-0.09
N/R-PF	0.72	0.07
RO	0.60	0.04
PF	0.56	-0.24
FR	0.45	0.42
N/R-F	0.35	0.30

Oblimin rotation converged in 5 iterations.

PATTERN MATRIX

	FACTOR 1	FACTOR 2
RJ	0.77	0.11
DR	0.75	0.00
N/R-EV	0.70	0.06
PF	0.68	-0.15
N/R-PF	0.54	0.25
RO	0.47	0.19
FR	0.02	0.61
N/R-F	0.03	0.43

STRUCTURE MATRIX

	FACTOR 1	FACTOR 2
RJ	0.84	0.55
DR	0.75	0.43
N/R-EV	0.73	0.46
N/R-PF	0.69	0.56
PF	0.59	0.23
RO	0.58	0.46
FR	0.36	0.62
N/R-F	0.28	0.45

FACTOR CORRELATION MATRIX

	FACTOR 1	FACTOR 2
FACTOR 1	1.00	
FACTOR 2	0.57	1.00

Note. FR=Test of Minimal Formal Reasoning. N/R-F=Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking. N/R-PF=Test of Postformal Form of N/R Thinking. N/R-EV=Test of Epistemic View of N/R Thinking. PF=Test of Problem Finding. DR=Test of Dialectical Reasoning. RO=Test of Relativistic Operations. RJ=Test of Reflective Judgment.

As revealed in the pattern matrix, all the 6 postformal level tests (N/R-PF (postformal form), N/R-EV (epistemic view), PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment)) yielded medium to high loadings (0.47 to 0.77) on the factor of postformal level reasoning whereas the 2 formal level tests (N/R-F (formal form) and FR (Minimal Formal Reasoning)) yielded extremely low loadings (0.02 to 0.03) on the factor of postformal level reasoning.

On the other hand, all the 6 postformal level tests yielded very low loadings (-0.15 to 0.25) on the factor of formal level reasoning whereas the 2 formal level tests yielded medium to moderately high loadings (0.43 to 0.61) on the factor of formal level reasoning.

The above results lend support to both Hypotheses 4c(1) and (2).

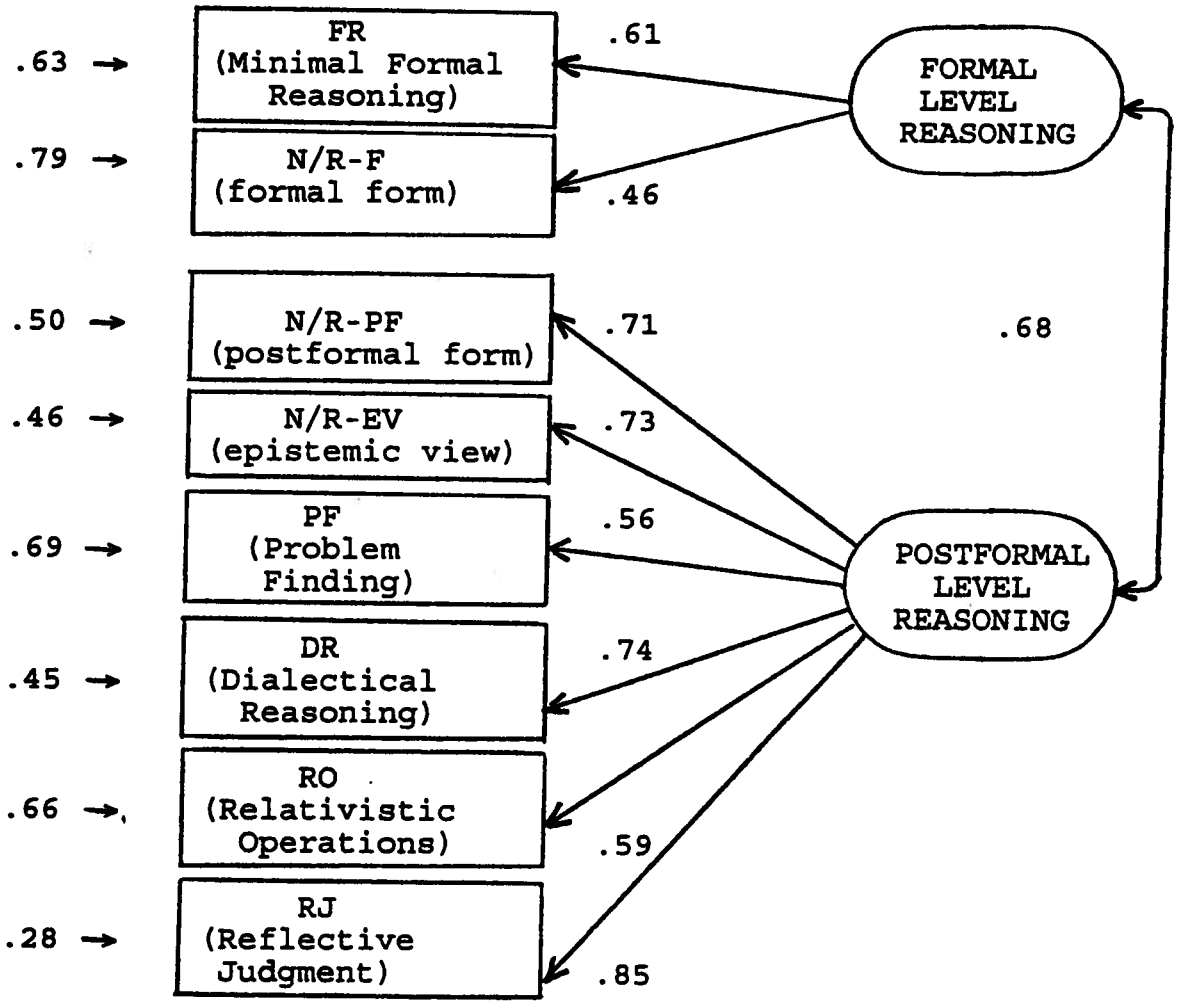
The second approach to Question 4c was to conduct confirmatory factor analysis using LISREL 8. The method of estimation was Maximum Likelihood (ML). The analysis was based on the covariances among the scores of the 8 tests. The results reported were based on completely standardized solutions.

Model C1 (see Figure 26)

This model was based on 8 tests. N/R-F (formal form) and FR (Minimal Formal Reasoning) were specified to load on the factor of formal level reasoning; and N/R-PF (postformal form), N/R-EV (epistemic view) and the 4 postformal tests (PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment)) were specified to load on the factor of postformal level reasoning. These two factors were specified to correlate with each other.

The following fit indices are obtained:

Figure 26
Model C1: Results of Confirmatory Factor Analysis



Note. N/R=Nonabsolute/ relativistic.
Fit-indices: X^2=13.56, df=19, p=.81, Q=.71, RMR=.016, SRMR=.027, GFI=.99, AGFI=.97, NFI=.98, NNFI=1.0 (see Appendix I for explanation of fit-indices).

The Chi-Square is 13.56 with 19 Degrees of Freedom (df) and a probability (p) of 0.81. The Chi-Square/df Ratio (Q) is 0.71. The Root Mean Square Residual (RMR) and the Standardized RMR (SRMR) are 0.016 and 0.027 respectively. The Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI) are 0.99 and 0.97 respectively. The Normed Fit Index (NFI) and the Non-normed Fit Index (NNFI) are 0.98 and 1.0 respectively.

As shown in the above results, the model provides a very good fit to the data. The good fit is evidenced in the small Q ratio, the high p level, the small RMR and SRMR, and the high GFI, AGFI, NFI and NNFI. Besides, the two factors were found to be correlated as specified in the model (r=0.68). The results lend support to Hypotheses 4c(1) and (2).

Based on the conventional criterion of 0.30 and above for the acceptability of a factor loading, the factor loadings of this model which ranged from 0.46 to 0.85 fell within the acceptable range.

Based on the conventional criterion of 0.91 and below for the acceptability of an error or unique variance, the unique variances of this model which ranged from 0.79 to 0.28 fell within the acceptable range.

For the factor of "formal level reasoning", the factor loadings of the 2 tests were 0.61 and 0.46. For the factor of "postformal level reasoning", the factor loadings of the 6 tests ranged from 0.56 to 0.85. Therefore, all the tests could be considered as quite good indicators of their corresponding factors.

To conclude, results of both the exploratory and the confirmatory factor analyses suggested that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking.

The analyses and results of Question 4d are presented in the following.

4d. Which of the performances in the 3 N/R tests would singly or in combination best predict the performances in each of the 4 postformal tests?

In relation to this question, the following hypothesis was evaluated.

Hypothesis 4d(1): Performances in N/R-PF (postformal form) and in N/R-EV (epistemic view) rather than that in N/R-F (formal form) would be better predictors of the performances in the 4 postformal tests.

To address this question, 4 separate multiple regression analyses were conducted. The predictors in each of the 4 analyses were the performances in the 3 N/R tests. The criterion variable in each analysis was the performance in Problem Finding (PF), Dialectical Reasoning (DR), Relativistic Operations (RO) and Reflective Judgment (RJ) respectively. When the 3 predictors (performances in N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view)) were entered using a stepwise regression method, results showed that N/R-F (formal form) did not make an additional contribution to the prediction equations for each of the criterion variables. This is probably due to the fact that N/R-F (formal form) represents formal reasoning.

The four prediction equations are presented below:

The prediction equation for PF (Problem Finding) was PF=0.44 + 0.33 (N/R-EV) + 0.25 (N/R-PF). Standard errors associated with the betas were 0.14, 0.07, 0.07. The multiple R was 0.47 (F=35.83, p=0.0000, df(2, 251)).

The prediction equation for DR (Dialectical Reasoning) was DR= -0.19 + 0.56 (N/R-EV) + 0.40 (N/R-PF). The standard errors of the betas were 0.16, 0.08, 0.08. The multiple R was 0.61 (F=72.48, p=0.0000, df(2, 251)).

The prediction equation for RO (Relativistic Operations) was RO=0.57 + 0.40 (N/R-EV) + 0.36 (N/R-PF). The standard errors of the betas were 0.16, 0.08, 0.08. The multiple R was 0.51 (F=45.22, p=0.0000, df(2, 251)).

The prediction equation for RJ (Reflective Judgment) was RJ= -0.12 + 0.47 (N/R-EV) + 0.41 (N/R-PF). The standard errors of the betas were 0.11, 0.06, 0.05. The multiple R was 0.71 (F=126.31, p=0.0000, df (2. 251)).

The above results show that performances in N/R-PF (postformal form) and N/R-EV (epistemic view) were better predictors than that in N/R-F (formal form) in predicting the performance in each of the 4 postformal tests. These results lend support to Hypothesis 4d(1). The implication of such findings is that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking.

The analyses and results of Question 4e are presented in the following.

4e. Between the performances in N/R-F (formal form) and in N/R-PF (postformal form), which would be better predicted by the performance in N/R-EV (epistemic view)?

In relation to this question, the following hypothesis was evaluated.

Hypothesis 4e(1): Performance in N/R-PF (postformal form) rather than that in N/R-F (formal form) would be better predicted by performance in N/R-EV (epistemic view).

To address this question, 2 separate simple regression analyses were conducted. The predictor in each analysis was the performance in N/R-EV (epistemic view). The criterion variable in each analysis was the performances in N/R-F (formal form) and in N/R-PF (postformal form) respectively. The results are presented below.

The prediction equation for N/R-F (formal form) was N/R-F=0.90 + 0.38 (N/R-EV). The standard errors of the betas were 0.22 and 0.10. The multiple R was 0.23 (F=14.26, p=0.0002, df (1, 252)).

The prediction equation for N/R-PF (postformal form) was N/R-PF=0.46 + 0.53 (N/R-EV). The standard errors of the betas were 0.12 and 0.06. The multiple R was 0.50 (F=86.25, p=0.0000, df (1, 252)).

The above results lend support to Hypotheses 4e(1). The implication of such findings is that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking.

All in all, all the findings of Research Question 4 also consistently suggest that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking, thus supporting the general hypothesis that nonabsolute/ relativistic (N/R) thinking is an instance of both formal and postformal reasoning.

In summary, chapter IV contains the analyses and results of the main study which was specifically designed to address Research Questions 3 and 4 of this study. Findings of Research Question 3 seem to support the general hypothesis that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the models of postformal reasoning. Findings of Research Question 4 seem to support the general hypothesis that nonabsolute/ relativistic (N/R) thinking is an instance of both formal and postformal reasoning.

CHAPTER V: DISCUSSION

This final chapter consists of two parts. Part A contains a summary of the study and interpretation of the findings. Part B contains the implications of the findings and suggestions for future research. Part C contains the concluding remarks.

A. SUMMARY AND INTERPRETATION OF FINDINGS

In the recent growing interest in unifying the diverse models of postformal reasoning, there has been speculation that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the selected models of postformal reasoning.

In this study, four of the unresolved issues pertaining to this speculation were identified. In order to address these four unresolved issues, four general research questions were raised and addressed.

The first research question, **"How can nonabsolute/ relativistic (N/R) thinking be operationally defined?"**, was designed to address the unresolved issue concerning the need for an operational definition of nonabsolute/ relativistic (N/R) thinking. An operational definition of nonabsolute/ relativistic (N/R) thinking was proposed in chapter III. To summarize, "nonabsolute/ relativistic (N/R) thinking" refers to a specific type of nonabsolute thinking that involves the use of relativistic thinking as a form of cognitive operation. Nonabsolute/ relativistic (N/R) thinking was conceptualized and defined as a multidimensional and multilevel construct (see Figure 1). Two of the more important dimensions of nonabsolute/ relativistic (N/R) thinking were proposed: a) the basic form dimension and b) the epistemic view dimension. Within the basic form dimension, two levels were proposed: 1) the formal form and 2) the postformal form.

a) The operational definition of the basic form dimension of nonabsolute/ relativistic (N/R) thinking is as follows: 1) The formal form of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on well-defined problems". 2) The postformal form of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on ill-defined problems".

b) The operational definition of the epistemic view dimension of nonabsolute/ relativistic (N/R) thinking is as follows. The epistemic view associated with nonabsolute/ relativistic (N/R) thinking is operationally defined in terms of four specific aspects pertinent to the nature of knowledge of reality. They concern: 1) the means of knowledge, 2) the limits of knowledge, 3) the criteria of knowledge, and 4) the nature of reality.

The above definition of nonabsolute/ relativistic (N/R) thinking was used as a basis for the design of a battery of three tests of nonabsolute/ relativistic (N/R) thinking.

The second research question, **"How can nonabsolute/ relativistic (N/R) thinking be measured?"**, was designed to address the unresolved issue concerning the need for a design of a measure of nonabsolute/ relativistic (N/R) thinking. A battery of three tests of nonabsolute/ relativistic (N/R) thinking was specifically designed to measure the construct of nonabsolute/ relativistic (N/R) thinking. These three tests of nonabsolute/ relativistic (N/R) thinking are: 1) the test of the formal form of nonabsolute/ relativistic thinking (N/R-F), 2) the test of the postformal form of nonabsolute/ relativistic thinking (N/R-PF), and 3) the test of the epistemic view of nonabsolute/ relativistic thinking (N/R-EV). The N/R-F (formal form) was adapted from a subtest of the Arlin Test of Formal Reasoning (Arlin, 1984b). The N/R-PF (postformal form) and N/R-EV (epistemic view) were specifically designed by Arlin and the author for this study. The detailed descriptions of these three tests were presented in chapter III.

The third research question, **"Is nonabsolute/ relativistic (N/R) thinking a common factor underlying the selected tests of postformal reasoning?"**, was

designed to address the unresolved issue concerning the lack of empirical evidence in support of the proposition that nonabsolute/ relativistic (N/R) thinking is one of the possible unifying commonalities underlying the models of postformal reasoning.

A number of researchers have independently suggested that nonabsolute/ relativistic (N/R) thinking is required for the operations of postformal reasoning (e.g. Arlin, 1974, 1975/6; Basseches, 1980; Cavanaugh, Kramer, Sinnott, Camp & Markley, 1985; King, Kitchener, Davidson, Parker & Wood, 1983; Kitchener & King, 1981; Riegel, 1973; Sinnott, 1981, 1989). In a similar vein, Kramer (1983a) proposed that nonabsolute/ relativistic (N/R) thinking might be one of the core features of postformal reasoning. However, the proposition that nonabsolute/ relativistic (N/R) thinking is one of the commonalities underlying the models of postformal reasoning was yet to be empirically tested. This unresolved issue was addressed in the third research question which consists of two subquestions, Questions 3a and 3b. The analyses and results of Research Question 3 were presented in chapter IV.

Question 3a is **"What, if any, commonalities exist among the items of the 3 N/R tests?"**. The purpose of this question was to analyze the test items of the 3 N/R tests in order to provide a foundation for the analyses conducted at the next level using test scores instead of item scores. Confirmatory factor analysis was conducted on the items of the 3 N/R tests. Three test factors, namely the N/R-F (formal form) test factor, the N/R-PF (postformal form) test factor and the N/R-EV (epistemic view) test factor, are identified. These factors appear to underlie all of the 12 test items. Moreover, the 3 test factors are shown to be correlated and a second order factor, namely the N/R test factor, underlies these 3 test factors. The implication of such findings is that these 3 test factors measure three different aspects of the same construct, namely nonabsolute/ relativistic (N/R) thinking.

In the second order factor model, except for 2 test items, namely NRF2 and NREV4, which yielded low factor loadings of -0.18 and 0.18 respectively, the other 10

test items yielded factor loadings ranging from 0.31 to 0.92 which fell within the acceptable range. Despite their low factor loadings, NRF2 and NREV4 were retained in the test due to their uniqueness. On the whole, the 12 test items could be considered as fairly valid indicators of their respective test factors. Subsequently, the item scores of each test could be combined into a single composite score to reflect the corresponding test factor.

Question 3b is **"What, if any, commonalities exist among the 3 N/R tests and the 4 postformal tests?"**. Confirmatory factor analysis was conducted on the test scores of the 3 N/R tests and the 4 postformal tests. As shown in the results of the analysis, an N/R (nonabsolute/ relativistic thinking) test factor underlies the 3 N/R tests and a postformal test factor underlies the 4 postformal tests. Furthermore, these two test factors are shown to be perfectly correlated (r=1.0). This relationship between the two test factors could be explained either by a second order common factor model or by a more parsimonious model. In the more parsimonious model, these two test factors were replaced by one first order common factor which was hypothesized to be nonabsolute/ relativistic (N/R) thinking. Such findings lend support to the general hypothesis that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the selected models of postformal reasoning as postulated in the literature.

As shown in the results of further analysis, a factor of basic form dimension underlies the N/R-PF (postformal form) and 3 of the 4 postformal tests (Problem Finding, Dialectical Reasoning and Relativistic Operations) and a factor of epistemic view dimension underlies the N/R-EV (epistemic view) and the postformal test of Reflective Judgment. Furthermore, these two factors are shown to be perfectly correlated (r=1.0). The implication of such findings is that two dimensions (basic form and epistemic view) could be differentiated within the postformal level of nonabsolute/ relativistic (N/R) thinking. Such findings lend support to the conceptualization that nonabsolute/ relativistic (N/R) thinking is a multidimensional construct. The hypothesis

that nonabsolute/ relativistic (N/R) thinking is also a multilevel construct was further explored in the fourth research question.

The fourth research question, **"Is nonabsolute/ relativistic (N/R) thinking an instance of formal or postformal reasoning or of both?"**, was designed to address the unresolved issue concerning whether nonabsolute/ relativistic (N/R) thinking is formal or postformal in nature.

An implicit assumption held by some postformal researchers is that in order for nonabsolute/ relativistic (N/R) thinking to be qualified as a common feature underlying the postformal models, it is necessary to demonstrate that it possesses a form or structure that is postformal in nature (Cavanaugh et al., 1985; Kramer, 1983b). While a number of researchers (e.g. Arlin, 1984, 1990; Kramer, 1983a; Sinnott, 1981) suggested that some kind of relativistic thinking is required for postformal operations, others (Cavanaugh et al., 1985) questioned the postformal level status of relativistic thinking. Thus the postformal level status of relativistic thinking has been a debatable issue. This unresolved issue was addressed in the fourth research question which consists of five subquestions, Questions 4a to 4e. Analyses and results of Research Question 4 were presented in chapter IV.

Question 4a is **"What is the order of difficulty among the 8 tests -- FR (Minimal Formal Reasoning), N/R-F (formal form), N/R-EV (epistemic view), N/R-PF (postformal form), PF (Problem Finding), DR (Dialectical Reasoning), RO (Relativistic Operations) and RJ (Reflective Judgment)?"**.

As a result of the analysis, it appears that a non-linear model* might be more appropriate in describing the relationships among the 8 tests. When only Minimal Formal Reasoning and the 3 N/R tests were rank ordered according to their level of difficulty, results show that Minimal Formal Reasoning was less difficult than N/R-F (formal form) and that N/R-F (representing the formal level of nonabsolute/ relativistic thinking) was less difficult than N/R-PF and N/R-EV (representing the postformal level

of nonabsolute/ relativistic thinking). Analysis of contingency table was used to establish that N/R-F (formal form) was a necessary but not sufficient condition for N/R-PF (postformal form). The hypothesis that N/R-F (formal form) is a necessary but not sufficient condition for N/R-EV (epistemic view) was not supported by virtue of the entry in the target cell exceeding the arbitrary cut-off point of 13 (5%). As the excess was only 2 cases (0.9%) over the arbitrary cut-off point, the hypothesis though not supported could still be considered plausible.

When the 4 postformal tests were also rank ordered, the level of difficulty of Relativistic Operations and of Dialectical Reasoning was found to approximate that of N/R-F (formal form), falling within the moderately difficult range, and that of Reflective Judgment and of Problem Finding to approximate that of N/R-EV (epistemic view) and of N/R-PF (postformal form), falling within the most difficult range.

Question 4b is **"What is the order of the 8 tests according to their ages of onset of task mastery?"**.

Similarly, findings suggest that a non-linear model* might be more appropriate in describing the relationships among the 8 tests. When only Minimal Formal Reasoning and the 3 N/R tests were rank ordered according to their respective ages of onset, results indicate that Minimal Formal Reasoning preceded N/R-F (formal form) and that N/R-F (formal form) preceded N/R-EV (epistemic view) and N/R-PF (postformal form). When the 4 postformal tests were also taken into consideration, Relativistic Operations was found to precede the other 3 postformal tests and Dialectical Reasoning and Problem Finding to precede Reflective Judgment. Correspondingly, Relativistic Operations approximated N/R-F (formal form) and Dialectical Reasoning and Problem Finding approximated N/R-EV (epistemic view) and N/R-PF (postformal form).

Question 4c is **"How do the 3 N/R tests correlate with the factors of formal level reasoning and of postformal level reasoning?"**.

Exploratory factor analysis resulted in N/R-F (formal form) loading primarily on the factor of formal level reasoning, and N/R-PF (postformal form) and N/R-EV (epistemic view) loading primarily on the factor of postformal level reasoning. Such results were further supported through confirmatory factor analysis.

Question 4d is **"Which of the performances in the 3 N/R tests would singly or in combination best predict the performances in each of the 4 postformal tests?"**.

As shown in the results of multiple regression analysis, performances in N/R-PF (postformal form) and in N/R-EV (epistemic view) were better than that in N/R-F (formal form) as predictors of the performances in the 4 postformal tests (Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment).

Question 4e is **"Between the performances in N/R-F (formal form) and in N/R-PF (postformal form), which would be better predicted by the performance in N/R-EV (epistemic view)?"**.

As shown in the results of simple regression analysis, performance in N/R-PF (postformal form) rather than that in N/R-F (formal form) was better predicted by performance in N/R-EV (epistemic view). The implication of such findings is that N/R-PF (postformal form) and N/R-EV (epistemic view) both represent the postformal level of nonabsolute/ relativistic (N/R) thinking.

All in all, it was consistently suggested in all the findings of the fourth research question that the formal and the postformal levels could be differentiated within nonabsolute/ relativistic (N/R) thinking, thus supporting the general hypothesis that nonabsolute/ relativistic (N/R) thinking is an instance of both formal and postformal reasoning. The implication is that nonabsolute/ relativistic (N/R) thinking is a multilevel construct. As a result of these findings, an alternative perspective to the debate concerning the stage level of nonabsolute/ relativistic (N/R) thinking is available. The alternative perspective is that it is not necessary to categorize nonabsolute/ relativistic

(N/R) thinking strictly into either formal or postformal level as it can be conceptualized as a multilevel construct.

***Non-linear Model of Development**

According to certain ordering criteria, when the tests could be arranged one after another in a straight line, the pattern of the relationships among the tests could be described as a linear model. When the tests could not be arranged one after another in a straight line, the pattern of the relationships among the tests would be described as a non-linear model.

An interesting pattern concerning the relationships among formal reasoning, nonabsolute/ relativistic (N/R) thinking and postformal reasoning appears to emerge from the findings. In rank ordering of the 8 tests by their level of difficulty as well as by ages of onset of task mastery, it is consistently shown in the results that when only Minimal Formal Reasoning and the 3 N/R tests -- N/R-F (formal form), N/R-PF (postformal form) and N/R-EV (epistemic view) -- were considered, the assumption of a linear model could still be applied. However, when the 4 postformal tests (Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment) were also taken into consideration, the assumption of a non-linear model rather than a linear model would be more appropriate in describing the relationships among the 8 tests. In other words, the 4 postformal tests were found to approximate the 3 N/R tests in terms of their level of difficulty as well as of their ages of onset of task mastery. Such findings are contrary to the assumption of a linear model that all 4 postformal tests would be more difficult than the 3 N/R tests and that the ages of onset of task mastery of the 4 postformal tests would be later than those of the 3 N/R tests.

A probable explanation for such findings might be related to the scoring criteria of the 4 postformal tests. The 4 postformal tests used in this study are adapted from the

original tests in order to tap the minimal presence of postformal reasoning specific to their respective models. The original tests were Problem Finding, Dialectical Reasoning, Relativistic Operations and Reflective Judgment. It is crucial to point out that the minimal presence of these forms of postformal reasoning does not represent the fully developed forms of postformal reasoning but rather some variation of them. As the scoring criteria of the original tests of the selected postformal models are very stringent, it is obvious that the adapted scoring criteria would deflate the level of difficulty of the 4 postformal tests. They would probably also be responsible for the relatively low correlations between each of the 4 postformal tests and Minimal Formal Reasoning and between each of the 4 postformal tests and N/R-F (formal form). It is speculated that if these selected postformal tests were administered and scored in accordance with their original criteria, they would probably be more difficult than the 3 N/R tests, and their ages of onset of task mastery would probably be later than those of the 3 N/R tests. Furthermore, the correlations between each of the 4 postformal tests and Minimal Formal Reasoning and between each of the 4 postformal tests and N/R-F (formal form) would probably increase. However, the interest of this study is on the basic forms or structures as postulated in the above selected models of postformal reasoning. Therefore, tapping only the minimal presence of postformal reasoning specific to their respective models suffices. The non-linear model suggested by the findings in fact reveals the nature of the interconnectedness among the development of nonabsolute/ relativistic (N/R) thinking and the emergence of these specialized forms of postformal reasoning.

Volatility due to individual differences and sampling errors can be expected on the ages of onset of task mastery, defined as the basal age at and above which age level there is a minimum of at least one incidence of task mastery. The ages of onset of task mastery should not, therefore, be taken as a conclusive point of reference for the relationships among the 8 tests. They should rather be used as a supplementary reference to the level of task difficulty according to the percentage of task mastery and the results

of the contingency tables. Therefore, all three sets of information, namely ages of onset of task mastery, percentage of task mastery and the contingency tables, should be integrated in order to provide a better and more consolidated representation of the relationships among the 8 tests.

As shown in the results, the ages of onset of task mastery of both nonabsolute/ relativistic (N/R) thinking and postformal reasoning span from age 13 to 17, concentrating around age 15 particularly. Such findings are not incompatible with the logic that the emergence of these forms of higher order thinking happens to coincide with the consolidation period of formal reasoning which was suggested by Piaget (1972) to be around age 15 though many researchers would hypothesize an age above 15.

B. IMPLICATIONS OF FINDINGS AND SUGGESTIONS FOR FUTURE RESEARCH

Findings of this study are discussed in four contexts and suggestions for future research would be made accordingly. These four contexts are: 1) nonabsolute/ relativistic (N/R) thinking as a commonality underlying postformal models, 2) nonabsolute/ relativistic (N/R) thinking as a multidimensional and multilevel construct, 3) nonabsolute/ relativistic (N/R) thinking as a form of metamorphosis from closed-system to open-system thinking, and 4) nonabsolute/ relativistic (N/R) thinking as a potential springboard in the development of higher order thinking.

1. Nonabsolute/ relativistic (N/R) Thinking as a Commonality underlying Postformal Models

Findings in this study supported the proposition that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the selected models of postformal reasoning. These findings would shed light to clarify the logical relationships existing among the said models as well as provide a common link unifying these diverse models. However, the claim is not made that nonabsolute/ relativistic (N/R) thinking is the sole unifying commonality underlying the selected models nor that it is a possible commonality underlying all models of postformal reasoning. The work reported here serves as an alternative perspective in the attempt to unify the diverse models. Therefore, other possible unifying commonalities warrant exploration.

As this study was an initial attempt to provide empirical evidence to support the proposition that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality, only the minimal presence of postformal reasoning specific to the selected models was tapped. Though the hypothesis was supported that nonabsolute/ relativistic (N/R) thinking is a possible unifying commonality underlying the selected models of postformal reasoning, further studies are called for to explore the relationships between nonabsolute/ relativistic (N/R) thinking and the fully developed forms of postformal reasoning.

2. Nonabsolute/ relativistic (N/R) Thinking as a Multidimensional and Multilevel Construct

In this study, nonabsolute/ relativistic (N/R) thinking was defined as a multidimensional and multilevel construct. Two of the important dimensions of nonabsolute/ relativistic (N/R) thinking were proposed: 1) basic form dimension and 2) epistemic view dimension. Within the basic form dimension, two levels were proposed:

1) formal form and 2) postformal form. It is suggested in the findings that the two dimensions and the two levels can be differentiated within the construct of nonabsolute/ relativistic (N/R) thinking. As construct validation was not the main focus of this study, this construct as defined needs to be validated by further studies specific to this purpose. Furthermore, other dimensions and other levels of nonabsolute/ relativistic (N/R) thinking have yet to be explored.

3. Nonabsolute/ relativistic (N/R) Thinking as a Form of Metamorphosis from Closed-system to Open-system Thinking

A simple form of relativity which is one of the eight concepts of formal operations was defined by Piaget (1958) as "co-ordination of two or more systems or frames of reference". Arlin (1984) suggested that this might represent a pivotal concept that marks the transition from high formal to postformal reasoning. Based on this suggestion, two forms of nonabsolute/ relativistic (N/R) thinking, namely formal and postformal, were proposed in this study.

The formal form of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on well-defined problems" as measured by N/R-F (formal form) which is adapted from the Piagetian task "Coordinations of two or more systems or frames of reference". The task requires the ability to coordinate multiple frames of reference within a well-defined and closed-system as a whole. For well-defined problem, all information necessary to produce a solution is given or can be derived form what is given. On the other hand, the postformal form of nonabsolute/ relativistic (N/R) thinking is operationally defined as "multiple-frame operations on ill-defined problems" as measured by N/R-PF (postformal form) which is one of the three

N/R tests specifically designed for this study. This test was designed to measure the ability to think flexibly in terms of multiple frames within self-constructed as well as open systems. As the task involves ill-defined problems, a person would be required to generate information beyond that which is given including relevant frames of reference. Since absolute answers cannot be expected for this kind of task, the recognition of uncertainty and indeterminacy is necessarily implied.

In view of the above, one could argue that the postformal form of nonabsolute/ relativistic (N/R) thinking, although structurally similar to, is qualitatively more advanced than the formal form. Correspondingly, the representation of reality associated with the postformal form is more dynamic and allows for uncertainty, and therefore, is more compatible with the notion of modern science that reality is in a constant flux.

It is my argument that the transition from the formal form to the postformal form might represent a form of metamorphosis from closed-system thinking (associated with well-defined problems) to open-system thinking (associated with ill-defined problems), and that the transition might be explained by a paradigm shift from an absolute to a nonabsolute epistemic view. In this light, Piaget's formal operations would mark the final stage not of cognitive development but of closed-system thinking.

At the postformal level, the functions of nonabsolute/ relativistic (N/R) thinking are double-edged. On the side which is more recognized and duly emphasized, nonabsolute/ relativistic (N/R) thinking could function to generate, construct and co-ordinate complex dynamic systems of thinking which allow for uncertainty, indeterminacy, and subjectivity. On the other side which is less recognized, nonabsolute/ relativistic (N/R) thinking could function to free fixed perspectives and to break mental sets. If reality is the construction of the mind, nonabsolute/ relativistic (N/R) thinking might serve to liberate the mind's construction of reality.

At the postformal level, formal reasoning is not necessarily abandoned but incorporated into a higher order system of cognitive operations. In nonabsolute/

relativistic (N/R) thinking, the ability to generate self-constructed open systems involves in essence the ability to create space for imagination. In this light, the postformal form of nonabsolute/ relativistic (N/R) thinking defined as multiple-frame operations on ill-defined problems represents an interplay between the use of logic and imagination. Thus the difference between formal and postformal reasoning is not so much in the level of complexity but creativity. In this context, nonabsolute/ relativistic (N/R) thinking has a close affinity to the works on creative intelligence (Sternberg, 1990) and on wisdom as advanced by researchers such as Arlin (1990, 1993), Baltes and Smith (1990; in press), Chandler and Holliday (1990), and Meacham (1990). Future study is suggested to explore the possible role of nonabsolute/ relativistic (N/R) thinking in these and related domains. The basic form and the epistemic view associated with the postformal level of nonabsolute/ relativistic (N/R) thinking as definable and measurable constructs might provide an alternative and viable basis for the analysis of higher order thinking with particular regards to creative intelligence and wisdom.

4. Nonabsolute/ relativistic (N/R) Thinking as a Potential Springboard in the Development of Higher Order Thinking

As shown in the four prediction equations generated for the four postformal tests (Problem Finding, Dialectical Reasoning, Relativistic Operations, and Reflective Judgment), the performance in the two postformal N/R tests -- N/R-PF (postformal form) and N/R-EV (epistemic view) -- taken in combination could serve as potentially useful predictors of higher order thinking as characterized in the 4 selected postformal tests. This is particularly so with N/R-EV (epistemic view) as a predictor.

In addition, the mastery of N/R-EV (epistemic view) was found to be necessary but not sufficient for the mastery of N/R-PF (postformal form) as hypothesized in this study. The implication for such findings is that N/R-EV (epistemic view) might be construed as a crucial antecedent to the development of N/R-PF (postformal form).

The transitional development of N/R-EV (epistemic view) was also found to be necessary but not sufficient for the mastery of each of the 4 postformal tests. Furthermore, the transitional development of N/R-PF (postformal form) was found to be necessary but not sufficient for the mastery of two postformal tests, namely Problem Finding and Reflective Judgment. Such findings seem to suggest that the transitional development of nonabsolute/ relativistic (N/R) thinking indeed plays a crucial role in the development of the basic forms or structures of higher order thinking specifically postformal reasoning. In view of this role of nonabsolute/ relativistic (N/R) thinking in the development of higher order thinking, nonabsolute/ relativistic (N/R) thinking could be taken as a potential springboard in the development of postformal reasoning and other forms of higher order thinking. A similar argument was presented in a study yielding evidence that relativistic thinking can play a major role in identifying exceptional cognitive ability in adolescents (Worthen, paper presented in 1992). Conversely, the absence of nonabsolute/ relativistic (N/R) thinking in the course of cognitive development might have a hindering effect on the development of higher order thinking or might even reflect difficulties in cognitive functioning. Research in a similar vein suggested that relativistic thinking was typically absent in groups of psychiatrically hospitalized youth (Chandler & Boyes, 1990). Thus future research is needed to explore the specific effects of the presence or absence of nonabsolute/ relativistic (N/R) thinking on the development of higher order thinking as well as of optimal cognitive functioning.

C. CONCLUDING REMARKS

Some researchers in the field of cognitive development had associated postformal reasoning with advanced scientific thinking. As observed by Einstein (Infeld & Einstein, 1938), "to raise new questions, new possibilities, to regard old questions from a new angle requires creative imagination and marks real advance in science" (p. 92). This view was taken by Arlin (1989) to be an instance of quality problem-finding which is a specialized form of postformal reasoning. Sinnott (1989) associated post-Einstein physics with postformal reasoning and pre-Einstein physics with formal reasoning. And Oser and Reich (1987) associated postformal reasoning with the concept of complementarity.

It could be argued that the theories of relativity and of complementarity only epitomize the ingenious application of nonabsolute/ relativistic (N/R) thinking in the field of physics. From a wider perspective, it could be further argued that nonabsolute/ relativistic (N/R) thinking could also be applied to other domains with far-ranging benefits. These domains would include arts and humanities, economics and politics, physical and social sciences, and philosophy and religion as well as real life problems of everyday living.

The application of nonabsolute/ relativistic (N/R) thinking into specific domains is a challenge and calls for interdisciplinary research.

In light of the significant role of nonabsolute/ relativistic (N/R) thinking in the development of higher order thinking, findings of this study have particularly important implications for research on cognitive development, clinical and counselling psychology, educational psychology, and education with particular reference to higher education, curriculum and instruction, and teachers' training.

In this age of advanced technology in information and communication, information has never been so readily accessible. For students, the task of obtaining

information has never been so convenient. With such profusion of information, the teacher's role to provide guidance in the use and integration of information and to stimulate critical and original thinking has never been so important. One of the prime concern of education is the development of cognitive potentials in the individual. Thus research is recommended to explore how teachers could best function as a catalyst for developing cognitive potentials in students through the application of the understanding of the significant role of nonabsolute/ relativistic (N/R) thinking in the development of higher order thinking.

Cognitive development could be conceptualized as potentially multidirectional and non-teleological (Chapman, 1988). The notion of multidirectional development implies that there could be more than one developmental pathway. The notion of non-teleological development implies that it is not exactly necessary to establish a fixed endpoint of development. Nonabsolute/ relativistic (N/R) thinking, by its emancipatory potentials, might serve as one of the propelling forces in the evolution of human cognition.

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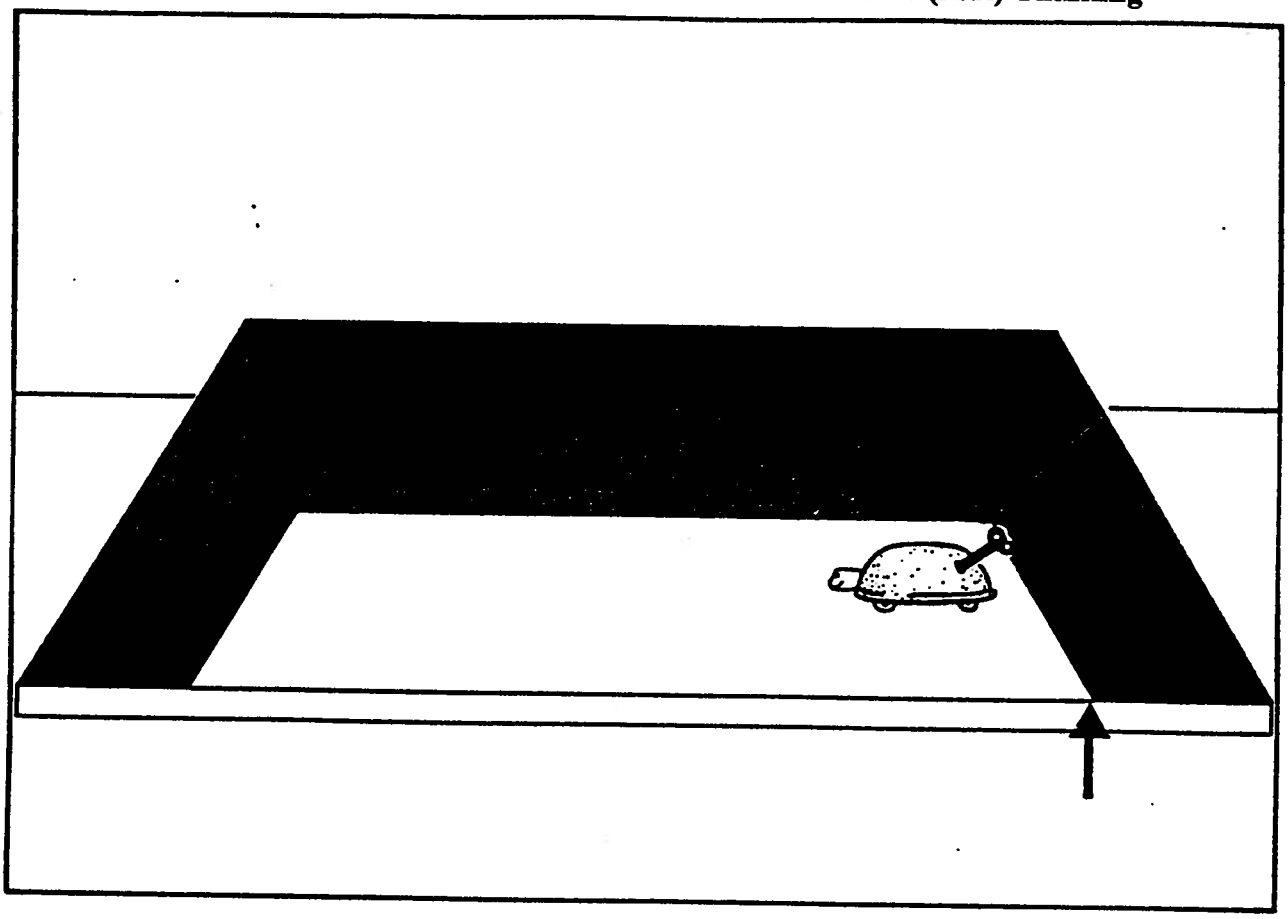
Appendix A

Test Items of Test of Formal Form of Nonabsolute/ relativistic (N/R) Thinking



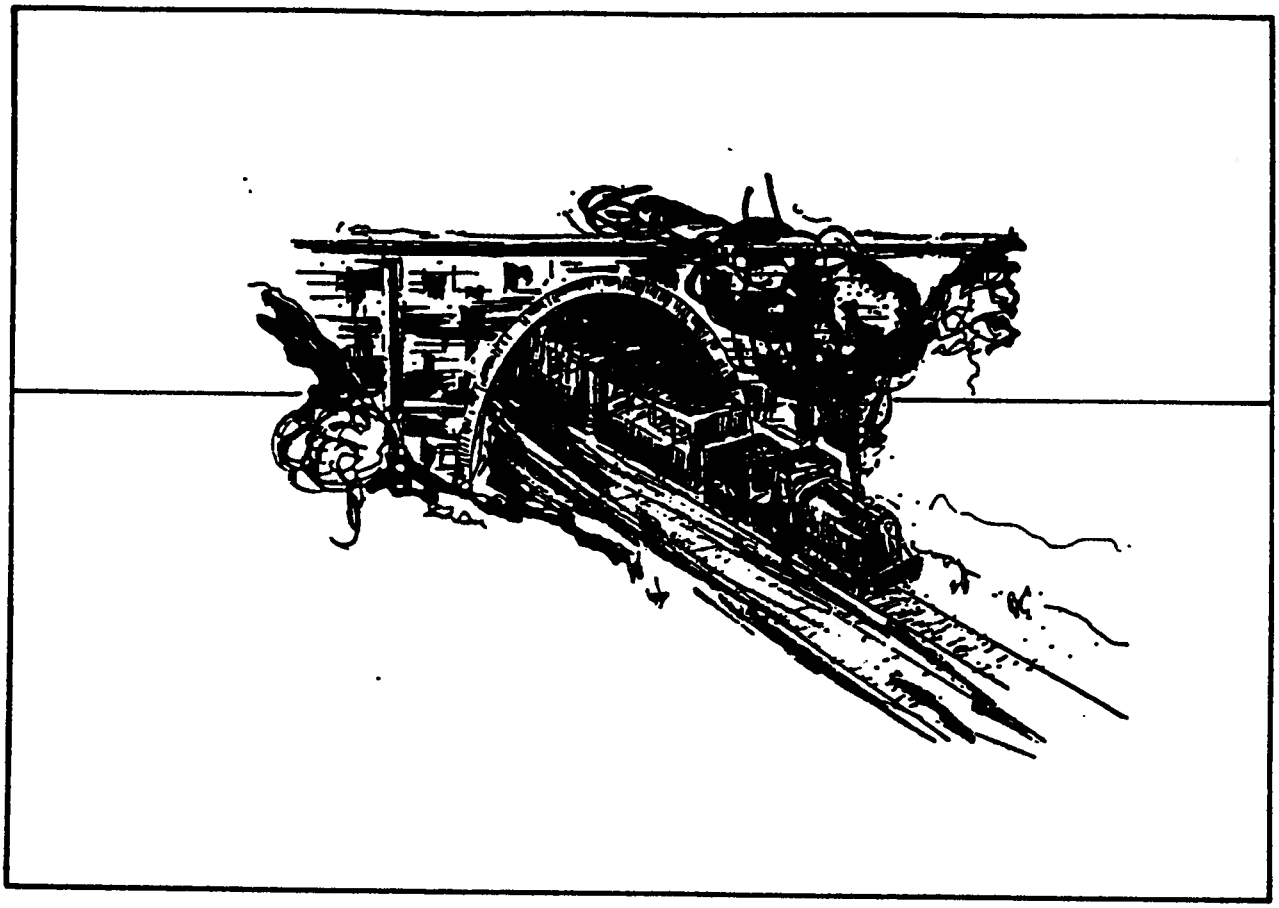
A small toy wind-up turtle is placed on a shaded strip of paper. The paper strip is lined up along the edge of a board as shown in the picture. The turtle can be moved along the paper strip. The paper strip can also be moved along the board. Both the toy and the paper strip can be moved forward or backward. The toy, the end of the paper strip, and the starting point on the board are all lined up as shown.

1. If the turtle moves forward at the same speed that the paper strip moves backward, how far will the turtle be from the starting point after a short time (as long as the turtle is still on the strip of paper)?

   A. It would be at the starting point.
   B. One-fourth the distance of the paper strip from the starting point.
   C. Double the distance of the paper strip from the starting point.
   D. It would be behind the starting point.

2. If the turtle moves forward at 1/3 the speed that the paper strip moves backward, where would the turtle be after a short period of time (as long as the turtle is still on the strip of paper)?

   A. Three times as far forward as the paper strip is backward from the starting point.
   B. One-third the distance in front of the starting point as the paper strip is behind the starting point.
   C. It would be behind the starting point.
   D. As far in front of the starting point as the end of the paper strip is in back of it.



Two people are sitting on this train as it passes through a long tunnel in the side of a mountain. Mr. Red (R) is sitting at the front of the train and Mr. Blue (B) is sitting at the back of the train. For the following two situations, decide whether Mr. R and Mr. B will stay in the tunnel for the same amount of time.

3. SITUATION 1: After the train enters the tunnel Mr. R gets up from his seat in the front, and walks back to sit with Mr. B. How much time altogether will Mr. R spend in the tunnel?

A. Less time in the tunnel than Mr. B.
B. Twice the time in the tunnel as Mr. B.
C. The same amount of time in the tunnel as Mr. B.
D. More time in the tunnel than Mr. B.

4. SITUATION 2: After the train has entered the tunnel, Mr. B gets up from his seat in the back. He walks forward to sit with Mr. R. Halfway on his trip forward, he decides to go back to his seat for his paper. He gets his paper and then goes forward again and joins Mr. R, while the train is still in the tunnel. How much time did Mr. B spend in the tunnel?

A. Less time in the tunnel than Mr. R.
B. More time in the tunnel than Mr. R.
C. One-and-one-half as much time in the tunnel as Mr. R.
D. The same amount of time in the tunnel as Mr. R.

Appendix B

The Test of Minimal Formal Reasoning (FR)

Test Description

The purpose of this test is to assess the presence of the minimal ability rather than the maximal ability for formal reasoning. This test adopts 3 subtests of the Arlin's Test of Formal Reasoning (ATFR) (Arlin, 1984b). The ATFR was originally designed to assess the ability to use all of the eight Piagetian concepts/ schemata of formal operations.

The 3 subtests adopted for the present test are: 1) Multiplicative compensations, 2) Probability, and 3) Correlations. The rationale for selecting these 3 subtests is that they make up the most elementary or the first tier of ATFR. Thus they should reflect the presence of the minimal ability for formal reasoning.

The 3 concepts of formal operations as assessed by the 3 subtests are briefly introduced as follows.

"Multiplicative compensations" refers to "the concept which supports the understanding that when there are two or more dimensions to be considered in a problem, gains or losses in one dimensions are made up for by gains or losses in the other dimensions (Arlin, 1984b, p.10)".

"Probability" refers to "a concept that supports the ability to develop a relationship between the confirming and the possible cases (Arlin, 1984b, p.10)".

"Correlations" refers to a concept that implies the ability "to conclude that there is or is not a causal relationship, whether negative or positive, and to explain the minority cases by inference of chance variables (Arlin, 1984b, p.10)".

This test (FR) is a pencil-and-paper test made up of 12 multiple-choice items organized into 3 subtests. The subtest of multiplicative compensations contains items 1 to 4; the subtest of probability contains items 5 to 8; and the subtest of correlations contains items 9 to 12.

Test Items

Insert test items about here

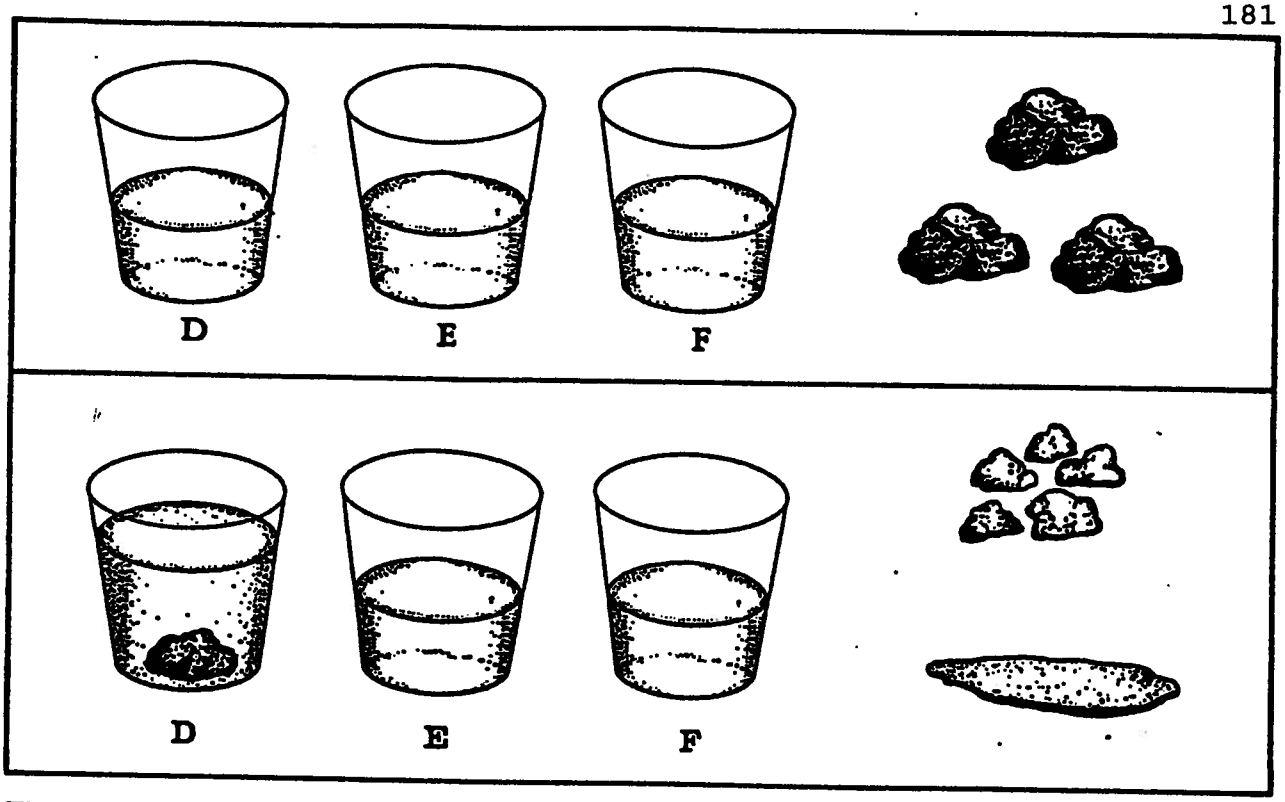
(see next 4 pages)

Scoring Criteria

The correct answers for the test items are follows.

Subtest I:	1. C	2. B	3. A	4. B
Subtest II:	5. D	6. B	7. D	8. C
Subtest III:	9. D	10.A	11.C	12.A

Score 1 point for each correct answer to an item. A subtest score is the sum of its item scores. An individual test score is the average of the scores of the 3 subtests, that is, (subtest 1 + subtest 2 + subtest 3) /3.



Three cups, (Cup D, Cup E, and Cup F) are partially filled with water. Beside the three cups are three balls of clay. These three balls are exactly the same size as each other. The first ball is placed in Cup D as shown. The water level in Cup D rises. Before placing the second ball into Cup E, it is flattened into a pancake shape as shown. The third ball of clay is broken into five pieces as shown and then placed into Cup F.

1. What do you think will happen to the water level in Cup E when this pancake shaped piece of clay is placed into it?

   A. The water level will rise up higher than the level in cup D.
   B. The water level will rise to half the level of cup D.
   C. The water level will go up to the same height as that in cup D.
   D. The water level will rise to one-fifth the height of that in cup D.

2. What is the reason for your answer to the question just above?

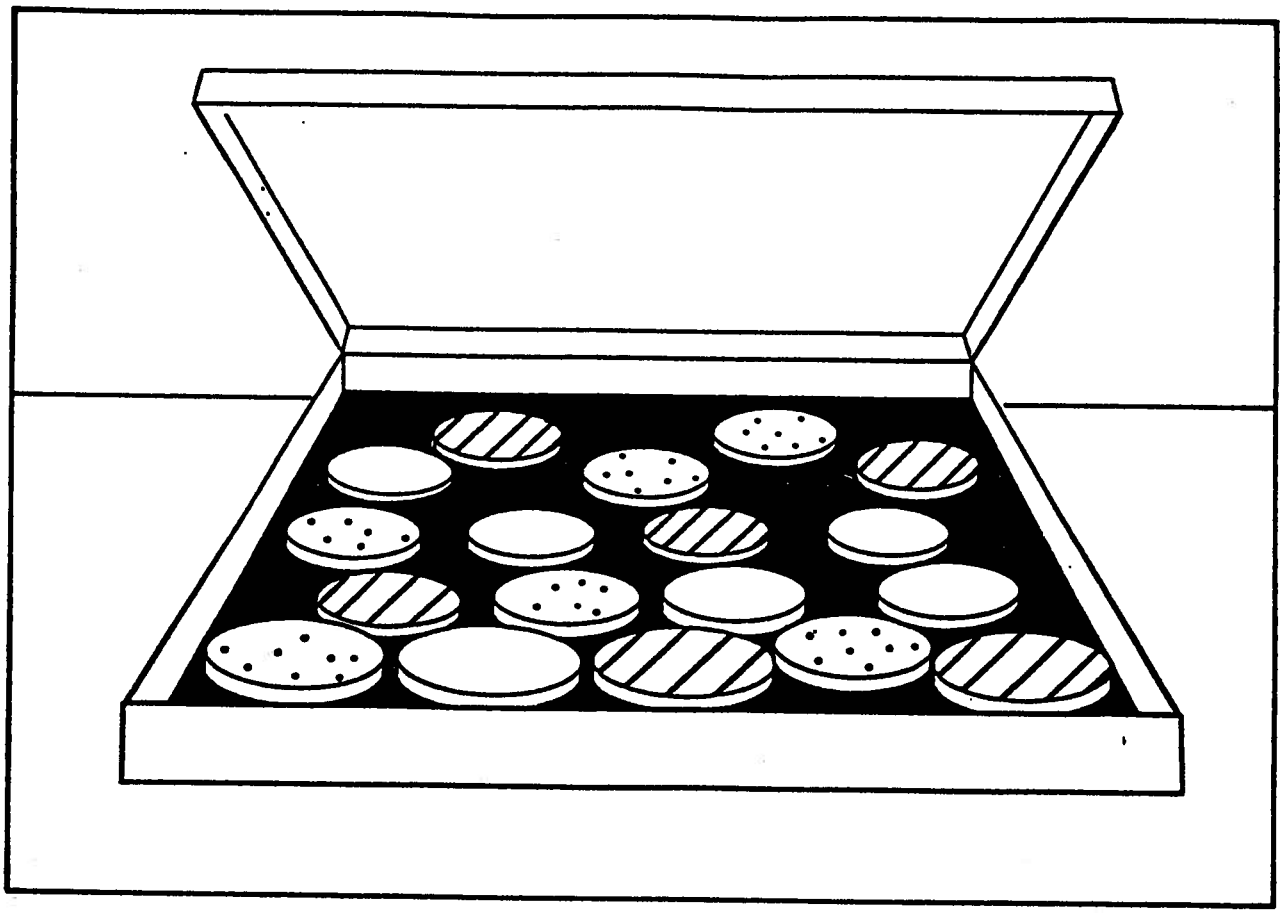
   A. The pancake shape takes up more space.
   B. The balls were the same size at the start.
   C. The pancake shape is flat and therefore it takes up less space.
   D. The ball and pancake weigh the same.

3. What do you think will happen to the water level in Cup F when the five small balls of clay are placed in it?

   A. The water level will go up to the same height as that in Cup D.
   B. The water level will NOT rise up as high as that in Cup D.
   C. The water level will rise up higher than the level in Cup D.
   D. The water level will rise one-fifth the height as that in Cup D.

4. What is the reason for your answer to the question just above?

   A. The five balls of clay take up more space.
   B. The balls were the same size before the one ball was broken into pieces.
   C. The five small balls take up less room.
   D. The five small balls weigh the same as the one large ball.



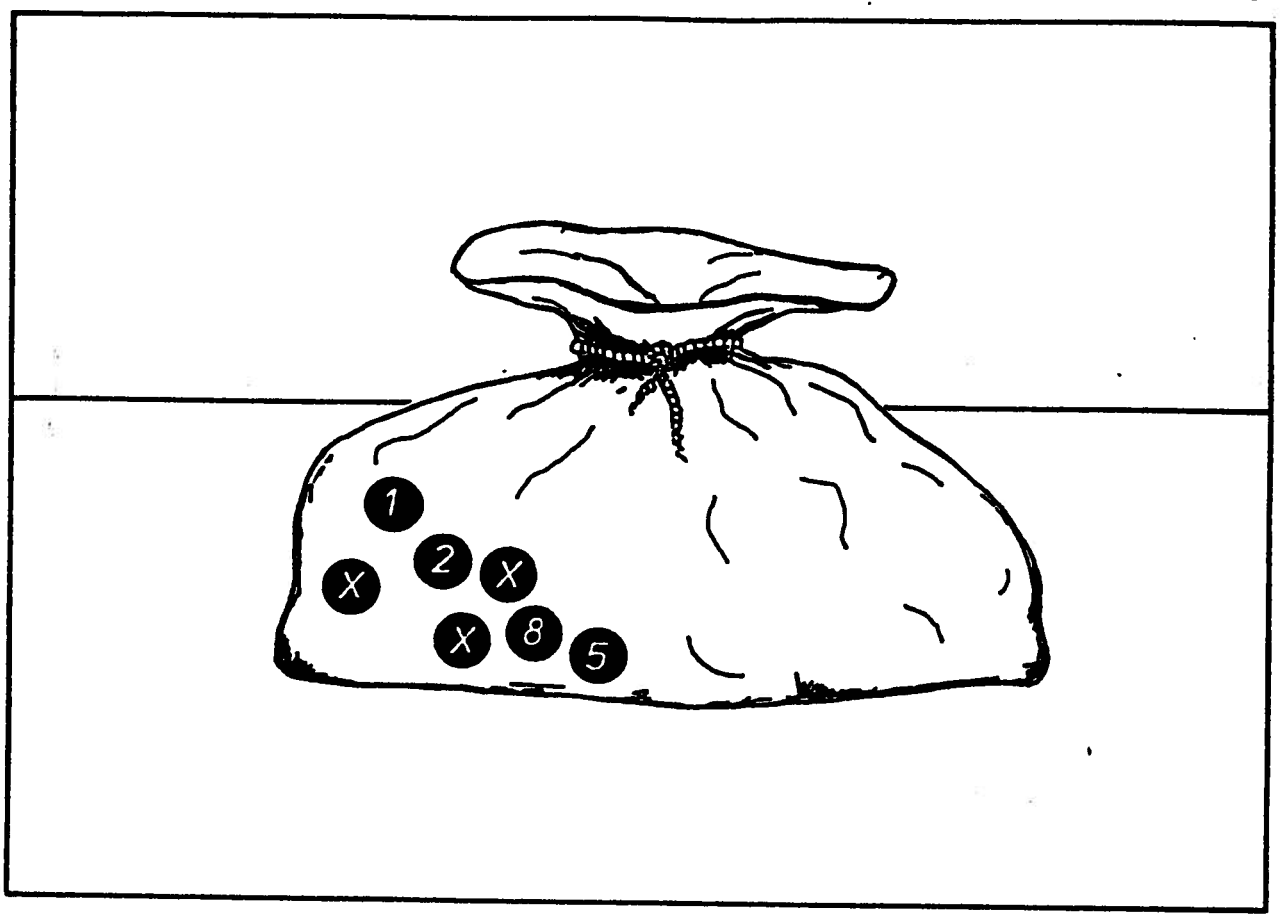
In a new game of chance, six plain tokens, six striped tokens and six dotted tokens are placed in a box as pictured above. The box is held above your head so that you cannot see the tokens. You are asked to draw one token out of the box.

5. What do you think your chances are of drawing a striped token on your very first draw?

   A. One chance out-of-two.
   B. One chance out-of-eighteen.
   C. One chance out-of-twelve.
   D. One chance out-of-three.

6. Why did you choose your answer for the question just above?

   A. My chances are the same as those for flipping a coin and getting heads.
   B. My chances are based on the fact that the number of striped tokens has to be compared to the total number of tokens.
   C. My chances are good to draw it in the first two or three draws because I am lucky.
   D. My chances are based on the fact that there are twelve tokens that are not striped and I need to eliminate these first.



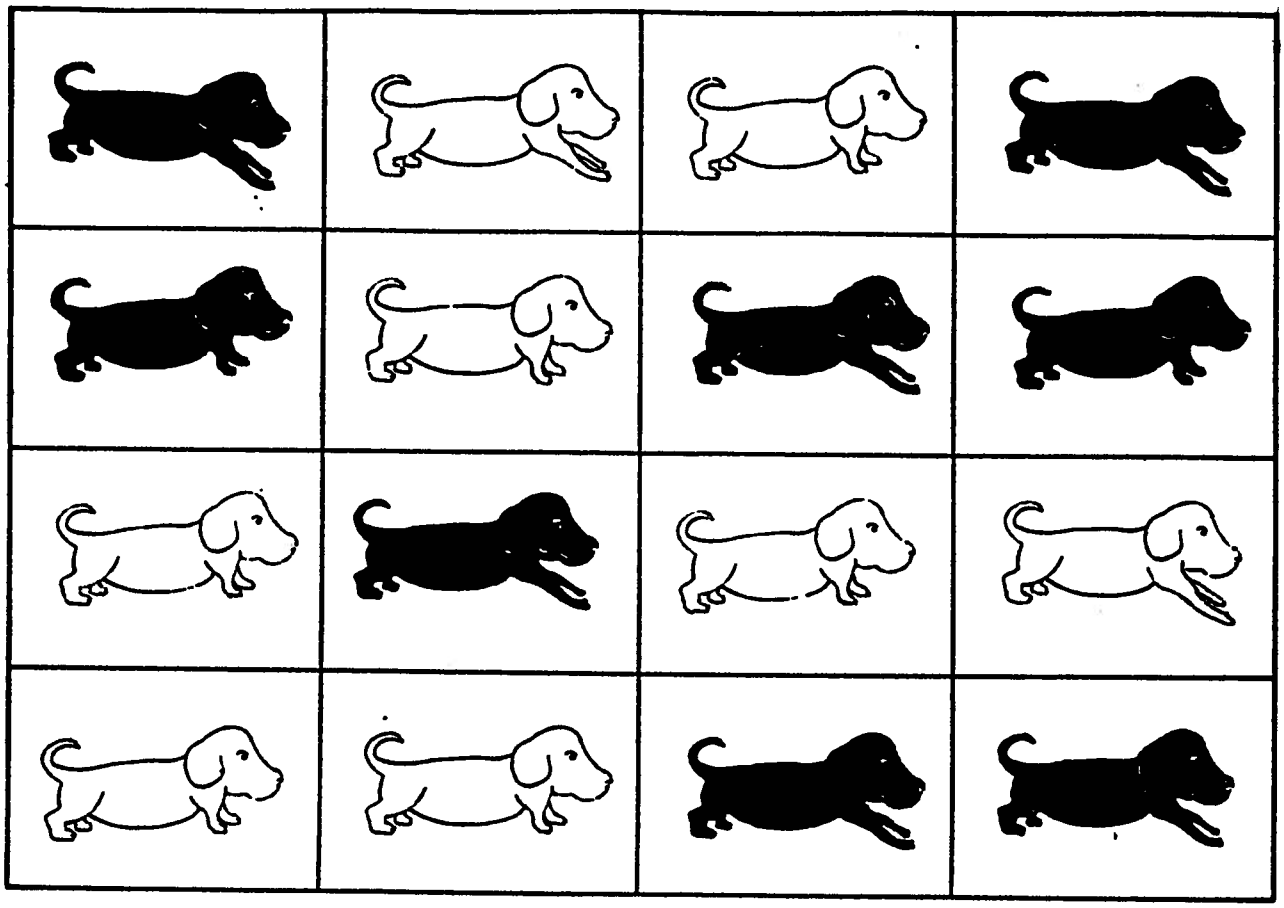
There is a game on a well-known TV quiz show that contestants play to win a new car. Seven tokens are placed in a cloth bag. Three tokens contain an X. If these three tokens are drawn from the bag before the four numbers in the price of the car, the contestant loses. If, however, the contestant draws the four numbered tokens before drawing the third token marked with an X, the contestant wins a new car. Each time a token is drawn it remains out of the bag. The following questions are based on this game.

7. If a contestant draws 3 numbered tokens and 1 token marked X, what are the chances of winning the car on the next draw?

A. Three-out-of-seven
B. Three-out-of-four
C. Two-out-of-three
D. One-out-of-three

8. What is the reason for your answer to this question?

A. There are three tokens without numbers that have to be taken into account.
B. Three of the numbered tokens have already been drawn and there are four numbered tokens in all.
C. Two of the remaining tokens contain X's out of the three possible tokens from which you can draw.
D. There is only one numbered token that remains out of the total.



You are given a set of 16 cards. Each card has a picture of a hound dog which is either black or white in color, and who has either long or short legs. Card 1 represents a black dog with long legs. The following questions are to be answered on the basis of these 16 cards.

9. Can you find a relationship between body color and leg size for this type of dog, on the basis of these 16 cards?

   A. No, because there is an even number of black and of white dogs with short legs.
   B. No, because 8 dogs have short legs and 8 dogs have long legs and therefore there is no relationship.
   C. Yes, because all of the black dogs have short legs.
   D. Yes, because most of the black dogs have long legs and most of the white dogs have short legs.

10. What are the chances of a black dog having long legs based on the 16 cards above?

   A. Six-out-of-eight
   B. Four-out-of-eight
   C. One-out-of-four
   D. Nine-out-of-sixteen

11. What are the chances of a white dog having long legs based on these 16 cards?

   A. One-out-of-six
   B. One-out-of-eight
   C. Two-out-of-eight
   D. One-out-of sixteen

12. What are the chances of a black dog having short legs based on these 16 cards?

   A. Two-out-of-eight
   B. Three-out-of-eight
   C. Three-out-of-sixteen
   D. No chance at all

Interpretation

A score of 0 to 1 is interpreted as the absence of the minimal ability for formal reasoning due to insufficient evidence. A score of greater than 1 to 2 is interpreted as a transitional development of the minimal ability for formal reasoning. A score of greater than 2 to 3 is interpreted as a partial mastery of the minimal ability for formal reasoning. Finally, a score of greater than 3 to 4 is interpreted as a full mastery of the minimal ability for formal reasoning. However, it must be emphasized that full mastery here does not refer to the full mastery of the maximal ability for formal reasoning which could be represented as the mastery of all of the eight concepts of formal operations.

Technical information about ATFR

In a multi-trait, multi-method validity study of the ATFR, the test-retest reliabilities yielded were of the order of .76 to .89 (Arlin, 1982). For the total test, the Hoyt estimates of reliability ranged from .71 to .89. The Cronbach Alphas for the total test composites ranged from .60 to .73 (Arlin, 1984b).

Appendix C

The Test of Problem Finding (PF)

Test Description

In this study, this test is used to tap the minimal presence of postformal reasoning specific to the model of Problem Finding. This test, originally known as the "Arlin Problem Finding Task" (Arlin, 1975, 1975-76), was designed to assess the ability of problem finding in the cognitive domain. According to Arlin (1975), problem finding was operationally defined in terms of three conditions: 1) a problematic situation; 2) an opportunity for subjects to raise questions; and 3) a way of categorizing the questions raised.

Thus the problem finding task consisted of a problematic situation: an array of twelve objects. This array was accompanied by a set of directions which provided the subjects with the opportunity, in a five-minute time period, to raise as few or as many questions as they could. Finally the data were analyzed according to the "intellectual products" categories of Guilford's structure of the intellect model (1956).

The test is in pencil-and-paper format.

Test Items

Insert test items about here

(see next 2 pages)

Scoring Criteria

The data are analyzed according to the "intellectual products" categories of Guilford's structure of the intellect model (1956). The questions raised by the subjects are categorized according to the following: 1) units, 2) classes, 3) relations, 4) systems, 5) transformations, and 6) implications.

PROBLEM FINDING TASK

Please read the following instructions carefully before proceeding with this instrument:

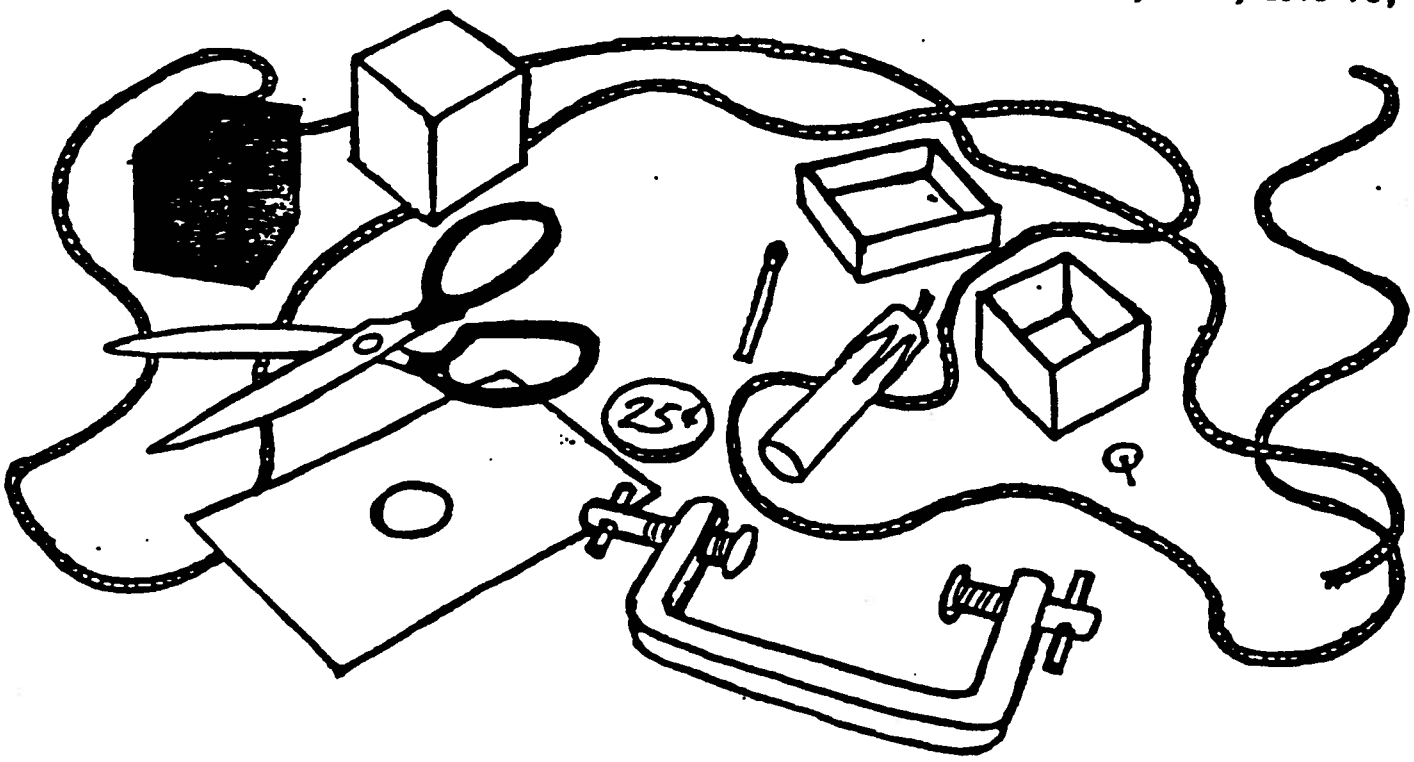
Please time yourself for: 5 minutes.

In five minutes, please make up as few or as many questions as you can about any object or objects that are listed and illustrated on the attacked task sheet. Your questions can take any form that you wish them to take. They can be brainteasers, puzzles to solve, novel questions. An example is: "Can you form four triangles out of these six match sticks?". Your questions can be any type that you wish them to be. The only thing that you have to remember is that for each of your questions you must refer to one or more of the objects that are listed and illustrated on the attached response sheet.

Thank you.

ARLIN PROBLEM FINDING TASK

(Arlin, 1975, 1975-76, 197



SOME OBJECTS

1	C-clamp
1	black wooden block (2cm. × 2 cm.)
1	plain wooden block (1cm. × 1 cm.)
1	small index card (3" × 5") with a dime-sized hole in the center.
1	25 cent piece
1	small box top
1	small box bottom
3	small colored candles
6	wooden matches
10	thumb tacks
2	2-meter long cords
1	pair of scissors.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

_____

_____

Definitions and examples of the above six intellectual products categories are presented in the following.

The Intellectual Products Categories

Category	Definition	Example
1. Units	Basic units of information	"How many objects are there here?"
2. Classes	Class can be embodied using different sets of particulars	"Can I arrange these according to size or color or shape?"
3. Relations	Connections between objects or units such as opposition, part-whole, agent-action,etc.	"If this paper's hole was bigger, I could put this quarter through it. Maybe, can I put the quarter through the hole without ripping it?"
4. Systems	To talk about rules, principles, orders, orientations, and structures is to speak of the psychological product of system.	"I bet this box, open up, how do you open it, there is a way, isn't there?"
5. Transformations	A transformation is any kind of change such as expanding, reversal, interchange, and so on.	"If you were given this steel thing, what could you change it into? What could you make?"
6. Implications	A connection between two units of information. Relations are definable kinds of connections ... comes nearest to the traditional notion of association.	"In what ways can you arrange the objects on the table to represent how you feel at this moment?" "How could These matches be man's enemy?"

Note. From the chapter "New Psychological Conceptions of Memory" in Intelligence, Creativity and their Educational Implications, by J. P. Guilford, 1968.

For the purpose of this study, the original scoring criteria were adapted in order to tap the minimal presence of postformal reasoning specific to the model of Problem Finding. A subject's response would be scored according to the following 3 groupings of the above 6 categories: score 1 for the presence of category 1, 2 or 3; score 2 for the presence of category 4; and score 3 for the presence of category 5 or 6 both of which represent the presence of postformal reasoning.

When the values of the yielded item scores vary, the highest score value would be taken as the individual test score to indicate the highest level of performance attained by the subject.

Should there be more than one rater, the final score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of postformal reasoning specific to the model of Problem Finding. A score of 2 to less than 3 would be interpreted as the transitional development of postformal reasoning specific to the aforementioned model. A score of 3 would be interpreted as the minimal presence of postformal reasoning specific to the aforementioned model.

Technical information about Arlin Problem Finding Task

Arlin (1975/76) reported that the inter-rater reliabilities for classification according to the six intellectual products categories were of the order of .80.

Appendix D

The Test of Dialectical Reasoning (DR)

Test Description

In this study, this test is used to tap the minimal presence of postformal reasoning specific to the model of Dialectical Reasoning.

The original test designed by Basseches (1980) consists of a set of structured questions to be administered through an interview. The content of these questions is adapted for use in this study. The test is in pencil-and-paper format. The adapted items are presented in the following.

Test Items

Please respond to the following questions about "saving the environment".

1. How would you go about deciding what does "saving the environment" mean?
2. How do you think "saving the environment" is being done in your community (e.g. your family, school, town)?
3. What do you see as the relation between your idea about "saving the environment" and your experience and activities as a member of your community?
4. Some people believe in "saving the environment". Others think that it could cause major problems in the country such as the loss of jobs, etc. How do you feel about this? What is your opinion?

Scoring Criteria

The original scoring criteria were designed to produce a Dialectical Schemata Index. The presence of dialectical reasoning would be scored according to 24 dialectical schemata (or "moves in thought") which are organized into 4 categories of schemata. For the purpose of this study, a simplified version of Arlin's adaptation of Basseches' scoring system is used.

In the adapted scoring criteria, a subject's responses are scored for the presence of the following 4 categories of schemata.

A. A Motion-oriented schemata

1. Thesis-antithesis-synthesis movement in thought
2. Affirmation of the primacy of motion
3. Recognition and description of thesis-antithesis-synthesis movement
4. Recognition of correlativity of a thing and its others
5. Recognition of ongoing interaction as a source of movement
6. Affirmation of the practical or active character of knowledge
7. Avoidance or exposure of objectification, hypostatization, and reification
8. Understanding events or situations as moments (of development) of a process

B. Form-oriented schemata

9. Location of an element or phenomenon with the whole(s) of which it is a part
10. Description of a whole (system, form) in structural, functional, or equilibrational terms
11. Assumption of contextual relativism

C. Relationship-oriented schemata

12. Assertion of the existence of relations, the limits of separation and the value of relatedness
13. Criticism of multiplicity, subjectivism, and pluralism

14. Description of a two-way reciprocal relationship
15. Assertion of internal relations

D. Meta-formal schemata

16. Location (or description of the process of emergence) of contradictions or sources of disequilibrium within a system (form) or between a system (form) and external forces or elements which are antithetical to the system's (form's) structure
17. Understanding the resolution of disequilibrium or contradiction in terms of a notion of transformation in developmental direction
18. Relating value to (a) movement in developmental direction and/or (b) stability through developmental movement
19. Evaluative comparison of forms (systems)
20. Attention to problems of coordinating systems (forms) in relation
21. Description of open self-transforming systems
22. Description of qualitative change as a result of quantitative change within a form
23. Criticism of formalism based on the interdependence of form and content
24. Multiplication of perspectives as a concreteness-preserving approach to inclusiveness

Score 1 for any schema in the following 3 categories of schemata: the motion-oriented schemata, the form-oriented schemata and the relationship-oriented schemata.

Score 2 for schema 16 in the meta-formal schemata (location of contradictions) which is taken in this study to represent the transitional development of postformal reasoning, because the subjects in the original study who had the ability to employ this schema also included those classified under elementary dialectical reasoning.

Score 3 for any schema in the meta-formal schemata (excepting schema 16) which are taken to represent the presence of postformal reasoning, because most of the subjects in the original study who had the ability to employ these schemata were classified under intermediate or advanced dialectical reasoning.

When the values of the yielded item scores vary, the highest score value would be taken as the individual test score to indicate the highest level of performance attained by the subject.

Should there be more than one rater, the final score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of postformal reasoning specific to the model of Dialectical Reasoning. A score of 2 to less than 3 would be interpreted as the transitional development of postformal reasoning specific to the aforementioned model. A score of 3 would be interpreted as the minimal presence of postformal reasoning specific to the aforementioned model.

Appendix E

The Test of Relativistic Operations (RO)

Test Description

In this study, this test is used to tap the minimal presence of postformal reasoning to the model Relativistic Operations.

This test is adapted from one of the six problem sets, namely the "Bedroom" problem set, developed by Sinnott (1984). These 6 problem sets were originally designed to assess the presence of both formal and relativistic operations. However, only relativistic operations are scored in this adapted version.

The rationale for selecting the "Bedroom" problem set is that it is argued to be one of the more discriminative problem sets for detecting the presence of relativistic operations, specifically self-referential ordering of multiple solutions. (For substantial support of this rationale, see technical information about RO presented at the end of the test description.)

This is a pencil-and-paper test containing one problem set.

Test Item

A family consisting of a mother in her forties, a father in his forties, a 10-year-old girl, a 12-year-old girl, and a 15-year-old boy live in a small two-bedroom house. One of the bedrooms is large and has a single bed; the other bedroom also has a single bed. This summer the family learns that a grandfather who lives alone in a one-bedroom apartment two blocks away can no longer live alone. He might move in with the family.

Question: What are all the possible ways that the six persons can use the two bedrooms in the house? Explain your answer.

Scoring Criteria

Responses are scored for the presence of the relativistic operations listed below (Sinnott, 1984 p. 314):

1. Metatheory shift: There is the production of abstract and practical (real-life) solutions as well as a shift between conflicting abstract and real a priories. This shift is stated by the subject. The solution always included problem definitions. For example, the subject might ask whether we want the hypothetical solution that is logical on paper or the solution that would really be viable. (The respondent may or may not then proceed to give both solutions.)

2. Problem definition: There is a statement of the meaning and demands of the problem for the subject. There is also the decision to define problems in a certain, chosen way. The subject indicates a change in the types of parameters from solution to solution. Defining the problem is the first concern, but the subject need not give alternative solutions since these solutions might be precluded by the problem definition. The problem definition may include a metatheory shift. For example, the subject might wonder what the real problem is, whether it is the need to have peace in the family or to use all the space. The subject might then decide to treat it like an algebra problem.

3. Process/product shift: There is a description of a process as one answer and an outcome as another answer. Or there may be a description of two processes that achieve the9 same outcome. Often there is a statement by a subject that there is a solution and that finding the solution is actually a never-ending process. There may be a discussion of process differences in arriving at two different outcomes.

4. Parameter setting: The subject names key variables to be combined or made proportional in the problem other than those given in the written demands of the problem. Often the subject explicitly writes out key variables. Alternatively she or he may change the variables that limit the problem from solution 1 to solution 2. Parameter setting differs from problem definition in that it is less inclusive.

5. Pragmatism: One can choose a best solution among several, or, one can choose the best variant of a solution that has two processes. For example, the subject might say that if you want the most practical solution, it's number 2, but if you want the quickest, easiest solution, it's number 1. This is the only operation that cannot be given a passing score unless the subject actually gives more than one solution.

6. Multiple solutions: There is a direct statement that there are many correct solutions intrinsic to a problem with several causes, or that no problem has only one solution. Also, the subject may create several solutions. For example, the subject might respond that he or she sees four solutions that could be termed correct or there are limitless arrangements that would be correct if your change the constraints.

7. Multiple causality: There is a statement that multiple causes exist for any event or that some solutions are more probable than others. For example, some subjects state that the solution depends on all past relations of the persons in the problem. As such, when the three persons in the problem get together anything could happen, depending on personalities and on how each reacts.

8. Paradox: The subject gives a direct statement or question about perceived, inherently conflicting demands that are integral to the problem, not simply two solutions with different parameters. For example, the Bedroom Problem can be read in two conflicting ways. The subject notices that two different things are being said at once, both of which could change the way the problem should be solved.

Score 1 for the total absence of the above listed relativistic operations typically exemplified by the giving of a single solution.

Score 2 for the presence of the sixth relativistic operation, i.e. Multiple Solutions, but without a direct statement implying that there can be an indefinite number of solutions, because the subjects might hold the opinion that the number of solutions is finite and they are merely naming a few solutions. There is also the possibility that some or all of the solutions given are irrelevant.

Score 3 for the presence of at least one of the above relativistic operations. If Multiple Solutions was given as the only relativistic operation, the subject would also have to give a direct statement implying that there can be an indefinite number of solutions in order to receive a score of 3.

When the values of the yielded item scores vary, the highest score value would be taken as the individual test score to indicate the highest level of performance attained by the subject.

Should there be more than one rater, the final score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of postformal reasoning specific to the model of Relativistic Operations. A score of 2 to less than 3 would be interpreted as the transitional development of postformal reasoning specific to the aforementioned model. A score of 3 would be interpreted as the minimal presence of postformal reasoning specific to the aforementioned model.

Technical information about RO

Findings of Sinnott's studies (1984, 1989) revealed that the social problem sets were most often stimuli for self-referential thought and were sometimes the only problem that occasioned such a pattern. The "Bedroom" problem set elicited this response pattern in seven of the eight cases selected from a pool of 80 subjects for an individual-intensive analysis. Findings also revealed that of the five social problem sets, the "Bedroom" problem set differed most from the abstract "Alphabet" problem set in that the "Bedroom" problem set was associated with more cases of multiple solutions ($F(1,73)=25.73$, $p<.001$). The abstract "Alphabet" problem set was most unlikely to elicit relativistic operations. The above information could be used as support to the selection of the "Bedroom" problem set for use in the present study.

Regarding the use of the eight relativistic operations, Sinnott (1984) reported that no one individual subject articulated a complete profile of these relativistic operations. In addition, not every problem elicited statements confirming the presence of all eight operations. Similar findings were also reported by Lee (1989).

Appendix F

The Test of Reflective Judgment (RJ)

Test Description

In this study, this test is used to tap the minimal presence of postformal reasoning specific to the model of Reflective Judgment (King, Kitchener, Davison, Parker & Wood, 1983; Kitchener & King, 1981).

This test is adapted by Arlin from the "Reflective Judgment Interview" (RJI) copyrighted by King and Kitchener in 1978. The original RJI was designed to assess how people justify their beliefs or decisions when faced with ill-defined problems.

The original version of RJI is comprised of four ill-defined problems and a set of standardized probe questions. The four problems represent four domains: history, science, current events and religion (see King et al., 1983; Kitchener & King, 1981 for examples). Each problem contains two contradictory points of view. Subjects are asked to state and justify their point of view about the issues in each problem. The probe questions are designed to elicit information from subjects about how certain they are regarding their knowledge about each issue, how they have obtained that knowledge and how they justify their beliefs about the issue.

The present test adopts one of the four subtests from the RJI, namely the "Food Additives" subtest which falls within the domain of science. The rationale for selecting this subtest is that it is argued to be the most neutral among the four problems in terms of value judgment.

This test is in pencil-and-paper format.

Test Items

Dilemma:

There have been frequent reports about the relationship between chemicals that are added to foods and the safety of these foods. Some studies indicate that such chemicals can cause cancer, making these foods unsafe to eat. Other studies, however, show that chemical additives are not harmful, and actually make the foods containing them more safe to eat.

Questions:

1. What do you think about these statements?
2. How did you come to hold that point-of-view?
3. Can you ever know for sure that your position is correct? How or Why not?
4. When people differ about matters such as this, is it the case that one opinion is right and one is wrong?
   (If yes) What do you mean by right?
   (If no) Can you say one opinion is better and one is worse? Why or Why not?
   (If yes) What do you mean by better?
5. How is it possible that people can have such different points-of-view about this subject? What does it mean when experts in the field disagree?

Scoring Criteria

The responses are scored according to the match between the type of reasoning observed in the responses and the type of reasoning described in the 7 stages of development of reflective judgment (King & Kitchener, 1978). These developmental stages are presented in the following:

Stage 1: Subjects use the simplest of black and white, concrete categories. Knowledge is seen as absolute, and authorities are seen as the source of knowledge. Problems are solved simply by following rules, tradition, or the norm. Judgment is seen as unnecessary since alternatives are not acknowledged.

Stage 2: Subjects perceive alternative views but reject them without examination. They believe that "right" answers exist and that authorities usually "have" them. Their arguments are often not coherent; they offer pieces of unrelated information as "evidence", and then decide on the basis of the norm or others' views.

Stage 3: Subjects acknowledge the existence and temporary legitimacy of different views. Authority and knowledge become further separated and they begin to see authorities as "biased" or arbitrary. Without their formerly-held absolutes, decision-making is confusing. Everyone's view is seen as equally correct and/or equally biased. Decisions are based predominantly on personal whim or bias.

Stage 4: Subjects acknowledge the lack of absolutes in some areas, but not others. They begin to evaluate evidence, but do not understand that evidence entails a conclusion. They use both unsupported belief and considered judgment in decision-making. Cynicism toward the expertise of authorities is evidenced.

Stage 5: Subjects here begin to understand that knowledge is embedded in a context and that a frame of reference is important for understanding a point of view. Authorities are seen as experts who have a reasoned point of view. They evaluate evidence on several sides of issues, from several perspectives. They try to present a balanced view of an issue, but do not integrate evidence into their own view.

Stage 6: Subjects acknowledge different points of view, they analyze them separately, and see the need for synthesis. Usually they rely on the synthesis of others (e.g. experts) rather than offering a synthesis of their own. They rely on experts only after personally examining the evidence and alternatives. That is, experts' views, too, are seen as subject to evaluation.

Stage 7: These subjects present an examined point of view. It is based on an integration of evidence, the opinions of experts, as well as their own personal experience. They understand that one's point of view may need to be reformulated in light of additional formation gained in the future. Their point of view is presented as being probably correct.

Score 1 for the presence of stage 1, 2 or 3.

Stages 1-3 imply that there is no recognition that real uncertainty of knowledge exists. Rather it would be assumed that ultimately uncertainty can be translated to certainty, for example, by consulting an authority or by waiting until the truth is known sometime in the future.

Score 2 for the presence of stage 4.

Stage 4 implies the recognition of the uncertainty of knowledge in some areas but not in others and that knowledge is uncertain for situational reasons. Stage 4 is considered more advanced than Stage 3 in that there would be the recognition that uncertainty is not a temporary condition of the knowing process but a legitimate part of it.

Score 3 for the presence of stage 5, 6 or 7.

Stages 5-7 imply the recognition of the real uncertainty of knowledge but with subtle differences in the understanding of the causes of uncertainty. What appears to

advance in the later stages is the understanding of how judgments can be made in the face of this uncertainty.

When the values of the yielded item scores vary, the dominant score value (the most frequently occurred) would be taken as the individual test score to indicate the dominant stage of reflective judgment demonstrated by the subject.

Should there be more than one rater, the final score would be the average of the individual test scores provided by the different raters.

Interpretation

A score of 1 to less than 2 would be interpreted as the absence of postformal reasoning specific to the model of Reflective Judgment. A score of 2 to less than 3 would be interpreted as the transitional development of postformal reasoning specific to the aforementioned model. A score of 3 would be interpreted as the minimal presence of postformal reasoning specific to the aforementioned model.

Technical information about RJI

In general, inter-rater reliability was reported to be moderate to high, depending on the heterogeneity of the sample tested, and the inter-rater agreement for first-round ratings (the most conservative index) consistently ranged between 70 and 80 percent (Kitchener & King, 1990). Test-retest reliability on four small homogeneous samples over a three-month period ranged from .71 to .83 (Sakalys, 1982). Cronbach's alpha, a measure of internal consistency, ranged from .62 (Welfel, 1982) to .92 (Kitchener & King, 1981) for a homogeneous and a heterogeneous sample respectively.

Note. The responses obtained from the pencil-and-paper format of this test may not be comparable to those obtained from the original interview format of RJI. Consequently their respective scores may not be comparable.

Appendix G

A Sample of the Complete Set of Tests

THE UNIVERSITY OF BRITISH COLUMBIA

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Faculty of Education
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Vancouver, B.C. Canada V6T 1Z4
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Fax: (604) 822-3302

INTRODUCTORY NOTES

A study about the development of reasoning ability. (Project title:-- "Nonabsolute/ relativistic Thinking: a Possible Unifying Commonality underlying the Models of Postformal Reasoning")

Dear Participant:

Thank you very much for volunteering to participate in this study. Briefly speaking, the purpose of this study is to try to understand how people reason. It is hoped that the benefits of this study will help us to understand better the development of reasoning ability and will contribute towards the improvement of education.

You will be asked to do a pencil-and-paper task made up of a set of questions. You are free to refuse to participate or to withdraw at any time. Your refusal or withdrawal will not affect your grades or class standing if you were contacted through you teacher or course instructor. The amount of time required to answer this set of questions is 1 session of about 1 1/2 hours or 2 sessions of about 45 minutes each. But you are free to finish in a shorter or longer period of time.

Your name will be kept confidential, as you will be assigned a code number. Results will be analyzed by group, not by individuals using this code number.

Thank you for your willingness to participate in this study. If the pencil-and-paper task is completed it will be assumed that consent has been given to participate in this study.

If you have any further questions, please contact us at the phone numbers below.

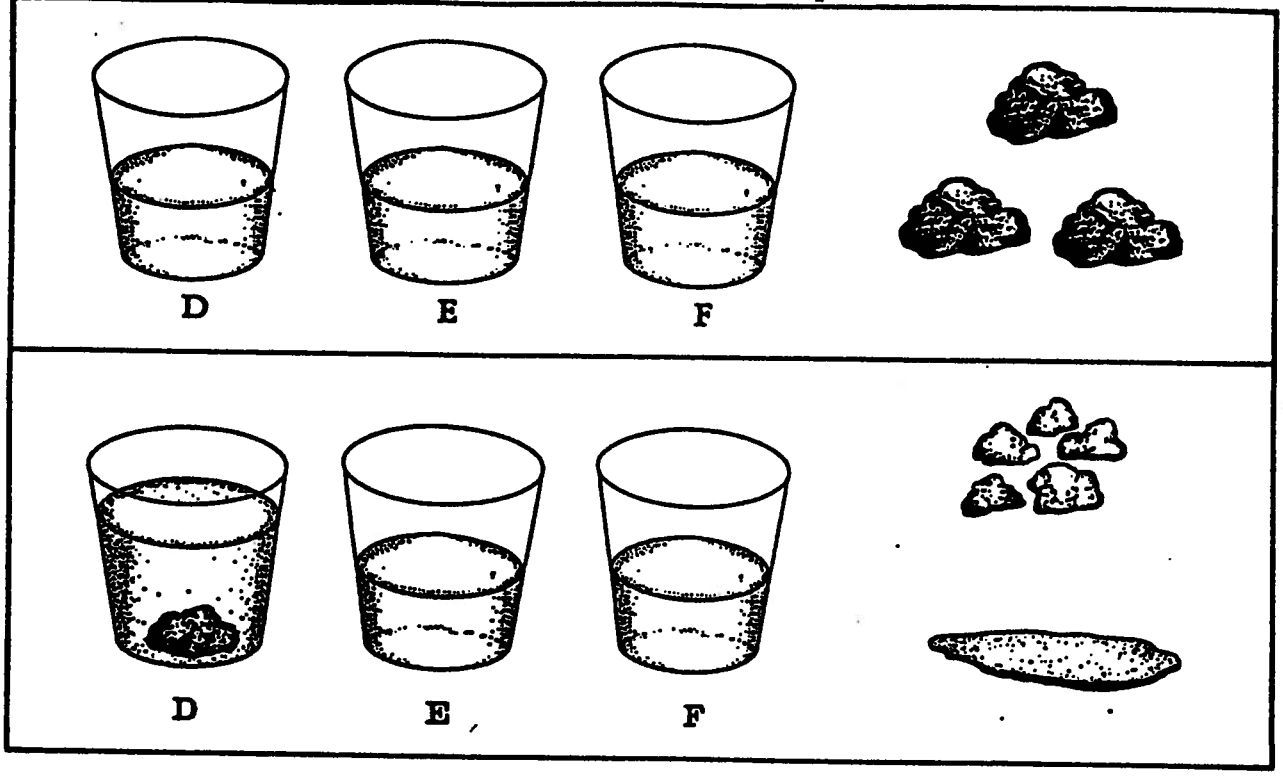
Identification of investigators:

Dr. Patricia Arlin, Ph.D. (Faculty Advisor)
Professor and Head
Department of Educational Psychology & Special Education
University of British Columbia
(Phone: 822-6223)

Bernice Yan (Doctoral Student)
Ph.D. Candidate
Department of Educational Psychology & Special Education
University of British Columbia
(Phone: 738-9923)

Age:_____ Sex:_____ Educational Level:_____

SECTION I. Please choose the best answer for each question.



Three cups, (Cup D, Cup E, and Cup F) are partially filled with water. Beside the three cups are three balls of clay. These three balls are exactly the same size as each other. The first ball is placed in Cup D as shown. The water level in Cup D rises. Before placing the second ball into Cup E, it is flattened into a pancake shape as shown. The third ball of clay is broken into five pieces as shown and then placed into Cup F.

1. What do you think will happen to the water level in Cup E when this pancake shaped piece of clay is placed into it?

   A. The water level will rise up higher than the level in cup D.
   B. The water level will rise to half the level of cup D.
   C. The water level will go up to the same height as that in cup D.
   D. The water level will rise to one-fifth the height of that in cup D.

2. What is the reason for your answer to the question just above?

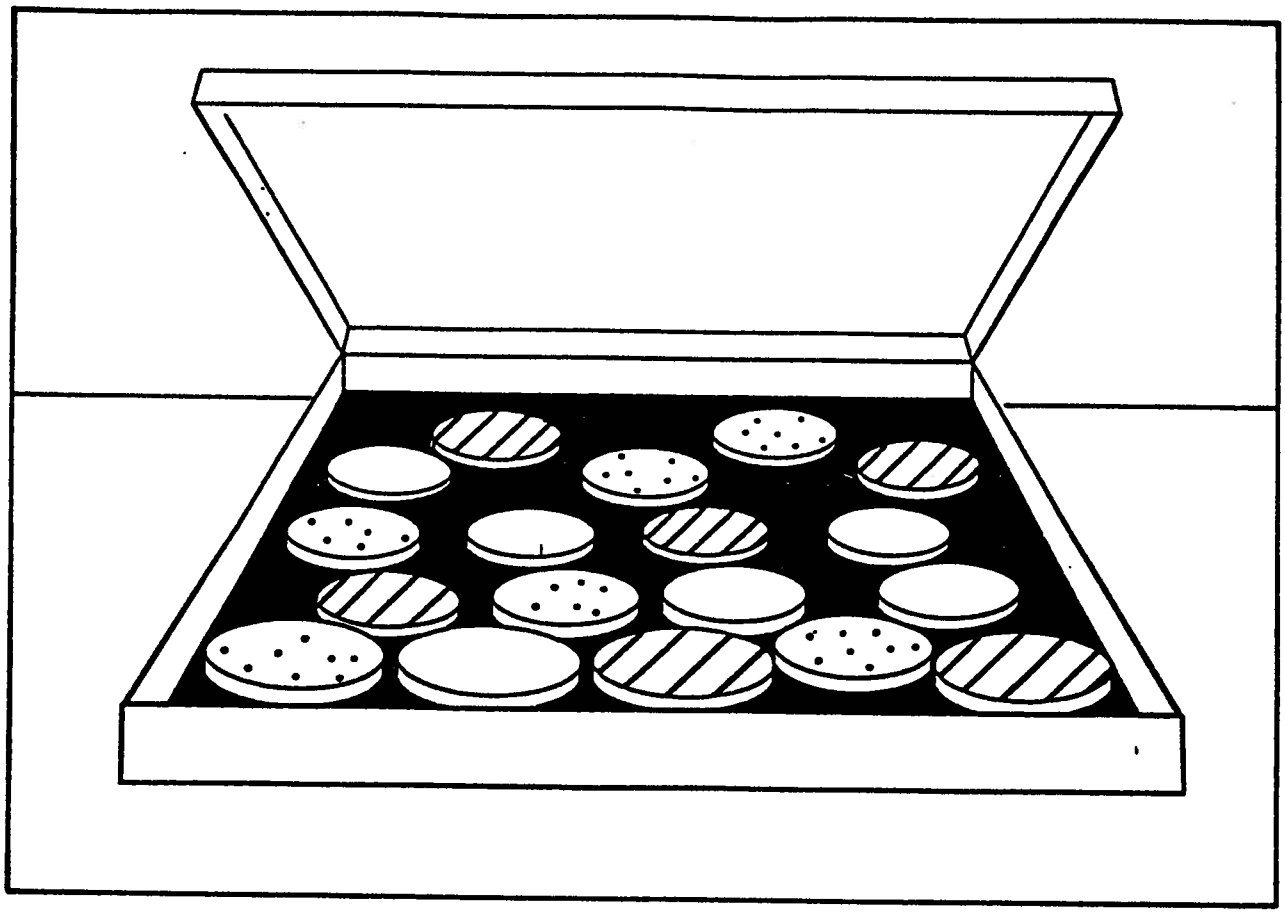
   A. The pancake shape takes up more space.
   B. The balls were the same size at the start.
   C. The pancake shape is flat and therefore it takes up less space.
   D. The ball and pancake weigh the same.

3. What do you think will happen to the water level in Cup F when the five small balls of clay are placed in it?

   A. The water level will go up to the same height as that in Cup D.
   B. The water level will NOT rise up as high as that in Cup D.
   C. The water level will rise up higher than the level in Cup D.
   D. The water level will rise one-fifth the height as that in Cup D.

4. What is the reason for your answer to the question just above?

   A. The five balls of clay take up more space.
   B. The balls were the same size before the one ball was broken into pieces.
   C. The five small balls take up less room.
   D. The five small balls weigh the same as the one large ball.



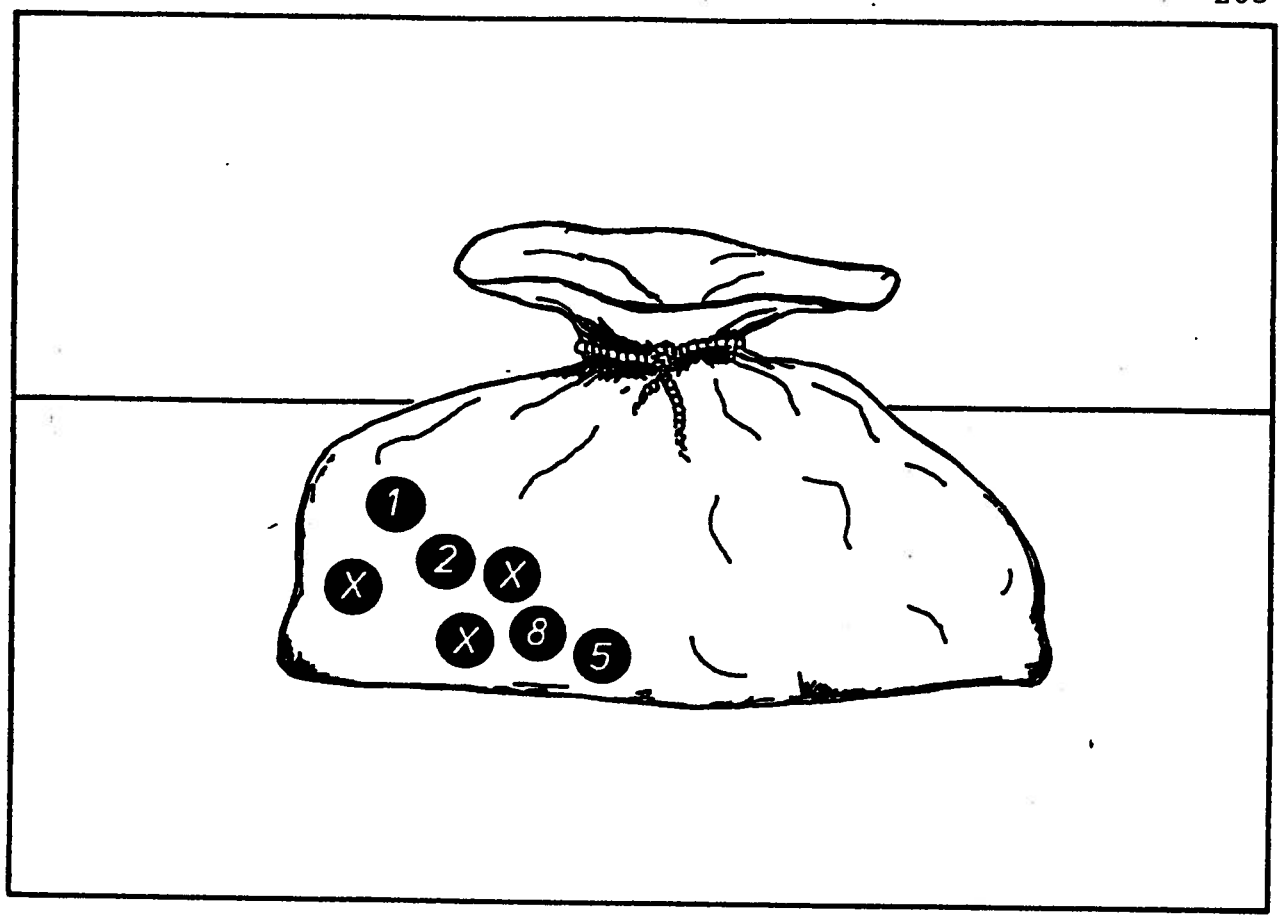
In a new game of chance, six plain tokens, six striped tokens and six dotted tokens are placed in a box as pictured above. The box is held above your head so that you cannot see the tokens. You are asked to draw one token out of the box.

5. What do you think your chances are of drawing a striped token on your very first draw?

   A. One chance out-of-two.
   B. One chance out-of-eighteen.
   C. One chance out-of-twelve.
   D. One chance out-of-three.

6. Why did you choose your answer for the question just above?

   A. My chances are the same as those for flipping a coin and getting heads.
   B. My chances are based on the fact that the number of striped tokens has to be compared to the total number of tokens.
   C. My chances are good to draw it in the first two or three draws because I am lucky.
   D. My chances are based on the fact that there are twelve tokens that are not striped and I need to eliminate these first.



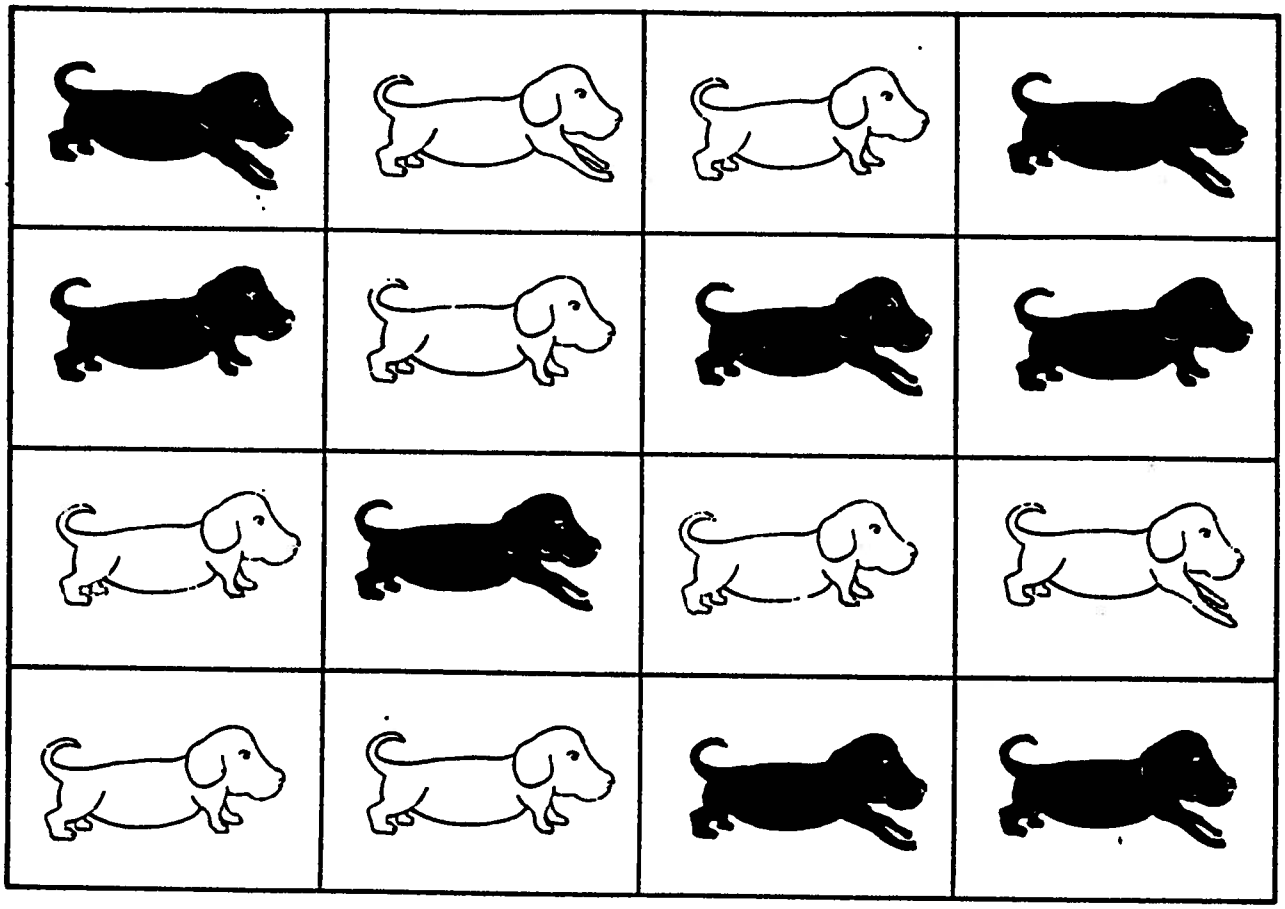
There is a game on a well-known TV quiz show that contestants play to win a new car. Seven tokens are placed in a cloth bag. Three tokens contain an X. If these three tokens are drawn from the bag before the four numbers in the price of the car, the contestant loses. If, however, the contestant draws the four numbered tokens before drawing the third token marked with an X, the contestant wins a new car. Each time a token is drawn it remains out of the bag. The following questions are based on this game.

7. If a contestant draws 3 numbered tokens and 1 token marked X, what are the chances of winning the car on the next draw?

A. Three-out-of-seven
B. Three-out-of-four
C. Two-out-of-three
D. One-out-of-three

8. What is the reason for your answer to this question?

A. There are three tokens without numbers that have to be taken into account.
B. Three of the numbered tokens have already been drawn and there are four numbered tokens in all.
C. Two of the remaining tokens contain X's out of the three possible tokens from which you can draw.
D. There is only one numbered token that remains out of the total.



You are given a set of 16 cards. Each card has a picture of a hound dog which is either black or white in color, and who has either long or short legs. Card 1 represents a black dog with long legs. The following questions are to be answered on the basis of these 16 cards.

9. Can you find a relationship between body color and leg size for this type of dog, on the basis of these 16 cards?

   A. No, because there is an even number of black and of white dogs with short legs.
   B. No, because 8 dogs have short legs and 8 dogs have long legs and therefore there is no relationship.
   C. Yes, because all of the black dogs have short legs.
   D. Yes, because most of the black dogs have long legs and most of the white dogs have short legs.

10. What are the chances of a black dog having long legs based on the 16 cards above?

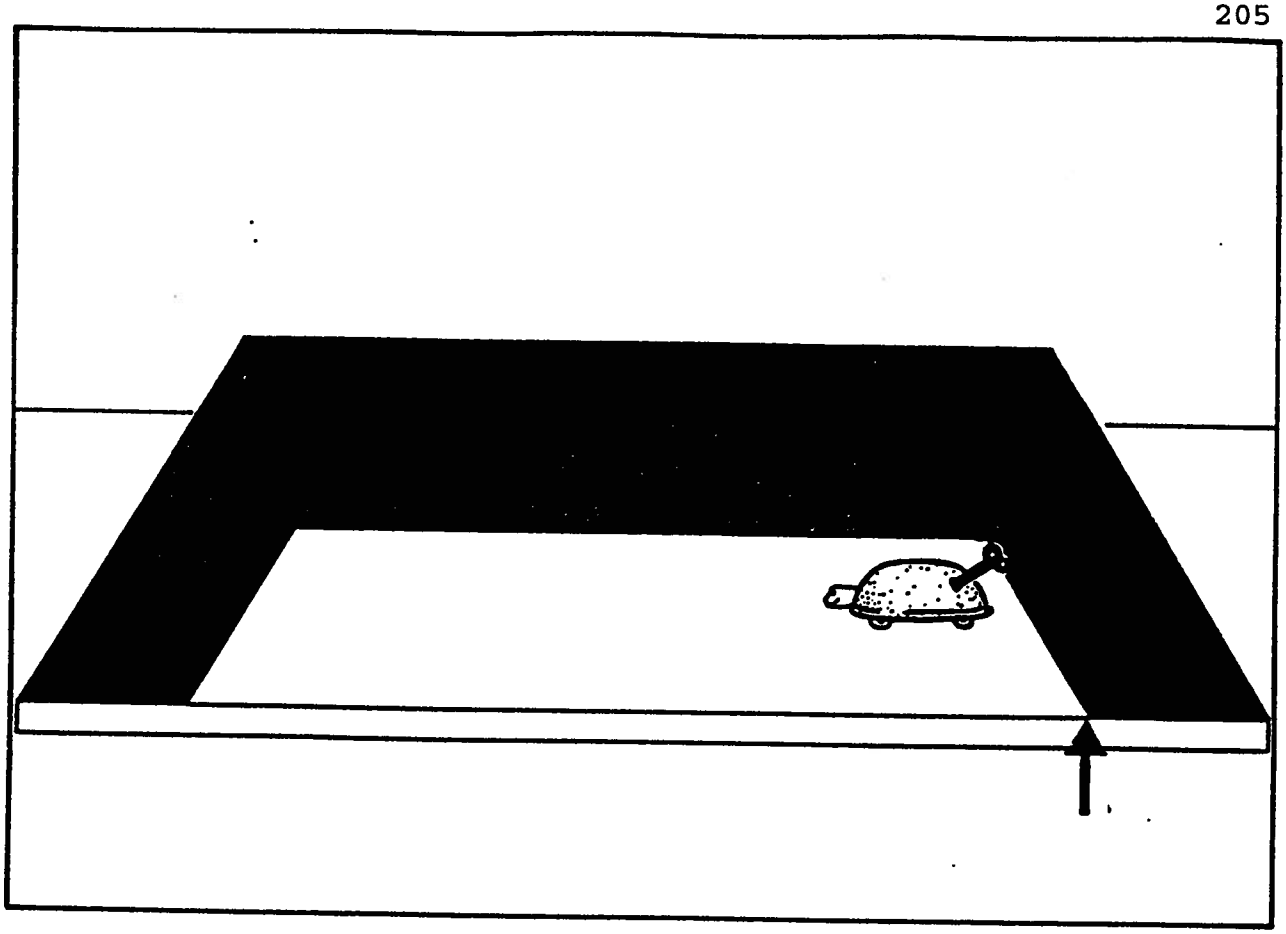
   A. Six-out-of-eight
   B. Four-out-of-eight
   C. One-out-of-four
   D. Nine-out-of-sixteen

11. What are the chances of a white dog having long legs based on these 16 cards?

   A. One-out-of-six
   B. One-out-of-eight
   C. Two-out-of-eight
   D. One-out-of sixteen

12. What are the chances of a black dog having short legs based on these 16 cards?

   A. Two-out-of-eight
   B. Three-out-of-eight
   C. Three-out-of-sixteen
   D. No chance at all



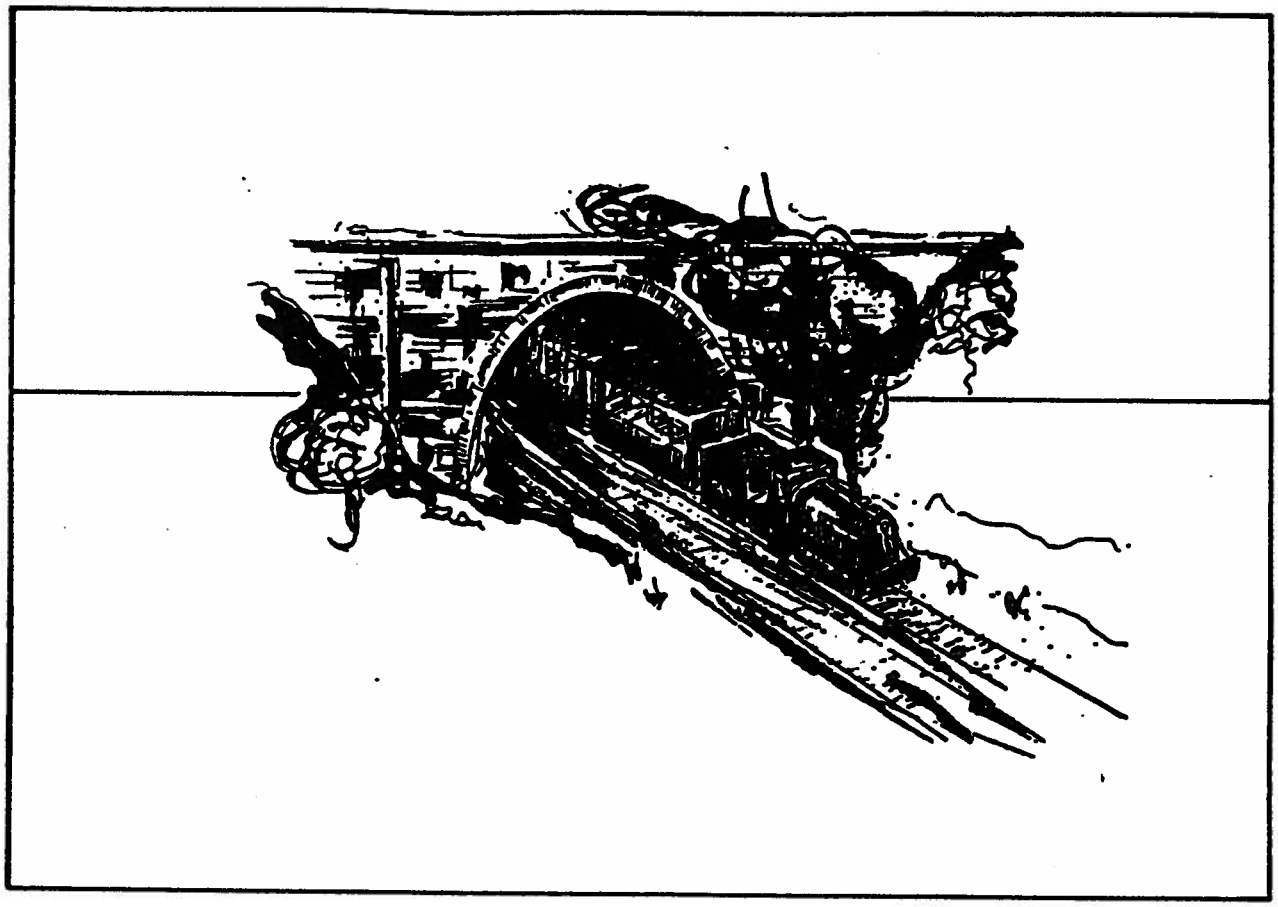
A small toy wind-up turtle is placed on a shaded strip of paper. The paper strip is lined up along the edge of a board as shown in the picture. The turtle can be moved along the paper strip. The paper strip can also be moved along the board. Both the toy and the paper strip can be moved forward or backward. The toy, the end of the paper strip, and the starting point on the board are all lined up as shown.

13. If the turtle moves forward at the same speed that the paper strip moves backward, how far will the turtle be from the starting point after a short time (as long as the turtle is still on the strip of paper)?

A. It would be at the starting point.
B. One-fourth the distance of the paper strip from the starting point.
C. Double the distance of the paper strip from the starting point.
D. It would be behind the starting point.

14. If the turtle moves forward at 1/3 the speed that the paper strip moves backward, where would the turtle be after a short period of time (as long as the turtle is still on the strip of paper)?

A. Three times as far forward as the paper strip is backward from the starting point.
B. One-third the distance in front of the starting point as the paper strip is behind the starting point.
C. It would be behind the starting point.
D. As far in front of the starting point as the end of the paper strip is in back of it.



Two people are sitting on this train as it passes through a long tunnel in the side of a mountain. Mr. Red (R) is sitting at the front of the train and Mr. Blue (B) is sitting at the back of the train. For the following two situations, decide whether Mr. R and Mr. B will stay in the tunnel for the same amount of time.

15. SITUATION 1: After the train enters the tunnel Mr. R gets up from his seat in the front, and walks back to sit with Mr. B. How much time altogether will Mr. R spend in the tunnel?

A. Less time in the tunnel than Mr. B.
B. Twice the time in the tunnel as Mr. B.
C. The same amount of time in the tunnel as Mr. B.
D. More time in the tunnel than Mr. B.

16. SITUATION 2: After the train has entered the tunnel, Mr. B gets up from his seat in the back. He walks forward to sit with Mr. R. Halfway on his trip forward, he decides to go back to his seat for his paper. He gets his paper and then goes forward again and joins Mr. R, while the train is still in the tunnel. How much time did Mr. B spend in the tunnel?

A. Less time in the tunnel than Mr. R.
B. More time in the tunnel than Mr. R.
C. One-and-one-half as much time in the tunnel as Mr. R.
D. The same amount of time in the tunnel as Mr. R.

SECTION II. Please answer the following questions.

(PART A)

1. "A" grows 1 cm per month. "B" grows 2 cm per month.
   Who is taller?
   ANSWER:_____
   Why? Explain your answer.

2. City "A" is 12^0 C. City "B" is 10^0 C.
   Which city is warmer?
   ANSWER:_____
   Why? Explain your answer.

3. "A" can run at 15 k.p.h. "B" can run at 12 k.p.h.
   Who would arrive earlier?
   ANSWER:_____
   Why? Explain your answer.

4. "A" weighed 8 kg. "B" weighed 9 kg.
   Which one is heavier?
   ANSWER:_____
   Why? Explain your answer.

(PART B)

1. How do you know about the world around you?
   a. through your senses (eyes, ears, nose, etc.)
   b. through your own interpretation (thinking).
   c. others
   Why? Explain your chosen answer.

2. It is possible for you to understand something completely without doubt.
   a. agree
   b. disagree
   c. others
   Why? Explain your chosen answer.

3. When three persons have three different solutions to the same problem, at least one of them must be wrong.
   a. agree
   b. disagree
   c. others
   Why? Explain your chosen answer.

4. Some things will never change.
   a. agree (What are they?_____)
   b. disagree
   c. others
   Why? Explain your chosen answer.

(PART C)

PROBLEM FINDING TASK

Please read the following instructions carefully before proceeding with this instrument:

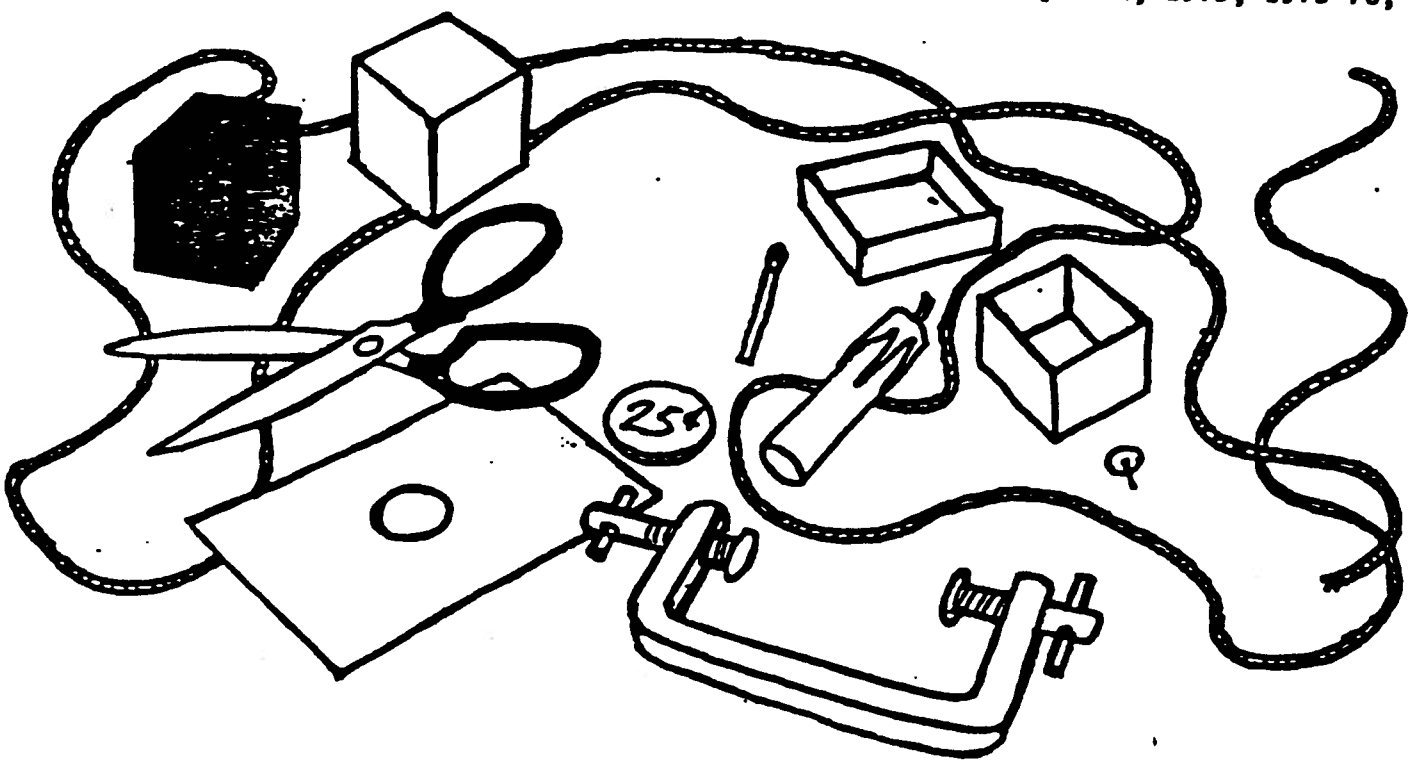
Please time yourself for: 5 minutes.

In five minutes, please make up as few or as many questions as you can about any object or objects that are listed and illustrated on the attacked task sheet. Your questions can take any form that you wish them to take. They can be brainteasers, puzzles to solve, novel questions. An example is: "Can you form four triangles out of these six match sticks?". Your questions can be any type that you wish them to be. The only thing that you have to remember is that for each of your questions you must refer to one or more of the objects that are listed and illustrated on the attached response sheet.

Thank you.

ARLIN PROBLEM FINDING TASK

(Arlin, 1975, 1975-76, 197



SOME OBJECTS

1	C-clamp
1	black wooden block (2cm. × 2 cm.)
1	plain wooden block (1cm. × 1 cm.)
1	small index card (3" × 5") with a dime-sized hole in the center.
1	25 cent piece
1	small box top
1	small box bottom
3	small colored candles
6	wooden matches
10	thumb tacks
2	2-meter long cords
1	pair of scissors.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

_____

_____

(PART D)

Please respond to the following questions about "saving the environment".

1. How would you go about deciding what does "saving the environment" mean?

2. How do you think "saving the environment" is being done in your community (e.g. your family, school, town)?

3. What do you see as the relation between your idea about "saving the environment" and your experience and activities as member of your community?

4. Some people believe in "saving the environment". Others think that it could cause major problems in the country such as the loss of jobs etc. How do you feel about this? What is your opinion?

(PART E)

A family consisting of a mother in her forties, a father in his forties, a 10-year-old girl, a 12-year-old girl, and a 15-year-old boy live in a small two-bedroom house. One of the bedrooms is large and has a single bed; the other bedroom also has a single bed. This summer the family learns that a grandfather who lives alone in a one-bedroom apartment two blocks away can no longer live alone. He might move in with the family.

Question: What are all the possible ways that the six persons can use the two bedrooms in the house? Explain your answer.

(PART F)

Dilemma:

There have been frequent reports about the relationship between chemicals that are added to foods and the safety of these foods. Some studies indicate that such chemicals can cause cancer, making these foods unsafe to eat. Other studies, however, show that chemical additives are not harmful, and actually make the foods containing them more safe to eat.

Questions:

1. What do you think about these statements?

2. How did you come to hold that point-of-view?
   On what do you base that point of view?

3. Can you ever know for sure that your position is correct?
   How or Why not?

(to be continued)

(PART F)

4. When people differ about matters such as this, is it the case that one opinion is right and one is wrong?
   (If yes) What do you mean by right?

   (If no) Can you say one opinion is better and one is worse? Why or Why not?

   (If yes) What do you mean by better?

5. How is it possible that people can have such different points-of-view about this subject? What does it mean when experts in the field disagree?

Appendix H

Glossary of Abbreviations and Symbols

FR	Test of Minimal Formal Reasoning
N/R Thinking	Nonabsolute/ relativistic Thinking
N/R Tests:	
N/R-F	Test of the Formal Form of N/R Thinking
N/R-PF	Test of the Postformal Form of N/R Thinking
N/R-EV	Test of the Epistemic View of N/R Thinking
Postformal Tests:	
PF	Test of Problem Finding
DR	Test of Dialectical Reasoning
RO	Test of Relativistic Operations
RJ	Test of Reflective Judgment
<<	is a necessary but not sufficient condition for

Appendix I

Explanation of Fit Indices in Confirmatory Factor Analysis

CHI-SQUARE

Chi-square statistics can be used to test whether there is any significant difference between the observed and the reproduced covariance/correlation matrices. In confirmatory factor analysis, contrary to conventional interpretation of Chi-square statistics, a small Chi-square value and high probability (p) level would indicate a good fit. The degrees of freedom (df) would serve as a standard for judging the size of a Chi-square value. Some researchers proposed a Chi-square/df ratio (Q) of below 2 or 3 as a criterion of fit (Carmines & McIver, 1981). Thus the size of Chi-square is affected by the number of parameters to be estimated.

In this study, a significance level of p=0.05 is used. In other words, a Chi-square value associated with a probability level greater than 0.05 would be considered significant.

ROOT MEANS SQUARE RESIDUAL (RMR)

RMR can be interpreted as an average of the fitted residuals. Specifically, it is the square root of the average of the squared fitted residuals. Theoretically, an RMR of 0.00 indicates a perfect fit.

STANDARDIZED ROOT MEANS SQUARE RESIDUAL (SRMR)

SRMR represents the standardized RMR. Its interpretation is similar to that of RMR. Theoretically, an SRMR of 0.00 indicates a perfect fit.

GOODNESS OF FIT INDEX (GFI)

GFI is based on the properties of the observed and the reproduced correlation (covariance) matrices. The index should be between 0 and 1 although it is theoretically possible for it to be negative. Theoretically, an GFI of 1.00 indicates a perfect fit.

ADJUSTED GOODNESS OF FIT INDEX (AFGI)

AGFI refers to an adjusted GFI for degrees of freedom in the model. The index should be between 0 and 1 although it is theoretically possible for it to be negative. Theoretically, an AGFI of 1.00 indicates a perfect fit.

NORMED FIT INDEX (NFI)

NFI is based on the notion of improvement of fit provided by a given model as compared with some baseline model. A general pattern of the baseline model has the number of factors set equal to the number of variables. The NFI may range from 0 to 1. Theoretically, an NFI of 1.0 indicates that the improvement of fit has reached a maximum limit. It is suggested that 0.9 could be used as a threshold (Bentler & Bonett, 1980). Models with an NFI less than 0.9 can usually be improved substantially.

NON-NORMED FIT INDEX (NNFI)

NNFI is similar to NFI except that it is adjusted for degrees of freedom. Unlike the NFI, it is possible for the NNFI to have a negative value. Theoretically, an NNFI of 1.0 also indicates that the improvement of fit has reached a maximum limit.