1

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No 2)

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

**Metacognition: A Developmental Study of
Intellectually Gifted and Average Children**

**Sandra L. Nandi
Department of Psychology
Carleton University
Ottawa**

July 1990

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-68858-0

Canada

The undersigned hereby recommend to
the Faculty of Graduate Studies and Research
acceptance of the thesis
submitted by
Sandra Nandi
in partial fulfilment of the requirements
for the degree of
Doctor of Philosophy

.....
Chair, Department of Psychology

.....
Thesis Supervisor

.....
External Examiner

Carleton University

November, 1990

Acknowledgements

I would like to acknowledge the many hours of support and advice provided by Dr. H.B. Ferguson in his multifaceted role as advisor and counsellor to this project. To my colleague Sue Baxt-Kreisman whose interest preceded mine in metacognition, I wish to extend my thanks for her efforts and insights in the development of the metacognitive instruments used in this study. I would also like to thank all the members of the thesis committee for their assistance: Dr. W. Jones, Dr. T. Daniels-Bierness, and Dr. B. Hoge. Dr. B. Estabrooks (Computing Services) and Barb Watkinson (Psychology) also provided a guiding overview and much appreciated advice in the statistical analysis.

In the end highest praise and appreciation must be given to my patient and long suffering family: Atulesh, Shawn and Monisha whose love and caring provided the strength to persist. To my parents thanks for a lifetime sustained with the belief that no challenge is too great.

Abstract

Metacognition, described as personal knowledge and awareness of one's own cognitive processes, has been postulated as an important variable in the monitoring, regulating and evaluating of thinking. Sternberg (1981, 1986, 1990) has proposed a theory that the gifted are those who have "superior access" and "high proficiency" in implementing metacomponents, the executive functions in intellectual performance. Brown (1978) distinguishes between knowledge of metacognition in hypothetical situations and the actual use of metacognition during problem solving. The purpose of the present study was to investigate the role of metacognition in intellectual giftedness, the development of metacognition during the childhood years, and to assess the interaction of metacognitive and cognitive functioning.

One hundred and twenty-two students at the Grade 3, 6, and 8 level were assessed on metacognitive and cognitive measures. A Metacognitive Questionnaire (MCQ) was developed to assess a priori knowledge of metacognition and a Metacognitive Interview (MCI) was designed to measure student awareness of metacognitive processes immediately following the completion of a problem-solving task.

Intellectually gifted subjects scored higher than average students at each grade level, on questionnaire, interview and observational measures of metacognition. Metacognitive sub-

processes differentiating ability levels included planning, strategy selection, monitoring and flexibility of strategy use.

For both gifted and average subjects, metacognitive processing increased significantly between ages 8 and 11 years, but only metacognitive knowledge differed between ages 11 and 13 years. When matched on the basis of mental age, intellectually gifted and average students did not differ significantly on measures of metacognition, with the exception of the gifted at the M.A. = 13 year level who scored higher on the metacognitive interview. This suggests that an important developmental change for the intellectually gifted was noted in metacognitive processing between the M.A. = 11 and 13 year level.

Measures designed for the current study were investigated for reliability and validity. Intra-rater and test-retest correlations were considered within acceptable limits. Evidence for the validity of a composite or global measure of metacognition was supported. Equivocal findings on the validity of the six proposed metacognitive sub-processes suggests further research is required to describe the relevant sub-skills and to develop appropriate measures.

In conclusion Sternberg's notion that the intellectually gifted possess higher levels of metacognition was supported by the present findings. Brown's distinction between metacognitive knowledge and metacognitive processing was particularly useful in describing intellectual and developmental differences.

Table of Contents

	Page
Acknowledgements	ii
Abstract	iii
Introduction	1
Review of the Literature	6
1. Notions of Intelligence	6
2. Metacognition	20
3. Metacognition/Intelligence	31
4. Additional Variables	40
5. Metacognitive Assessment	43
6. Description of the Present Study	52
Method	57
1. Subjects	57
2. Cognitive Measures	62
A) Kemler Hypothesis Formation Task	62
B) Pattern-matching Task	65
3. Metacognitive Measures	68
A) Metacognitive Interview	69
B) Metacognitive Questionnaire	72
C) Metacognitive Observations/Cognitive Tasks	78
4. Background Information	82
5. Validity Study	82
6. Procedures	84
A) Pilot Study	84
B) Current Study	84

Table of Contents

	Page
Acknowledgements	ii
Abstract	iii
Introduction	1
Review of the Literature	6
1. Notions of Intelligence	6
2. Metacognition	20
3. Metacognition/Intelligence	31
4. Additional Variables	40
5. Metacognitive Assessment	43
6. Description of the Present Study	52
Method	57
1. Subjects	57
2. Cognitive Measures	62
A) Kemler Hypothesis Formation Task	62
B) Pattern-matching Task	65
3. Metacognitive Measures	68
A) Metacognitive Interview	69
B) Metacognitive Questionnaire	72
C) Metacognitive Observations/Cognitive Tasks	78
4. Background Information	82
5. Validity Study	87
6. Procedures	84
A) Pilot Study	84
B) Current Study	84

Table of Contents cont'd.

	Page
7. Statistical Procedures	86
Results	95
1. Analysis of Metacognitive Measures	96
A) Metacognitive Interview	97
B) Metacognitive Questionnaire	120
C) Metacognitive Observations during Cognitive Tasks	136
D) Summary of Metacognitive Measures	141
2. Comparison of Mental Age Matched Groups	143
3. Analysis of Cognitive Measures	151
A) Kemler Hypothesis Formation Test	151
B) Pattern-matching Test	156
4. Analysis of Cognitive/Metacognitive Association	159
5. Additional Variables	166
6. Analysis of Validity: Metacognitive Measures	168
A) Developmental Changes	169
B) Internal Consistency	169
C) Factor Analysis	171
D) Intercorrelations of Metacognitive Measures	173
E) Correlation with Selected Tasks	178
Discussion	186
1. Metacognition and Intelligence	186
2. Development of Metacognition	194

Table of Contents cont'd.

	Page
3. Metacognition/Cognition Relationship	203
4. Metacognitive Assessment	207
5. Future Research	214
6. Summary and Conclusions	216
References	219
Appendices	236
A. Parental Consent Letters	236
B. Kemler Hypothesis Formation Task	239
C. Pattern Matching Task	243
D. Metacognitive Interview Protocol	252
E. Metacognitive Interview	256
F. Metacognitive Questionnaire	260
G. Metacognitive Questionnaire Scoring Guide	271
H. Mixed Kemler Task	278
I. Validity Study	281
J. Metacognitive Interview: Composite Means and Standard Deviations by Intellectual Level and Grade	298
K. Metacognitive Interview: Qualitative Scoring System Means and Standard Deviations by Intellectual Level and Grade	300
L. Metacognitive Questionnaire: Means and Standard Deviations by Intellectual Level and Grade	302

Table of Contents cont'd.

	Page
M. Metacognitive Questionnaire: Summary of Chi Square Analyses	304
N. Metacognitive Observations: Means and Standard Deviations by Intellectual Level and Grade	307
O. Matched Mental Age Groups: Multivariate Analysis of Variance Using Metacognitive Questionnaire Sub-process Scores as Dependent Variables	309
P. Kemler Task: Means and Standard Deviations of Problem-solving Efficiency and Non-informative Moves	311
Q. Pattern-matching Task: Means and Standard Deviations	313
R. Descriptive Statistics: Other Variables	315
S. Correlation of Validity Measures and Metacognitive Instruments	317

List of Tables

	Page
1 Synthesis of Sternberg and Brown and Flavell Models of Metacognition	30
2 Studies on Metacognition and the Gifted	33
3 Standardized Group Test Results by Intellectual Level	60
4 Intra-rater Reliability on Metacognitive Interview	73
5 Test-Retest Reliability Scores on Metacognitive Interview	74
6 Intra-rater Reliability on Metacognitive Questionnaire	79
7 Data Collection Procedures	87
8 Overview of Experimental Variables	88
9 Research Design: Mental Age Matched Groups	93
10 Comparison of MCI Composite Scores Following the Kemler and Pattern-matching Tasks	99
11 Pearson Correlation Coefficients of Two Administrations of the MCI on Total Sample	100
12 Multivariate Analysis of Variance Metacognitive Interview - Metacognitive Sub-processes as Dependent Variables	103
13 Discriminant Function Analysis - Intellectually Gifted vs. Average Students using Six Metacognitive Processes on Metacognitive Interview as Dependent Variables	105

List of Tables cont'd.

	Page
14 Discriminant Function Analyses: Intellectually Gifted vs. Average Students by Grade Level Using Six Metacognitive Processes on Metacognitive Interview as Dependent Variables	108
15 Discriminant Function Analysis - Quantitative Scoring System of Metacognitive Interview - Intellectually Gifted vs. Average Students	115
16 Classification results of Discriminant Analysis of Qualitative Analysis measures of MCI	117
17A Multivariate Analysis of Variance: Metacognitive Questionnaire using Metacognitive Subprocesses as Dependent Variables	125
17B Discriminant Function Analysis - Intellectually Gifted vs. Average Students on Metacognitive Questionnaire	126
18 Discriminant Function Analysis - Intellectually Gifted vs. Average Students by Grade Level on Metacognitive Questionnaire	128
19 Multivariate Analysis of Variance for Intellectual Group and Grade using Mixed Kemler Measures as Dependent Variables	137
20 Discriminant Function Analysis: Intellectually Gifted vs. Average Students Using Metacognitive Measures as Dependent Variables	144

List of Tables cont'd.

	Page
21 Metacognitive Interview. Means Scores for Groups Matched for Mental Age	146
22 Multivariate Analysis of Variance for Matched Mental Age Groups using Metacognitive Interview Sub- process scores as Dependent Variables	149
23A Multivariate Analysis of Variance for Intellectual Group and Grade using Kemler Hypothesis Formation Task Measures as Dependent Variables	155
23B Multivariate Analysis of Variance Pattern-matching Task using Cognitive Measures as Dependent Variables	157
24A Correlation Matrix: Intercorrelations of Pattern- matching Cognitive Measures and Metacognitive Measures	161
24B Correlation Matrix: Intercorrelations in Kemler Cognitive Measures and Metacognitive Measures	162
24C Correlation Matrix: Intercorrelations between Pattern-matching and Kemler Cognitive Measures and the Metacognitive Interview Measures	165
25 Internal Consistency: Correlations between MCI Sub- processes and Total MCI Composite Score	170
26 Factor Loadings for Six-Factor Principal Factors Extraction, and Varimax Rotation on Metacognitive Measures	172

List of Tables cont'd.

	Page
27 Correlation matrix: Intercorrelations between Metacognitive Interview and Questionnaire Sub-processes	174
28 Correlation matrix: Intercorrelations between Metacognitive Observations and Metacognitive Interview/Questionnaire	175

List of Tables cont'd.

	Page
27 Correlation matrix: Intercorrelations between Metacognitive Interview and Questionnaire Sub-processes	174
28 Correlation matrix: Intercorrelations between Metacognitive Observations and Metacognitive Interview/Questionnaire	175

List of Figures

	Page
1 Metacognitive Interview composite mean scores by intellectual group and grade	102
2 Metacognitive Interview mean scores on the Six Metacognitive Sub-processes by Intellectual Group	106
3A Intellectually Gifted Subjects: Metacognitive Interview Mean Scores on Six Metacognitive Sub-processes	109
3B Average Subjects Metacognitive Interview Mean Scores on Six Metacognitive Sub-processes	110
4A Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 3	112
4B Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 6	113
4C Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 8	114
5 Metacognitive Questionnaire Composite Mean Scores by Intellectual Group and Grade	121
6A Metacognitive Questionnaire Mean Scores on Six Metacognitive Subprocesses by Grade - Intellectually Gifted Subjects	122
6B Metacognitive Questionnaire Mean Scores on Six Metacognitive Subprocesses by Grade - Average Subjects	123

List of Figures cont'd.

	Page
7A Incorrect Elimination Errors by Intellectual Group and Grade on Pattern-matching Task	139
7B Omitted Elimination Errors on the Pattern-matching Task by Intellectual Group and Grade	140
8 Mental Age Matched Groups: Composite Mean Scores on MCI	147
9 Mental Age Matched Groups: Metacognitive Subprocess Mean Scores on MCI	148
10A Kemler Hypothesis Formation Task: Mean Task Efficiency by Intellectual Group and Grade	152
10B Kemler Hypothesis Formation Task: Mean Non- Informative Moves by Intellectual Group and Grade	153

INTRODUCTION

During the past decade, there have been significant changes in how intelligence is conceptualized and measured with important implications for both developmental and educational psychology. In particular, Sternberg (1986, 1990) has proposed an information processing theory of intelligence and intellectual giftedness while Brown (1978) has explored the role of metacognition in intelligence from a developmental perspective. Sternberg has, on one hand, directed much of his research to the study of cognition in the intellectually gifted whereas Brown has focussed on how to enhance learning and retention of that learning among those with intellectual handicaps.

These two new theoretical approaches are significant in that it is possible to formulate hypotheses about the differences in intellectual processes between children of various abilities such as gifted and average students. To quote Sternberg (1981), "attempts to understand intellectual giftedness must identify the underlying differences in mental structure, content and processes that differentiate the gifted from their ungifted peers" (p. 86). Despite considerable theoretical discussion of "process" versus "product" definitions of intellectual functioning, there is a dearth of research describing these processes and how they are manifested across age and ability levels. One of the most promising venues for process notions of intelligence is the concept of metacognition. Exploration of the development

of metacognition in students differing in intellectual level is an attempt to synthesize the theoretical perspectives of Sternberg and Brown. Recognition of the need to identify and measure the componential sub-skills of metacognition directed the focus of the current study.

One aspect common to both Sternberg and Brown is an interest in the relationship between metacognition and intelligence. Although both theorists consider intelligence as consisting of elements additional to metacognition, both perceive metacognition as pivotal to intellectual achievement. Consequently it is reasonable to assume that a difference in metacognitive functioning will also be a measure of the difference in intelligence. Furthermore, on the basis of the Sternberg model, one would predict that levels and types of metacognitive functioning could be used to differentiate between groups differing widely in ability levels such as intellectually gifted and average students. According to Brown, one would predict a critical developmental role for metacognitive functioning in differentiating students of varied ability levels.

The rationale for research in this area rests with its implications for the construct of intellectual giftedness, measurement of metacognition and the applied benefits to the field of education. For instance, there exists considerable debate as to appropriate identification procedures for selecting students for gifted or enrichment programs. A

clearer notion of what constitutes the underlying processes and development of intellectual giftedness could in turn provide direction to those involved in devising instruments to deal with the practical problems of selection. In some educational jurisdictions, mandatory Special Education legislation requires the formal identification of intellectual exceptionalities. The need to move beyond the measurement of what a student can do to examine the means by which a student has achieved the product represents an important research goal. As well, there has been considerable discussion of meeting the needs of bright students through "differentiated" curriculum (Gallagher, 1985). A fuller understanding of the processes involved in higher-level thinking might allow a match between teaching strategies and processing styles of students to develop maximum potential. Also, if the processes critical to intellectual giftedness could be isolated, then the possibility exists that these skills could be taught and enhanced in the average student as well. Several researchers (Borkowski, 1985; Brown, 1978; Flavell, 1976; Sternberg & Davidson, 1986) have suggested that the effectiveness of intellectual functioning can probably be attributed to a large extent to the quality and quantity of the metacognitive functioning of an individual. The majority of research to date on metacognition and intellectual giftedness, however, has focussed on conceptual issues (Sternberg, 1982; 1983;

1986), the investigation of metamemory (Borkowski & Peck, 1986; Kurtz & Weinert, 1989; Scruggs, Mastropieri, Jorgensen & Monson, 1986), or assessed children within a limited age range (Ajchenbaum, 1983; Wong, 1982).

The present study is an attempt to expand on previous research by operationally defining and measuring these "theorized" aspects of metacognitive functioning that are considered to differentiate the intellectually gifted and average students. The question of whether it is the level of metacognition or the ability to implement this metacognitive knowledge that differentiates these two ability levels is addressed by designing measures of (1) a priori metacognitive knowledge using a questionnaire format; (2) an interview following task completion; and (3) the direct observation of metacognitive processing during problem-solving tasks. In the assessment of metacognition, priority was given to the notion of reliability and validity as well as a multi-method approach. These measures are so designed that they could realistically be implemented in educational or clinical practice, following further psychometric investigation. Another notable aspect of the current study is the investigation of developmental changes across a six year age span (Grades 3, 5 and 8). The research design also allows for the distinction between which aspects of metacognitive functioning are related to maturation (chronological age) and which aspects appear to be dependent on intelligence (mental

age). Finally, research on metacognition has been investigated primarily on aspects of memory (Brown, 1978; Flavell & Wellman, 1977), reading comprehension (Kirby, 1984; Paris & Oka, 1989; Pressley, Johnson, Symons, McGoldrick & Kurita, 1989) and behavioural control (Meichenbaum & Asarnow, 1979). Relatively few studies have investigated metacognition and problem-solving (Borkowski, Estrada, Milstead & Hale, 1989; Stober, 1983), and none to our knowledge has probed this relation between metacognition, problem-solving and intelligence from a developmental perspective.

age). Finally, research on metacognition has been investigated primarily on aspects of memory (Brown, 1978; Flavell & Wellman, 1977), reading comprehension (Kirby, 1984; Paris & Oka, 1989; Pressley, Johnson, Symons, McGoldrick & Kurita, 1989) and behavioural control (Meichenbaum & Asarnow, 1979). Relatively few studies have investigated metacognition and problem-solving (Borkowski, Estrada, Milstead & Hale, 1989; Stober, 1983), and none to our knowledge has probed this relation between metacognition, problem-solving and intelligence from a developmental perspective.

REVIEW OF THE LITERATURE

1. Notions of Intelligence

A discussion of the role of metacognition in relation to prevailing concepts of intelligence can best be understood by reviewing the major issues that have dominated this field. Psychometrics, multiple versus single factor theories, process versus attribute concepts of intelligence have produced interesting and divergent viewpoints. Placing these trends in historical context, particularly as they relate to metacognition, is the focus of the following overview.

Since Galton first published his book Hereditary Genius: An Inquiry into Its Laws and Consequences (Galton, 1869), there have been ongoing attempts to conceptualize and measure intelligence. While there is probably no complete definition, most psychologists would agree that intelligence represents the ability to reason abstractly and solve problems in order to adapt to one's environment. Examples of definitions over the past 65 years are informative in that they underscore the diversity and complexity of the concept. Binet and Simon (1916) for instance defined intelligence as "the tendency to take and maintain a definite direction; the capacity to make adaptations for the purpose of attaining a defined end; the power of auto criticism". Wechsler (1958) described intelligence as the "global capacity of the individual to act purposefully, to think rationally and to deal effectively with his environment". Lately, Das (1973)

described intelligence as the "ability to plan and structure one's behaviour with an end in view" and Sternberg (1985) considered intelligence to be "those mental functions purposively employed for purposes of adaptation to and shaping and selection of real-world environments". These descriptions of intelligence have demonstrated considerable consistency over time and are noteworthy in the emphasis on "self-direction" and "self-awareness" terms increasingly associated with the concept of metacognition. Although there is some agreement as to the definition of intelligence, consensus in theoretical notions as to what constitutes intelligence has been more elusive.

The longest standing theory is the "psychometric" perspective whereby individual differences in performance on a series of tasks are used to decide what constitutes various levels of intelligence. The origin of the psychometric tradition is usually attributed to Galton who devised various psycho-physiological measures such as reaction time, auditory and visual acuity, and head size, for example, to delineate individual differences. Binet and Simon (1905) continued the psychometric perspective by selecting a series of tasks at various age levels that would predict success or failure in school. Tasks ultimately selected, represented abilities considered critical for adaptation to the environment such as verbal abilities, problem-solving, social awareness and perceptual functioning. It is important to point out that

psychometric theory tended to begin with this type of task selection then proceeded to the development of a theoretical rationale in contrast to others in the field such as Piaget and Sternberg who started with a theoretical notion of intelligence and then proceeded to develop hypotheses. The research on metacognition falls in the latter category, emerging only recently from a strong theoretical basis but having to date little empirical validation.

The issue of how skills develop and manifest themselves as intelligence continues to be a source of debate. For instance, Spearman (1927) proposed that marked intercorrelations between performances of individual subjects on the various tasks suggested the notion of "g" or an overall general ability factor that described intelligence. Over the years, refinements to the concept of "g" have included the idea of a hierarchical format. Vernon (1950) proposed an overall "g" factor at the top of the hierarchy relating to a wide variety of tasks followed by two sub-factors, verbal-educational and spatial-mechanical abilities. At the next level, there were minor group factors related to each sub-factor. For example, number skills, verbal fluency, and creative abilities fall under the verbal-educational factor. At the bottom are "specific" factors particular to behaviours on certain tasks. More recently Horn and Cattell (1967) have suggested there are two types of intelligence that constitute this "general" ability.

On the one hand there is "fluid intelligence" which requires flexible problem solving in novel, relatively culture-free situations. The alternate form, "crystallized intelligence", represents acquired learning primarily on academic tasks. This distinction has been particularly useful in directing attention to the process/product dimension in the selection of tasks used to measure intelligence.

In contrast to the notion of "g" or a hierarchical explanation, some theorists consider intelligence to be composed of separate, independent factors. Thurstone (1938) first suggested that intelligence was the result of seven primary mental abilities labelled verbal comprehension, word fluency, number, space, memory, perceptual speed and reasoning respectively. Jensen (1979) provided arguments for two types or levels of intelligence; Level I: "the registration and consolidation of input and the formations of associations" and Level II: "abstraction, conceptual elaboration and transfer of information". Guilford (1967) furthered a multiple factor perspective by selecting 120 factors to constitute his Structure of the Intellect Model. Intelligence, according to this cubic representation, is composed of the interaction of 4 types of content (figural, symbolic, semantic, behavioural) with 5 types of mental operations (evaluation, convergent production, divergent production, memory, cognition) which are manifested by 6 alternate types of products (units, classes, relations,

systems, transformation, implications). Guilford's model is of particular note in that it attempts to explain the complex processes of intelligence albeit from a factor analytic perspective based on between subject differences. The failure to develop tasks that operationalize all 120 factors and independent factor analytic studies demonstrating inter-correlations between test items suggesting an underlying "g" factor, have diminished support for Guilford's model in recent years (Sattler, 1988). The latest argument for a multifactorial view of intelligence has been outlined by Gardner (1982) in his text Frames of Mind. The seven intelligences proposed include linguistic, musical, logical, mathematical, spatial, bodily-kinesthetic and personal. To support the notion of separate, distinct intelligences Garner cites evidence from brain-damaged individuals left with intact skills and the feats of child prodigies with highly developed yet select abilities. It is interesting to note that Gardner has extended the psychometric approach beyond the boundaries of performance on short-term paper-pencil measures to include evidence from the biological and cultural literature related to intelligence. In spite of the continuing controversy over a "general" or "separate" factor notion of intelligence, the psychometric perspective has remained focused on content of test items rather than the processes individuals use to solve these tasks. Regardless of one's theoretical position, however, it is expected that

any new development in intelligence will be discussed in relation to this longstanding issue of "general" versus "separate" factors. With the present study investigating the relationship of metacognition and intelligence, questions naturally arise. For instance, can metacognition be considered as "g" or is it a separate unique aspect of intelligence, or when intelligence is controlled for is there still some unique variance in metacognitive performance between individuals?

In summary, according to the psychometric approach a definition of intellectual giftedness would be considered to be a quantitative difference in an IQ test score. However, it is relevant to enquire whether intellectual giftedness is merely a difference in degree or in kind? The recognition of the need to progress from attribute descriptions of intelligence to theories which probed the underlying processes of intelligent behaviour led to the development of the information processing perspective.

One of the major contributions of information processing theories of intelligence is a focus on task rather than subject attributes. According to Hunt "intelligence should be determined by absolute measures of aspects of a person's information-processing capacity rather than by measure of his performance relative to the performance of others" (Hunt, 1978, p. 119). In comparing theoretical approaches, some researchers have considered that a greater depth of

understanding of the cognitive processes associated with intelligent behaviour has replaced the breadth or scope of psychometric theories. It is interesting to note the efforts to integrate the psychometric and information processing perspectives. The research of Hunt, Lunneborg and Lewis (1975) on verbal processing and individual differences in intelligence is exemplary of this type of research. Described as a "cognitive correlates" approach (Pellegrino & Glaser, 1980; Larson & Saccuzzo, 1989), this methodology closely parallels the current study.

The research of Sternberg (1981, 1985) and Campione and Brown (1978) are elaborations of the information processing approach to intelligence which are particularly relevant to the formation of testable hypotheses regarding the development of intellectual abilities especially in children. Sternberg's Componential Model of Intelligence (1981) proposes three distinct types of processes involved in problem solving/ intelligence: (1) "metacomponents", (2) "performance components", (3) "acquisition", "retention" and "transfer components". Intellectual giftedness then may be conceptualized as the superior functioning of these three types of components.*

*Sternberg (1977) defines a component as "an elementary information process that operates upon internal representation of objects or symbols. The component can translate a sensory input into a conceptual representation, transform one conceptual representation into another or translate a conceptual representation into a motor output" (p. 86, 1981).

understanding of the cognitive processes associated with intelligent behaviour has replaced the breadth or scope of psychometric theories. It is interesting to note the efforts to integrate the psychometric and information processing perspectives. The research of Hunt, Lunneborg and Lewis (1975) on verbal processing and individual differences in intelligence is exemplary of this type of research. Described as a "cognitive correlates" approach (Pellegrino & Glaser, 1980; Larson & Saccuzzo, 1989), this methodology closely parallels the current study.

The research of Sternberg (1981, 1985) and Campione and Brown (1978) are elaborations of the information processing approach to intelligence which are particularly relevant to the formation of testable hypotheses regarding the development of intellectual abilities especially in children. Sternberg's Componential Model of Intelligence (1981) proposes three distinct types of processes involved in problem solving/ intelligence: (1) "metacomponents", (2) "performance components", (3) "acquisition", "retention" and "transfer components". Intellectual giftedness then may be conceptualized as the superior functioning of these three types of components.*

*Sternberg (1977) defines a component as "an elementary information process that operates upon internal representation of objects or symbols. The component can translate a sensory input into a conceptual representation, transform one conceptual representation into another or translate a conceptual representation into a motor output" (p. 86, 1981).

Metacomponents are described as the higher order control processes used in executive planning and decision making prior to and during problem solving. According to Sternberg (1981), there are six distinct metacomponents.

Intellectually gifted individuals have greater knowledge of these metacomponents and are more likely to use them in problem-solving, compared to students of lower intellectual levels. The six metacomponents include:

1. Deciding just what the problems are that need to be solved, their relative importance and ordering or prioritizing alternative approaches to problems.

2. Selecting sequential strategies that may eventually lead to a solution and the ability to retrieve the elements pertinent to a solution.

3. Deciding on the strategies optimal to one's unique abilities.

4. Representing information in ways appropriate to the subject, ie., linear syllogisms are initially solved using a linguistic representation followed by a spatial representation.

5. Deciding how much time, effort and resources should be allocated in solving a problem.

6. Monitoring progress and remaining flexible in problem solving to allow for midcourse adjustments.

Performance components are the processes actually used to execute the problem-solving strategy. Such processes include:

1. Encoding the terms of a problem, gathering information needed for solution.
2. Detecting relations between objects.
3. Mapping, seeing commonalities between domains of knowledge.
4. Applying knowledge by using relations inferred in one domain to make predictions about another domain.
5. Comparing predictive outcomes.
6. Justifying the preferred prediction as the best option.
7. Responding by communicating the solution in terms others can understand.

The remaining components are defined as follows: "acquisition components" are skills needed to learn new information which can then be retrieved using "retention components". "Transfer components" are the skills involved in generalizing retained information from one setting to another.

Sternberg views the metacomponents as the key or executive process in an interactive system. Only the metacomponents can directly activate and receive feedback from the other components. They are the central elements in the information-processing system. Therefore, in Sternberg's

conceptualization, metacomponents are crucial to the manifestation of intelligence in problem solving situations. In other words, how one plans to solve a problem, how one monitors what one is doing and how one evaluates the results are the key elements to successful problem solving (Sternberg, 1986; 1990).

It should be pointed out that Sternberg does not conceive of metacomponents as the sole source of differences in intellectual performance, but considers them as being the major source. Another aspect of Sternberg's model which deserves mention, is the distinction made between "global" and "local" processing. "Global" processing requires "executive" processes to control the selection, sequencing, and duration of nonexecutive processes. It is used primarily when the material is unfamiliar and consequently requires the metacomponents. "Local" processing in contrast, is largely automatised and it occurs when a task is familiar. Metacognitive processing is no longer considered necessary at this level. This distinction in levels of processing is relevant to experimental task selection when metacognition is under investigation. It suggests that a moderately difficult task is necessary to elicit metacognitive functioning. In contrast, less evidence of metacognition would be expected in the completion of an "easy" task.

In summary, on the basis of Sternberg's model, one would predict an important role for metacomponents during childhood

development in differentiating between groups widely different in ability level such as between the intellectually gifted and the average students.

The Brown Cognitive Developmental Model (1978) is a model of intelligence which evolved from research with the mentally retarded. The model consists of two interactive, hierarchical levels: (1) the architectural system; and (2) the "executive" system. The function of the architectural system is to register and respond to sensory input. Therefore, it consists of the basic structures/processes for information processing. The features identified for discussion are capacity or amount of space, durability or rate of information loss and efficiency or the temporal characteristics associated with the selection and storage of information (eg., rate of memory search). These three features of the architectural system do not appear to develop much beyond 5 years of age in normal children (M.A. = 5 years). Borkowski (1985), however, suggests that perceptual efficiency is a fundamental intellectual skill even though marked changes or differences in performance require the metacognitive aspects of the executive system as well.

The second level or "executive" system contains three important components: 1) the general knowledge base; 2) the demonstration of strategic behaviours; and 3) metacognitive knowledge and processes. Chi (1978), in particular, has argued that developmental differences can be attributed to

increased knowledge about a task rather than changes in memory strategies. It is clear then that intellectually gifted students have higher levels of knowledge that distinguish them from their average peers. It is therefore important to establish a control for knowledge requirements in an experimental design attempting to isolate level of metacognitive functioning as distinct from levels of knowledge. Research on the use of strategic behaviour has led to the conclusion that on memory tasks, in contrast to average students, the performance of children of superior intelligence is characterized by the efficient use of strategies rather than the type of strategies employed. Robinson and Kingsley (1977) studied the recall strategies of Grade 2 and 4 students on a list of ten unrelated words. Average children regardless of age were as capable as superior-intellect students when required to verbally formulate an appropriate strategy but were not as capable in executing it. Similarly it is this area of metacognition which forms the pivotal point of the executive system in the Campione-Brown model and is perceived as critical in a child's selection and implementation of problem-solving strategies, lower-level control processes and higher order executive routines. Research with the mentally retarded (MR) revealed these students did not use metacognition when solving memory tasks (Campione & Brown, 1978). For example, when trained to acquire a memory strategy, MR students lacked

awareness of when to utilize the strategy in an appropriate manner. Brown (1978) states unequivocally that metacognition is the underlying force in intelligent behaviour. In her conception, intelligence is defined as thinking efficiently and effectively and controlling one's own cognitive processes, all the resultant outcome of the process of metacognition.

According to Borkowski's interpretation of the research on metamemory in intellectually gifted versus average students, both efficiency (architectural system) and metacognition (executive system) are key aspects of intelligence. In fact, Borkowski points to a causal relationship such that increased perceptual efficiency leads to greater reinforcement of metacognitive awareness by concerned adults such as parents. It is of interest then in the present study to investigate the interaction of notions of cognitive efficiency and metacognition in the manifestation of intellectual giftedness.

The biologically-based theory proposed by Piaget (1972) is also important since it emphasized the developmental aspects of intellectual growth by adapting to one's environment through set stages and sequences. Piaget's discussion of intelligence also emphasized the individual as an active participant in exploring his or her environment. Although Piaget did not base his theory of intelligence on an analysis of individual differences, he did acknowledge that

progress through the stages proceeded perhaps at different rates for different individuals. Subsequent research (Keating, 1975) has demonstrated that psychometrically defined "gifted individuals" do attain concrete and formal operational stages earlier than average children. In a study of Grade 5 and 7 students divided into 2 subgroups of average and 2 groups of bright children, bright Grade 5 students outperformed average Grade 7 students on a Piagetian formal operational task suggesting qualitative differences in problem solving. The question arises then, could metacognition be a discriminating variable in the performance of these two groups of children?

Feldman (1982) has reviewed the literature on Piagetian theory concluding that Piagetian stages overall are still useful in describing the gifted child's development, except in the cases of prodigies. To date, however, there appears to be no research tracing the developmental trajectory of metacognition between intellectually gifted and average children across the concrete/formal operational period. The relatively weak relationship between Piagetian and psychometric measures of intelligence (Tuddenham, 1971) has resulted in some diminution of research using the Piagetian perspective. However, amalgamating the Piagetian and information processing theories of intelligence may provide interesting developmental insights. Questions which arise in relation to metacognition include: Do children progress

progress through the stages proceeded perhaps at different rates for different individuals. Subsequent research (Keating, 1975) has demonstrated that psychometrically defined "gifted individuals" do attain concrete and formal operational stages earlier than average children. In a study of Grade 5 and 7 students divided into 2 subgroups of average and 2 groups of bright children, bright Grade 5 students outperformed average Grade 7 students on a Piagetian formal operational task suggesting qualitative differences in problem solving. The question arises then, could metacognition be a discriminating variable in the performance of these two groups of children?

Feldman (1982) has reviewed the literature on Piagetian theory concluding that Piagetian stages overall are still useful in describing the gifted child's development, except in the cases of prodigies. To date, however, there appears to be no research tracing the developmental trajectory of metacognition between intellectually gifted and average children across the concrete/formal operational period. The relatively weak relationship between Piagetian and psychometric measures of intelligence (Tuddenham, 1971) has resulted in some diminution of research using the Piagetian perspective. However, amalgamating the Piagetian and information processing theories of intelligence may provide interesting developmental insights. Questions which arise in relation to metacognition include: Do children progress

through stages of metacognitive sophistication? Is there a hierarchy of metacognitive processes?

Throughout the discussion of theories of intelligence and the relationship of these theories to notions of intellectual giftedness, the importance of metacognition as a concept has been frequently stated. What is metacognition? How does it develop? are questions that guide the following review.

2. Metacognition

In the early 1970s, Brown, Flavell and others introduced the concept of metacognition to refer to an individual's knowledge and awareness about themselves and their cognitive processes which enable them to monitor, regulate and evaluate their own thinking. To quote Flavell, "Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g., learning the relevant properties of information or data. For example, I am engaging in metacognition (metamemory, metalearning, metattention, metalanguage or whatever) if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in any multiple choice task before deciding which is the best one; If I sense I had better make a note of D because I may forget it....Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the

cognitive objects on which they bear, usually in the service of some concrete goal or objective" (Flavell, 1976, p. 232).

Since the introduction of this concept, metacognition has been used to explain a broad range of cognitive endeavours. A significant role for metacognition has been implicated in memory (Brown, 1975; Flavell & Wellman, 1977; Kurtz & Weinert, 1989; Pressley, Borkowski & O'Sullivan, 1985), attention (Miller & Bigi, 1979), problem solving (Brown, 1978; Flavell, 1978; Sternberg, 1981; Stober, 1983, 1984), self control and self instruction (Mischel & Mischel, 1983). Research on the role of metacognition has also extended to academic subjects such as study skills (Brown, 1980), reading comprehension (Brown & Smiley, 1978; Paris & Okra, 1989) and mathematics (Dirkes, 1985; Peterson, Swing, Baverman & Buss, 1982). Increasingly, the role of self awareness and self direction of one's thinking is seen as a relevant factor in learning (Rogers, 1983; Snow & Yalow, 1982).

The superordinate term "metacognition" has come to be used for research involving the general aspect of awareness of thinking processes that can be applied to diverse learning situations irrespective of the specific content (Brown, 1978; Flavell, 1979; Paris & Lindauer, 1982). This concept has evolved, in part, from the need to distinguish between individuals' knowledge about their own cognitions rather than the cognitive operations themselves. Hence one's conscious awareness and control of one's own cognitive processes is

seen as a relevant area of study distinct from the investigation of cognitive processes per se. Therefore, in the instance of memory, the distinction between one's use of a retrieval strategy and meta-memory, one awareness of the need to use such a strategy, are two variables which may result in different learning outcomes.

Metacognition is a global term which according to Brown (1981) can be divided into two components, namely (1) metacognitive knowledge defined as knowledge or conscious awareness about one's own cognitive abilities and (2) metacognitive processes defined as the ongoing self-regulation of cognition during problem-solving typified by activities such as planning, monitoring and checking. Chi (1986) has proposed a similar distinction dividing metacognitive knowledge into "declarative" and "procedural" knowledge. The first component represents the factual verbally expressed knowledge, for example, about memory, and the second refers to the translations of knowledge into efficient strategies and processes. Developmental psychologists have found this distinction particularly useful when attempting to answer the question of what aspect of metacognition develops first, at what age and how. These two subdivisions of metacognition are discussed in relation to the available developmental research.

Metacognitive knowledge has also been defined by Flavell (1979) to describe the knowledge that learners have about

aspects of the learning situation. Thus research efforts have been directed to how a person's metacognitive knowledge changes as a result of metacognitive experiences and how "person", "task", and "strategy" variables interact to affect metacognitive performance. These aspects of metacognitive knowledge will be briefly examined.

Flavell has used the term "sensitivity" to refer to the child's growing awareness of situations that necessitate voluntary, intentional memory storage. It also implies that this "sensitivity" leads the child to be a more efficient problem solver by his or her awareness of the need to be strategic. One of the leading developmental surveys of children's metamemory knowledge has been conducted by Kreutzer, Leonard, and Flavell (1975). Twenty children in kindergarten, Grade 1, 3 and 5 respectively were interviewed about how they would deal with a variety of hypothetical situations involving the necessity to remember. Results from the study indicated that the younger children had some knowledge that decay from short-term memory can be rapid and could propose suggestions using external mnemonic resources (ie., written records, other people) to aid memory retrieval. However, the older children in grade 3 and most notably Grade 5 impressed as considerably more planful, strategic and self-aware in verbalizing how they would handle a variety of situations requiring memory. The evidence that a child may possess "sensitivity" or awareness about the need

to remember but not necessarily demonstrate an appropriate strategy led to the investigation of the factors which might affect an individual's performance in a memory situation.

Flavell and Wellman (1977) have enumerated three factors that have influenced the role of metacognitive knowledge in cognitive performance namely (1) person variables - awareness of one's capabilities or limitations as a learner; (2) task variables - awareness of those task characteristics that might affect learning outcomes; and (3) strategy variables - awareness of the various ways to solve a problem and the relative effectiveness of strategies depending on the learning situation.

Person variables can be further subdivided into the degree of a person's awareness of his/her own cognitive abilities ("intra individual"), awareness of his/her cognitive abilities relative to others ("inter-individual") and the more "universal" aspects of metacognitive knowledge. Developmental studies of intra-individual aspects of metacognitive knowledge suggest that older children are more realistic in their estimation of their ability to memorize than younger children. For example, in a study of two groups of educable MR children with MA's = 6 and 8 years respectively, Brown, Campione, and Murphy (1977) reported that the younger children continued to overestimate their capacity to remember a series of pictures after a number of experiences of trials, whereas the older students tended to

revise their estimates. Flavell, Friedrichs and Hoyt (1970) instructed kindergarten, Grade 1, 2 and 4 students to study and memorize word items until they were sure they could recall them. Once again subsequent recall revealed that the self-assessments of the Grade 2 and 4 children were accurate whereas those of the younger children remained inaccurate despite additional study trials. Inter-individual person variables would refer to the ability of an individual to recognize that he is a better reader than another classmate who is perhaps good at math. Universal aspects of metacognitive knowledge refer to the awareness that one's performance may differ from situation to situation depending on the interest level or motivation of the person.

The second type of variable involved in metacognitive knowledge is the "task" variable. This variable refers to, among other things, knowledge that the number and type of items to be memorized affects the difficulty level of a task or how the relationships among elements within a task affect one's cognitive performance. For example Kreutzer et al. (1975) found that 9-11 year olds were aware of the relative ease of remembering opposite pairs of words (light-dark) rather than unrelated pairs (light-talk) and the relative difficulty level of gist versus verbatim recall of study items when compared to the naivety of 6 and 7 year old children.

The third type of variable important in metacognitive

knowledge is the strategy variable. Research studies to date mainly focussed on memory tasks, suggest that the older the child the more awareness of strategies they possess and utilize, also, the more planfulness they demonstrate in these situations. In a study involving 6, 7, 9 and 11 year old children, Kreutzer et al. (1975) asked how they would go about remembering a phone number and to imagine what they would do to remember to take their skates to school the following day. Their research found the responses of the 11 year old students revealed more planfulness and the ability to generate a greater variety and number of strategies. In another domain, reading comprehension, Myers and Paris (1978) reported Grade 2 students were unable to state how they would go about understanding the meaning of an unknown sentence.

It should be noted that these person, task and strategy variables do not operate in isolation, rather there appears to be an integrative action between the type of strategy employed, and certain task and person variables. Once again there appear to be important developmental differences in the acquisition of this ability to integrate the three variables. Wellman (1978) in a study of 5 and 10 year old children reported the older children were superior in recognizing task and strategy variables such that a difficult memory task was perceived as requiring mnemonic strategies in contrast with an easy memory exercise which the older children stated could be solved without the aid of a strategy.

knowledge is the strategy variable. Research studies to date mainly focussed on memory tasks, suggest that the older the child the more awareness of strategies they possess and utilize, also, the more planfulness they demonstrate in these situations. In a study involving 6, 7, 9 and 11 year old children, Kreutzer et al. (1975) asked how they would go about remembering a phone number and to imagine what they would do to remember to take their skates to school the following day. Their research found the responses of the 11 year old students revealed more planfulness and the ability to generate a greater variety and number of strategies. In another domain, reading comprehension, Myers and Paris (1978) reported Grade 2 students were unable to state how they would go about understanding the meaning of an unknown sentence.

It should be noted that these person, task and strategy variables do not operate in isolation, rather there appears to be an integrative action between the type of strategy employed, and certain task and person variables. Once again there appear to be important developmental differences in the acquisition of this ability to integrate the three variables. Wellman (1978) in a study of 5 and 10 year old children reported the older children were superior in recognizing task and strategy variables such that a difficult memory task was perceived as requiring mnemonic strategies in contrast with an easy memory exercise which the older children stated could be solved without the aid of a strategy.

Andreassen and Waters (1989) reported that metamemory questioning after a task was related to behaviour in Grade 1 students whereas Grade 4 pupils demonstrated a significant metamemory-memory association whether questioned before or after the task. These results lead them to conclude that strategy awareness may initially arise after reflection of one's own strategic behaviours. It is only later that strategy use is related to planful, pre-task activities as noted with the older Grade 4 children.

Thus, the literature suggests that there is marked developmental progress for these aspects of metacognitive knowledge with a gradual enhancement of capabilities from age six to age eleven.

Whereas metacognitive knowledge represents an individual's stated awareness of his/her cognitive processes, Brown (1978) has suggested another subdivision of metacognition namely the domain of metacognitive processes. These processes refer to the higher order executive decisions of directing a student's thinking and actions during a learning situation. These processes are considered to be transituational and can be applied in academic and problem solving tasks as well as memory situations. Brown's description of these metacognitive processes include "predicting cognitive limitations, defining the particular task, being aware of available routines and their utility, planning appropriate problem solving strategies, monitoring

the effectiveness of these routines and evaluating the success or failure of the cognitive enterprise" (Stober, 1983, p. 56). Brown's (1978) taxonomy of metacognitive processes can be considered in three categories described as planning, monitoring and evaluation.

Planning ahead has been studied primarily in terms of study time apportionment. Brown (1980) investigated metacognitive aspects of studying such as how well students can determine what is important to remember and what is not, choose a strategy to improve learning, can evaluate if that strategy worked or not, and decide if another strategy should be used. In an experiment with Grade 1 and 3 children, students were asked to remember a series of pictures over several trials. After each trial the child was allowed to choose half the pictures for further study. Only the Grade 3 students demonstrated the ability to select pictures they had missed on the preceding trial. Young children in contrast tended to choose the pictures at random.

Monitoring during task performance has been found to be a metacognitive process differentiating younger and older students. For example, Markman (1977) requested Grade 1 and Grade 3 students to assist in teaching the class a Magic Trick. The directions to the exercise were purposely incomplete. Markman used 40 probing questions to assess the children's awareness that the instructions were insufficient. The Grade 3 students realized the instructions were

incomplete with minimal probing while the Grade 1 students had to actually try the trick before they realized it was impossible. This aspect of self-questioning such as How am I doing on this task? Am I finished? Is this making sense? is an important aspect of metacognition namely monitoring one's thinking processes during a learning situation.

Evaluation involves the metacognitive process of predicting one's upcoming performance on a task in a realistic manner. In other words, the child is asked to imagine how he/she would think in a situation. Brown and Smiley (1977) asked children to predict the importance of story units in a text from least to most important. It was found that 8 year olds made no distinction between levels of importance whereas the 10 year olds could distinguish the most important units.

In the preceding review, it is apparent that the study of metacognition has been approached from varied perspectives. Sternberg, for example, focussed on the role of "metacomponents" in intelligence, Flavell on the role of metacognitive knowledge, and Brown on the developmental aspects of metacognition and the notion of metacognitive processes. Table 1 presents a scheme of how a synthesized model using Brown and Flavell's notions of metacognition might overlap with the elements of Sternberg's notion of metacomponents. Six key metacognitive processes have been identified: Problem Definition, Planning, Strategy Selection,

Table 1. Synthesis of Sternberg and Brown and Flavell Models of Metacognition.

Metacognitive Processes	Sternberg's (1981) "Metacomponents"
Problem Definition	1. Decision as to just what the problems are that need to be solved.
Planning	2. Selection of lower-order components of problem-solving.
Strategy Selection	3. Selection of strategies for solving problems.
Planning	4. Selection of representations for information.
Planning	5. Decision regarding allocation of componential resources in problem solving.
Monitoring	6. Solution monitoring in problem solving.
Flexibility of Strategy use	Flexibility in changing plans as needs dictate.
Evaluating	7. Evaluating

Flexibility of Strategy Use, Monitoring and Evaluation. This framework directs the proposed investigation of metacognitive knowledge and processes in students of average and gifted intelligence.

3. Metacognition/Intelligence

The previous sections have dealt primarily with theoretical notions prevalent in current thinking on intelligence and metacognition. Empirical evidence linking the two fields is at the initial stages. It can only be reiterated that if metacognition proves to be an important factor in the manifestation of intelligence, then educators can be directed as to what aspects of metacognition should be encouraged, what grade level is optimal to begin this instruction, and what might be the appropriate timing and type of instruction according to the intellectual abilities of the student.

The problems of defining "giftedness" continue to make comparisons between studies and generalizations from the research data complicated. For the most part, researchers continue to use psychometric definitions of "giftedness", that is to say students with demonstrated abilities in the superior ($IQ > 120$) or very superior range ($IQ > 130$) on a standardized intelligence test. Other criteria cited are high achievement in math and reading, teacher recommendations or satisfactory progress following placement in a gifted program. Some studies require only high IQ's, others some combination of the criteria cited above. A summary of the

findings of studies relating metacognition and giftedness is presented in Table 2. A discussion of the main results follows.

According to Borkowski (1985) what flows from metacognition is "planfulness, self-monitoring and inventiveness, the hallmarks of intelligent behaviour". In the research of Borkowski an index of metacognition correlated significantly with verbal intelligence (WISC-R vocabulary subtest) for Grade 1 ($r = .64$, $p < .001$) and Grade 3 ($r = .54$, $p < .001$) students (Borkowski, Ryan, Kurtz, & Reid, 1983). Metacognition was defined as metamemory knowledge and assessed in a group-administered questionnaire. The children were required to answer questions on five sub-tests such as "Organized list" (recognition that a list of words made up of one category, ie., fruit was easier to remember than a list without a semantic category); "Preparation Object" (how many strategies could be generated in a situation which required the children to bring roller skates to school the following day); "Memory monitoring" (the child's capacity to estimate how many words in a 15-word list they could remember after 1 minute). Further research by Borkowski and Peck (1986) revealed that metamemory knowledge is a better predictor of strategy transfer in gifted children, following incomplete strategy instructions, than measures of perceptual efficiency.

Recently Kurtz and Weinert (1989) investigated the

Table 2. Studies on Metacognition and the Gifted

Study	Sample	Description	Outcome
Ajchenbaum (1983)	Gr. 9 (38) Short-Form of WISC-R IQ 80-137	Three problem-solving tasks (Mazes) Digit backwards, Logical Analysis problems Students interviewed on (1) awareness of strategies and (2) metacognitive knowledge	No significant relationship between metacognitive measures and intelligence
Anderson (1985)	Gr. 4-6 (90) Gifted, Average, Below Average	Protocol analysis in solving 8 tasks of Ross Test of Higher Cognitive Processes	Gifted Ss more successful in (1) identifying problem to be solved and (2) greater adequacy of strategy awareness
Borkowski & Peck (1986)			Metamemory is predictive of strategy transfer in gifted Ss following incomplete strategy instructions; better predictor than measures of perceptual efficiency
Borkowski, Ryan, Kurtz & Reid (1983)			Metamemory significant correlated with IQ
Carr & Borkowski (1987)	Gr. 5 & 6 (98) Gifted Ss WAIS (Infor & Voc.	Metamemory battery (questionnaire)	Gifted children who understand their memory capabilities possess a mature metamemory knowledge and are more likely to achieve academically, irrespective of IQ, than gifted children with less mature metamemory
Chatman & Williford (1982)	Gr. 4 Gifted Ss	Exp. 1: Unstructured interview of Ss awareness and use of cognitive strategies while solving problems Exp. 2: Children asked whether particular strategies could have been helpful in solving problems	None of Ss could verbalize thought processes Many of Ss understood how strategies could have helped yet didn't report using them

Table 2. Studies on Metacognition and the Gifted

Study	Sample	Description	Outcome
Ajchenbaum (1983)	Gr. 9 (38) Short-Form of WISC-R IQ 80-137	Three problem-solving tasks (Mazes) Digit Backwards, Logical Analysis Problems Students interviewed on (1) awareness of strategies and (2) metacognitive knowledge	No significant relationship between metacognitive measures and intelligence
Anderson (1985)	Gr. 4-6 (90) Gifted, Average, Below Average	Protocol analysis in solving 8 tasks of Ross Test of Higher Cognitive Processes	Gifted Ss more successful in (1) identifying problem to be solved and (2) greater adequacy of strategy awareness
Borkowski & Peck (1986)			Metamemory is predictive of strategy transfer in gifted Ss following incomplete strategy instructions; better predictor than measures of perceptual efficiency
Borkowski, Ryan, Kurtz & Reid (1983)			Metamemory significant correlated with IQ
Carr & Borkowski (1987)	Gr. 5 & 6 (98) Gifted Ss WAIS (Infor & Voc.)	Metamemory battery (questionnaire)	Gifted children who understand their memory capabilities possess a mature metamemory knowledge and are more likely to achieve academically, irrespective of IQ, than gifted children with less mature metamemory
Chatman & Williford (1982)	Gr. 4 Gifted Ss	Exp. 1: Unstructured interview of Ss awareness and use of cognitive strategies while solving problems Exp. 2: Children asked whether particular strategies could have been helpful in solving problems	None of Ss could verbalize thought processes Many of Ss understood how strategies could have helped yet didn't report using them

Table 2 cont'd.

Study	Sample	Description	Outcome
Das (1984)	Gr. 3 (70) C.C.A.T.	Investigated correlations between CCAT scores and a planning factor (TRAIL-MAKING TEST)	No significant relationship between IQ & Planning
Davidson & Sternberg (1984)	Gr. 4, 5, 6 Gifted/Normal	Three processes view of insight assessed on math & verbal problems	Gifted scored higher on tests of selective encoding, selective comparison & selective combination
Dover (1983)	Gr. 5 & 6 (50) Gifted/Average	Students solved Luchins's (1942) water-jar task and administered structured interview on their solution process	Gifted Ss performed more quickly, gave alternative solution when available, greater awareness of their solution processes, more efficient monitoring skills
Kontos & Swanson & Swanson & Fraser (1984)	13 year old Ss (27) Gifted (IQ = 142) Average (IQ = 107) Otis-Lennon IQ	Metamemory battery - (story list, study plan, study time, effort and experience). Questions on memory, monitoring and checking. Recall tasks-categorizable list, unrelated list, recall of 2 stories	MANOVA - no significant difference between gifted & average on 5 measures of Metamemory and 5 of memory. Only knowledge of effort differentiated Ss
Kurtz & Weinert (1989)	Gr. 5 & 7 (113)	Students tested on metacognitive knowledge, attributional beliefs & memory task	Gifted scored higher on meta-memory & memory performance. Non-significant differences between Gifted Gr. 5 & Average Gr. 7 Ss.
Robinson & Kingsley (1977)	Gr. 2 & 4 (56) Superior (127-129) IQ vs. Average (109-115)	Free-recall task (10 words) Verbatim report of strategies; level of recall; & amount of sequential organization recorded	Gr. 2 (Superior Intelligence) exhibited metacognitive behaviour more frequently than Gr. 4 (Average Ss). Average Ss as capable of formulating strategies but gifted Ss more capable in actual execution of strategy.
Shore & Carey (1984)	Gr. 6-10 (122) Gifted WISC-R (Block Design & Voc.)	Portable Rod & Frame Test	When spatial ability higher than verbal scores, Ss reported more frequent use of spatial procedure to solve task. Vice versa for higher verbal ability Ss. Ability to switch cognitive strategy in recognition of personal strengths might be meta-cognitive component of giftedness

development of metamemory in a sample of gifted and average Grade 5 and 7 students. Gifted students outperformed average subjects on measures of metamemory knowledge. Metamemory in gifted Grade 5 students did not differ significantly from Grade 7 average students. Kurtz and Weinert concluded that their study discounted the hypothesis that gifted performance is simply accelerated development given other evidence such as correlations among metacognitive and performance variables, combined with different causal models for the two ability groupings.

Other investigators have reported a predictable relation between psychometric measures of intelligence and 1) the ability to choose strategies appropriate to verbal abilities (MacLeod, Hunt, & Matthews, 1978); 2) the ability to use a sequential organization on a free-recall task (Robinson & Kingsley, 1977); and 3) the use of monitoring and spontaneous self checking behaviours in a story recall exercise (Wong, 1982), favouring students of high intelligence.

There are, however, contradictory findings when metamemory knowledge is related to intelligence. For instance, Kontos et al. (1984) found no significant difference between 13 year old gifted (Otis-Lennon IQ = 142) and average students on a questionnaire adapted from the Kreutzer et al. (1975) metamemory battery. The Kontos study, it should be noted, had a relatively small sample size (N = 28) suggesting that rather large differences would be

necessary to produce a significant result. Also it is possible that there might have been a ceiling effect on the questionnaire items for this age level. A similar study using one of the identical meta-memory subtests (the ability to explain why related word pairs would be easier to remember than unrelated words) found a significant difference in a younger age group (Grade 3) favouring gifted as compared to average IQ students (Geis & Corriher, 1977). Focussing as well on only metamemory knowledge measures may have prevented the discovery of relations between other areas of metacognitive functioning and intelligence.

The investigation of metacognition in problem solving situations among bright students has supported the relevance of this concept in studying intellectual differences. For example, metacognitive awareness of an analogy reasoning task differentiated the successful performance of university undergraduates (Sternberg & Weil, 1980). Davidson and Sternberg (1984) reported gifted Grade 4-6 students as well demonstrated a greater ability to identify problems to be solved and more strategy awareness in problem solving than their average peers. Gifted and non-gifted students were significantly differentiated on the use of three processes deemed important for insightful solutions to math problems namely, (1) selective encoding or the ability to sift out relevant from irrelevant information; (2) selective combination or the ability to synthesize disparate pieces of

information into a unified product; and (3) selective comparison or the skill involved in relating new to old information. It can be argued that these three processes, more prevalent in the intellectually gifted subjects, are essentially metacognitive in nature and hence demonstrate a tentative link between metacognition and intelligence.

Shore (1986) has reported on a possible link between giftedness and an aspect of metacognition, namely the flexibility of strategy use during problem-solving. A study by Shore and Carey (1984) suggested a possible metacognitive basis of giftedness in the ability to match strategies to personal strengths. In this study, gifted students (Grade 6 to 10) were found to select a cognitive strategy to complete the Portable Rod and Frame test compatible with their relative strength in either verbal or spatial skills. For instance those gifted students with a higher verbal than performance IQ, tended to solve the problem by verbalizing their strategies. In a related study, using Luchins's (1942) water jar task, Dover (1983) compared gifted and non-gifted Grade 5 students on measures of flexibility of strategy use, solution accuracy and speed. Gifted students were significantly superior in providing verbal descriptions of their solution processes, providing alternate solutions to the problem, and in monitoring their cognitive performance. One only dissenting study found in the literature involved the verbalized awareness of strategy use following three

problem solving tasks. Ajchenbaum (1983) reported no significant relationship between IQ level and these metacognitive measures using a multiple regression analysis. The Otis-Lennon IQ levels ranged from 80-137 (N = 38). Problems involved with the use of post-performance interviews rather than ongoing measures of metacognition were interpreted as the reason for these non-significant findings.

Developmental differences among bright students in the ability to activate metacognitive processes during problem-solving is suggested in separate studies by Moss (1983) and Chatman and Williford (1982). Moss (1983) reported differences in metacognitive behaviours among pre-school children observed while their mothers taught them three problem-solving tasks. The gifted youngsters appeared more knowledgeable about the rules and relationships among objects, and employed metacognitive strategies to regulate their actions more frequently than their average peers. Chatman and Williford (1982) found Grade 4 gifted children were unable to demonstrate or verbalize their thought processes on the awareness and use of cognitive strategies during a problem-solving task. A follow-up experiment in which the children were asked specifically whether a particular strategy would have been helpful in solving a problem revealed the students did in fact know which strategies might have been most useful. This points out the possibility that there may be a developmental difference in

the possession of metacognitive knowledge and the appropriate utilization of that knowledge.

In summary, there is some preliminary evidence that in comparison to average learners, intellectually gifted students do possess enhanced metacognitive knowledge and are more adept in switching strategies to match their particular cognitive strengths (Shore & Carey, 1984; Sternberg & Weil, 1980). Other metacognitive processes such as monitoring, checking, and spontaneous strategy use have been reported to be more prevalent in gifted as compared to average students (Dover, 1983; Hannefen & Carey, 1981) or compared to the learning disabled (Wong, 1982). However, there are but a few studies (Sternberg & Davidson, 1983) investigating the developmental progression of metacognition in problem solving skills among students of varying intellectual capacities.

To our knowledge there is no study which systematically investigates the sub-skills of metacognitive knowledge and metacognitive processing during problem-solving between intellectually gifted and average students. To quote Shore (1986) "there are a mere handful of publications which have explicitly linked metacognition and giftedness, and the area of study is open for interesting exploration" (p. 26). Also relatively unexplored is the relation of other factors such as male/female differences, socio-economic levels, achievement and motivation on metacognitive functioning.

4. Additional Variables

The issue of whether there are sex differences in metacognitive functioning and whether such differences could be used to explain variations in cognitive abilities between the sexes, is research which is currently at a descriptive level. There is some evidence to suggest there are cognitive differences between gifted males and females, generally favoring the males. In a study of Grade 8 students of superior intelligence (WISC-R IQ > 120), Karnes and Brown (1980) report males outperformed females on nine of the ten subtests of the WISC-R with the exception of coding. In a study of 828 bright students, similar findings were reported with males scoring higher on both the Verbal and Full Scale IQ of the WISC-R across Grades 3, 5 and 8 (Daniels-Bierness & Nandi, 1986). Further comparisons using the Bannantyne re-categorization system of the WISC-R revealed a significant sex effect on the Acquired Knowledge factor (Information, Arithmetic and Vocabulary) favouring males. Schlieper and Alberts-Corush (1985) and Karnes (1980) have independently reported differences in the WISC-R factor structure for intellectually gifted males and females suggesting qualitative differences as well may exist in cognitive functioning between the sexes. One possible variable which might contribute to these cognitive discrepancies is the notion of metacognition.

As the literature available on metacognition and the

4. Additional Variables

The issue of whether there are sex differences in metacognitive functioning and whether such differences could be used to explain variations in cognitive abilities between the sexes, is research which is currently at a descriptive level. There is some evidence to suggest there are cognitive differences between gifted males and females, generally favoring the males. In a study of Grade 8 students of superior intelligence (WISC-R IQ > 120), Karnes and Brown (1980) report males outperformed females on nine of the ten subtests of the WISC-R with the exception of coding. In a study of 828 bright students, similar findings were reported with males scoring higher on both the Verbal and Full Scale IQ of the WISC-R across Grades 3, 5 and 8 (Daniels-Bierness & Nandi, 1986). Further comparisons using the Bannantyne re-categorization system of the WISC-R revealed a significant sex effect on the Acquired Knowledge factor (Information, Arithmetic and Vocabulary) favouring males. Schlieper and Alberts-Corush (1985) and Karnes (1980) have independently reported differences in the WISC-R factor structure for intellectually gifted males and females suggesting qualitative differences as well may exist in cognitive functioning between the sexes. One possible variable which might contribute to these cognitive discrepancies is the notion of metacognition.

As the literature available on metacognition and the

intellectually gifted is still relatively sparse, little evidence is currently available to clarify this situation. Those few studies reporting findings on the basis of sex, suggest no significant differences between intellectually gifted males and females in metacognitive functioning (Sternberg & Davidson, 1983; Ajchenbaum, 1983). In other studies where intellectual level was not a factor, there also did not appear to be a significant relationship between sex of the subjects and metacognitive abilities (Bizanz, Vesonder & Voss, 1978; Brown & Barclay, 1976; Brown & Smiley, 1978; Yussen & Levy, 1975). It is of note that all these latter studies involved metamemory. A review of these studies suggests that sex may not be a relevant variable in the development of metacognition. However, investigation of sex differences in metacognition during problem solving and especially among gifted students has not been fully investigated.

Another variable to consider, socio-economic status (SES), has rarely been cited even as a control factor in metacognitive research. The issue of SES is of particular concern in studies of the intellectually gifted as often students so defined tend to be over-represented in the middle and upper levels of society. Therefore the measurement of SES becomes important to rule out the possibility of its confounding effects in any study comparing students of varied ability levels. In addition, the notion that educated

parents may teach metacognitive strategies to their children suggests a possible indirect effect of SES levels. Moss (1983) reported differences in the verbal interactions between mothers and their pre-school children in the reinforcement of metacognitive strategies during three problem solving tasks. Findings of this nature warrant further verification of the relationship between SES and metacognition.

School achievement and motivation as they relate to the development of metacognition are additional variables of interest. In a study of Grade 5 and 6 children, Peterson et al. (1982) found that independent of a student's intellectual ability, students report of their understanding of the lesson was significantly related to achievement. This would suggest some aspects of metacognition may impact on achievement irrespective of a pupil's intellectual level. This investigation involved average and above average rather than intellectually gifted students and was restricted to mathematics. Nevertheless knowing what and/or why one does not understand in an instructional situation was found in this study to be evidence of the relation between metacognition and achievement. Interestingly, in the same article, the awareness of specific cognitive strategies to use in mathematical problem-solving was related to the student's level of intelligence rather than achievement. This suggests it is worthwhile to investigate the

differential impact on ability and academic achievement of the various sub-skills of metacognition.

Similarly motivation or perceived effort towards school work is a variable of interest. Metacognitive functioning may not be activated by students who care little for their school work. Expressed differently, perhaps motivated students, irrespective of achievement levels, differ in metacognitive awareness in contrast to unmotivated pupils. Wong (1989) has recently pointed out the need to consider relevant personal attributes (ie., locus of control, field independence/dependence) in conducting research on the effectiveness of metacognitive strategy training. However, no study could be found in the literature that pursued this relation between achievement, motivation and metacognitive processing in a problem-solving situation.

In addition to the theoretical issues and variables postulated to relate to metacognition, the necessity of appropriate assessment techniques dominates as one of the crucial factors influencing the future of this construct.

5. Metacognitive Assessment

As metacognition refers to one's thoughts about the thinking process, verbal reports are a primary means of gaining information regarding those thoughts. One of the major issues in the field is whether a subject, especially a child, is consciously aware of his or her cognitions. Almost all methods of assessing metacognition are based on the

assumption that indeed a subject can state overtly their "inner speech". The debate on the veracity of verbal reports, feasibility of alternative measurement techniques and their relative advantages have been outlined in a review article by Meichenbaum, Burland, Gruson and Cameron (1985). In general the current status of metacognitive assessment suggests the existing methodologies can be divided into three categories consisting of: 1) the concurrent or post-performance interview, 2) the think-aloud method and observation of spontaneous private speech, and 3) the inference of metacognition from task performance. A discussion of these three categories of assessment organizes the following review.

Central to the first method, the interview, is the question of whether subject self-reports are accurate reflections of thoughts or confabulation influenced by post-performance rationalization. Especially when the subjects are children, the possibility exists that immature verbal ability may be influencing the quality of verbal descriptions. In addition, the issue of experimenter expectations raises the question of whether the children are responding freely or merely trying to please the experimenter by saying what they think he or she wants to hear.

Critical to the self-report measurement of metacognition is the assumption that a subject has conscious awareness of their own inner thoughts. There is always a possibility,

however, that if responses to a task are automatic, conscious awareness may not be reported. Memory, lack of motivation, or denial may further complicate the description of cognitive processes.

The efficacy of the self-report procedure is further affected by the format of the interview. For instance, interviews can vary in terms of timing (before, during, or after a task), type of question (open-ended, closed, multiple-choice, short-answer) and question content (hypothetical situations, personal events). To date the literature points to the merits of interviews administered immediately following a task consisting of open-ended questions (Meichenbaum et al., 1985).

It is possible to take certain steps to enhance the accuracy of verbal reports. Guidelines proposed by Ericsson and Simon (1980) to increase the likelihood of obtaining accurate verbal data are as follows. In their estimation it is important to (1) request information from subjects with minimal probing so subjects have to remember rather than infer their mental processes; (2) obtain reports as soon as possible after task completion while the information is still in short-term memory; (3) request verbal descriptions of experiences rather than asking questions requiring the subjects to answer why they engaged in a particular behaviour or to provide motives for their actions, (4) collect multiple measures of subjects' verbal reports in a variety of

situations to provide some estimate of internal consistency of reporting.

Further suggestions provided by Adair and Spinner (1979) cite the merits of providing retrieval cues when a subject is describing their behaviours. In addition, priming subjects' motivation to respond honestly, to assist the experimenter and having subjects' report their impressions of experiences in a free-flowing fashion rather than in response to a series of factual questions are recommended ways to improve the quality of verbal report data.

In the present study interviews comprised the major means of obtaining data. Efforts to incorporate the suggestions mentioned above to enhance the veracity of verbal reports were seen as a priority in the development of the metacognitive knowledge questionnaire and the metacognitive interview.

Although methods to improve the interview have been delineated, the complexity of scoring the interview data presents its own set of challenges. Typically individual researchers develop scoring procedures to reflect the particular requirements of their study. Classification systems are devised which then form the basis for a quantitative analysis. For example calculations can be made on the number of spontaneous self-corrections or the number of incorrect eliminations. Rating systems can also be devised to measure the quality of responding by assigning 2,

1 or 0 points, depending on the level of the answer.

Whether a quantitative or qualitative mode is chosen, the development of a reliable scoring system involves investigation of inter-rater and test/re-test reliability. The related issue of validity is made more difficult by the dearth of established metacognitive measures in the field. Interestingly, there is now a test of metalinguistics, The Analysis of the Language of Learning (Blodgett & Cooper, 1987), which represents a beginning for standardized instruments in this domain. A further need identified by Meichenbaum et al. (1985) is the advisability of diversifying the measurement categories to include ratings of overall abstraction, generality and differentiation. Consideration of global ratings of the entire protocol as well as individual item by item analyses could also serve to supplement current scoring procedures.

The second category of metacognitive assessment, the Think-Aloud method, is a long-standing procedure in psychological research. Typically, subjects are asked to express all their thoughts as they complete a task. The interference of verbalizing on the ongoing thought processes is considered minimal according to data presented by Ericsson and Simon. Although Henshaw (1978) used this technique in analysing the metacognitive awareness of high and low creative subjects during problem-solving, the think aloud method presents considerable concerns with the large quantity

of data for analysis and the possibility of interfering with the normal process of metacognition in such an artificial situation. It may be that what is being measured is the ability to talk and work simultaneously rather than levels of metacognitive awareness. An extension of this method, the observation of spontaneous private speech, consists of recording non-solicited verbalizations during task performance. Once again inter-subject variability as to the appropriateness of this behaviour may be the measure rather than indications of advanced levels of metacognitive functioning.

Meichenbaum's third category, inferring metacognition from task performance, has interesting possibilities and perhaps lends itself to more objective measurement of metacognition. The movement away from reliance on verbal report data is considered a positive development in extending knowledge of metacognition and how it is manifested in problem-solving situations. Several methods of deducing metacognition from behaviour have been described in the literature, namely (1) observation of the types of errors committed while performing a task (Cameron, 1976; Stober, 1983; Wong, 1982), (2) task alteration or changing an exercise in a deliberate manner in order to elicit metacognitive behavior (Davidson & Sternberg, 1984; Markman, 1977), and (3) analysis of training studies comparing the effects of teaching metacognitive strategies between control

and experimental subjects (Butterfield, Wambold, & Belmont, 1973; Palinscar & Brown, 1988).

In studies by Cameron (1976) and Stober (1983), errors during the solving of a pattern-matching task were considered to be indicative of a lack of metacognitive awareness. Cameron (1976) used a testing the limits approach to select the level of a child's understanding of the task or metacognitive awareness. Stober (1983) rated either omitted or incorrect pattern eliminations as demonstrating a weakness in the monitoring process. A somewhat different technique was used by Wong (1982) who recorded spontaneous self-correcting behaviour on a story task which required the children to select idea units. These self-correcting actions were interpreted as evidence of the metacognitive processes of planning and strategy selection.

Several studies are now available to typify the task alteration technique (Sternberg, 1983). The manner in which Sternberg measures metacognitive functioning deserves comment as it represents the application of an established experimental tool of cognitive research, namely "cueing". In Sternberg's estimation, a task which is not cued requires more metacognitive processing than performance on a task on which a subject is already informed beforehand as to the type of problem. In his research on problem solving among college students (Sternberg & Weil, 1980), subjects were either cued or not cued as to the structure of the upcoming analogy. The

differences in decision time (reaction time to the offering of an answer) and error rate between these two conditions (cued/non-cued) were used to infer evidence of metacognitive processing.

Another variation of task alteration is exemplified by Markman (1977) who deliberately provided incomplete instructions to a magic task to see at which level of probe questions the child acknowledged his or her lack of understanding. According to Markman (1977) the sooner the student recognized the problem, the higher the level of metacognitive awareness. Simplicity, ease of scoring and level of interest for children make this latter task a model for creative approaches to metacognitive measurement.

Finally, a somewhat different approach to inferring metacognition from task performance derives from examples of the following training studies. In a memory training study with the educable retarded Butterfield et al. (1973) compared subjects trained using only a rehearsal strategy to those taught rehearsal plus executive type processes. Students taught when to sequence rehearsal strategies, how to combine acquisition and retrieval strategies, and when to use their memory strategies performed at a high level of recall. This difference was attributed to the metacognitive aspects of the experimental subjects training which stressed when and where to use memory strategies, not just knowledge of the strategies per se. Differential effects of training in

metacognition on reading comprehension has been documented in a series of studies by Palinscar and Brown (1984, 1986, 1988). This research, based on a "reciprocal teaching" approach, encourages a small group of students to ask a series of questions using thinking strategies. Group problem-solving stimulates the participants to predict upcoming story content, question, summarize and clarify text meaning. Data collected on Junior High School students indicated 70% of the experimental students achieved at grade level on criterion-referenced assessment as compared to 19% of the control group who received skill instruction only (Palinscar, 1987). The improvement in reading comprehension was attributed to the enhanced awareness and use of metacognition.

It is interesting to note the paucity of training studies with average and above-average students. Comparisons of direct instruction of metacognition using these populations would add to the investigation of measuring metacognition by the training study method. Extension of teaching studies to areas other than memory and reading research awaits clear delineation of the metacognitive processes essential to the process of problem-solving.

In summary, a review of the literature on the measurement of metacognition points to the centrality of the concept of multi-method assessment. Not only is convergence between multiple measures seen as an important goal but also the

integration of metacognitive measures with other childhood behaviours such as social development, play, reactions to pain, etc. Meichenbaum et al. (1985) make a strong argument for the "integration of metacognitive assessment, in a holistic fashion, into the study of the developing child" (p. 27). Generally, optimism prevails as to the veracity of verbal reports as data, provided the guidelines to minimize the influence of experimenter expectations and demand characteristics of the assessment are followed. Nevertheless, the outcome of metacognitive measures should be interpreted with these limitations in mind and generalizations of the results carried out with caution.

6. Description of the Present Study

In the present study, the development of metacognition was studied in a sample of intellectually gifted and average students at the Grade 3, 6 and 8 levels. Of interest was the relationship between intelligence and metacognition as well as the development of metacognition in each of these ability groups. The issue of devising reliable and valid instruments was also addressed. Two measures were developed, a metacognitive questionnaire (MCQ) and a metacognitive interview (MCI). Observations of metacognitive processes during problem solving completed the assessment. Test/re-test and intra-rater reliability of the instruments were investigated. A separate concurrent validity study assessed the relation between the present study's instruments

and four measures selected from the literature.

Metacognition is now recognized as a global term which may consist of several sub-processes. In this study a distinction was made first between metacognitive knowledge (awareness of metacognitive processes) and metacognitive processing (actual demonstrated use of these skills in problem-solving situations). Next, six sub-processes were identified from existing research to provide a framework within which to refine the concept of metacognition. Selected sub-skills included problem definition, planning, strategy selection, monitoring, flexibility of strategy use, and evaluating. Questions were formulated to elicit responses appropriate to each sub-skill.

The first major hypothesis of the study investigated the role of metacognition as a contributing factor to the construct of intelligence. Sternberg (1981, 1986) has proposed the notion of a triarchic theory of intelligence with the "metacomponents" functioning as the executive or overseer. Theoretically, the intellectually gifted are those individuals who have greater access to and possession of these metacomponents. Therefore the present study further probed the hypothesis that the intellectually gifted in contrast to average students do indeed demonstrate a greater quantity and a higher level of metacognition. In addition, the present research design enabled comparisons to be made between mental age and chronological age matched groups. For

example, bright Grade 3 pupils could be matched with average Grade 6's as both groups have an equivalent mental age (MA) of approximately 11 years. A similar match occurs between intellectually gifted Grade 6's and average Grade 8's (MA = 13 years). A non-significant difference between these students of equivalent mental age could provide evidence that intellectual rather than chronological age is associated with metacognitive development. Although Brown and Barclay (1976) have reported using this methodology within the EMR population, this is the first study to our knowledge using such a design to investigate differences in metacognition between intellectually gifted and average students.

Apart from the investigation of metacognition as a factor in describing intellectual differences, the development of metacognition across age levels is the second major purpose of this study. Researchers suggest metacognition develops in an incremental manner during the childhood years. Yet questions arise as to whether this developmental progression is the same for bright as compared to average students or do bright students advance more quickly with both groups reaching similar levels at an older age. If the notion is valid that metacognition is an important factor in definitions of intelligence, it is expected that the intellectually gifted should outperform the average students at all age levels, even Grade 8 and beyond.

The final hypothesis of this thesis refers to the

example, bright Grade 3 pupils could be matched with average Grade 6's as both groups have an equivalent mental age (MA) of approximately 11 years. A similar match occurs between intellectually gifted Grade 6's and average Grade 8's (MA = 13 years). A non-significant difference between these students of equivalent mental age could provide evidence that intellectual rather than chronological age is associated with metacognitive development. Although Brown and Barclay (1976) have reported using this methodology within the EMR population, this is the first study to our knowledge using such a design to investigate differences in metacognition between intellectually gifted and average students.

Apart from the investigation of metacognition as a factor in describing intellectual differences, the development of metacognition across age levels is the second major purpose of this study. Researchers suggest metacognition develops in an incremental manner during the childhood years. Yet questions arise as to whether this developmental progression is the same for bright as compared to average students or do bright students advance more quickly with both groups reaching similar levels at an older age. If the notion is valid that metacognition is an important factor in definitions of intelligence, it is expected that the intellectually gifted should outperform the average students at all age levels, even Grade 8 and beyond.

The final hypothesis of this thesis refers to the

relationship between metacognition and cognitive functioning. It appears logical to assume that the two factors would be related such that cognitive problem-solving efficiency and metacognitive knowledge/processing would co-vary. The literature, however, is divided with negative findings reported predominately (Cavanaugh & Borkowski, 1980; Yussen, Levin, Berman & Palim, 1979). It is possible that the lack of observed relationship may be due to a failure to separate metacognition into its knowledge and processing dimensions. Cognitive efficiency may be related to the latter aspect of metacognition. That is to say, students may well be able to state examples of metacognitive behaviours but fail to deploy them in problem-solving tasks. This situation has been described by Flavell (1976) as a "production deficiency". The present study allows for the investigation of age and intellectual factors as they affect the relation between cognition and metacognition. In addition, the measurement of metacognitive sub-skills and problem-solving efficiency can also be delineated. It may be that the six sub-processes differentially interact such that planning or monitoring, for example, may explain more of the variance in cognitive functioning than say problem definition or evaluating.

In summary, the main purpose of this present study was to measure metacognition in students varying in ability level and age, in order to examine the importance of

metacognition to "process" notions of intelligence and childhood development. Inclusion of intellectually gifted and average students at the Grade 3, 6 and 8 levels permitted comparisons between students matched for mental age as well as chronological age. A multi-method approach to the measurement of metacognition included a questionnaire devised to measure differences in metacognitive knowledge, observations of metacognitive behaviours during the solving of two problems, and an interview immediately following task completion. Background information included measures of achievement, school motivation and socio-economic level.

METHOD

1. Subjects

One hundred and twenty-two children from the Carleton Board of Education participated in this study. Following acceptance of the research proposal by the Research Advisory Committee of the Carleton Board of Education, the principals of four elementary and three middle schools were contacted to assist in the facilitation of this study in their schools. The schools, selected by Board personnel, were considered similar with respect to economic factors and urban location.

A meeting was held with each principal to review the purpose of the study, types of tests involved, and the subject requirements. Lists of the identified gifted students at the school were provided to the present investigator by the Board's Educational Services (Special Education) Department. Within each school, the intellectually gifted students had been selected previously by school board identification procedures. These intellectually gifted subjects were matched with a group of similarly aged average students.

The sample of 122 students was divided, such that 20 intellectually gifted and 20 average students were selected from grades three, six, and eight respectively. Half the students in each ability and grade grouping were male while half were female. An additional gifted grade three and average grade six student raised the total sample to 122 subjects.

Intellectually gifted children were all selected on the basis of identification procedures mandated by the Carleton Board of Education. The Board followed closely the Ontario Ministry of Education guidelines which defined this exceptionality as an "unusually advanced degree of general intellectual ability which requires programming of a breadth and depth not currently available in the regular classroom." In the Carleton Board students are identified as gifted by an Identification, Placement and Review Committee if they obtain a Full Scale IQ score of 130 or above on the Weschler Intelligence Scale for Children - Revised (Weschler, 1974) or if they obtain scores at the 99th percentile on certain sub-tests of the Canadian Test of Basic Skills (King, 1981) and the Canadian Cognitive Abilities Test (Wright, 1982). Statistical data collected at the Carleton Board (March 1985-June 1987) indicated approximately 5.5% of the student population fell within the "very superior" category based on these criteria, somewhat higher than the expected proportion of 2%. Another finding of interest was the 2 to 1 ratio of males to females within this category. It should also be mentioned that students were seen only for individual intellectual assessment on the WISC-R following parental request or if school screening on group-administered standardized tests revealed a score at or above the 98th percentile. For instance, if students scored at the 98th percentile on any of the CTBS (Reading, Math or Composite

scales) or CCAT (Verbal, Quantitative or Non-Verbal scales) they could be referred for individual testing.

Average students were selected on the basis of recent scores on the CCAT, administered within the past two years by school personnel. To be considered as "average", students' scores had to have been between the 34-68 percentiles (90-110 standard score) on all three scales of the CCAT (Verbal, Quantitative and Non-Verbal). The CCAT, a revised version of the Lorge Thorndike Intelligence Test, is well regarded as a group administered test standardized with Canadian norms and also standardized in conjunction with the CTBS. Data collated at the Carleton Board indicated a moderately high correlation ($r=.66$) between the CCAT Verbal Scale and the WISC-R Full Scale IQ ($p=.05$). Description of the intellectually gifted and average groups on the CCAT and CTBS variables is found in Table 3.

Students with severe emotional problems, language and/or physical handicaps (as per parent/teacher identification) were excluded from the study. Once the students were selected on the basis of the various test scores, letters were sent to their parents informing them of the nature of the study and requesting permission for their child to participate (see copy in Appendix A). Several parents called requesting further details about the study. Parental response to the request for permission to participate in the study was very positive. In the total sample, permission was

Table 3. Standardized Group Test Results by Intellectual Level

Standardized Test	Intellectually Gifted		Average	
	$\bar{X}$	sd	$\bar{X}$	sd
Canadian Cognitive Abilities Test				
Verbal Percentile	93.811	6.03	48.46	12.6
Quantitative Percentile	91.887	11.08	47.84	13.80
Non-Verbal Percentile	92.0	8.99	48.77	13.99
Verbal Standard Score	128.81	8.9	99.46	5.25
Quantitative Standard Score	128.13	11.1	99.15	6.02
Non-Verbal Standard Score	127.64	10.69	99.54	5.96
Canadian Test of Basic Skills				
Reading Percentile	90.79	10.18	52.70	21.41
Math Percentile	92.84	9.85	46.21	17.09
Composite Percentile	95.07	4.76	51.20	15.69

granted for 92.4% of the intellectually gifted students contacted and 82.2% of the average students. Generally, participation rates were slightly higher for the grade three and eight students (93%) as compared to the grade six pupils (76.9%). Among the grade six students, there were some concerns expressed about participating in group testing where they might appear less than competent in the opinion of their peers. Once this concern was dispelled, more students chose to join the study.

Two reasoning tests, the Kemler Hypothesis Formation task and the Pattern-matching task, were selected to serve as stimulus tasks to elicit, and consequently measure, both cognitive and metacognitive processing. Although these two tasks are essentially nonverbal in presentation, they were selected to differ on a level of difficulty dimension.

Metacognitive processing was evaluated by a series of questions given at the completion of each cognitive task, referred to as the Metacognitive Interview (MCI). A Metacognitive Questionnaire (MCQ) and observations of metacognitive behaviours during problem solving completed the assessment battery. A description of each instrument follows.

2. Cognitive Measures

A) Kemler Hypothesis Formation Task (Kemler)

The Kemler is considered to be a thinking task which is unique in allowing for the observation of problem-solving processes in young children. The task is so structured that the thought patterns of children can be inferred from the choices (hypotheses) they make as to which of a set of attributes is common to a series of figures. Detailed information as to the materials, instructions and scoring procedures is contained in Appendix B.

The decision to use the Kemler for the purposes of the present study was based on a number of considerations. First, research using this task has been effective in demonstrating developmental changes in the use of goal-directed strategies in a wide range of elementary-aged children. For instance, Kemler (1978) in a series of experiments reported quantitative and qualitative differences in the ability of children between the ages of 7 and 10 to formulate hypotheses. Second, evidence for differences in performance on the Kemler task among students of varied ability has also been cited. Ferguson (1985) reported strategic problem-solving behaviour as significantly greater among average as compared to learning disabled students at both the grade three and grade five level on the Kemler task. Finally, observations during a preparatory pilot study revealed the Kemler test was interesting to children from the

grade three to grade eight level and provided several levels of challenge that made it motivating for both intellectually gifted and average students.

Test stimuli, presented in a story/game context, required the child to decide which items of clothing, jewelry or headwear identified an identical twin. Prior to starting the task, students were told the twins, named Amy and Betty, changed their clothing to confuse their classmates but they always kept one item constant. The purpose of the game then was to deduce this "secret" item. Laminated cards, consisting of a drawing of a girl's upper torso, were presented in pairs. Students were asked to identify one of the twins (Amy) by choosing the attribute which remained constant. Feedback was given after each presentation as to which of the twins was Amy, but no feedback as to the correctness of the item choice. Therefore, the only way to successfully solve this problem was to employ a reasoning strategy involving the formation and elimination of hypotheses in response to evaluating feedback. If random choices were used, the problem remained unsolved.

The Kemler task comprised three separate trials namely a 1) three attribute, (2) five attribute, and (3) eight attribute problem, respectively. Clothing choices altered were hats, glasses, hair ribbons, belts, necklaces, waist bands, balloons and jackets. Each of these eight attributes appeared in one of two forms (a) crown or party hat, (b)

sunglasses or clear glasses, (c) brown or purple hair ribbons, (d) buckle or bow, (e) beaded necklace or medallion, (f) watch or bracelet, (g) round or elongated balloon, (h) striped or dotted jacket.

Two measures formed the basis for the analysis of the Kemler task: Problem Solving Efficiency and Response Type. Adaptations of the Kemler scoring system were developed so that each move made by the student was rated as either a focussing, gambling or a non-informative hypothesis choice.

In the present study, a focussing response was defined as an appropriate choice which successively eliminated alternatives without repetition. A gambling response, described as the choice of the correct twin but wrong attribute was not as efficient as a focussing response. A non-informative response reflected a choice which had already been made previously and should have been eliminated on the basis of examiner feedback or was an obviously random choice ignoring feedback from the preceding trial. Identification of these three types of response choice was preliminary to the development of an overall index of problem solving ability. The Problem-Solving Efficiency score was calculated for each problem as the ratio of Number of Focussing Responses/Total Number of Responses. Each problem was also coded dichotomously as correctly solved or not solved. Therefore the frequency of successful problem solutions on the three, five and eight attribute problems could be

analyzed across grade and ability levels.

Stability of these Kemler measures over time was assessed on a sub-sample of ten students retested after an interval of about two and a half months. The test-retest reliability coefficients were significant for some but not all aspects of problem solving on the Kemler. For instance, measures of the number of focussing responses were stable for the Five and Eight Attribute problem respectively ($r = .55$, $p < .05$; $r = .60$, $p < .03$). It may be that experience with the Kemler, maturation over the intervening time period, or small re-test sample affected re-test reliability patterns.

B) Pattern-matching Task

In contrast to the Kemler task, the Pattern-matching Test can be described as a relatively easy task for school-aged children. Hence, this task allows the elimination of the variable of differential performance due to differences in knowledge levels. It also allows for the investigation of metacognitive functioning in a simple as compared to a difficult problem-solving situation. This task, initially devised by Neimark and Lewis (1967) to research the development of logical problem solving during childhood, was subsequently used to study the interaction of conceptual tempo and problem-solving abilities (Cameron, 1976). Essentially this task requires the child to determine which of a choice of eight patterns is hidden behind the box, by opening a set of 8 windows one at a time. A detailed

description of the materials, instructions and scoring procedures is contained in Appendix C.

The Pattern-matching Task was selected for the present study for several reasons. First it is a task which is nonverbal in stimulus presentation and response, hence eliminates the variable of differing language abilities. Second, this task has already been employed in a study of metacognition and conceptual tempo among average students at the Grades 4 and 6 level, allowing for direct comparison between the present study and past research (Stober, 1983). Replication studies are a cited need in the relatively recent area of metacognitive research (Borkowski, 1985; Meichenbaum et al., 1985).

The Pattern-matching task consists of a board with eight holes created by small hinged doors and positioned in a circular fashion. The card with the correct pattern choice is placed in a slot at the top of the box, hidden from the student's view. File cards with eight possible pattern combinations, including the correct one, are laid on a table in front of the child for their perusal. Behind each hole on the Pattern board is either a black or white dot. The child's task is to determine which of the eight possible patterns lies behind the movable shutters. Each choice the child makes eliminates possible solutions. For instance if upon opening the top middle door the child finds a black dot, then this would eliminate all the file cards with a white dot

in the middle position from further consideration.

Instructions to the student state that they are to find the answer by opening as few doors as possible.

All children were given four practise problems with four pattern choices. Then the 4 test items consisting of problems with 8 pattern choices were administered. Testing continued until the student either solved 2 consecutive problems without error or made mistakes on 2 consecutive problems. Throughout the testing process, it was essential that the child make use of feedback and logical analysis in order to reduce the alternatives in a systematic fashion to arrive most efficiently at the correct answer. It is similar in concept to the response narrowing inherent in games such as Twenty Questions.

The dependent variables derived from the Pattern-matching task were overall problem-solving efficiency and response type. Student responses were averaged across the four test items administered to all students. Practise questions and supplementary items administered to reach the test ceiling were not used in these averaged scores.

Problem-solving Efficiency was calculated according to a formula developed by McKinney (1975). A copy of the scoring system is available in Appendix C. Each move made by the child was evaluated as either a focussing, gambling or non-informative response. A focussing response is highly efficient in that it eliminates half the pattern choices in a

single response. In contrast, a gambling response removes either one of eight or one of four choices. A non-informative response occurs when the child's choice eliminates no alternatives. A focussing response which provides the maximum information is scored as providing 1.0 bits of information, a gambling response .5, bits of information and a non-informative response 0.0 bits of information. The expected information value of each response is thus calculated and averaged across each problem by dividing the expected information score by the number of responses made by the child to solve the problem.

3. Metacognitive Measures

Measurement issues in research on metacognition have presented considerable challenge to researchers. Reliance on verbal self-reports has limited the measurement techniques available. As always the discrepancy between what a person says and what they ultimately do has to be acknowledged in research of this type. Consequently a multi-method measurement approach was preferred for the present study. The measurement of metacognition proceeded with three techniques: 1) the measurement of metacognition through an interview immediately following task completion (MCI); 2) a questionnaire designed to assess general knowledge of metacognition (MCQ); and 3) inferences of metacognitive processing from behaviour (observed) during task performance (MCOs). Across the three measures, the metacognitive

sub-processes selected for measurement remained the same, namely: Problem definition, Planning, Strategy Selection, Monitoring, Flexibility of Strategy Use and Evaluating. As there is presently no standardized test of metacognition available, it was necessary to devise questions and/or synthesize examples from research studies in the field.

A) Metacognitive Interview (MCI)

The MCI was designed to assess students' awareness of their metacognitive processes immediately following the completion of a problem-solving task. A copy of the MCI is presented in Appendix D. In contrast to measures that assessed metacognition by questioning during a task, this technique was considered to be more conducive to reflection regarding strategies. The questions that were formulated were open-ended and non-directive in order to elicit maximum responsiveness and a minimum of response bias from the students.

A number of the questions were similar to those used by Stober (1984) and Cameron (1976) from separate studies on conceptual tempo and metacognition. Unique to this study, however, were questions pertaining to the Flexibility of Strategy use and the Evaluation component of metacognition. As mentioned earlier, the timing of the MCI interview, immediately after task completion, was essentially different from the Stober and Cameron studies in which the students were questioned at pre-determined points during the

problem-solving process.

The MCI begins with an open-ended question used to stimulate the child's relatively spontaneous verbalization of his/her thinking processes. This first general question, pertaining to how the child would explain the task to another student, seeks to assess the child's metacognitive awareness of Problem definition, Planning and Strategy selection. Two supplementary questions designed to probe further the student's response follow. An additional four questions which are more specific and directive in wording assess the metacognitive processes of Monitoring, Flexibility of Strategy Use and Evaluating. Question 6 is administered only after both cognitive tasks are completed as it pertains to noting the differences between the two tasks.

During the interview, the cognitive test items remained in view and could be manipulated or referred to by the child if such aids were required to prompt their responses. Supplementary probe questions were kept to a minimum in order to ensure standardized administration across subjects. Questions were administered orally and responses recorded verbatim by the examiner. Tape recording of the proceedings were also available for verification of the examiner's written notes. If a child expressed discomfort with the presence of a tape recorder, this procedure was suspended.

According to a recent review of metacognitive assessment, Meichelbaum (1985) recommended not only multiple methods to

assess metacognition but also that more attention be given to differentiation of the metacognitive processes. Therefore a grid scoring system was developed for the MCI. A description of the scoring manual for the MCI is found in Appendix E. First, questions were scored according to one of the six metacognitive categories. For each question a further refinement of the scoring system was used to assess the dimensions of Clarity, Specificity, Reflectivity, Organization and Conceptualization. Responses were scored on a scale from 0 to 2, indicating a minimal, average or superior answer.

In order to develop the MCI and its scoring system, a pilot study was conducted to evaluate the suitability of the questions across the age and ability groupings of the present study. Several of the questions were re-worded and ambiguous items removed to refine the instrument. The scoring system was constructed and refined by three researchers independently scoring ten MCI protocols. The resolution of scoring discrepancies lead to alterations in the wording of several categories. The investigator then scored all 122 protocols twice resolving any discrepancies in the scoring. Despite the subjective nature of the scoring system, reliability measures were notably high. Intra-rater reliability of the scoring system was evaluated after a two-month interval on a randomly selected sample of twenty-four students. Agreement co-efficients were

calculated for each of the six metacognitive categories and total MCI score by using the following formula:

$$\frac{\text{number of agreements}}{\text{total number of agreements plus disagreements}} \times 100$$

Agreement was defined as the identical score given to the same student in the same category. On the MCI scoring system there were 53 categories. Scores were either 0, 1 or 2 points. In the present study, intra-rater reliability scores for the total MCI scores was 80% after the Kemler and 83% after the Pattern-matching test. Agreement on the six metacognitive categories ranged from 72% to 94% with highest agreement noted on Strategy Selection, Flexibility of Strategy Use and Evaluating categories. These results are depicted in Table 4.

Second, test-retest reliability after a mean period of 2.7 months (N=10) revealed a significant correlation on total scores of the MCI ($r=.63$, $p < .04$) and the MCI following the Kemler ($r=.55$, $p < .05$) and Pattern Matching tasks ($r=.611$, $p < .04$) respectively.. Calculations of the test-retest correlations on the total scores of the six sub-processes are produced on Table 5. In summary, both test-retest reliability of the MCI and intra-rater reliability of the scoring system were considered within acceptable limits.

B) Metacognitive Questionnaire (MCQ)

Several researchers have emphasized the need to distinguish between a student's prior metacognitive knowledge and the

Table 4. Intra-rater Reliability on Metacognitive Interview (N=24)

<p style="text-align: center;">Agreement Coefficients on Metacognitive Interview following</p>		
Metacognitive Sub-Processes	Kemler Task	Pattern-Matching Task
Problem Definition	72%	83%
Planning	80	78
Strategy Selection	72	85
Monitoring	77	77
Flexibility	92	88
Evaluating	92	94
Total	80	83

Table 5. Test-Retest Reliability Scores on Metacognitive Interview (N=10)

Metacognitive Sub-Processes	Metacognitive Interview following	
	Kemler Task	Pattern-Matching Task
Problem Definition	.70**	.58*
Planning	ns	.57*
Strategy Selection	.59*	.87***
Flexibility	ns	ns
Monitoring	ns	.66*
Evaluation	.55*	.87***
Total	.55*	.61*

*p < .05, **p < .01, ***p < .001.

application of that knowledge in real life problem-solving situations (Borkowski, 1985; Slife, Weiss, & Bell, 1985). Consequently, a questionnaire was designed with the goal of measuring children's stated prior knowledge of the six key metacognitive processes selected for the study in this research project. A copy of the MCQ is reproduced in Appendix F.

Although a number of researchers have reported using a questionnaire format to assess metacognition (Borkowski & Cavanaugh, 1985; Paris & Landauer, 1982; Stober, 1983), the present design is unique in several respects. First, two rather different problem-solving situations were chosen to elicit evidence of metacognition. These involved practical problem-solving experiences of 1) how to find one's way home when abandoned at a shopping centre and 2) how to study for a math exam when one has left the books at school. The children found these questions relevant and meaningful with considerable discussion and strategy generation ensuing as a result. Comparison of problem-solving in a more social as compared to academic situation was afforded by these two questions. The second unusual aspect of this questionnaire was the complexity of the design. In addition to the two open-ended questions referred to above, the MCQ has a section of fifteen short-answer questions and a series of fifteen true/false queries. The dichotomy of social/academic questioning was continued throughout the questionnaire.

Therefore, metacognition was assessed by three different styles of questioning across social and academic problem-solving settings.

In the development of the MCQ, a pilot study ($N = 16$) resulted in alterations in the administration order of the three sub-sections and some rewording of the questions. The questions also were sorted by four independent raters into the six metacognitive process categories. Only those items with 75% agreement or more were retained for analysis. It was also apparent from the pilot study that the MCQ could be self-administered by the students except for some of the younger children whose written expressive skills were less well-developed. Ultimately, the examiner only recorded the answers of eighteen grade 3 pupils. A t-test of administration type and MCQ responses revealed no significant differences between self- or examiner-administered test scores of either the individual sub-sections or total questionnaire ($F=2.45$, $p < .09$) among these grade 3 students ($N=29$).

The scoring system of the MCQ was devised for each of the three sub-sections to reflect both quantitative and qualitative levels of responding. A description of the scoring system is found in Appendix G.

On Section A, the two open-ended questions, student responses were first scored for the number of strategies generated and for the presence or absence of the six

hypothesized metacognitive processes. Then the degree of sophistication of the answers reflecting each of the six metacognitive processes was evaluated according to a four point rating system from no evidence (1 point), minimal (2 point), average (3 point) to superior (4 point) responses. The short answer questions of Section B were scored according to the same four point rating system. Section C, the True/False questions were justified so that a response could be coded either positive or negative. Scores were tabulated for each question then summed across the three sections for a total score for each metacognitive process.

The issue of reliability was addressed in two ways. First, the intra-rater reliability of the scoring system of the MCQ was assessed after a two month time interval. Agreement coefficients were calculated on a randomly selected sample of 24 study participants. Agreement was defined as the identical score given to the same student on the same question for that scoring category. A formula of

$$\frac{\text{Number of agreements}}{\text{Total number of agreements plus disagreements}} \times 100$$

was used to calculate the percentage of agreement. Overall intra-rater agreement on the MCQ was 84% with agreement ranging from 68% to 96% across the six metcognitive sub-processes. Agreement on scoring was especially high for the problem definition and evaluation categories, 96% and 92% respectively. The intra-rater agreement coefficients for the

MCQ are displayed in Table 6.

Second, test-retest reliability information was available only on five subjects. Agreement coefficients were calculated on MCQ scores obtained at time 1 and time 2. Agreement was defined as the identical score given to the same student on the same question for that scoring category. A total of 54 categories were available for scoring on the MCQ. The agreement coefficients on the total MCQ test scores averaged 65%. As this is a rather small sample of only grade 6 students, results should be considered inconclusive awaiting further investigation.

C) Metacognitive Observations/Cognitive Tasks

The third category of metacognitive measures was based on observations of metacognition inferred from behaviours occurring during the cognitive tasks. In addition, the Kemler and Pattern-matching tasks both allowed for adaptations in which several processes of metacognition could be inferred from student responses.

Mixed Kemler. Markman's (1977) work provided the inspiration for the modifications to the Kemler task titled the "Mixed Kemler" in this study. In Markman's research, students were given incorrect instructions about how to do a magic trick. The number of probe questions required before the children realized they did not possess sufficient information to complete the task constituted a measure of

**Table 6. Intra-rater Reliability on Metacognitive
Questionnaire (N=24)**

<u>Metacognitive Sub-Process</u>	<u>Agreement Coefficient on Metacognitive Questionnaire</u>
Problem Definition	96%
Planning	68
Strategy Selection	85
Monitoring	83
Flexibility of Strategy Use	76
Evaluating	92
Total	84%

metacognitive awareness and the ability to monitor one's performance. In the present study, the four-attribute Kemler problem, consisting of 14 trials, was re-administered at the end of the testing period. This time, however, the order of the "secret" item was completely random. Therefore there could be no possible correct solution to the problem. Students were queried as to their experiences with this particular problem and if they had any comments they wished to make. Metacognitive awareness of Problem Definition, Monitoring and Evaluation were evaluated by the student answers to this "Mixed Kemler" problem. Appendix H contains a copy of the test and the scoring system.

Although some students were perplexed by the changes inherent in the Mixed Kemler task, none of the students appeared unduly concerned with not being able to solve the problem. All students were debriefed at the end that this was a particularly difficult item which very few children could solve.

Pattern-matching Task: Self Correction. The design of the Pattern-matching task also allowed the direct measurement of metacognition through the analysis of student behaviour during problem-solving. Several authors have described the importance of self-corrections as indicators of metacognitive awareness (Wong, 1982; Davidson & Sternberg, 1984). Two slightly different types of

2

"self-corrections" were delineated in this study, namely spontaneous self-corrections and self-corrections following errors.

During the preparation phase of this project, it became apparent that a number of children made corrections on their own initiative just prior to presenting their final solution. These corrective behaviors were labelled spontaneous self-corrections. On the other hand, a number of subjects completed their problem choice but then made a correction when the examiner asked if that was the solution. Corrections made at this stage were termed self-corrections, as compared to spontaneous self-corrections. Both types of student corrections were considered to be indicative of the metacognitive process of monitoring.

Pattern-matching Task: Error Patterns. Observation of error patterns also provided an additional measure of a student's monitoring skills during problem solving. On the Pattern-matching task, two types of errors were prevalent: omitted eliminations and incorrect eliminations. A student who neglected to turn over one of the eight cards which should have been eliminated by his/her window choice, made an omitted elimination. On the other hand, if the student turned over a card that should not have been eliminated based on the window choice, this constituted an incorrect elimination. According to previous research by Stober (1983), error rate was considered a measure of the metacognitive process of monitoring.

4. Background Information

The Ontario School Record (OSR) of each student was reviewed and details of standardized test results and effort/motivation were noted, the latter from the student's most recent report card. Motivation/effort was rated as either Excellent (1), Average (2), or Below Average (3).

Sociodemographic data on parental occupational and/or educational levels was either elicited from conversations with the student, parent or frequently from the developmental history form available in the OSR. This information, obtained on 45% of the sample was analyzed according to a six level socioeconomic index for occupations in Canada developed by Blishen and McRoberts (1976).

In summary, the dependent measures used for the present study fall into two categories; Cognitive and Metacognitive. Consistent across both the Kemler and Pattern-matching cognitive tasks was a problem solving efficiency measure and measures of focussing, gambling and non-informative responses. Similarly the Metacognitive Interview and Metacognitive Questionnaire were designed to allow a comparative analysis of the six metacognitive sub-processes. Observations of Metacognitive behaviours concluded the assessment. Background information was also collected to investigate the relation of variables such as sex, socio-economic status and motivation on metacognitive functioning.

Reliability information collected on the individual test measures has already been reported in the general descriptions of each test. Validity measures, however, are described in a separate section which follows. The section ends with a description of the study procedures.

5. Validity Study

One of the important issues in metacognitive research is the development of valid instruments. Without adequate measures it is difficult to assess whether inconclusive results are due to inadequate measurement devices or incorrectness of the construct (Cavanaugh & Borkowski, 1980). Consequently in the present study, validity was assessed first by investigating correlations between the six metacognitive processes of the interview (MCI) and questionnaire (MCQ).

Also, a separate validity study was conducted on a subset of 23 students randomly chosen from the present research. The sample consisted of four children from each grade and ability grouping with the exception of the grade 3 Average group which had three students. The validity study was designed as follows.

Four established measures of metacognition were selected from a review of the available literature. The degree of relationship between these measures and the two instruments developed for the present study was considered

to provide possible evidence of construct validity. Established measures were chosen from studies that reflected a particular metacognitive process. All validity measures were administered individually within a mean time interval of 1.7 months from the initial study. Instructions and examples of these four measures are available in Appendix I.

6. Procedures

A) Pilot Study

Preliminary testing of the two problem-solving instruments, the metacognitive interview and metacognitive knowledge questionnaire was conducted on twelve grade 9 students (four gifted, eight average) and four students (two gifted, two average) at grade 6 and grade 3 levels respectively. This pilot testing in January 1987 permitted refinement in the wording of questions and the number of test items to be administered. Most importantly, the tasks chosen for the study were found to be appropriate for both gifted and average students at the grade levels selected and group administration of the metacognitive questionnaire was found to work well for the older students.

B) Current Study

School records were examined initially to select subjects in the gifted or average ability groupings. Letters were then sent to the chosen families. Upon

receipt of signed parental consent, arrangements were made with the school principal to assess each child.

Children were tested on two separate occasions. One session consisted of the Pattern-matching and Kemler cognitive tasks administered individually to each participant. During this session, the metacognitive interview (MCI) was given twice, once at the termination of each cognitive task. Students responded orally to the interview questions and all answers taperecorded and recorded verbatim by the examiner. The duration of this assessment session varied for each individual depending on their verbosity and ability, but averaged about 1.5 hours per child. The order of cognitive task presentation (Pattern-matching/Kemler) was counterbalanced to control for possible practise effects in task completion and in responding to the MCI.

The other session consisted of administration of the Metacognitive Knowledge Questionnaire (MCQ). Total time to complete the MCQ was approximately one hour, whether given in a small group or on an individual basis. Personality tests were also administered by Baxt-Kreisman as part of an independent doctoral study investigating metacognition and personality functioning. The order of the two sessions was counterbalanced across grade and ability groupings. That is to say, half the students were administered the questionnaire first followed by the cognitive tasks/

metacognitive interview, the other half reversed the order. The inter-session interval averaged 1.7 months

The entire sample was tested by two experienced examiners. This investigator tested all the children on the two cognitive tasks and metacognitive interview (N=122). The other examiner (S. Baxt-Kreisman) administered the Metacognitive Knowledge Questionnaire (MCQ) and personality tests to 106 children. Originally it was expected to test all children on the MCQ, however, absenteeism, re-location and other factors resulted in a reduction of 13 percent of the sample. Assessments of the children were conducted between February and September 1987.

7. Statistical Procedures

Data were analyzed using group comparisons based on a factorial model between-subjects design. Two groups, intellectually gifted and average subjects, were compared on metacognitive and cognitive dependent measures at three grade levels (Grades 3, 6 and 8). An overview of the experimental variables is provided in Table 8.

Multivariate analysis was selected in order to take into account the intercorrelations among the dependent

Table 7. Data Collection Procedures

<u>Session 1</u>	<u>Session 2</u>
Kemler Hypothesis Formation Task	Metacognitive Knowledge Questionnaire
Metacognitive Interview	Personality Tests
Pattern-Matching Task	
Metacognitive Interview	
(Administered by S. Nandi Carleton University)	(Administered by S. Baxt- Kreisman, Carleton University)

Table 8. Overview of Experimental Variables

Independent Variables			
<u>Intelligence</u>	<u>Grade Level</u>	<u>Sex</u>	<u>Task Type</u>
Gifted	3	Male	Easy
Average	6	Female	Difficult
	8		

Dependent Variables	
<u>Cognitive Tasks</u>	<u>Metacognitive Measures</u>
Kemler Hypothesis Formation	Questionnaire
Pattern-matching Task	Interview
	Observations
<u>Cognitive Variables</u>	<u>Metacognitive Subprocesses</u>
Task Efficiency	Problem Definition
Focussing	Planning
Gambling	Strategy Selection
Non-Informative	Monitoring
	Flexibility of Strategy Use
	Evaluating

variables, especially the metacognitive sub-processes as measured on the interview and questionnaire protocols. Another reason to use multivariate procedures was to minimize the possibility of Type I error that can be increased by multiple univariate analyses. Prior to multivariate analyses, however, the data was examined by computing descriptive statistics. Through this process, coding accuracy was checked, missing data investigated, outliers identified and normality of distributions verified. Further assumptions of multivariate analysis, namely homogeneity of variance/covariance matrices also were examined.

Missing data was not an issue for data collected on the Metacognitive Interview and cognitive measures. All but one subject had complete results, representing a loss of only .02% of the total sample. On the Questionnaire, however, only 106/122 students were tested due to a variety of administrative problems (attrition, school closing). It was decided not to use procedures such as recoding missing values with mean scores given that the MCQ was a new instrument. Therefore in order to limit a further reduction in sample size by listwise deletion, questions that either were not completed by a large proportion of the subjects or which were ambiguous in scoring were removed from the analysis of the Questionnaire data. Ultimately 87 completed protocols were available for analysis. Analysis

of the pattern of missing data indicated no significant differences between experimental groups.

Examination of univariate outliers identified less than 2% of the sample had standard score values of $2 \geq 3.0$. Since approximately 2% of the subjects in a normal distribution would be expected at the extremes, it was decided to retain these cases. Homogeneity of variance/covariance, a further assumption of multivariate statistics, was examined using Box's M test. In the present study, if Box's M indicated a significant result, the multivariate analysis was computed again without the offending variable. In these instances, if the results were not altered, it was considered appropriate to report the original findings. It should be noted that the Box M test is considered a highly conservative test of homogeneity of the variance/covariance matrix. However, to be more confident of the findings, it was decided to use Pillai's Criterion as the preferred test of statistical significance rather than Wilks Lambda or Hotelling's Trace. Pillai's test has several advantages in that it is considered to be more robust to decreased sample size, unequal n's and violations to the assumption of homogeneous variance/covariance matrices (Tabachnick & Fidell, 1983, p. 249).

Once the assumptions for multivariate analysis were verified, SPSSX MANOVA was used to investigate whether differences were significant between intellectual and grade

levels on each of the metacognitive and cognitive measures considered separately. If significant group differences were obtained, Discriminant Analysis (DA) was then conducted to examine the dimensions along which the two ability groups differed. A decision to use both MANOVA and DA was based on arguments by Pedhauzer (1982) that significant MANOVA results be followed by DA, in lieu of multiple group comparisons, in order to establish the variables that contribute most to the differences between the groups. Pedhauzer (1982) cites difficulties in interpreting group comparisons on multivariate statistics and suggests DA as a more appropriate technique to obtain this information. A second reason is based on the argument put forth by Tabachnick and Fidell (1983) that although MANOVA and DA are similar procedures mathematically, these analyses differ in emphasis and the type of questions that can be addressed. Whereas MANOVA indicates whether the differences between groups produces reliable changes in the means of the dependent variables, DA is designed to answer queries about predictability of group membership, and the adequacy of group classification based on the dependent variables selected.

Chi square analyses were also computed as it could be argued that the data generated by the scoring system of the Metacognitive Interview and Questionnaire could be considered ordinal rather than interval data. In essence

the Chi square results were similar to Multivariate analysis findings but it is important not to assume such data can be analyzed by parametric statistics.

Intellectual and grade differences were further investigated using an experimental design which permitted mental age as well as chronological age comparisons. Backman, Mameh, and Ferguson (1984) used a similar experimental format to investigate individual differences in students matched for reading level versus chronological age. A model of this design is found in Table 9. This format allowed for the comparison of two groups matched for mental age. In the present study, for instance, Grade 3 intellectually gifted and Grade 6 average students could be considered to have approximate mental age matches (M.A. = 11 years) as could Grade 6 intellectually gifted and Grade 8 average students (M.A. = 13 years). Examination of CA and MA matches may permit insight into the role of cognitive level (as assessed by intelligence test scores) versus maturation/schooling (as measured by grade level) in the development of metacognition. Conversely, we may also learn which variables are involved in producing superior IQ scores at a given age level. This matched mental age design could be considered a substitute for techniques such as Analysis of Covariance in which age differences would be investigated while controlling for the effect of intelligence. Pedhauzer (1982) argues that using IQ as a

Table 9. Research Design: Mental Age Matched Groups

<u>Chronological</u>	<u>Mental Age Average</u>	<u>Mental Age Intellectually Gifted</u>
		1
Grade 3 8 years	8 years	11 years
Grade 6 11 years	11 years	13 years ²
Grade 8 13 years	13 years	17 years

<u>Mental Age Matched Groups</u>	<u>Mental Age*</u>	
	<u>Mean</u>	<u>Standard Deviation</u>
1 Grade 3 Gifted	11.09	.90
Grade 6 Average	11.46	.72
2 Grade 6 Gifted	13.82	1.31
Grade 8 Average	13.33	1.17

*Mental age calculation based on formula by Sattler (1988, p. 21):

$$MA = (IQ \times CA)/100$$

co-variate in ANOVA analysis can lead to serious interpretational problems. Statistically equating intact groups especially on a variable such as IQ fails to allow for the possibility of other variables which may also be correlated with intelligence. Therefore use of a matched mental age design was considered to be a preferred alternative in investigating the role of intelligence in the development of metacognition.

Once the metacognitive and cognitive data were analyzed separately, the relation between these two measures was examined by correlation analyses. Multiple Regression analyses using SPSSX Regression were computed to evaluate the effect of other variables such as SES and motivation on metacognitive functioning. Gender differences were analyzed by MANOVA, using sex as an independent variable.

The analysis concluded with an examination of the metacognitive instruments from the perspective of validity. Principal components factor analysis (Varimax rotation) was used to assess the relation between the metacognitive sub-processes from the MCI and MCQ data. In addition, four exemplary metacognitive tasks were selected from the literature and correlation analysis used to examine the relation with the metacognitive instruments developed for the current study.

RESULTS

Intellectually gifted and average children were compared on metacognitive and cognitive measures at the grade 3, 6 and 8 level. Sex and task type (easy/difficult) were additional independent variables. Multivariate analyses were conducted on each of the metacognitive measures separately, followed by Discriminant Analysis to determine which of the metacognitive sub-processes differentiated the intellectual groups. Further analyses using a Matched mental age design assisted in identifying which aspects of metacognition were related to cognitive level from those dependent on maturation, or chronological age.

The problem-solving measures were then analyzed for intellectual and grade level differences, with a summary analysis examining the relation between cognitive and metacognitive functioning. Multiple regression was used to examine the effect of additional variables such as socioeconomic status and motivation on metacognition. Finally, the validity of the metacognitive instruments designed for the present study was examined by procedures such as factor analysis and correlation analyses. Therefore, the Results section is ordered as follows:

1. Analysis of Metacognitive Measures
2. Comparison of Mental Age Matched Groups
3. Analysis of Cognitive Measures

4. Analysis of Cognitive/Metacognitive Correlations
5. Additional Variables
6. Analysis of Validity/Metacognitive Measures

1. Analysis of Metacognitive Measures

Three types of measures were used to assess metacognitive functioning. First, an interview (MCI) was administered after each problem-solving task to obtain the subject's immediate recall of metacognitive processes. Second, a questionnaire (MCQ) was used to quantify a student's global knowledge of metacognition on a series of questions relating to practical as well as academic situations. Dependent measures of both the Interview (MCI) and Questionnaire (MCQ) included a composite score and scores on each of six metacognitive sub-processes namely: Problem definition, Planning, Strategy selection, Monitoring, Flexibility of strategy use and Evaluating. The third measure consisted of several observations of metacognition (MCOs) obtained by examining the children's responses to a distorted presentation of the Kemler task (Mixed Kemler). Further observations of metacognitive behaviors were afforded by recording the incidence of self-correcting behaviours and analysis of the type of errors committed on the Pattern-matching task.

The Interview, Questionnaire, and Observation data are each presented separately. For each measure, the composite

score findings are described first, followed by the results of the metacognitive sub-process scores. Within each section a discussion of intellectual differences precedes grade level findings.

A) Metacognitive Interview (MCI)

Several issues had to be resolved prior to analyzing the MCI results. It was necessary first to verify whether the counterbalanced administration of the cognitive tasks and accompanying MCI had been effective in eliminating possible order effects. The MCI was administered twice to each subject, once after the Pattern-matching task and again after the Kemler (KMF). Therefore, in order to counterbalance the design, the order of the cognitive tasks and accompanying interview were randomly assigned such that half the subjects within each grade and ability grouping were given the Kemler task plus interview first followed by the Pattern-matching task plus interview. The other half were given the Pattern-matching task first, followed by the Kemler. Separate ANOVAs computed on the order of administration revealed no order effects on the MCI scores given after the Kemler ($F = 0.5, p > .82$) or Pattern-matching task ($F = 2.9, p > .09$). The second issue concerned the relation between the two interviews and whether the analysis should be conducted for each interview separately or whether the results from both interviews could be combined. A summary by intellectual level and

grade of the MCI mean scores following the Kemler and Pattern-matching tasks respectively is found in Table 10. As it had been predicted that metacognition would vary depending on the difficulty level of the cognitive task, it was expected the MCI scores would be higher after the Kemler, the more difficult of the two tasks. In fact, the mean score differences between the two MCIs were relatively small ranging from one to five points depending on the grade level, except for the Grade 8 gifted students. Overall the mean score differences were slightly larger for the intellectually gifted students ($\bar{x}$ difference = 7.34) when compared to the average pupils ($\bar{x}$ difference = 1.55). However, the direction of the scores was not compatible with the premise of the Kemler being a harder task. The findings indicated the Pattern-matching task, supposedly an easier set of problems, resulted in higher scores on the MCI. Strong correlations between the MCI scores on the two interviews ($r = .70$, $p < .000$) further supported the feasibility of amalgamating the scores. A summary of the Pearson Product correlations for the composite and the sub-process scores of the MCI given after the Kemler and Pattern-matching tasks is found in Table 11. After consideration of these findings, a single set of variables was created combining the results of both interviews. A summary by intellectual level and grade of the combined MCI scores is found in Appendix J.

**Table 10. Comparison of MCI Composite Scores Following the
Kemler and Pattern-matching Tasks**

Group	MCI (Kemler)	MCI (Pattern-matching)	Mean Score Difference
Average			
Grade 3	15.60	16.95	-1.35
Grade 6	30.62	28.66	1.96
Grade 8	30.30	28.95	-1.35
Intellectually Gifted			
Grade 3	21.14	26.85	5.71
Grade 6	42.30	47.73	-5.43
Grade 8	39.37	50.25	-10.88

Table 11. Pearson Correlation Coefficients for Two Administrations of the MCI on Total Sample

	MCI (After Kemler Task)						
MCI (After Pattern-							
matching Task	1	2	3	4	5	6	7
Problem Definition	.58						
Planning		.60					
Strategy Selection			.51				
Monitoring				.37			
Flexibility of Strategy Use					.31		
Evaluating						.32	
Composite							.70

All correlations were significant at the .01 level.

Composite Score (MCI). One of the primary questions of this research was whether metacognitive functioning differed between intellectually gifted and average children. An ANOVA calculated on the MCI composite score indicated a significant main effect for intellectual level ($F = 67.33$, $d.f. = 1,119$, $p < .00$) and grade ($F = 55.74$, $d.f. = 2,119$, $p < .00$). The intellectual level $\times$ grade interaction was not statistically significant ($F = 2.61$, $d.f. = 2,119$, $p < .078$). These results are presented graphically in Figure 1. Examination of the MCI composite mean scores revealed that at each grade level the intellectually gifted were superior to average students. Grade level effects were also examined within each intellectual group separately. Results indicated that differences in MCI composite scores were significant only between Grades 3 and 6, not Grades 6 and 8. This pattern of findings was consistent for both intellectual groups.

Metacognitive sub-processes (MCI). Given that the gifted excelled in overall metacognitive functioning on the MCI, the dimensions of metacognition were examined to determine whether some metacognitive sub-processes are more critical than others in defining intellectual giftedness. The MCI sub-process scores were analyzed by MANOVA using intellectual level and grade as independent variables. Results are presented in Table 12. A significant main effect was obtained for intellectual level ($F = 14.85$,

Figure 1. Metacognitive Interview composite mean scores by intellectual group and grade

Table 12. Multivariate Analysis of Variance Metacognitive Interview - Metacognitive Sub-processes as Dependent Variables

Effect	F	Significance of F
Intellectual Level	14.85	.00
Grade	7.32	.00
Interaction	1.25	.25

Univariate F tests				
Intellectual Level			Grade	
Effect	F	Sig of F	F	Sig of F
Problem Definition	6.39	.01	1.09	.34
Planning	30.15	.00	40.05	.00
Strategy Selection	52.08	.00	41.88	.00
Monitoring	14.61	.00	6.24	.00
Flexibility of				
Strategy Use	16.24	.00	20.43	.00
Evaluating	.04	.84	6.17	.00

d.f. 1,108

d.f. 2,108

d.f. = 1,108, $p < .00$) and grade ($F = 7.32$, d.f. = 2,108, $p < .00$). The intellectual level $\times$ grade interaction was not significant ($F = 1.25$, d.f. = 2,108, $p > .25$). Univariate F -tests revealed significant intellectual group effects for all the metacognitive sub-processes except for evaluating and significant grade differences except for problem definition.

As a further analysis, a direct discriminant function was performed using the scores on the six metacognitive sub-processes of the MCI as variables predicting membership in the intellectually gifted or average groups. The results are presented in Table 13 and represented graphically in Figure 2. Metacognitive sub-process scores on the MCI when considered jointly accounted for 31.2% of the variance between the intellectual groups. The loading matrix of correlations between predictor variables and the discriminant function (Table 13) suggests that the maximum spread among the two groups is primarily based on the metacognitive processes of strategy selection ($r = .68$) and planning ($r = .51$). Intellectually gifted students were also superior in their descriptions of the use of monitoring ($\bar{x} = 9.53$) and in responses indicating an awareness of the need to be flexible in using alternative strategies ($\bar{x} = 6.53$) than average students ($\bar{x} = 6.7$, $\bar{x} = 3.8$, respectively). Only the sub-skill of evaluation failed to discriminate between intellectual groups. Using the SPSS-X classification procedures for the total sample of 121 students, 73.3% ($N = 69$) were classified

Table 13. Discriminant Function Analysis - Intellectually Gifted vs. Average Students using Six Metacognitive Processes on Metacognitive Interview as Dependent Variables

Predictor Variable	Correlations of Predictor Variables with Discriminant Function	Univariate F(1,83)
Problem Definition	.34	4.43*
Planning	.51	9.75**
Strategy Selection	.68	17.53**
Monitoring	.47	8.40**
Flexibility of Strategy Use	.42	6.54**
Evaluating	.17	1.16
Canonical Correlation	.559	
Eigen value	.455	

* $p < .05$

** $p < .01$

Figure 2. Metacognitive Interview mean scores on the Six Metacognitive Sub-processes by Intellectual Group

correctly. The classification function was somewhat more accurate for the average pupils classifying 80.3% of them correctly compared to 66.1% of the intellectually gifted.

In order to investigate whether there were differences in the use of metacognitive sub-processes between intellectually gifted and average students, depending on their grade level, direct discriminant function analyses were performed for each grade separately. Results are presented in Table 14 and depicted graphically in Figure 3A for the intellectually gifted, Figure 3B for the average students. Scores of the MCI sub-processes accounted for 37.5% of the variance at Grade 3, 64.2% at Grade 6 and 46% at Grade 8.

Table 14 indicates the maximum spread between intellectually gifted and average students was attributed primarily to strategy selection, problem definition and monitoring at Grade 3; strategy selection, planning and flexibility of strategy use at Grade 6; and strategy selection, planning, flexibility of strategy use and monitoring at Grade 8. Notable is the primacy of strategy selection in discriminating between intellectual groups at all grade levels. Planning and flexibility of strategy use also distinguish between intellectual groups at the Grade 6 level suggesting these may be important metacognitive sub-processes developmentally. For example, on the flexibility of strategy use category, mean scores are similar for Grade

Table 14. Discriminant Function Analyses: Intellectually Gifted vs. Average Students by Grade Level Using Six Metacognitive Processes on Metacognitive Interview as Dependent Variables

Predictor Variable	Correlations of Predictor Variables with Discriminant Function		
	Grade 3	Grade 6	Grade 8
Problem Definition	.54	.06	.26
Planning	.26	.39	.55
Strategy Selection	.59	.70	.55
Monitoring	.39	.23	.37
Flexibility of Strategy Use	.02	.37	.37
Evaluating	-.13	-.14	-.14
Canonical Correlation	.612	.801	.678
Eigenvalue	.599	1.79	.852

Figure 3A. Intellectually Gifted Subjects: Metacognitive Interview
Mean Scores on Six Metacognitive Sub-processes

Figure 3B. Average Subjects Metacognitive Interview Mean Scores on Six Metacognitive Sub-processes

3 intellectually gifted and average students ($\bar{x} = 2.10$ and $\bar{x} = 2.20$). A marked increase in flexibility scores is noted for the intellectually gifted students in Grade 6 ($\bar{x} = 9.21$) compared to average pupils ($\bar{x} = 4.38$).

Examination of the classification results revealed the percentage of students correctly classified for intellectual level increased with age from 75.6% at Grade 3 to 82.5% at Grade 6 and 89.7% at Grade 8 respectively. Across grade levels, intellectually gifted students were classified correctly in 71.4%, 84.2%, 84.2% of the cases while the percentages for average students were 80%, 81%, 95%.

Qualitative Scoring System (MCI). Student responses to the Metacognitive Interview were assessed according to a second scoring approach designed to evaluate qualitative aspects of the students' answers. A description of the scoring system is outlined in Appendix E. The five qualitative dimensions include clarity, specificity, reflectivity, organization and conceptualization. A summary of the mean scores and standard deviations of the MCI by intellectual group and grade level are found in Appendix K and presented graphically in Figures 4A, 4B and 4C.

Results of a direct discriminant function analysis using the five qualitative ratings of the MCI as predictors of membership in intellectually gifted and average groups are found in Table 15. These variables considered jointly

Figure 4A. Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 3 Students

Figure 4B. Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 6 Students

Figure 4C. Metacognitive Interview Mean Scores (Qualitative Scoring System) by Intellectual Group - Grade 8 Students

Table 15. Discriminant Function Analysis - Quantitative Scoring System of Metacognitive Interview - Intellectually Gifted vs. Average Students

Predictor Variable	Correlations of Predictor Variables with Discriminant Functions	Univariate F(1,120)
Clarity	.86	37.73*
Specificity	.88	35.66*
Reflectivity	.63	18.32*
Organization	.95	41.30*
Conceptualization	.76	21.15*
Canonical Correlation	.527	
Eigenvalue	.382	

*** p < .000**

accounted for 27.6% of the variance between intellectually gifted and average students. The loading matrix of correlation between predictor variables and the discriminant function, indicate the maximum spread between the two groups is primarily based on organization scores ($r = .95$), specificity ($r = .88$) and clarity ($r = .86$). Examination of developmental differences proceeded by computing direct discriminant function analyses separately at each grade level. These results are presented in Table 16.

At the Grade 3 level, a direct discriminant function analysis of the five qualitative scores of the MCI indicated 49% of the variance between gifted and average students was accounted for by the discriminant function. The loading matrix of correlations between predictor variables and the discriminant function suggest the spread among the two groups is primarily due to the variables of organization ($r = .73$), clarity ($r = .63$), specificity ($r = .61$) and reflectivity ($r = .39$). Of the Grade 3 students in the sample 85.4% were correctly classified broken down to include 90.5% of the Gifted and 80% of the Average students (see Table 16).

Similar results were found at the Grade 6 and Grade 8 level with conceptualization now also functioning as a discriminator between intellectually gifted and average students. The conceptualization mean score difference

Table 16. Classification results of Discriminant Analysis of Qualitative analysis measures of MCI

Actual Group	Average			Predicted Group	
	N	N	%	Intellectually Gifted	%
Grade 3					
Average	20	16	80	4	20
Intellectually Gifted	21	2	9.5	19	90.5

Total percent of cases correctly classified = 85.37%

Grade 6

Average	21	19	90.5	2	9.5
Intellectually Gifted	20	2	10	18	90

Total percent of cases correctly classified = 90.24%

Grade 8

Average	20	18	90	2	10
Intellectually Gifted	20	4	20	16	80

Total percent of cases correctly classified = 85%

Predictor Variable	Correlation of Predictor Variables with Discriminant Function		
	Grade 3	Grade 6	Grade 8
Clarity	.63	.71	.94
Specificity	.61	.69	.74
Reflectivity	.39	.50	.59
Organization	.73	.87	.92
Conceptualization	.19	.75	.70
Canonical Correlation	.717	.731	.704
Eigenvalue	1.06	1.15	.984

between Grade 3 and Grade 6 for gifted students was 10.64 compared to 4.50 for average pupils, showing a marked increase for the Grade 6 gifted students (see Table in Appendix K).

It appears that use of a scoring system based on a qualitative analysis of student responses to the Metacognitive Interview questions resulted in similar findings to the initial analysis of metacognitive functioning. Intellectually gifted students obtained higher mean score responses on measures of clarity, specificity, reflectivity, organization and at the Grade 6 and 8 level on measures of conceptualization than their average peers.

Metacognitive Interview: Chi Square Analysis. In addition to the multivariate analyses which investigated differences between intellectual groups and grades based on mean scores, it was also considered appropriate to examine the frequency of higher and lower level responses among the experimental groups. Answers to the interview questions were assigned two points for a superior response, one point for an average response and zero for a minimal response. The overall scoring system can best be described as a grid of six metacognitive sub-processes x five qualitative dimensions. For example, each question of the MCI represented one of the six metacognitive sub-processes. Each sub-process in turn was evaluated on each of the five

qualitative dimensions. In total, each metacognitive interview generated twenty-nine categories suitable for separate Chi-square analysis. The SPSS-X Cross Tabs program was used to obtain frequency counts for each grid category of the MCI by intellectual group and grade. As will be recalled from previous description, the MCI was administered twice, once after each cognitive task. Therefore the results will be reviewed for each interview separately.

The majority of the Chi-square analyses (22/29) on the scores of the MCI following the Pattern-matching task indicated a significant relation between intellectual group and level of response (2, 1, 0 points). Likewise, the majority of Chi-square analyses (16/29) suggested a significant association between grade and level of response.

Chi-square analyses of the relation between intellectual group and response level based on the responses to the MCI following the Kemler task resulted in only 8/29 significant Chi-square analyses. However, there was evidence for an association between grade and response level with 22/29 significant Chi-square results.

Therefore, in general, the Chi-square analyses supported the previously reported parametric findings that there is a significant association between intelligence and metacognition based on MCI scores, especially following the

Pattern-matching task. As well the majority of Chi-square analyses were significant for grade and level of responses on the Metacognitive Interviews following both cognitive tasks.

B) Metacognitive Questionnaire (MCQ)

The second metacognitive measure, the MCQ, was administered in counterbalanced order once to each child either before or after the cognitive tasks and accompanying metacognitive interviews. A description of the MCQ and Scoring Procedures are found in Appendices F and G. Analysis of order effects revealed no statistically significant difference in the total MCQ scores ($F_{1, 84} = .38, p = .54$). Once order effects were eliminated as a possible confounding factor, the analyses proceeded to investigate intellectual group differences followed by an analysis of the developmental data. The MCQ composite scores by intellectual level and grade are presented in Figure 5. The metacognitive sub-process scores by grade are presented graphically in Figure 6A for gifted subjects and 6B for average subjects. The means and standard deviations of these variables may be found in Appendix L.

Composite score (MCQ). Analysis of variance on the Composite score of the MCQ revealed a significant main effect for intellectual level ($F = 22.01, d.f. = 1, 85, p < .00$) and grade $F = 37.29, d.f. = 2, 85, p < .00$). The interaction of intellectual group x grade was not

Figure 5. Metacognitive Questionnaire Composite Mean Scores by Intellectual Group and Grade

Figure 6A. Metacognitive Questionnaire Mean Scores on Six Metacognitive Sub-processes by Grade - Intellectually Gifted Subjects

Figure 6B. Metacognitive Questionnaire Mean Scores on Six Metacognitive Sub-processes by Grade - Average Subjects

statistically significant ($F = .356, p > .702$). Examination of the mean scores indicated the gifted students obtained higher scores than the average students at each grade level. Separate ANOVAs calculated for each intellectual group on the composite MCQ scores indicated significant grade effects for the intellectually gifted ($F = 14.3, d.f. = 2,40, p < .00$) and average students ($F = 25.72, d.f. = 2,44, p < .00$). Comparisons revealed a significant difference between Grades 3 and 6 as well as Grade 6 and 8 for both intellectual groups.

Metacognitive sub-processes (MCQ). Investigation of intellectual group differences on the six metacognitive sub-processes using MANOVA revealed a significant main effect for intellectual group ($F = 5.08, d.f. = 1,75, p < .000$) and grade ($F = 5.52, d.f. = 2,75, p < .001$). The intellectual group $\times$ grade interaction was significant ($F = 1.80, d.f. = 2,75, p > .053$). A distinct grade effect was noted for average students on all the metacognitive sub-processes. However, intellectually gifted students in Grades 6 and 8 both differed from Grade 3 but themselves differed only on the flexibility of strategy use sub-process. Results are presented in Table 17A and Figures 6A and B.

A direct discriminant function analysis was conducted in order to establish the relative importance of the six metacognitive processes in differentiating between intellectual levels. Results presented in Table 17B

**Table 17A. Multivariate Analysis of Variance:
Metacognitive Questionnaire using Metacognitive Sub-
processes as Dependent Variables (MCQ)**

<u>Effect</u>	<u>Pillais</u>	<u>F Approx</u>	<u>Sig of F</u>
Intellectual Level	.303	5.079	.000
Grade	.636	5.516	.000
Interaction	.264	1.80	.053

Univariate F-tests

	Intellectual Level		Grade	
<u>Effect</u>	<u>F</u>	<u>Sig of F</u>	<u>F</u>	<u>Sig of F</u>
Problem Definition	.12	.727	1.904	.156
Planning	24.69	.000	25.47	.000
Strategy Selection	15.52	.000	15.35	.000
Monitoring	9.84	.002	19.13	.000
Flexibility of				
Strategy Use	5.57	.021	26.24	.000
Evaluating	2.44	.122	8.29	.001

d.f. = 1,75

d.f. = 2,75

Table 17B . Discriminant Function Analysis - Intellectually Gifted vs. Average Students on Metacognitive Questionnaire

Predictor Variable	Correlations of Predictor Variables with Discriminant Functions	Univariate F(1, 83)
Problem Definition	.10	.18
Planning	.95	18.3**
Strategy Selection	.76	11.6**
Monitoring	.66	9.0**
Flexibility of Strategy Use	.57	4.4*
Evaluating	.42	3.3
Canonical Correlation	.443	
Eigenvalue	.244	

* p < .05

** p < .01

indicate these variables considered jointly accounted for 19.4% of the variance between intellectual groups. The maximum spread between groups is attributed primarily to planning ($r = .95$) and strategy selection ($r = .76$) followed by monitoring ($r = .66$) and flexibility of strategy use ($r = .57$). It should be noted that the same four sub-processes were identified by the Metacognitive Interview (MCI) as important discriminators between intellectually gifted and average students. Only the order of importance differs slightly with planning identified as most significant on the MCQ and strategy selection on the MCI. Using the SPSS-X classification procedures, 67.8% ($N = 61$) were classified correctly. The classification scheme identified 74.5% of the average students compared to 60.5% of the intellectually gifted.

Direct discriminant function analyses were computed separately for each grade level in order to investigate which metacognitive sub-processes on the MCQ discriminated between gifted and average children. A summary of these results is presented in Table 18. A marked difference in MCQ results between grade levels was observed. For instance, scores of the MCQ sub-processes accounted for 57.3% of the variance at Grade 3, 59.2% at Grade 6 yet only 22% at Grade 8 in differentiating between intellectual groups. The percentage of students correctly classified decreased slightly from 86.6% at Grade 3 to 78.6% at Grade 6

Table 18. Discriminant Function Analysis - Intellectually Gifted vs. Average Students by Grade Level on Metacognitive Questionnaire

Predictor Variable	Correlations of Predictor Variables with Discriminant Functions		
	Grade 3	Grade 6	Grade 8
Problem Definition	.31	.09	-.53
Planning	.59	.53	.83
Strategy Selection	.30	.79	.25
Monitoring	.07	.47	.55
Flexibility of Strategy Use	.01	.17	.55
Evaluating	.38	.02	.05
Canonical Correlation	.757	.77	.47
Eigenvalue	1.35	1.48	.28

and 72.7% at Grade 8. Intellectually gifted students were classified correctly in 85.7%, 76.9%, 76.5% of the cases. While the percentages for average students were 87.5%, 80%, 68.8% at the Grade 3, 6 and 8 level respectively. These findings may reflect the variable compliance of Grade 8 students in completing a self-administered questionnaire. The loading matrix of correlations between predictor variables and the discriminant function, indicates the maximum spread between the intellectual groups was attributed primarily to planning and evaluating at Grade 3; planning, strategy selection and monitoring at Grade 6; and planning, monitoring and flexibility of strategy use at Grade 8.

Metacognitive Questionnaire: Chi-square Analysis. In addition to the analysis of the MCQ using mean score data summed across the six metacognitive processes, it is also of interest to examine the frequency of higher or lower level responses among the students for each of the questionnaire items. The majority of responses on the MCQ were scored according to a 4 point scale ranging from a low of 0 to a high level response equal to 4 points. The true/false questions and presence/absence of a metacognitive process were dichotomous variables. The SPSS-X Cross Tabs program was used to obtain frequency counts for each question by intellectual group and grade. Appendix M contains a summary of Chi square results for each questionnaire item.

In essence the overall results are similar to parametric findings presented above. For example, where the results were significant, the intellectually gifted students were more frequently represented in the higher scoring levels than the average pupils. Grade 8 and 6 pupils, irrespective of intellectual level, more frequently demonstrated higher level responses to the questions than Grade 3 students. As the MCQ is divided into three sections representing distinct types of questions, the findings will be discussed in that order.

Section A: Open-ended Questions

Section A contained two open-ended questions, one asking what the student would do if lost in a shopping centre, the other related to how a student would prepare for an exam after leaving their math book at school. Several observations emerged from analysis of the results. First, Chi-square analysis showed an association between responses to the shopping centre question and both intellectual level and grade. In contrast, answers to the math dilemma were not associated with the intellectual group according to the Chi-square results. This raises the issue of whether questions of a more practical, social nature may be more effective in providing evidence for metacognition than academic or school-based queries. Second, when students' answers were scored for evidence of the presence or absence of each of the six metacognitive processes, two processes

were infrequently represented, namely problem definition (10% of sample) and evaluating (30% of sample). Therefore results on these two processes should be interpreted with caution on Section A of the MCQ. However, the remaining processes of planning, strategy use, monitoring and flexibility of strategy use were present in at least 50% of the respondents. A higher frequency of planning responses was noted by the gifted students. The processes of planning, monitoring and flexibility of strategy use were more frequent in the responses of Grade 8 and 6 students versus the Grade 3's.

A subsequent analysis examined the quality of the students' answers based on information as to the level of awareness of these metacognitive processes (scale of 1-4). Only the responses to the shopping centre question will be discussed in detail given the above reported significant Chi-square findings. In the planning category, for instance, the gifted students more frequently described the steps, or sequence of steps, they intended to use to solve the problem than their average peers. In strategy use, while all subjects verbalized evidence of problem-solving techniques, only the gifted and older students (Grade 6 and 8) more frequently provided clear and complete explanations of the strategies they would employ. A non-parametric measure of association, Kendall's Tau C, also demonstrated a significant association between intellectual level and the

degree of monitoring present in the student answers ($\text{Tau } C = .23, p < .004$). Gifted students more frequently provided one or more examples of self-checking statements as they discussed how they would handle being left at a shopping centre. Similarly Grade 8 students were more expressive of monitoring techniques than Grade 6 pupils who in turn were more aware of the need to monitor than the Grade 3's. The results of Chi-square analysis between grade and four levels of flexibility of strategy use reveal a significant association ($X^2 = 20.14, df = 6, p < .01$). Examination of the contingency table indicated Grade 8 and 6 students more frequently than Grade 3's gave responses that demonstrated awareness of the need to switch strategies if indeed previous attempts were not successful. The expected association between intellectual group and degree of flexibility was not observed ($X^2 = 5.78, df = 3, p > .12$), although a moderate association was noted ($\text{Tau } C = .19, p < .03$) such that 23/51 gifted pupils received a superior (level 4) score in flexibility of strategy use compared to 16/54 average pupils.

Section B: Short Answer Questions

The fifteen short answer questions were scored according to a 1, 2, 3, 4 point rating scale representing minimal, some, average and superior levels of responses, respectively. Chi-square analyses indicated all but two of the questions (#4, #6) showed either significant differences

between intellectual groups and/or grade levels.

Differences in the metacognitive processes between gifted and average subjects will be discussed first, followed by analysis of grade effects.

On a question designed to evaluate the ability to plan, ie., how to begin a math test with more than one problem, intellectually gifted students (26/49) were able to articulate that they would read over all the problems first or start with the least difficult solution in contrast to only 10/52 average pupils. On another planning query, when asked what to do when faced with a large puzzle in pieces, more gifted students (23/48) versus average pupils (6/49) stated they would engage in two or more sequential actions such as sorting, assembling outer pieces, doing the edge first, etcetera. On a strategy selection item, when asked what they would do differently when asked to read a book for pleasure or for school, 12/52 gifted students provided a reason revealing a need to pay closer attention, keep notes, read it more carefully if it was for school compared to 5/53 average pupils ($Tau C = .19, p < .02$). The awareness of strategy selection among the bright students demonstrated not only greater awareness of strategy options but also a higher level of sophistication with regard to the need to use strategies. A monitoring question asking how you would know whether a math problem was wrong or not, revealed that a greater proportion of average students (22/51) versus

gifted (3/49) indicated they would check with others such as a parent or teacher. On the other hand, gifted students (22/49) in contrast to average students (11/51) said they would personally perform a specific monitoring action such as re-reading the test or re-working the answer. Note the marked difference in personal responsibility observed in the responses of the intellectually gifted students. When asked what they would do when a puzzle became too difficult, a question designed to measure flexibility of strategy use, gifted students (10/52) more frequently generate alternate strategies such as focussing on a part of the puzzle, seeking help from others or returning to the task after a break, than average students (2/54).

Analysis of grade differences revealed a greater frequency of higher level scores (3 or 4 points) for planning, strategy selection, monitoring, flexibility of strategy use and evaluating questions by Grade 8 and 6 students than by the Grade 3 students. For instance, on the three evaluating questions, the Grades 6 and 8 students compared to Grade 3's felt they could find as many solutions to a problem as their peers (31 vs. 5), decide on the difficulty level of a puzzle (27 vs. 3) and obtain correct solutions to a math problem (30 vs. 5). Overall, the short answer format in Section B was considered to differentiate between experimental groups in that seven of the thirteen questions revealed a significant association

with intellectual level, while grade effects were found on ten items.

Section C: True/False Questions

In contrast to the questions of Sections A and B of the questionnaire which differentiated between intellectual and grade levels, only two of the fifteen true/false questions of Section C met this criterion. Specifically on Question #13, "I don't think there is much difference between solving a math problem and learning a list of words in spelling", intellectually gifted students were more aware that a difference did exist than average students ($\chi^2 = 6.71$, df 1, $p < .01$). Grades 6 and 8 students were more likely to see a difference than Grade 3 pupils ($\chi^2 = 9.73$, df = 2, $p < .01$) on this item designed to assess the ability to define the problem prior to starting problem-solving. On Question #14 "I always listen when the teachers give instructions but I sometimes have trouble knowing what to do when I start an exercise", average students more frequently replied in the affirmative (43/50) than gifted students (24/46). Also Grade 3 students were more likely to respond in the affirmative than Grade 6 or 8 subjects ($\chi^2 = 6.51$, df = 2, $p < .04$). The remaining 13 true/false questions did not reveal significant Chi square results for either intellectual group or grade level.

C) Metacognitive Observations during Cognitive Tasks

Inferred observations of metacognitive behaviour during problem solving provided the third type of metacognitive measure and an alternative to direct questioning used for the interview and questionnaire. Opportunities to assess metacognition in the present study occurred during the random presentation of the Kemler task labelled as the Mixed Kemler and through two other means including the student's self-correcting behaviours and the type of elimination errors committed on the Pattern-matching task. A summary of means and standard deviations of the metacognitive observations is found in Appendix N. The results of each measure will be discussed separately.

Mixed Kemler. After presentation of the Mixed Kemler students were asked to describe their experiences on this task. Responses were coded according to levels of awareness of the problem definition, demonstrated awareness that they used a monitoring process, and their ability to evaluate their performance on the problem. Multivariate Analyses of Variance using these three measures as dependent variables revealed a significant main effect for grade ($F = 2.96, p < .008$) but not intellectual level ($F = 2.03, p > .114$) (see Table 19). Grade 8 students scored higher than Grade 6 pupils who in turn outperformed Grade 3 students.

Self-corrections. Two types of self-correcting behaviours were recorded: the number of spontaneous

**Table 19. Multivariate Analysis of Variance for
Intellectual Group and Grade using Mixed Kemler Measures as
Dependent Variables**

Effect	Pillais	F Approx	Sig. of F
Intellectual Level	.949	2.03	.114
Grade	.859	2.96	.008
Interaction	.943	1.18	.352

Univariate F tests for effect of Intellectual Group

Problem Definition	1.19	.278
Monitoring	3.97	.049
Evaluating	5.65	.019

All F ratios based on 1 and 115 df.

self-corrections observed during problem solving and the number of self-checking actions noted after making an error. The latter measure revealed no statistically significant intellectual grouping or grade effects. Examination of the number of spontaneous self-corrections (see Appendix N) revealed that the majority of average students (59/61) used no self-corrections. Thus only 2 of the average students spontaneously corrected their work in contrast to 13 of the gifted students. The low incidence of this measure precluded statistical analysis.

Elimination Errors. During the completion of the pattern-matching cognitive task, the structure of the test allowed the student to make two types of errors. Either they could incorrectly eliminate a pattern choice or they could omit turning over a pattern card. Incorrect elimination error results are displayed in Figure 7A and omitted elimination errors in Figure 7B. Both elimination errors were considered by Stober (1983) to evidence a lack of awareness of the metacognitive process of monitoring.

Results of a multivariate analysis of variance of these errors revealed a significant main effect for intellectual level ($F = 9.00$, d.f. = 1,116, $p < .00$) and grade ($F = 3.390$, d.f. = 2,116, $p < .01$). The interaction was not significant ($F = 1.06$, d.f. = 2,116, $p > .373$). Intellectually gifted students made fewer errors of both types across the three grade levels. Overall, Grade 3

Figure 7A. Incorrect Elimination Errors by Intellectual Group and Grade on Pattern-matching Task

Figure 7B. Omitted Elimination Errors on the Pattern-matching Task by Intellectual Group and Grade

average students demonstrated significantly more errors than their counterparts in Grade 6 and 8. Findings also suggest marked differences in the monitoring behaviour of students such that Grade 3 gifted pupils made fewer errors of both types than average students at all grade levels.

D) Summary of Metacognitive Measures

Metacognitive interview. Overall, results of the Metacognitive Interview support the hypothesis of superior metacognitive functioning in the intellectually gifted, a finding consistent at the Grade 3, 6 and 8 levels.

Examination of the six metacognitive sub-processes indicated strategy selection was most effective in differentiating between intellectual groups. For the gifted, the processes of planning and flexibility of strategy use predict group membership at Grade 6 and the process of monitoring also became important at Grade 8. Analysis of grade effects within each intellectual group suggest MCI scores differ between Grade 3 and 6 but plateau between Grade 6 and 8 for both gifted and average students.

Metacognitive Questionnaire. Non-parametric analysis of the MCQ was useful in clarifying which items of the questionnaire were more suited to differentiating between intellectual groups and grade levels. Most appropriate were the open-ended question pertaining to the shopping centre and the short-answer questions. Parametric analyses of the MCQ scores revealed significant group differences in

overall composite scores and on the metacognitive sub-processes of planning, strategy selection, monitoring and flexibility of strategy use favoring the intellectually gifted. Analysis of grade effects indicated differences for the average and intellectually gifted students between the three grade levels. The metacognitive sub-process of planning differentiated intellectually gifted from average students at all three grade levels. In addition, problem definition and evaluating sub-processes differentiated average and gifted students at Grade 3, strategy selection and monitoring at Grade 6, and flexibility of strategy use and monitoring at Grade 8.

Metacognitive observations. Results provide consistent evidence that awareness of the monitoring process and the ability to evaluate one's own performance, were important variables in differentiating average and intellectually gifted students. Developmentally there is some suggestion that these metacognitive processes are already present to a greater degree in Grade 3 gifted students especially the awareness of errors and spontaneous self-correcting behaviours when compared with their intellectually average peers. These differences in the observation of metacognitive behaviours continue to be in evidence at the Grade 6 and Grade 8 level with intellectually gifted pupils outperforming their average peers.

To end this section, a discriminant function analysis

between gifted and average subjects was computed on the summary scores of all the metacognitive measures. The results are presented in Table 20. The loading matrix of correlations between predictor variables and the discriminant function suggests that the maximum spread among the two intellectual groups is primarily based on the metacognitive interview ($r = .75$) and metacognitive questionnaire ($r = .61$). Also discriminating between the groups are the observations of metacognitive behaviours namely the omitted elimination errors ($r = -.45$).

2. Comparison of Mental Age Matched Groups

It is not surprising to find differences in metacognition when intellectually gifted and average students at the same chronological age are compared. However, the question of which variables distinguish these two intellectual groups when they are matched for mental age may begin to provide information about the nature of intelligence. Stated simply, the simultaneous comparisons of intellectual levels, chronological age and mental age allow us to know what variables are unique to intellectual giftedness and what processes develop as a function of intelligence (mental age) or maturation (chronological age). In order to probe these associations, two sets of mental age equivalencies were provided for in the design of the present study. First, a set of M.A. equivalent

Table 20. Discriminant Function Analysis: Intellectually Gifted vs. Average Students Using Metacognitive Measures as Dependent Variables

Predictor Variable	Correlations of Predictor Variables with Discriminant Functions	Univariate F(1,81)
MCI Interview	.752	19.66**
MCQ Questionnaire	.617	13.23**
Omitted Eliminations	-.456	7.22**
Mixed Kemler (Monitoring)	.33	1.61
Mixed Kemler (Evaluating)	.26	1.43
Canonical Correlation	.547	
Eigenvalue	.428	

* p < .05

** p < .01

subjects (MA = 11 years) included intellectually gifted Grade 3's and average Grade 6's. A second set of M.A. equivalent subjects (MA = 13 years) included intellectually gifted Grade 6's and average Grade 8's. As the primary interest was to investigate the role of developmental and intellectual factors in metacognitive functioning, the following analyses included metacognitive measures from the Interview (MCI) and the Questionnaire (MCQ). The results of each M.A. equivalent grouping will be discussed separately followed by an overview of both mental age sets. As the MANOVA results on the Metacognitive Questionnaire (MCQ) (presented in Appendix O) indicated no significant differences between the intellectually gifted and average students at either M.A. equivalent comparison, all subsequent analyses to be discussed will focus on the findings from the Metacognitive Interview. Mean scores on the MCI for average and intellectually gifted students matched for mental age are presented in Table 21. A graph of these results is provided in Figure 8 for the composite MCI score and Figure 9 for the MCI metacognitive sub-processes. The results of separate multivariate analyses of variance completed on the M.A. = 11 and M.A. = 13 equivalencies are presented in Table 22.

A cognitive level explanation of the development of metacognitive functioning was suggested by MANOVA results of the matched M.A. = 11 years subjects. Analysis of the

**Table 21. Metacognitive Interview. Means Scores for
Groups Matched for Mental Age**

Metacognitive Interview	Mental Age (11 yrs)		Mental Age (13 yrs)	
	Gifted (Gr. 3)	Average (Gr. 6)	Gifted (Gr. 6)	Average (Gr. 8)
Problem Definition	12.28	10.62	12.47	9.4
Planning	8.86	13.95	22.37	13.70
Strategy Selection	9.33	13.19	25.42	13.55
Monitoring	7.33	7.24	10.05	7.55
Flex. of Strat. Use	2.10	4.38	9.21	4.85
Evaluating	8.10	9.90	10.53	10.20
Composite	48.0	59.3	90.5	59.25

Figure 8. Mental Age Matched Group: Composite Mean Scores on MCI

Figure 9. Mental Age Matched Groups: Metacognitive Sub-process Mean Scores on MCI

Table 22. Multivariate Analysis of Variance for Matched Mental Age Groups using Metacognitive Interview Sub-process scores as Dependent Variables

Effect	Pillais	F Approx	Sig. of F
Matched Mental Age			
(MA = 11 Years)	.722	2.25	.061
Matched Mental Age			
(MA = 13 years)	.492	5.50	.001
Univariate F-Tests for Effect of Matched Mental Age Group (MA = 11 Years)			
Problem Definition		.34	.566
Planning		8.01	.007
Strategy Selection		4.46	.041
Flexibility of Strategy Use		5.00	.031
Monitoring		.01	.939
Evaluating		3.87	.056.
Univariate F-Tests for Effect of Matched Mental Age Group (MA = 13 years)			
Problem Definition		.75	.392
Planning		17.20	.000
Strategy Selection		24.96	.000
Flexibility of Strategy Use		10.24	.003
Monitoring		3.19	.082
Evaluating		.12	.729

All F-ratios based on 1 and 40 df

MCI sub-test scores revealed no significant difference overall between the intellectually gifted and average students matched for mental age ($F = 2.24$, $df\ 6, 35$, $p > .06$). For the older M.A. match (M.A. = 13 years), multivariate analysis of variance of the MCI sub-scale scores indicated a significant difference between intellectual levels ($F = 5.05$, $d.f. = 1, 37$, $p < .001$) favoring the gifted. Mean scores on three of the six metacognitive processes (planning, strategy selection, and flexibility of strategy use) were significantly higher for bright Grade 6's compared to the average Grade 8's.

As a final observation, metacognitive functioning appears to increase markedly for the intellectually gifted between the mental ages of 11 and 13 years as compared to the similar levels of performance of the average students at these two mental ages (note Figures 8 and 9). Higher scores on the metacognitive sub-processes of planning, strategy selection, and flexibility of strategy use support the argument of qualitative differences for the intellectually gifted in these areas.

3. Analysis of Cognitive Measures

Two problem-solving tasks, the Kemler Hypothesis Formation test and the Pattern-Matching test, were used in the present study. Although these tasks were chosen primarily to elicit metacognitive processing, the results allowed for the investigation of the relation between cognitive and metacognitive functioning. Findings for each task are discussed separately first from the perspective of intellectual group differences followed by an analysis of grade effects.

A) Kemler Hypothesis Formation Test (KHF)

The mean task efficiency scores and number of non-informative moves of the KHF are presented graphically in Figures 10A and 10B, while the means and standard deviations of these variables may be found in Appendix P. A Multivariate Analysis of Variance computed on problem-solving efficiency scores and the number of non-informative moves across the three Kemler problems revealed a significant main effect for intellectual status ($F = 5.02$, $df\ 1, 116$, $p < .000$) and grade ($F = 3.57$, $df\ 2, 116$, $p < .001$). The grade $\times$ intellectual status interaction failed to reach statistical significance ($F = 1.62$, $df\ 2, 116$, $p > .09$). Overall the intellectually gifted students outperformed average pupils in developing efficient problem solutions to the Kemler task. Univariate F tests revealed these intellectual group differences to be

Figure 10A. Kemler Hypothesis Formation Task: Mean Task Efficiency by Intellectual Group and Grade

Figure 10B. Kemler Hypothesis Formation Task: Mean Non-Informative Moves by Intellectual Group and Grade

particular to the Five ($F = 24.95$, $df\ 1, 116$, $p < .000$) and Right ($F = 6.47$, $df\ 1, 116$, $p < .01$) Attribute Kemler problems but not the easier Three Attribute problem ($F = 3.06$, $df\ 1, 116$, $p > .08$). These results are presented in Table 23A.

In addition to problem solving efficiency (a ratio of the number of focussing moves divided by the total number of moves), the number of non-informative moves per problem was also calculated. As expected the intellectually gifted demonstrated fewer moves of this type across the three problem sets. The difference was especially pronounced at the Grade 3 level with the average students demonstrating considerably more non-informative moves across the three problems ($\bar{x} = 4.35$) than their intellectually gifted peers ($\bar{x} = 1.29$).

In order to gain a more complete understanding of the student's performance on each of the three KHF tasks, each subject was assigned either a zero score for non-solution or a one point score if correct in solving the problem. Results of separate Chi-square analyses on each problem revealed a significant association between intellectual level and problem solution only at the Grade 3 level. For instance, the intellectually gifted Grade 3 students were more frequently successful in solving the three attribute ($\chi^2 = 5.85$, $df = 1$, $p < .02$) and five attribute tasks ($\chi^2 = 4.26$, $df = 1$, $p < .04$) than their average peers.

**Table 23A. Multivariate Analysis of Variance for
Intellectual Group and Grade using Kemler Hypothesis
Formation Task Measures as Dependent Variables**

Effect	Pillais	F Approx	Sig of F
Intellectual Level	.213	5.02	.000
Grade	.321	3.57	.000
Interaction	.159	1.62	.086

Univariate F-tests for effect of Intellectual Group

Focussing Moves

3 Attribute Problem	3.06	.083
5 Attribute Problem	24.95	.000
8 Attribute Problem	6.47	.012

Non-Informative Moves

3 Attribute Problem	8.80	.004
5 Attribute Problem	17.93	.000
8 Attribute Problem	10.43	.002

All F ratios based on 1 and 116 df.

Such an association between problem solution and intellectual level was not significant at the Grade 6 or Grade 8 level for the three KHF problems. These results suggest that there were intellectual group differences in the component problem-solving strategies such as the use of focussing and non-informative moves. However, the incidence of successful problem solution did not differentiate between intellectually gifted and average students, except for the Grade 3 pupils. This accentuates the need to investigate more closely the processes by which children solve problems rather than concentrating only on the final solution.

B. Pattern-matching Test

On the second cognitive task, analyses were performed on the mean scores averaged for the six individual pattern presentations.

A summary of the means and standard deviations of the Pattern-matching variables by grade and intellectual level are shown in Appendix Q. Measures of task efficiency, average focussing, gambling and non-informative responses were entered as dependent variables in a multivariate analysis of variance.

The results, presented in Table 23B, indicated a significant main effect for intellectual level ($F = 9.15$, $df\ 1, 110$, $p < .00$), grade ($F = 9.15$, $df\ 2, 100$, $p < .00$), and a significant grade $\times$ intellectual group interaction

**Table 23B. Multivariate Analysis of Variance Pattern
Matching Task using Cognitive Measures as Dependent
Variables**

Effect	Pillais F Approx	Sig of F
Grade	.599	9.15
Intellectual Level	.460	18.10
Interaction	.488	6.92

Univariate F-tests

Effect	F	Sig of F
Intellectual Level		
Focussing Responses	11.29	.001
Gambling Responses	22.97	.00
Non-Informative Responses	73.66	.00
Pattern-Matching Efficiency	39.04	.00
df 1,110		
Grade		
Focussing Responses	3.80	.025
Gambling Responses	18.21	.000
Non-Informative Responses	50.70	.000
Pattern-Matching Efficiency	40.90	.000
df 2,110		
Intellectual Level x Grade		
Focussing Responses	1.49	.229
Gambling Responses	1.85	.161
Non-Informative Responses	44.69	.00
Pattern-Matching Efficiency	10.91	.00
df 2,110		

($F = 6.92$, $df\ 2, 110$, $p < .00$). Multiple comparisons using the SPSSX contrast command showed significant differences between gifted and average Grade 3 students, favoring the former group, on measures of task efficiency and the mean number of non-informative responses. Average Grade 3 students made significantly more Non-Informative choices ($x = 12.70$, $SD = 6.2$) than gifted Grade 3 pupils ($x = .71$, $SD = 1.6$). Examination of the significant IQ $\times$ grade interaction revealed that at the Grade 6 level only, average students did not differ from gifted subjects on Task Efficiency and Non-Informative response measures. Analysis of the remaining measures of focussing and gambling responses revealed no significant differences between gifted and average subjects at the Grade 3, 6, or 8 level respectively.

In order to assess differences between grade levels, a MANOVA computed separately on average pupils revealed a significant grade effect ($F\ 2, 58 = 9.28$, $p < .000$). Scores on all cognitive measures were lower for students in Grade 3 compared to Grade 6 and 8. Similarly for intellectually gifted students a significant grade effect was found on MANOVA analysis of the cognitive measures ($F\ 2, 58 = 2.57$, $p < .008$). Univariate F tests, however, indicated a significant grade effect for only the number of gambling moves and level of task efficiency. The direction of the effect was the same as the average students with

intellectually gifted Grade 3 students performing at lower levels than their ability level peers at Grades 6 and 8.

In summary, cognitive test performance was generally superior for Grade 3 intellectually gifted as compared to their average peers on both the Kemler and Pattern-Matching tests. Problem-solving efficiency measures revealed similar levels of cognitive performance between gifted and average students at Grade 6 and 8. Grade effects were noted for both tasks with the performance of the older students (Grades 6 and 8) being superior to that of Grade 3 pupils.

4. Analysis of Cognitive/Metacognitive Association

After separate analyses of the differences in cognitive and metacognitive functioning between intellectual groups and grade levels, it is of interest to examine the interrelations between these two types of variables. Typically one would assume a positive relation such that a student who scores high on measures of metacognition would also perform well on cognitive tasks. Contradictory results in the literature (Kontos et al., 1983) suggest this relation cannot always be assumed and may vary depending on the type of task or age of the subjects. Matrices of the Pearson correlation coefficients between the Pattern-matching cognitive measures and the Metacognitive Interview (MCI) and Questionnaire (MCQ) and Observations (MCOs) are

presented in Table 24A. Present results are supportive of the hypothesis of a moderate relation between cognitive performance on the Pattern-Matching task and Metacognition as measured by the composite score of the MCI ($r = .55$) and MCQ ($r = .42$). Task efficiency is also correlated significantly with metacognitive observations on the Mixed Kemler ($r = .28$).

Examination of this relation between cognitive functioning and the metacognitive sub-processes, indicated task efficiency is significantly correlated with planning ($r = .50$), strategy use ($r = .46$) and flexibility of strategy use ($r = .37$) on the MCI. A significant negative relationship was observed between the incidence of gambling and non-informative moves on the one hand, and the MCI processes of planning ($r = -.53$, $r = -.47$), strategy use ($r = -.55$, $r = -.43$), monitoring ($r = -.38$, $r = -.31$) and flexibility of strategy use ($r = -.38$, $r = -.31$). A similar pattern of findings was noted on the Metacognitive Questionnaire, where once again the planning and strategy use processes were strongly associated with task efficiency and inversely related to the number of gambling and non-informative moves.

The correlations between the cognitive measures of the Kemler Hypothesis Formation test and the metacognitive measures are less definitive. These results are presented in Table 24B. Overall the associations are relatively weak

Table 24A. Correlation Matrix: Intercorrelations of Pattern-matching Cognitive Measures and Metacognitive Measures

Metacognitive Measures	Pattern-matching		
	Task Efficiency	Gambling Responses	Non-Informative Responses
<u>MCI</u>			
Problem Definition	.24**	-.16*	-.26**
Planning	.50***	-.53***	-.47***
Strategy Use	.46***	-.55***	-.43***
Monitoring	.25**	-.38***	-.31***
Flex. of Strat. Use	.37***	-.38***	-.31***
Evaluating	.22**	-.26**	-.17*
Composite	.55***	-.57***	-.54***
<u>MCQ</u>			
Problem Definition	n.s.	n.s.	-.22*
Planning	.45***	-.46***	-.44***
Strategy Use	.36***	-.30***	-.37***
Monitoring	.24**	-.23**	-.31***
Flex. of Strat. Use	.31***	-.35***	-.28**
Evaluating	.17*	-.25**	-.23**
Composite	.42***	-.49***	-.47***
<u>MCO</u>			
Mixed Kemler	.28***	-.32***	-.20**
Omitted Elimination	-.32***	.30***	.35***

*p < .05; **p < .01; ***p < .001

n.s. = not significant

Table 24B. Correlation Matrix: Intercorrelations in
Kemler Cognitive Measures and Metacognitive Measures

Metacognitive Measures	Kemler Cognitive Measures		
	Problem Solving Efficiency		
	3 Attrib.	5 Attrib.	8 Attrib.
<u>MCI</u>			
Problem Definition	n.s.	.20*	n.s.
Planning	.27**	.31***	n.s.
Strategy Use	.28***	.30***	n.s.
Monitoring	n.s.	.25**	.21**
Flex. of Strategy Use	.21**	.18*	n.s.
Evaluating	n.s.	n.s.	n.s.
Composite	.28**	.35***	.22**
<u>MCQ</u>			
Problem Definition	n.s.	n.s.	n.s.
Planning	.28**	.38***	.20*
Strategy Use	.32***	.36***	.21*
Monitoring	n.s.	.22**	.21*
Flex. of Strategy Use	.20*	.32***	.25**
Evaluating	.19*	n.s.	n.s.
Composite	.29**	.41***	.26**

* $p < .05$

** $p < .01$

*** $p < .001$

n.s. = non significant

between cognitive processing ability and metacognitive functioning. Only on the five attribute problem was the problem solving efficiency score correlated significantly with the composite score of the MCI ($r = .35$) and MCQ ($r = .41$). These results were unexpected in that Flavell et al. (1978) have contended that metacognition is most likely to be elicited by a particularly challenging task. However, examination of the correlational matrices reveals that even for the more difficult eight attribute Kessler problems, there is a minimal but statistically significant relation between problem solving efficiency and metacognition as measured on the Interview ($r = .22$) and Questionnaire ($r = .26$). The relation between cognitive functioning and the individual metacognitive sub-processes revealed a moderate relationship between problem-solving efficiency on the Three and Five attribute problems and the metacognitive processes of planning ($r = .27$, $r = .31$) and strategy use ($r = .28$, $r = .30$) of the MCI. Similar findings were noted on the Questionnaire in that the sub-processes of planning and strategy use also correlated with efficiency measures on the Three Attribute ($r = .28$, $r = .32$) and Five Attribute problems ($r = .38$, $r = .36$) respectively. Flexibility of strategy use as measured on the Questionnaire was moderately predictive of problem solving efficiency on the Five Attribute problem only ($r = .32$). Correlational results also indicate that children who make a large number

of non-informative moves on the Five Attribute problem of the Kemler tend to do more poorly on planning sections of the Interview ($r = -.36$) and Questionnaire ($r = -.41$).

The correlations between the Qualitative scoring system of the Interview (MCI) and the cognitive measures of the Pattern-Matching and Kemler tasks are presented in Table 24C. It is noted that there is a highly significant association between task efficiency on the Pattern-Matching test and Interview measures of clarity ($r = .59$), specificity ($r = .49$), reflectivity ($r = .50$), organization ($r = .57$) and conceptualization ($r = .44$). Problem-solving efficiency on the Three and Five Attribute Kemler problems was moderately related to these qualitative dimensions, and there is a weak but statistically significant relationship with the Eight Attribute Kemler problem.

In summary, analyses of the inter-correlational results suggest the Metacognitive processes of planning, strategy use, and flexibility of strategy use as measured on the MCI and MCQ are especially predictive of cognitive functioning. The relations are generally stronger for the measures of the Pattern-matching test. In addition, the results of the qualitative scoring system developed for the MCI demonstrated significant associations with the cognitive measures of the present study.

Table 24C. Correlation Matrix: Intercorrelations between Pattern-matching and Kemler Cognitive Measures and the Metacognitive Interview Measures

Scale	Cognitive Measures			
	Pattern	Kemler		
	Matching	Problem Solving Efficiency		
	Task Effi-	3	5	8
	ciency	Attrib.	Attrib.	Attrib.
<u>MCI</u>				
Clarity	.59***	.31***	.35***	.22**
Specificity	.49***	.23**	.34***	.23**
Reflectivity	.50***	.20**	.33***	.15*
Organization	.57***	.29***	.38***	.20**
Conceptualization	.44***	.28***	.33***	

* p < .05

** p < .01

*** p < .001

5. Additional Variables

The reader is referred to Table 3 for a description of the CCAT and CTBS scores for each intellectual grouping. Descriptive statistics on measures of socio-economic status, and academic motivation are presented in Appendix R. An explanation of these variables is found in the Method section.

Multiple regression analyses were conducted in order to assess the effect of variables such as socio-economic status, school academic achievement and level of motivation towards school work in predicting metacognitive functioning. A joint variable of overall metacognitive functioning was computed by combining the composite scores of the Interview (MCI) and Questionnaire (MCQ). The contribution of intellectual level was also considered in the regression analysis by entering the standard scores from the Canadian Cognitive Abilities Test (C.C.A.T.). Given that the proportion of variance accounted for by a particular multiple regression equation is related to the number of subjects and the number of predictor variables (Pedhauzer, 1983) several steps were taken to reduce the number of variables entered in the analysis. First, in order to maximize the subject/variable ratio, the analysis was conducted on the entire sample. Steps were also taken to reduce the number of predictor variables by selecting a single measure of intellectual aptitude and achievement.

This was done by considering the F-to-enter values for each independent variable, computed as if the variable was entered first into the regression equation. Following this procedure, the Non-Verbal Scale of the CCAT was selected as the best predictor with the highest F-to-enter value. That is not to say the verbal and quantitative scales were not also important predictors of intelligence but that the variance accounted for by these scores was minimal after the variance explained by the Non-verbal Scale had been partialled out. Similar procedures with the scores of the Canadian Test of Basic Skills selected the composite scale as the best predictor of achievement. In the stepwise regression, Non-verbal CCAT entered the equation first ($R = .64$, $R^2 = .41$). In the second step, the addition of variables such as SES, achievement and motivation did not result in a statistically significant increment in the proportion of variance accounted for.

A second regression analysis was computed using only the variables of achievement, motivation and SES in predicting metacognitive functioning. In the stepwise regression, achievement entered the equation first ($R = .55$, $R^2 = .30$). Variables of SES and motivation did not significantly add to the proportion of variance accounted for. Therefore, multiple regression results suggest variables such as SES and motivation account for only a small proportion of the variance in predicting

metacognitive scores. Although SES mean score differences were noted between gifted and average students ($t = 3.62$, $p < .001$), these differences did not appear to be contributing variance to the described differences in metacognitive functioning between intellectual groups as assessed by regression analyses.

Sex differences. The possibility of differences in metacognitive functioning between males and females was investigated by MANOVA using the Metacognitive Interview sub-process scores, followed by a similar analysis of the Metacognitive Questionnaire. A main effect for sex was not obtained on the scores of the Metacognitive Interview ($F = 1.54$, $df\ 1,108$) or Metacognitive Questionnaire ($F = 2.09$, $df\ 1,75$, $p > .07$). Interactions of sex x intellectual level and sex x grade level were not statistically significant for either metacognitive measure.

6. Analysis of Validity: Metacognitive Measures

The validity of a test refers to the extent to which the test measures what it purports to assess. It is usual to think of instruments as possessing different degrees of validity for different purposes rather than simply as valid or invalid (Kaufman & Kaufman, 1983). In the present study, one of the major objectives was to design instruments that would assess metacognition, measure the six hypothesized metacognitive processes and discriminate

between students of varying age and intellectual levels.

One of the most important types of validity, construct validity, indicates the extent to which a test can be considered a valid measure of a particular theoretical construct or trait. Evidence of a test's construct validity according to Anastasi (1982) can be obtained from examining developmental changes, internal consistency, factor analyses, intercorrelations of metacognitive measures and finally correlations with other tests considered measures of the construct in question. This framework, described by Anastasi, will be used to present evidence to support the validity of the metacognitive measures used in the current study.

A) Developmental Changes. In the preceding results section, the findings generally supported the notion of developmental changes in the metacognitive instruments. Test scores increased between Grades 3, 6, and 8 on the MCQ and Grade 3 to 6 for the MCI. Furthermore, overall differences in metacognitive functioning between intellectually gifted and average students at each grade level added support for the validity of these instruments.

B) Internal Consistency. The homogeneity of a multiple score instrument can be determined by correlating, in this instance, the results of the metacognitive sub-process scores with the total composite score. Table 25 presents the internal consistency coefficients for the MCI and MCQ

Table 25. Internal Consistency: Correlations Between MCI Sub-processes and Total MCI Composite Score (N = 120)

MCI Sub-processes	MCI Composite Score
Problem Definition	.43***
Planning	.82***
Strategy	.80***
Monitoring	.65***
Flexibility	.66**
Evaluation	.47***

Correlation between MCQ Sub-processes and Total MCQ Composite Score (N = 86)

MCQ Sub-processes	MCQ Composite Score
Problem Definition	.26**
Planning	.81***
Strategy	.78***
Monitoring	.82***
Flexibility	.80***
Evaluation	.68***

composite scores. On the MCI these values range from .43 to .82 with a median of .64, suggesting evidence for the validity of the composite score. The range was greater for the MCQ with internal consistency coefficients ranging from .26 to .82 with a median of .69. For both instruments it was the sub-tests of planning, strategy selection, monitoring and flexibility of strategy use that had the highest coefficients with the total composite scores.

C) Factor Analysis. Since differences were hypothesized between the six metacognitive sub-processes as well as the knowledge (MCQ) and processing (MCI) dimensions of metacognition, it was considered important to examine whether there were empirical factors which corresponded to these constructs. A Varimax rotated factor analysis of the total subject sample computed using the six metacognitive sub-process scores of the MCI and MCQ sample produced six factors. Loadings of variances on factors are shown in Table 26. At the bottom of each column are suggested interpretive labels for each factor. The first factor, accounting for 36.8% of the variance, was weighted on the MCQ items (Planning, Strategy selection, Monitoring, and Flexibility of Strategy Use). The second factor, accounting for 14.6% of the variance, was weighted on the same four sub-processes but on the MCI. The remaining four factors consisted of two separate evaluation factors, accounting for 9.6% and 5.3% of the variance, and two

Table 26. Factor Loadings for Six-Factor Principal Factors Extraction, and Varimax Rotation on Metacognitive Measures

<u>Metacognitive Measure</u>	<u>Factors</u>					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>MCQ</u>						
Problem Definition	.00	.00	.00	.00	.96	.00
Planning	.74	.00	.00	.00	.00	.00
Strategy Selection	.76	.00	.00	.00	.00	.00
Flexibility of Strategy Use	.78	.00	.00	.00	.00	.00
Monitoring	.89	.00	.00	.00	.00	.00
Evaluation	.00	.00	.00	.00	.00	.76
<u>MCI</u>						
Problem Definition	.00	.00	.00	.93	.00	.00
Planning	.00	.84	.00	.00	.00	.00
Strategy Selection	.00	.86	.00	.00	.00	.00
Flexibility of Strategy Use	.00	.80	.00	.00	.00	.00
Monitoring	.00	.52	.00	.00	.00	.00
Evaluation	.00	.00	.95	.00	.00	.00

Label: 1 - Questionnaire
 2 - Interview
 3 - Evaluating
 4 - Problem Definition
 5 - Problem Definition
 6 - Evaluation

Correlations < .30 reported as .00

problem definition factors accounting for 8.2% and 7% of the variance. These results suggest there is an overall distinction between the Questionnaire and Interview measures. However, differences between the six metacognitive sub-processes are not supported as there is considerable overlap between four of the six sub-processes.

D) Intercorrelations of Metacognitive Measures.

Consideration of the relation between the three classes of metacognitive measurement used in this study is another means of assessing the validity of the concept of metacognition. Discussion of the correlations between the instruments proceeds as follows; first, a comparison of the interview (MCI) and questionnaire (MCQ) scores is presented in Table 27, then the relation between the observations of metacognition during problem solving (MCOs) and the two measures (MCI and MCQ) is described in Table 28.

Correlations of Interview (MCI) and Questionnaire (MCQ). A significant correlation between the summary score of the MCI and MCQ ($r = .56$), suggests both measures overlap to some degree and hence may be measuring a similar constructs. The unexplained variance, however, indicates the interview and questionnaire may also be assessing disparate aspects of metacognition. This is not surprising since one is a measure of metacognitive knowledge, the other an assessment of the use of metacognition. The difference between the two measures is further clarified by

Table 27. Correlation matrix: Intercorrelations between Metacognitive Interview and Questionnaire Sub-processes

Scale	Metacognitive Questionnaire				
	Problem Definition	Planning	Strategy Selection	Monitoring	Flexibility of Strategy Use
Metacognitive Interview					
Problem Definition	.31***	.26**	.14	.31***	.24**
Planning	.00	.47***	.34***	.23**	.31***
Strategy Selection	-.02	.45***	.47***	.33***	.35***
Monitoring	.09	.24**	.27**	.15	.34***
Flexibility of Strategy Use	.07	.32***	.29**	.08	.27**
Evaluating	-.00	.19*	.23**	.20*	.30***
Composite	.10	.53***	.44***	.37***	.43***

* $p < .05$

** $p < .01$

*** $p < .001$

Table 28. Correlation Matrix: Intercorrelations Between Metacognitive Observations and Metacognitive Interview/Questionnaire

Metacognitive Measure	Metacognitive Observations	
	Mixed Kemler	Omitted Elimination Errors
<u>MCI</u>		
Problem Definition	.16*	
Planning	.24**	-.23**
Strategy Selection	.18*	-.36***
Monitoring	.20**	-.27***
Flex. of Strategy Use	.27***	-.31***
Evaluation	.20**	
Composite	.32***	-.31***
<u>MCQ</u>		
Problem Definition		
Planning	.30**	-.23**
Strategy Selection	.16*	-.33***
Monitoring		-.26**
Flex. of Strategy Use	.29**	
Evaluation	.18*	
Composite	.31***	-.26**

*p < .05 **p < .01 ***p < .001

examining the correlations between the sub-processes. Whereas planning and strategy selection on the MCQ are correlated with the same processes on the MCI ($r = .47$, $r = .47$), there is no relation between the monitoring and evaluating sub-processes of the two measures ($r = .15$, $r = .20$). There is a small but significant relation for problem definition ($r = .31$) and flexibility of strategy use ($r = .27$).

Different results were obtained when separate MCI/MCQ correlations were calculated for the two intellectual groups. Although the MCI and MCQ composite scores correlated significantly among the average ($r = .42$) and intellectually gifted ($r = .49$) students, examination of the sub-processes revealed considerable variability. For instance the sub-processes of problem definition, planning and strategy use were correlated between the MCI and MCQ for the intellectually gifted, and the process of flexibility of strategy use for the average subjects, but not vice-versa. This suggests the two instruments may be measuring the metacognitive sub-processes differently depending on the intellectual level of the student or alternatively that processes may be related/associated differently for the two groups.

Correlations of Metacognitive Observations/Interview and Questionnaire. According to several investigators (Meichenbaum et al., 1985), observations of metacognition

during problem solving may be a more robust means of assessing these behaviours than relying solely on subject's verbal reports. Therefore, in order to supplement verbal report data, two types of MCO's were investigated: (1) performance on a distorted presentation of the Kemler task called the Mixed Kemler; and (2) examination of the types of errors committed during the task.

Mixed Kemler. Examination of the correlation matrix (Table 28) revealed scores on the Mixed Kemler, indicating awareness that something was amiss with the task, correlated significantly with the total scores on the MCI ($r = .32$) and MCQ ($r = .31$). A breakdown by metacognitive subprocesses indicated small but significant correlations ($r = .20$ to $r = .27$) between the Mixed Kemler and the planning, monitoring and flexibility of strategy use categories on the MCI. For the MCQ only the planning and flexibility of strategy use sub-sections correlated with the Mixed Kemler. Therefore it appears the Mixed Kemler is associated more strongly as a global measure of metacognition rather than any particular sub-process measured on the interview or questionnaire.

Elimination Errors. Intuitively it would be predicted that fewer errors on a problem solving task would be related to higher scores in strategy selection. A significant negative correlation was demonstrated between the number of omitted eliminations on the Pattern-Matching

3

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

task and the strategy selection scales of both the MCI ($r = -.36$) and MCQ ($r = -.33$). The expected inverse relation between the number of errors and the monitoring metacognitive process, as predicted by Stober (1983), was also supported.

E) Correlation with Selected Tasks

Another aspect of validity examines the relation of a test to other measures considered representative of a particular theoretical concept. At the outset of this dissertation it was decided to conduct a separate study investigating the correlations between the present instruments and established metacognitive measures. Following a review of the literature, four research tasks were selected as exemplary of the metacognitive processes of (1) planning, (2) strategy selection, (3) monitoring, and (4) evaluating (refer to Appendix I for a description of these measures). Correlational analyses were used to investigate the relation between each of these four measures and the results of the current study. Twenty-three students were chosen at random from the larger study to participate in the validity testing. The results for each validating task will be discussed separately. A synopsis of the findings are presented in Appendix S.

Planning. A measure considered representative of metacognitive awareness of the planning process was selected from the Kreutzer et al. (1975) battery of

metamemory tasks. In this study, children were asked to state what they would do to remember to bring their skates to school the following day. The youngsters particularly enjoyed responding to this item which was a fairly typical situation in their experience. Examination of the average number of strategies generated did follow the expected age trend reported by Kreutzer et al. (1975). In the present study, the younger children in Grades 3 and 6 obtained a mean score of 8 responses compared to 15.75 responses for the Grade 8 students. Further analysis of the content of these suggestions revealed that only particular responses were correlated with planning. For instance, "Writing a note to remember your skates" was significantly correlated with the planning scores of the MCI ($r = .34$, $p < .01$), the planning section of the MCQ ($r = .39$, $p < .01$) and the composite score of the MCI ($r = .44$, $p < .05$). On the Kreutzer et al. test, the overall total number of planful responses and the remaining categories of using the skates as a physical reminder or requesting other people to serve as memory prompts were not correlated with the planning sections of the MCI or MCQ. On the other hand, answers pertaining to self-directed reminding such as repeating the instructions to yourself, correlated with problem-definition ($r = .40$) and evaluating ($r = .43$) on the MCI and correlated inversely with strategy selection ($r = -.411$) on the MCQ. These results raise the possibility

that the Kreutzer planning task or the measures of the current study may be assessing different metacognitive processes within the same test.

Strategy Selection. The second measure was chosen from the research of Ajchenbaum (1983) in which students were required to complete two problem solving tasks; namely, finishing a maze puzzle and repeating a series of digits backwards after the examiner. A general question followed each task asking the children to describe to a fellow student what they would need to be aware of or think about when solving this type of problem. Scores were then calculated on the number of strategies recommended by the student and the quality/awareness level of these strategies based on a rating scale from deficient to superior. The results were as follows; a significant relation was obtained between the MCI strategy selection scores and the number of digit strategies ($r = .67$), awareness of strategy use on digits ($r = .69$), number of maze strategies ($r = .46$) and awareness of strategy use on mazes ($r = .59$). In contrast, the expected relation between MCQ strategy questions and the Ajchenbaum tasks did not materialize. Rather it was the MCQ Planning dimension that correlated with the number of digit strategies ($r = .61$) instead of the MCQ strategy selection questions ($r = .34$). A closer analysis, however, of specific responses on the MCQ revealed a difference in results depending on the type of

open-ended question. Scores on the item referring to strategies returning home from a shopping centre correlated with number of digit strategies ($r = .53$) and awareness of digits ($r = .43$). In contrast, no significant correlations were obtained on the MCQ question pertaining to strategies on how to study for a math test.

In the Ajchenbaum study, the tasks were considered to provide global measures of metacognition. No reference was made to a specific subskill of strategy selection, the latter being inferred by the present investigator. The present findings in fact support this test as a general measure of metacognition in that there was a strong correlation between the composite scores of the MCI and MCQ and the number of digit strategies ($r = .75$, $r = .54$), awareness level of digit strategies ($r = .79$, $r = .41$), number of maze strategies ($r = .46$, $r = .49$) and awareness of maze strategies ($r = .57$, $r = .57$). So while there was support for the MCI strategy scores as measures of strategy selection, the strong correlations between the composite scores of both the MCI and MCQ with the Ajchenbaum tasks, suggests these tasks may be more accurately considered global measures of metacognition.

Monitoring. The task considered most representative of the monitoring process was selected from the research of Markman (1977). In this study a magic trick was demonstrated with incomprehensible instructions. Scores

were recorded on how many probes were necessary before the child asked a question indicating they did not understand the directions. Therefore, those subjects who were more effective at monitoring their understanding would require fewer probes and hence obtain a lower score. Present results revealed significant negative correlations between the scores on the Markman test and the monitoring scale of both the MCI ($r = -.49$) and the MCQ ($r = -.54$). These findings suggest that children who obtained high scores on the metacognitive monitoring measures of the present study are those who also require fewer probes to recognize the incomplete instructions. It should be noted there were also significant correlations between the Markman task and measures of planning and strategy selection on the MCI ($r = -.41$, $r = .53$) and the MCQ ($r = -.45$, $r = -.43$). Once again this raises the issue of whether it is possible to obtain independent measures of the metacognitive sub-processes or whether the sub-processes are independent.

In addition to the instruments stated above, several observations of behaviours considered indicative of monitoring were available in the design of the present research. Stober (1983) proposed that problem solving errors on the Pattern-Matching task were indicative of deficient awareness of the monitoring process. There was a significant correlation between the Markman task and the number of omitted eliminations of designs on the Pattern-

Matching test ($r = .55$) but not with the number of incorrect eliminations ($r = .07$). It may be that errors of omission reflect a more serious inability to monitor than making incorrect choices. An unexpected finding was noted on the analysis of responses following the distorted presentation of the Kemler Hypothesis Formation task, labelled the "Mixed Kemler". There was no correlation between the children's awareness that something was wrong with the Kemler and their scores on the Markman test ($r = .28$).

Evaluating. The final concurrent validity measure was selected from the literature on meta comprehension. According to the research of Brown and Smiley (1977), awareness of the structural importance of an idea unit to the theme of a story was considered indicative of metacognition in a problem solving situation. On this task, students listened to a taped story, then for a second time followed the story in written format. Then the children were asked four times to progressively eliminate the least important story facts ending up with the ten most important story units. Scores were calculated of the final number of idea units compatible with the units considered most important by Brown and Smiley (1977). This measure was considered to most closely resemble the metacognitive process of evaluating.

Results of the correlational analyses revealed a

significant association between the Brown and Smiley task and the composite scores of the MCI ($r = .40$) and MCQ ($r = .58$). Investigation of the metacognitive sub-processes of the MCI indicated a significant correlation with the evaluating section ($r = .42$), but also with the planning ($r = .41$), strategy selection ($r = .46$), and monitoring scores ($r = .46$). In comparison, the Brown and Smiley task correlated with the MCQ sections of evaluating ($r = .39$), planning ($r = .41$) and strategy selection ($r = .78$). These results may reflect the quite different focus on evaluating assumed by these two studies. Evaluating in the present study was defined as the ability to evaluate one's performance after problem solving, not necessarily to evaluate the cognitive elements of a task as done in the Brown and Smiley (1977) experiment.

In summary, the results support the instruments of the present study as valid measures of global metacognitive processing. Generally significant correlations were found between the composite scores of the MCI and MCQ and each of the four measures selected from the literature. Inconsistent findings were reported on the association between the metacognitive sub-processes assumed to be tapped by each of these validating measures and the respective sections of the MCI and MCQ. For instance the MCI sections of planning, strategy selection, monitoring and evaluating compared favorably with the appropriate

validating measures. However, this relation was not specific in that other metacognitive sub-processes also correlated with each of the validating measures. A similar pattern of findings was noted on the MCQ. These findings suggest either the measures are not sufficiently focussed to assess the metacognitive sub-processes or these sub-processes may be difficult to measure independently.

In summary, data supporting the validity of the composite scores of the MCI and MCQ as a measure of global metacognitive functioning was provided by analysis of developmental differences, internal consistency, factor analysis and inter-correlational analysis of the metacognitive measures. The evidence for the valid assessment of each of the six distinctive metacognitive subprocesses was less definite.

DISCUSSION

In this chapter, the results will be discussed with respect to the stated research hypotheses. Implications for understanding the construct of intellectual giftedness and the status of metacognitive assessment are described. Metacognition, as observed in gifted and average students at the Grade 3, 6 and 8 level, will be reviewed from the perspective of intellectual and developmental (grade) differences. Defined as an individual's knowledge and awareness of his/her cognitive processes, metacognition is examined on the basis of sub-processes (problem definition, planning, strategy selection, monitoring, flexibility of strategy use and evaluating) derived from the work of Sternberg (1986, 1990), Brown (1978) and Flavell (1976). Issues essential to metacognitive assessment, including the reliability and validity of instruments concludes the discussion of the study's findings. Directions are offered for metacognitive assessment, educational intervention and future research.

1. Metacognition and Intelligence

Proficiency in metacognitive functioning was predicted to be a factor contributing to differences in general ability as assessed by standardized tests of intelligence. In order to evaluate this proposal, the performance of intellectually gifted and average students was compared on three measures of metacognition namely, an interview

immediately following a problem solving task, a questionnaire and observations of metacognitive behaviours. It should be reiterated that the intellectually gifted students were selected on the basis of standardized tests. It was expected that children of superior ability would exhibit higher levels of metacognitive functioning than children of average ability and this superiority would be consistent across all three types of metacognitive measure. Indeed, this expectation was confirmed by the results: third, sixth and eighth graders of superior ability attained higher levels of metacognitive functioning than their respective grade peers of average capabilities. Intellectually gifted students obtained higher scores on tests of metacognitive knowledge (MCQ), metacognitive processing (MCI), and on observational reports of metacognitive behaviour (self-corrections, error patterns). The only metacognitive measure that was not statistically significant between intellectual groups was the Mixed Kemler. This distorted presentation of the Kemler Hypothesis Formation test was expected to elicit student awareness that something was wrong with the task. It is possible the scoring system designed for this measure may not have been sufficiently refined to detect possible differences. With this one exception, the positive relation between metacognition and intelligence was noted both on quantitative measures of metacognitive functioning

as well as on qualitative measures including the clarity, specificity, reflectivity, organization and conceptualization of the student responses. One of the major queries of this study was whether specific or particular aspects of metacognition are more closely associated with intellectual level. Based on the present findings, it appears that the intellectually gifted are superior on overall global measures of expressed metacognitive knowledge and the observed implementation of metacognition in problem-solving situations. The fact that the intellectually gifted were superior on questionnaire, interview and observational measures supports the evidence for enhanced metacognitive abilities irrespective of the instrument used. Therefore, Sternberg's (1981, 1986) contention that the gifted are those who have "superior access to" and "implementation of" metacomponents, the essential executive abilities that oversee cognitive performance, appears to be supported by the present findings.

In order to answer the question of whether certain of the six proposed metacognitive sub-processes were differentially associated with intellectual level, the analyses examined each of the separate metacognitive sub-skills. Intellectually gifted students consistently outperformed average students on measures of planning, strategy selection, monitoring and flexibility of strategy

use. Student responses indicative of planful behaviour included comments as to the sequence of steps required to solve a problem, use of verbs such as look, think hard before you make a choice and awareness of the need to evaluate the difficulty level of a task before proceeding. The intellectually gifted obtained higher scores on both the interview and questionnaire items pertaining to an awareness of the usefulness of planning in the context of a problem solving situation.

One of the more interesting findings was the observation that on the questionnaire the number of strategies offered to solve the problem did not differ between intellectual groups. However, what did differ was the level of strategy use or in other words the student's ability to state how, when and in what way they would use these strategies. Thus, while both groups of students could generate strategies, it was the intellectually gifted who excelled in knowing how to proceed to use these strategies effectively. Robinson and Kingsley (1977) reported similar findings in that intellectual groups differed not on the number of strategies generated but in their actual use in a memory task.

Awareness of the ability to monitor one's problem-solving performance was a metacognitive sub-skill superior for the intellectually gifted on both the interview and questionnaire. In response to the interview question, "Did

you keep track of how you were doing on the game? If so how?", the intellectually gifted were more likely to indicate an understanding of the question, an affirmative response and an answer indicative of a checking strategy. It is especially notable that most average Grade 3 students appeared to have little notion of the concept of checking or monitoring their problem-solving activities.

Further evidence of the monitoring process is provided by the analysis of observational measures of metacognition. Wong (1983) reported results supporting the increased frequency of self-correcting behaviour by the gifted in solving a story comprehension problem in contrast to average and learning-disabled children. In the present study, self-correcting behaviour during a problem-solving task was more frequently shown by bright rather than average students at the 3rd, 6th and 8th grade level. Sternberg also has proposed that the gifted excel in this process of monitoring their problem solving and it would appear this is a highly significant marker of superior intelligence. One which clinicians would be advised to include in their repertoire of observational criteria of giftedness.

Error analysis also supported findings of superior monitoring abilities in gifted students across the three grade levels. Fewer elimination errors were observed both of omission and commission. Examiner observation suggests

this was directly related to the self-correcting actions of the gifted students which in effect prevented subsequent errors. Interestingly, the corrections for the most part occurred before task completion rather than after offering a solution providing further evidence that bright students tend to monitor prior to offering an answer rather than afterwards. Current instructional practise tends to correct or discuss errors after they have occurred. These results suggest teaching students to monitor and self-correct prior to finalizing problem solving solutions may be the more effective teaching method. As these present measures of self-correction changed very little between Grade 3 and 8 for average pupils, it may be important for curriculum planners to include this dimension of monitoring and self-correction in daily classroom instruction.

Flexibility of strategy use has been proposed by Shore (1986) and Sternberg (1981) as an important characteristic of intelligent behaviour. In response to the interview question designed to elicit this metacognitive sub-skill, the intellectually gifted were superior to average students at the Grade 6 and 8 levels in their awareness that indeed there might be another way to solve the problem and in their ability to generate alternate problem-solving approaches. On the Questionnaire, intellectual group differences were observed depending on the type of question. Evidence of higher scores on awareness of the

need to alter strategies was obtained for the gifted following an open-ended query about how to handle being lost in a shopping centre. Short-answer questions as to alternate methods to solve a puzzle or choose a TV program did not differ significantly between intellectual levels. The open-ended format may have allowed the intellectually gifted to demonstrate the broader extent of their metacognitive awareness than was possible on more closed questions.

The evidence is less definitive for the sub-process of problem definition which discriminated between intellectual groups, on the interview but not the questionnaire. Statistically significant differences were not obtained for the evaluating sub-skill on either metacognitive measure. This finding was unexpected in that both Sternberg and Brown considered these two skills to be important indicators of metacognition. Analysis of interview and questionnaire items tapping problem-definition and evaluating questions suggest either a low frequency of responses or a clustering of answers either at the high or low end of the scoring system may have affected the results. Therefore, an inability to detect intellectual group differences may be related to the psychometric properties of the measures or the inadequacy of the questions in eliciting these two sub-skills. Alternatively it may be that sub-processes other than problem definition

and evaluating are more central in differentiating between students of varied intellectual levels.

Although the current findings support the hypothesis that the intellectually gifted possess higher levels of global metacognitive functioning and excel in the sub-processes of planning, strategy selection, monitoring and flexibility of strategy use, other factors may be accounting for these superior scores. In order to reduce the possibility that the enhanced verbal capabilities of bright students were responsible for these results, several steps were taken in the design of the study. First the cognitive tasks chosen to elicit metacognition were essentially spatial or visual and non-verbal in response mode. In addition, word counts compiled from the interview protocols of a sub-sample (N=24) revealed similar mean scores across grade and intellectual groups. Inclusion of observational data provided an opportunity to measure metacognition independent of language factors. Therefore, the obtained association between observational data and the questionnaire/interview findings suggest greater confidence in the verbal report data. A final source of corroborative information to support the present findings is the results of multiple regression procedures. In predicting metacognitive scores, the CCAT Non-verbal scale results had the highest F-to-enter value over and above the CCAT Verbal and Quantitative scale scores. This suggests that verbal

ability may not be as strong a predictor of metacognition as has been suggested by previous investigations (Meichenbaum et al., 1985; Stober, 1983). This is not to say the issue of verbal skills confounding metacognitive measures is resolved. However, perhaps with appropriate task selection and care in formulating questions the effects can be minimized.

2. Development of Metacognition

Several investigators (Campione & Brown, 1978; Kreutzer et al., 1975; Myers & Paris, 1978; Wellman, 1978) have reported findings that suggest the development of metacognition proceeds in an incremental manner throughout the childhood years. The majority of previous research, however, has centered on a restricted age range or focussed on the development of metacognition in domains other than problem solving. The hypothesized prediction of higher metacognitive functioning for Grade 8 vs. Grade 6 vs. Grade 3 pupils was generally supported by the findings of the present study. For instance, scores on metacognitive measures (Interview and Questionnaire) were consistently higher for Grade 6 compared to Grade 3 children. These findings are corroborated by several studies reporting changes in metacognition in the 8 to 11 year age range (Stober, 1983). The Questionnaire data also indicated statistically significant differences in metacognitive

knowledge between Grade 6 and 8. An exception to the developmental trend was noted on the Metacognitive Interview data which did not differ significantly between the Grade 6 and 8 students. Possible explanations of this failure to find a difference could be due to ceiling effects of the interview items or that the scoring system was not sufficiently sensitive to detect differences.

The results of the current study also raise the possibility that regulation of cognition, as assessed on the Metacognitive Interview, may develop differently depending on the intellectual ability of the child. Analysis of the interview data, according to the six metacognitive sub-processes, suggests the intellectually gifted appear to demonstrate an increase in more of the sub-process skills than their average peers. Significant developmental differences between Grade 3 and 6, for the intellectually gifted only, indicated increased scores in all of the six metacognitive sub-processes with the exception of problem-definition. Average students, in contrast, improved only on the planning and strategy selection processes between Grade 3 and 6. Therefore, it could be concluded that the significant differences in the process scores of planning, monitoring, flexibility of strategy use and evaluating may represent critical differences in the development of metacognitive functioning for intellectually gifted students between these grade

levels.

The question of whether changes in metacognition are associated with maturational or intellectual factors was further analyzed in the design of the present study by comparing subjects matched on the basis of mental age as well as chronological age. The latter approach is more commonly reported in the literature. However, several studies have used this mental age matched design to assess differences in gifted and average students primarily on measures of cognitive functioning. For instance, superior performance of the gifted was reported by Keating (1975) on a series of Piagetian tasks, and by Froom (1986) on measures of information processing speed. Other researchers, however, such as Robinson and Kingsley (1977) report no significant difference between matched mental age groups in the use of mnemonic strategies to aid recall or organization on a memory retrieval task. In the present study, the results of mental age analyses depended on the age level and the particular aspect of metacognition that was measured.

Interestingly, intellectually gifted and average students with a matched mental age of 11 years did not differ statistically in metacognitive functioning. However, the results of the matched mental age groups at 13 years demonstrated superior scores for the intellectually gifted on the interview data. The metacognitive knowledge

(questionnaire) results did not discriminate between matched groups at either age level.

If age (maturation) was associated with the development of metacognition, one would have expected different results such that the older average subjects would surpass their younger mental-age matched peers on measures of metacognition. However, present findings indicated no significant differences between mental-age matched groups on metacognitive knowledge or, at the M.A. = 11 year level in metacognitive processing. A possible interpretation is that the development of metacognitive abilities may be associated with mental age rather than maturation or chronological age. Closer examination of the data, however, suggests that for some of the metacognitive sub-processes, maturity may be a factor. For instance, although multivariate analyses indicated no significant differences at the M.A. = 11 year level on the Metacognitive Interview data, univariate analyses revealed that the sub-processes of planning, strategy selection, and flexibility of strategy use were significantly different with higher scores obtained by the average Grade 6 compared to gifted Grade 3 students.

What emerged clearly from the present data was the finding that between the mental ages of 11 and 13, the intellectually gifted students demonstrate marked differences in the use of metacognition in problem solving

situations compared to their mental-age matched average peers. There is substantial overlap between intelligence and metacognitive knowledge. However, with the development of metacognitive skills at the M.A. = 13 year level, particularly in the intellectually gifted, the two processes become more distinct. It may be possible, therefore, to measure differences in metacognitive processing and intelligence.

The intellectually gifted were superior in their ability to use the metacognitive sub-processes of planning, strategy selection, monitoring, and flexibility of strategy use compared to average students, matched for mental age = 13 years level (see Figure 9). A number of explanations for this finding are possible. Perhaps a combination of maturation and mental age is important in the development of metacognition up to a certain age level (Grade 6). After which, metacognitive processing skills appear to develop in a different manner for the intellectually gifted. It could be suggested that metacognition may represent a qualitative difference in the gifted during Piaget's formal operational period. An alternative explanation is that although there is considerable overlap between current measures of intelligence and metacognitive knowledge as noted by the M.A. = 11 year and M.A. = 13 year group results, the overlap is not as apparent for metacognitive processing especially at the M.A. = 13 year

level. This suggests that factors unique to intellectual giftedness are not being measured by current standardized tests of intelligence and that one of these variables might be metacognitive processing.

Alternatively, as the findings were dependent on the measure of metacognition, it may be that whereas matched mental age groups have similar levels of metacognitive knowledge, it is the gifted that are able to use that knowledge in actual problem-solving situations as evidenced by their higher scores on the metacognitive interview at the MA = 13 year level.

Overall, these findings appear to lend support for Brown's (1978) stated position that metacognitive knowledge and use of that knowledge (metacognitive processing) are separate components especially important in defining intelligence. In Brown's words it is the appropriate use of a skill that defines intelligent behaviour, not knowledge of that skill per se. Statements such as this imply that it is the implementation of metacognitive processing that differentiates and defines intelligent behaviour. In their work with intellectually delayed subjects, Campione and Brown (1978) reported that although these students possessed similar levels of metacognitive knowledge compared to average subjects about strategies to use in a memory recall task, they were deficient in actual use of these strategies. Development in Brown's conception

is characterized by an increasing co-ordination between what one knows about memory and what one actually does about memorizing. In the present study it appears with increasing mental age, it is also this component of metacognitive processing rather than metacognitive knowledge that differentiates the performance of intellectually gifted students. The present findings appear to support Brown's notion of the salience of metacognitive processing in addition to metacognitive knowledge in determining the outcome of cognitive behaviour. Although the current research is based on a problem-solving rather than memory situation, the similarity with Brown's findings suggests that the intelligent control of one's actions when engaged in a cognitive behaviour, i.e., metacognition is a trans-situational concept important to definitions of individual differences.

How do the current findings relate to Sternberg's contention that the intellectually gifted excel in their access to and implementation of metacomponents? If one assumes that "access to" can be equated with the definition of metacognitive knowledge and "implementation of" to the notion of metacognitive processing, then the present findings suggest Sternberg's theory may need to be modified to take into account the importance of the "implementation of" component in defining intellectual giftedness.

Sternberg's current writings do not appear to assign differential importance to either "access to" or "implementation of" processes. The present study offers the possibility that qualitative differences in metacognition associated with intellectual giftedness may be related to the use of metacognitive processes rather than the level of metacognitive knowledge per se.

In reviewing the literature there appears to be no cited study that directly investigates metacognition and giftedness from the viewpoint of a matched mental age design. Similar in design, however, is a recent study by Kurt and Weinert (1989) on metamemory and giftedness. Fifth grade gifted and seventh grade average students did not differ statistically on a questionnaire measure of metamemory knowledge. Such a finding was similar to the non-significant differences on the Metacognitive Questionnaire reported between average and gifted students matched for mental age. Porath (1988), in conversation, reported using one metacognitive task as part of a battery designed to investigate problem solving ability in Gifted Grade 3 versus Average Grade 6 students (MA = 11 years). The difference in metacognitive scores was not statistically significant, providing some corroborative evidence that qualitative differences between the intellectually gifted and average population may occur after the MA = 11 year level. Although there are

limitations in using mental age definitions of intelligence (Spitz, 1982), the matched mental-age design serves to support and direct further investigation of the sub-processes of metacognition which may prove most relevant to study and which may not have been detected by traditional designs of only grade or intellectual level comparisons. This is certainly supported in the present study as individual analyses of grade differences would have lead one only to the hypothesis that chronological age or maturation was critical in the development of metacognition.

In summary, the present findings appear to support Roger's (1986) hypothesis that the difference in cognitive strategies between gifted and average students is a difference in degree rather than kind. Metacognitive processing was evident for both gifted and average students in the current study, however, at all grade levels and when matched for mental age, the gifted consistently demonstrated higher levels of metacognitive awareness in using the processes of planning, strategy use, monitoring and flexibility of strategy use. Rogers (1986) makes another important point that the differences delineated should not necessarily be the focus of instruction rather the goal of education should be to meet the special needs and problems these differences may create.

The results of the present study suggest that bright

students should be allowed time to plan, to generate strategies, to check over their work. All too often an over-crowded curriculum with mandated time allotments for subject areas reduces opportunities for thought and reflection. Similarly closed questions with the right answer reduce the gifted students' tendency to flexibility and alternate strategy use. They require encouragement of their proclivity to develop alternate solutions to problems, to figure out diverse ways to find an answer, skills which will benefit us all in the future.

3. Metacognition/Cognition Relationship

The final hypothesis concerned the association between cognitive performance on two problem-solving tasks and metacognition. Initial analysis of the cognitive tasks revealed that Grade 6 and 8 students performed more efficiently than Grade 3 pupils. These results were consistent with previous reports of age increments in Pattern-matching task scores (Cameron, 1976; McKinney, 1975; Stober, 1983) and the Kemler Hypothesis Formation task (Ferguson, 1985; Kemler, 1978). In addition, at the Grade 3 level, average students were found to perform less efficiently on cognitive measures than the intellectually gifted. Differences in the awareness of cognitive processes, ie., metacognition, were hypothesized as a possible explanation for the less efficient performance of

the younger average students. Therefore in order to investigate this possibility, correlations were computed between cognitive measures of the Pattern-matching and Kemler tasks and measures of metacognitive knowledge (Metacognitive Questionnaire) and metacognitive processing (Metacognitive Interview).

The findings were supportive of a cognitive-metacognitive association as noted by the significant correlations between Pattern-matching task efficiency and scores on the Metacognitive Interview and Questionnaire. The higher correlations with the Interview measures is not surprising since the metacognitive interview immediately followed the completion of the problem-solving tasks whereas the Questionnaire was administered at an alternate time. The importance of examining task variables is supported by the significant but smaller correlations between the Kemler task and the metacognitive measures. These findings were contrary to predictions that the more difficult Kemler task would generate higher levels of metacognitive awareness in contrast to the relatively straight-forward Pattern-matching problems. These results may serve to refine Flavell's (1977) contention that a moderately difficult task is necessary to activate metacognitive processing. It may be that a highly difficult task serves to inhibit metacognition as the subject is too involved in cognitive processing to reflect

on personal problem-solving behaviours.

In addition to the analysis of cognitive functioning and composite measures of metacognition, correlations with each of the six metacognitive sub-processes were also examined. The processes of planning, strategy selection, flexibility of strategy use and monitoring were predictive of problem solving efficiency. Small but significant correlations were also reported between cognitive functioning and the problem definition and evaluating sub-processes. In summary, the present findings serve to emphasize the need of future research to consider the mediating effects of cognitive task, metacognitive measure, and age in investigating the cognitive-metacognitive association.

Other researchers have been concerned not only with the association between cognition and metacognition but also whether metacognition can be considered as a factor separate from cognition (Brown, 1978; Cavanaugh & Perlmutter, 1982; Wertsch, 1977). Metacognition, as a distinct process, is in part supported by the correlational data of the present study which found some but not large overlap between cognitive and metacognitive functioning ($r = .42$ to $.55$). One would expect higher correlations if the processes were not distinct. How this cognitive-metacognitive association operates raises other, as yet, unanswered theoretical questions. Sternberg (1981)

postulates that the metacomponents are the central elements in an interactive system involving other performance and acquisition components. Cognitive processing proceeds by activating and receiving feedback from the metacomponents. This concept of an interactive system supercedes the issue of directionality, ie., do higher levels of metacognition lead to higher levels of cognition or vice-versa? Brown (1978) appears to endorse the theoretical positions that cognitive performance is the result of underlying metacognitive functioning which could be interpreted as a unidirectional position. It was of interest to note in the present study that as task performance increased between Grade 3 and 6, so did the levels of metacognitive processing and metacognitive knowledge. As the scores on the problem solving tasks levelled off between Grade 6 and 8 so did the metacognitive interview results. This sequence was observed independently in the intellectually gifted and average subject samples. That there is a relation between cognitive and metacognitive functioning appears evident. Whether this association is unidirectional or interactive will require further investigation.

Another related concern is that differences in cognitive functioning between subjects may be confounding findings of metacognitive differences. Slife et al. (1985) contend that it is necessary to first match subjects on the

cognitive task then measure metacognitive differences. In the present study, the number of focussing moves on the Pattern-matching tasks did not differentiate between subjects regardless of age or intellectual level. What did differ, however, was the efficiency in problem-solving between intellectual groups. Gifted students, even at Grade 3 level, made fewer non-informative moves although focussing moves for both Gifted and Average students remained the same. These results appear to support the notion of metacognition as a reflection on cognition and care in making cognitive decisions, hence, a reduction in inefficient choices. Therefore, although the present study suggests intellectual group differences in cognitive task efficiency for the Grade 3 students, these differences are only in the number of non-informative choices rather than focussing decisions. For students in Grade 6 and 8, overall cognitive efficiency levels, however, were not statistically different for gifted and average students. Therefore, the noted metacognitive differences between these intellectual groups is maintained for at least the Grade 6 and 8 level data.

4. Metacognitive Assessment

One of the objectives of the current study was to examine the inter-relation among various methods currently used to assess metacognition. The need for converging

evidence has been cited by several researchers (Meichenbaum et al., 1985; Sternberg, 1985) as essential given the emerging state of the construct. Multi-method measures in the present study included interview, questionnaire, and observational data. First, results confirmed statistically significant correlations between two measures of verbal report data namely the post-performance interview and the questionnaire of metacognitive knowledge ($r = .56$). More importantly, correlations were also statistically significant between global measures of metacognition on the interview and questionnaire respectively, and observational data of self-correcting behaviours, error patterns and reactions to a distorted task ($r = .30$ to $.43$). These findings linking verbal self-report data and observational measures of metacognition are considered a substantial contribution given the concerns expressed in the literature on the accuracy of subject's accounts of their thought processes (Ericsson & Simon, 1980; Nisbett & Wilson, 1977). It raises the interesting possibility that the relation between verbal reports of metacognition and observational data may be more closely associated in children than previously thought (Markman, 1977).

A critique of aspects of the present research instruments deemed to be effective or requiring attention may be instructive for future research. In the case of the Metacognitive Interview, the six questions were formulated

to be open-ended, non-judgmental and easily understood by children in the Grade 3-8 range. Pilot testing served to eliminate ambiguous items. The technique of requesting children to explain to a friend how they would play the game (problem-solving task) appeared effective in eliciting answers from the students. In the interest of maintaining consistency across subjects, probes were structured as part of the interview and consisted of general statements such as "tell me more". A further advantage, from a clinical perspective, is that the interview protocol is not task specific and could therefore be used following any problem-solving situation to assess a student's level of metacognitive functioning. The Metacognitive Questionnaire items most effective in discriminating between age and ability groups consisted of an open-ended question, asking how the student would solve a practical problem of being lost in a shopping centre, and a series of short-answer queries designed to measure metacognitive knowledge in practical and academic problem-solving situations. Several modifications, however, are indicated by the findings. For instance, the closed true-false questions of the Questionnaire did not discriminate levels of metacognitive functioning for students differing in age or ability. Myers and Paris (1978), in an investigation of metacognition and reading comprehension, reported similar concerns with the limitations of a checklist format as did

Stober (1983) in a dissertation on problem-solving strategies. Although a number of previous studies have reported forced-choice procedures (e.g., Borkowski et al., 1983; Kreutzer et al., 1975), the limitations of two alternatives may reduce the discriminatory values of the items. Alternatively, an open-ended question format may be more suited to assessing the complex personal nature of metacognition. Furthermore, experience with the present instruments indicates that the age and maturity of the subjects require particular consideration. A self-administered questionnaire, for example, might include a lie scale or be administered individually to ensure compliance especially among older students. The issue of reading level and fluency of written expression was of particular concern especially with the Grade 3 students. Although self-administered and experimenter administered questionnaire protocols did not differ statistically ($F = 2.45, p < .09$), the issue of self-administered questionnaires should be addressed in future research. In addition, it is not known to what extent tape recording may have inhibited verbal responding on the Metacognitive Interview. However on several occasions, especially with the Grade 3 children, it was necessary to stop recording in order for the child to respond comfortably. Verbatim recording of student answers is important in metacognitive research as it minimizes the possibility of experimenter

bias in selective note-taking. Nevertheless, less intrusive means, such as a pre-wired laboratory, could be considered in recording answers. Several investigators have reported a problem of "production deficiency" whereby subjects verbalize an awareness of strategic behaviours but are unable to use these abilities in problem-solving situations (Cosgrove & O'Brien, 1980; Flavell, 1979). In the present study, a reverse of this phenomenon was noted in two children, both highly intelligent Grade 3 youngsters. They were obviously using strategies but were unable to describe the processes to the examiner. Although this represents a low incidence rate (2/21 subjects), it is recommended records be kept of this behaviour for further analysis. In the case of both of these students, observational data revealed high levels of metacognitive behaviour such as frequent self-corrections and few monitoring errors which offset the limitations of their verbal reports.

The issues of verbal data and open-ended questions are further complicated by the need to develop adequate scoring systems. Two comprehensive scoring guides were devised, one for the interview, the other for the questionnaire with the measurement of the six metacognitive sub-processes providing a consistent framework. Despite the potential for subjective bias in scoring the test protocols, reliability measures were notably high for both overall and

individual sub-tests of metacognitive functioning. This was a positive finding as unreliable measures of individual differences can produce inflated correlations, a problem which according to Detterman (1989) should be more fully appreciated by researchers in the field of intelligence. Specifically, intrarater reliability coefficients averaged 83% for the interview (MCI) and 84% for the questionnaire (MCQ). In addition, test-retest reliability correlations on interview data in the range of .55-.87 compared favorably with results of the Kurtz et al. (1982) metamemory study indicating test-retest correlations from .13-.67. Nevertheless, future research should include measures of inter-rater reliability and test-retest correlations with larger samples of subjects.

Concern with psychometric properties of metacognitive instruments led to a detailed examination of the construct validity of the Metacognitive Interview and Questionnaire in the present study. The findings were supportive of a general/global measure of metacognition as well as the notion of a distinction between metacognitive knowledge and metacognitive processing. Two separate factors for the interview and questionnaire data respectively were derived on factor analytic studies. Internal consistency between the sub-scales and total score of the interview and questionnaire were within acceptable limits. Theoretical questions, however, emerge concerning the validity of

dividing the concept of metacognition into various sub-processes or "metacomponents" to use Sternberg's (1981) terminology. Evidence for six distinct metacognitive sub-skills as proposed in this study is somewhat equivocal. It may be that metacognition, like intelligence, is strongly weighted on a "g" or general factor. Despite efforts to identify distinctive factors in intelligence (Guilford, 1967; Meeker, 1969; Vernon, 1960), researchers have reported similar problems in finding statistically significant independent factors. For instance, Sattler (1982) notes that "a large number of Guilford's factors of intellect have failed to show any external validity that could not be accounted for by their general or group factors" (p. 39). Therefore, it may be that metacognition, as well, represents an overall general level of functioning. Alternatively, it could be that other measurement problems require resolution such as accurate description of the sub-processes, consensus among researchers as to the pertinent sub-skills or the development of means other than interview or questionnaire data to elicit responding. From the point of view of diagnostic prescriptive teaching, the delineation of metacognitive sub-skills is particularly suited to identification and remediation. Therefore, it is considered worthwhile to pursue the investigation of metacognitive sub-processes but continue efforts to find

valid measures.

Several suggestions to improve the assessment of metacognition might include use of a "peer teaching" technique (Meichenbaum et al., 1985) which allows the observation of metacognitive processing while students teach each other a task. A variation of this paradigm, cross-age tutoring (Garner & Alexander, 1989) was devised to measure children's awareness of specific reading comprehension strategies. Subject tutors help younger children in a reading exercise and measures were taken of the subject tutor's cueing strategies to the younger child. At times, the younger child was trained as a confederate to feign strategy deficits. Meichenbaum (1988) also has initiated classroom observational measures of metacognitive behaviours during daily lessons. It would be interesting to assess the interaction of a teacher's metacognitive behaviour and verbal statements on student performance. These, and other procedures, may begin to resolve issues related to the ecological validity of metacognitive measurement and serve to limit reliance on verbal self-report data and paper-pencil tests.

5. Future Research

Considerable concern has been expressed regarding the gifted underachiever (Whitmore, 1980). The potential for those bright students to become future delinquents or

school drop-outs has raised queries of how best to identify and rectify the learning gap of these students. There is a growing body of research to suggest that the learning disabled are less efficient in their use of metacognitive strategies (Torgeson, 1977; Wong, 1982). Therefore, it would be interesting to investigate whether the learning disabled are indeed less metacognitively aware than their normally achieving intellectual peers. If so, this would suggest the next step which would be the teaching of metacognitive strategies as a means of bridging the gap between their measured potential and lack of achievement. Whitmore has further delineated three specific sub-groups namely the learning disabled gifted, the culturally disadvantaged gifted, and the emotional behaviourally maladjusted gifted. It would be of interest if these groups could be validated and the level of metacognitive functioning within each of these groups investigated.

The second thrust of future research could be the analysis of instructional variables critical to the teaching of the various metacognitive processes. It appears from a converging body of evidence that metacognition is associated with intelligence, however, the essential issue is can metacognition be learned, retained, and generalized in different problem-solving situations. As Rogers (1983) reported in her study of student teachers,

educators find it difficult to recognize and reflect on their own learning processes as mature adults. It will be important to start an educational process within the teaching profession regarding awareness of metacognition then to proceed to direct instructional curriculum for children. Several programs are already available which appear to address the teaching of metacognitive skills such as the Philosophy for Children (Lipman, 1978) and the Instrumental Enrichment curriculums (Fuerstein, 1980). Nevertheless, none of these programs directly addresses the awareness of metacognitive processes in the teachers, which would appear to be an important first step in that the teacher must model, talk out problem solving steps, and reflect verbally before the children can be expected to grasp this concept. It would be of interest to investigate the effectiveness of training programs that focus on the student only in contrast to those programs which educate both the teacher and student in metacognitive strategies. Other studies could be designed to investigate the effectiveness of teaching the various sub-processes and the resultant effect on school achievement and/or intellectual measures.

6. Summary and Conclusions

The results of the present study support the construct of metacognition as a factor in the manifestation of

superior intelligence. Intellectually gifted children at the Grade 3, 6 and 8 level outperformed their age peers on measures of metacognitive knowledge and process skills. Age effects were found for each intellectual group considered independently. Older (Grade 6 and 8) students consistently obtained higher scores on metacognitive measures than Grade 3 students. Analysis of the metacognitive sub-processes between grades and intellectual groups indicated awareness of the need to plan prior to starting a problem, the ability to generate strategies and flexibility in the use of alternate strategies to solve problems differentiated between bright and average pupils.

In an effort to separate which aspects of metacognition were related to maturation from those related to intelligence, the present research design afforded the opportunity to analyze two matched mental age groups. The results generally supported the notion that the development of metacognition may be associated with intelligence or mental age rather than chronological age, experience or school instruction. The largest developmental change noted in the study was found for intellectually gifted subjects between Grades 3 and 6 (M.A. = 11 and 13 years). The differences are such that, by Grade 6, intellectually gifted subjects performed at higher levels of metacognitive processing than Grade 8 average students, their mental-age matched peers.

Furthermore, this present study has demonstrated that multiple measures of metacognition including observational as well as self-report data, are required to better understand the complex relation of this concept to the nature of intelligence. In conclusion, as Spitz (1982) has so aptly stated, "our brains are a self-organizing system of immense complexity with potentials we only occasionally glimpse in our most gifted individuals" (p. 187). Metacognition, the self-awareness of one's thinking, appears to be a promising new dimension for process definition of what constitutes intelligent behaviour witnessed by this comparative study of the development of metacognition in intellectually gifted and average children.

References

- Adair, J., & Spinner, B. (1979). Subjects access to cognitive processes: Demand characteristics and verbal report. Unpublished manuscript, University of Manitoba, Canada.
- Ajchenbaum, M. H. (1983). The relation between metacognition and intelligence in adolescents. Unpublished doctoral dissertation, University of Nebraska, Nebraska. Dissertation Abstracts International, 44, May 1984, 8320-A.
- Anastasi, A. (1982). Psychological testing (5th Ed.). New York: Macmillan.
- Anderson, M. A. (1985). Information processes used by gifted and average elementary students when solving written discourse problems. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, Illinois.
- Andreassen, C., & Walters, H. S. (1989). Organization during study: Relations between metamemory, strategy use and performance. Journal of Educational Psychology, 81, 190-195.
- Backman, J. E., Mamen, M., & Ferguson, H. B. (1984). Reading level design: Conceptual and methodological issues in reading research. Psychological Bulletin, 96, 560-568.
- Binet, A., & Simon, T. (1905). Methodes nouvelles pour le diagnostic du niveau intellectuel des anormaux. L'Annee Psychologique, 11, 191-244.

- Binet, A., & Simon, T. (1916). The development of intelligence in children. Baltimore: Williams & Wilkins.
- Bizanz, G. L., Vesonder, G. T., & Voss, J. F. (1978). Knowledge of one's own responding and the relation of such knowledge to learning. Journal of Experimental Child Psychology, 25, 116-126.
- Blishen, B. R., & McRoberts, H. A. (1976). A revised socioeconomic index for occupations in Canada. Canadian Review of Sociology and Anthropology, 13(1), 71-79.
- Blodgett, E. G., & Cooper, E. B. (1987). Analysis of the language of learning: A practical test of metalinguistics. Moline, Illinois: LinguiSystems Inc.
- Borkowski, J. G. (1985). Signs of intelligence: Strategy generalization and metacognition. In S. R. Yussen (Ed.), The growth of reflection in children (pp. 105-144). New York: Academic Press.
- Borkowski, J., Estrada, M., Milstead, M., & Hale, C. (1989). General problem solving skills: Relations between metacognition and strategic processing. Learning Disability Quarterly, 12(1), 57-70.
- Borkowski, J. G., & Peck, V. A. (1986). Causes and consequences of metamemory in gifted children. In R. J. Sternberg & J. E. Davidson (Eds.), Conceptions of giftedness (pp. 182-200). New York: Cambridge University Press.

- Borkowski, J. G., Ryan, E. D., Kurtz, B. E., & Reid, M. K. (1983). Metamemory and metalinguistic development: Correlates of children's intelligence and achievement. Bulletin of the Psychonomic Society, 21, 393-396.
- Brown, A. L. (1975). The development of memory: Knowing, knowing about knowing, and knowing how to know. In H. W. Reese (Ed.), Advances in child development and behaviour (Vol. 10). New York: Academic Press.
- Brown, A. L. (1978). Knowing when, where and how to remember: A problem of metacognition. In R. Glaser (Ed.), Advances in instructional psychology (pp. 77-165). Hillsdale, N.J.: Lawrence Erlbaum.
- Brown, A. L., & Barclay, C. R. (1976). The effects of training specific mnemonics on the metamnemonic efficiency of retarded children. Child Development, 47, 71-80.
- Brown, A. L., Campione, J. C., & Murphy, M. D. (1977). Maintenance and generalization of trained metamnemonic awareness in educable retarded children. Journal of Experimental Child Psychology, 24, 191-211.
- Brown, A. L., & Smiley, S. S. (1977). Rating the importance of structural units of prose passages: A problem of metacognitive development. Child Development, 48, 1-8.
- Brown, A. L., & Smiley, S. S. (1978). The development of strategies for studying texts. Child Development, 49, 1076-1088.

- Butterfield, E., Wambold, C., & Belmont, J. (1973). On the theory and practise of improving short-term memory. American Journal of Mental Deficiency, 77, 654-669.
- Cameron, R. (1976). Conceptual tempo and children's problem-solving behaviour: A developmental task analysis. Unpublished doctoral dissertation, University of Waterloo, Waterloo, Ontario.
- Campione, J. C., & Brown, A. L. (1978). Toward a theory of intelligence: Contributions from research with retarded children. Intelligence, 2, 279-304.
- Carr, M., & Borkowski, J. G. (1987). Metamemory in gifted children. Gifted Child Quarterly, 3(1), 40-44.
- Cavanaugh, J. C., & Borkowski, J. G. (1980). Searching for metamemory-memory connections: A developmental study. Developmental Psychology, 16, 441-453.
- Cavanaugh, J. C., & Perlmutter, M. (1982). Metamemory: A critical examination. Child Development, 53, 11-28.
- Chatman, S. P., & Williford, J. N. (1982). The gifted student's awareness and use of cognitive strategies in academic tasks: An exploratory study. Paper presented at the annual meeting of the National Association for Gifted Children, New Orleans.
- Chi, M. T. H. (1978). Knowledge structures and memory development. In R. Siegler (Ed.), Children's thinking: What develops?. Hillsdale, N.J.: Lawrence Erlbaum.

- Chi, M. T. H. (1986). Cited in R.J. Sternberg & J.E. Davidson (Eds.), Conceptions of giftedness (pp. 182-200). New York: Cambridge University Press.
- Daniels-Beirness, T., & Nandi, S. (1986). Sex differences in the intellectual abilities of children identified as gifted. Paper presented at Canadian Psychological Association Conference, Toronto, Ontario.
- Das, J. P. (1973). Cultural deprivation and cognitive competence. In N. R. Ellis (Ed.), International review of research in mental retardation (Vol. 6). New York: Academic Press.
- Das, J. P. (1984). Aspects of planning. In J. R. Kirby (Ed.), Cognitive strategies and educational performance (pp. 35-50). New York: Academic Press.
- Davidson, J. E., & Sternberg, R. J. (1984). The role of insight in intellectual giftedness. Gifted Child Quarterly, 28, 58-64.
- Detterman, D. K. (1989). The future of intelligence research. Intelligence, 13, 199-203.
- Dirkes, A. M. (1985). Metacognition. Students in charge of their thinking. Roeper Review, VIII(2), 96-100.
- Dover, A. C. (1983). Metacognition and problem solving in gifted children. Unpublished master's thesis in Educational Psychology, McGill University, Montreal.
- Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. Psychological Review, 87(3), 215-251.

- Feldman, D. H. (1982). Developmental approaches to giftedness and creativity. New Directions for Child Development (Vol. 17). San Francisco: Jossey-Boss.
- Feuerstein, R., Rand, Y., Hofman, M. D., & Miller, R. (1980). Instrumental enrichment. Baltimore: University Park Press.
- Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence. Hillsdale, N.J.: Lawrence Erlbaum.
- Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist, 34, 906-911.
- Flavell, J. H., Friedrichs, A. G., & Hoyt, J. D. (1970). Developmental changes in memorization processes. Cognitive Psychology, 1, 324-340.
- Flavell, J. H., & Wellman, H. M. (1977). Metamemory. In R. V. Kail & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition (pp. 3-33). Hillsdale, N.J.: Lawrence Erlbaum.
- Froom, C. A. (1986). Information processing strategies used by intellectually gifted, retarded and normal children. Unpublished doctoral dissertation, University of Toronto, Canada.
- Gallagher, J. J. (1985). Teaching the gifted child. Boston, MA: Allyn & Bacon, Inc.
- Galton, F. (1869). Hereditary genius. London: Macmillan Publishing Co., Inc.

- Gardner, H. (1982). Frames of mind. New York: Basic Books.
- Garner, R., & Alexander, P. A. (1989). Metacognition: Answered and unanswered questions. Educational Psychologist, 24(2), 143-158.
- Geis, M. F., & Corriher, S. E. (1977). Memory and organizational processes in high IQ children. Paper presented at the biennial meeting of the Society for Research in Child Development, March, New Orleans.
- Guilford, J. P. (1967). The nature of human intelligence. New York: McGraw-Hill.
- Hannafen, M. J., & Carey, J. O. (1981). Research in progress: Toward a procedure to identify the spontaneous memory strategies of children. Paper presented at the annual meeting of the Association for Educational Communication and Technology, Philadelphia.
- Henshaw, A. (1978). A cognitive analysis of creative problem-solving. Unpublished doctoral dissertation, University of Waterloo, Canada.
- Horn, J. L., & Cattell, R. B. (1967). Age differences in fluid and crystallized intelligence. Acta Psychologica, 26, 107-129.
- Hunt, E. (1978). Mechanics of verbal ability. Psychological Review, 85, 109-130.
- Hunt, E., Lunneborg, C., & Lewis, J. (1975). What does it mean to be high verbal?. Cognitive Psychology, 7, 194-227.

- Jensen, A. R. (1979). The nature of intelligence and its relation to learning. Journal of Research and Development in Education, 12(2), 79-95.
- Kaufman, A. S., & Kaufman, N. L. (1983). Kaufman Assessment Battery for Children: Interpretive manual. Minnesota: American Guidance Service.
- Karnes, F. A., & Brown, K. (1980). Factor analysis of the WISC-R scores of gifted students. Psychology in the Schools, 72(2), 197-199.
- Keating, D. P. (1975). Precocious cognitive development at the level of formal operations. Child Development, 46, 276-280.
- Kemler, D. (1978). Patterns of hypothesis testing in children's discriminative learning: A study of the development of problem solving strategies. Developmental Psychology, 14, 653-673.
- King, E. M. (1981). Canadian test of basic skills. Scarborough, Ontario: Nelson Canada.
- Kirby, J. R. (1984). Cognitive strategies and educational performance. New York: Academic Press.
- Kontos, S., Swanson, H., & Fraser, C. (1984). Memory-metamemory connections in intellectually gifted and normal children. Psychological Reports, 54, 930.
- Kreutzer, M. A., Leonard, C., & Flavell, J. H. (1975). An interview study of children's knowledge about memory. Monographs of the Society for Research in Child Development, 40 (1), Serial No. 159.

- Kurtz, B. E., & Weinert, F. E. (1989). Metamemory, Memory Performance, and Causal Attributions in gifted and average children. Journal of Experimental Child Psychology, 48. 45-61.
- Lanson, G., & Saccuzzo, D. P. (1989). Cognitive correlates of general intelligence: Toward a process theory of g. Intelligence, 13, 5-31.
- Lipman, M., Sharp, A. M., & Oscanyan, F. (1978). Philosophy in the classroom. Philadelphia: Temple University Press.
- Luchins, A. S. (1942). Mechanization in problem solving. Psychological Monographs, 54(6), Whole No. 248.
- MacLeod, C. M., Hunt, E. B., & Mathews, N. N. (1978). Individual differences in the verification of sentence-picture relationships. Journal of Verbal Learning and Verbal Behaviour, 17, 493-507.
- Markman, E. M. (1977). Realizing that you don't understand: A preliminary investigation. Child Development, 48, 986-992.
- McKinney, J. D. (1975). Problem-solving strategies in relective and impulsive children. Journal of Educational Psychology, 67, 807-820.
- Meeker, M. N. (1969). The structure of intellect. Columbus, Ohio: Charles E. Merrill.
- Meichenbaum, D. (1988). Cognitive Behaviour Therapy Symposium. Ottawa, Canada: Carleton University.

- Meichenbaum, D., & Asarnow, J. (1979). Cognitive-behavioural modification and metacognitive development. In P. C. Kendall & S. Hollen (Eds.), Cognitive behavioural interventions: Theory, research and procedures. New York: Academic Press.
- Meichenbaum, D., Burland, S., Gruson, L., & Cameron, R. (1985). In Yussen, S. R. (Ed.), The growth of reflection in children (pp. 3-30). New York: Academic Press.
- Miller, P. H., & Bigi, L. (1979). The development of children's understanding of attention. Merrill-Palmer Quarterly, 25, 235-250.
- Mischel, H. N., & Mischel, W. (1983). Children's metacognitive knowledge about reading. Journal of Educational Psychology, 70, 680-690.
- Moss, E. S. (1983). Maternal teaching strategies and information processing skills in gifted and nongifted preschoolers. Unpublished doctoral dissertation, McGill University.
- Myers, M., & Paris, S. G. (1978). Children's metacognitive knowledge about reading. Journal of Educational Psychology, 70, 680-690.
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. Psychological Review, 84(3), 231-259.
- Norusis, M. J. (1985). SPSS-X Advanced Statistics Guide. Chicago, Illinois: SPSS Inc.

- Palinscar, A. S. (1987). Collaborating for collaborative learning from text. Paper presented at the Annual Meeting of the American Educational Research Association, April, Washington, D.C.
- Palinscar, A. S., & Brown, A. L. (1984). The reciprocal teaching of comprehension - fostering and comprehension - monitoring activities. Cognition and Instruction, 1(2), 117-175.
- Palinscar, A. S., & Brown, A. L. (1986). Interactive teaching to promote independent learning from text. The Reading Teacher, 39(8), 771-777.
- Palinscar, A. S., & Brown, A. L. (1988). Teaching and practicing thinking skills to promote comprehension in the context of group problem-solving. Remedial and Special Education, 9(1), 53-59.
- Paris, S. G., & Lindauer, B. K. (1982). The development of cognitive skills during childhood. In B. B. Wolman (Ed.), Handbook of developmental psychology (pp. 333-349). Englewood Cliffs, N.J.: Prentice Hall.
- Paris, S., & Oka, S. (1989). Strategies for comprehending text and coping with reading difficulties. Learning Disability Quarterly, 12(1), 32-42.
- Paris, S. G., & Myers, M. (1981). Comprehension monitoring, memory and study strategies of good and poor readers. Journal of Reading Behaviour, 13, 5-22.

- Patterson, C. J., Cosgrove, J. M., & O'Brien, R. G. (1980). Nonverbal indicants of comprehension and noncomprehension in children. Developmental Psychology, 16, 38-48.
- Pedhazur, E. J. (1982). Multiple regression in behavioural research. New York: Holt, Rinehart & Winston.
- Pellegrino, J. W., & Glaser, R. (1980). Components of inductive reasoning. In R. E. Snow, P. A. Federico, & W. L. Montague (Eds.), Aptitude, learning and instruction: Cognitive process analyses. Hillsdale, N.J.: Lawrence Erlbaum Associates.
- Piaget, J. (1972). The psychology of intelligence. New Jersey: Littlefield, Adams.
- Peterson, P. L., Swing, S. R., Baverman, M. T., & Buss, R. (1982). Students' aptitudes and their reports of cognitive processes during direct instruction. Journal of Educational Psychology, 74, 535-547.
- Porath, M. (1988). Cognitive development of gifted children: A neo-Piagetian perspective. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans (April).
- Pressley, M., Borkowski, J. G., & O'Sullivan, J. T. (1985). Children's metamemory and the teaching of memory strategies. In D. L. Forest-Pressley, D. Mackinnon, & T. G. Waller (Eds.), Metacognition, cognition and human performance. San Diego: Academic Press.

- Pressley, M., Johnson, C., Symons, S., McGoldrick, J., & Kurita, J. (1989). Strategies that improve children's memory and comprehension of text. Elementary School Journal, 90(1), 3-32.
- Robinson, J. A., & Kingsley, M. E. (1977). Memory and intelligence: Age and ability differences in strategies and organization of recall. Intelligence, 1, 318-330.
- Rogers, B. G. (1983). Metacognition: Implications for training teachers of the gifted. Roeper Review, 6, 20-21.
- Rogers, K. B. (1986). Do the gifted think and learn differently? A review of recent research and its implications for instruction. Journal for the Education of the Gifted, 10(1), 17-39.
- Sattler, J. M. (1988). Assessment of children's intelligence and abilities (Third Edition). San Diego: Jerome H. Sattler.
- Schlieper, A., & Alberts-Corush, J. (1985). WISC-R factor patterns of gifted students. Paper presented at 6th World Conference on Gifted and Talented Children. Hamburg, Germany.
- Scruggs, T. E., Mastropieri, M. A., Jorgensen, C., & Monson, J. (1986). Effective mnemonic strategies for gifted learners. Journal of Education of the Gifted, 9(2), 105-121.

- Shore, B. M. (1986). Cognition and giftedness: New research directions. Gifted Child Quarterly, 30, 24-32.
- Shore, B. M., & Carey, S. M. (1984). Verbal ability and spatial task. Perceptual & Motor Skills, 59, 255-259.
- Slife, B. D., Weiss, J., & Bell, T. (1985). Separability of metacognition and cognition: Problem solving in learning disabled and regular students. Journal of Educational Psychology, 77, 437-445.
- Snow, R. E., & Yalow, E. (1982). Education and intelligence. In R. J. Sternberg (Ed.), Handbook of human intelligence. New York: Cambridge University Press.
- Spearman, C. (1927). The abilities of man. New York: Macmillan.
- Spitz, H. H. (1982). Intellectual extremes, mental age, and the nature of human intelligence. Merrill-Palmer Quarterly, 28(2), 167-192.
- Sternberg, R. J. (1981). A componential theory of intellectual giftedness. Gifted Child Quarterly, 25(2), 86-93.
- Sternberg, R. J. (1982). A componential approach to intellectual development. In R. J. Sternberg (Ed.), Advances in the psychology of human intelligence (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum.
- Sternberg, R. J. (1983). Components of human intelligence. Cognition, 15, 1-48.

- Sternberg, R. J. (1985). Human intelligence: The model is the message. Science, 230, 1111-1118.
- Sternberg, R. J. (1986). A triarchic theory of intellectual giftedness. In R. J. Sternberg & J. E. Davidson (Eds.), Conceptions of giftedness. New York, N.Y.: Cambridge University Press.
- Sternberg, R. J. (1990). New directions in intelligence. Presentation to Section of Psychology in Education, May 4th, Ottawa, Canada.
- Sternberg, R. J. & Davidson, J. E. (1983). Insight in the gifted. Educational Psychologist, 18(1), 51-57.
- Sternberg, R. J., & Weil, E. M. (1980). An aptitude-strategy interaction in linear syllogistic reasoning. Journal of Educational Psychology, 72, 226-234.
- Stober, S. (1983). Metacognition and conceptual tempo. Unpublished doctoral dissertation, Ontario Institute for Studies in Education, University of Toronto, Toronto, Ontario.
- Stober, S. (1984). A developmental perspective of metacognition: Implications for education. Paper presented at the University of Waterloo Conference on Child Development, May, Waterloo, Ontario.
- Tabachnick, B. G., & Fidell, L. S. (1983). Using multivariate statistics. New York: Harper & Row.
- Thurstone, L. L. (1938). Primary mental abilities. Chicago: University of Chicago Press.

- Torgesen, J. K. (1977). The role of nonspecific factors in the task performance of learning disabled children: A theoretical assessment. Journal of Learning Disabilities, 10, 27-34.
- Tuddenham, R. D. (1971). Theoretical regularities and individual idiosyncracies. In D. R. Green, M. P. Ford, & G. B. Flamer (Eds.), Measurement and Piaget. New York: McGraw-Hill.
- Vernon, P. E. (1950). The structure of human abilities. New York: Wiley.
- Wechsler, D. (1958). The measurement and appraisal of adult intelligence (4th ed.). Baltimore: Williams & Wilkins.
- Wechsler, D. (1974). Manual for the Wechsler Intelligence Scale for Children-Revised. New York: The Psychological Corporation.
- Wellman, H. M. (1978). Knowledge of the interaction of memory variables. Developmental Psychology, 14, 24-29.
- Wertsch, J. V. (1977). Metacognition and adult-child interaction. In Resources in Education. Phoenix, AZ: Oryx Press.
- Whitmore, J. R. (1980). Giftedness, conflict and under-achievement. Boston, Mass.: Allyn & Bacon Inc.
- Wong, B. Y. L. (1982). Strategic behaviours in selecting retrieval cues in gifted, normal achieving and learning disabled children. Journal of Learning Disabilities, 13, 33-37.

- Wong, B. L. (1989). Musing about cognitive strategy training. Intelligence, 13, 1-4.
- Wright, E. N. (1982). Canadian cognitive abilities test. Scarborough, Ontario: Nelson Canada.
- Yussen, S. R., & Levy, V. M. (1975). Developmental changes in predicting one's own span of short-term memory. Journal of Experimental Child Psychology, 19, 502-508.
- Yussen, S. R., Levin, J. R., Berman, L., & Palm, J. (1979). Developmental changes in the awareness of memory benefits associated with different types of picture organization. Developmental Psychology, 15, 447-449.

APPENDIX A
Parental Consent Letters

**PARENTAL CONSENT: Intellectually
Gifted Subjects**

January, 1987

Dear Parent,

The Research Committee of the Carleton Board of Education has given permission to doctoral students of Dr. H. B. Ferguson (Psychology Department, Carleton University) to conduct a study on the development of thinking processes in children.

It is expected that such research ultimately will provide teachers with curriculum guidelines and ways to enhance teaching methods.

This investigation will involve two one hour sessions to be arranged during school hours at the child's and teacher's convenience. The researchers will also require access to achievement and ability test results from the O.S.R.

Tasks to be completed include a knowledge questionnaire, personality measures and two "thinking" games. Personality measures will examine the characteristic ways that children have of approaching problem-solving situations. Past experience with these measures suggest most children have found them enjoyable and challenging.

In order to maintain the confidentiality of students identified as exceptional, the CRF cannot release the names of students without parental consent. Given the above condition, we would appreciate your signing the form below indicating approval or disapproval of your child's participation in this study. Please return the form in the enclosed envelope.

If you would like more information about this study, please contact the researchers directly (Sandra Nandi, Office 820-1820, ext. 498, Home 828-7943 or Sue Bext 727-0846).

Thank you for your interest in this project.

Yours sincerely,

John M. Beatty
Superintendent, Educational Services

Please Return to Gifted Study

I agree ☐ do not agree ☐ to the participation of my child (_____) in the research project conducted by S. Nandi/S. Bext under the supervision of Dr. H. B. Ferguson (Psychology Dept. Carleton University).

Parents Signature _____

Date _____

PARENTAL CONSENT: Average Subjects

January, 1987

Dear Parent,

The Research Committee of the Carleton Board of Education has approved our request to conduct a study on the development of children's problem-solving skills. This study is part of our doctoral research in educational psychology at Carleton University. The goal of this research is ultimately to provide teachers with curriculum guidelines and ways to enhance instructional methods.

Your child has been randomly selected for this study. Students so selected will not be identified by name or by school in the final analysis of the results.

During the study students will be requested to complete two "thinking" games, a knowledge questionnaire and several personality measures. We estimate two 1 hour sessions will be required. Testing sessions will be scheduled during school hours. Past experience with these measures suggests most children have found them enjoyable and challenging. Of course, your child's participation will be voluntary. If at any time your child wishes to discontinue, testing will be terminated.

We would appreciate your signing the form below indicating approval or disapproval of your child's participation in this study. Please have your child return the form in the envelope to the school office.

If you would like more information or a summary of the research findings, please contact us directly (Sandra Nandi, Office 820-1820 ext. 498, Home 828-7943 or Sum Baxt 727-0846).

Thank you for your interest in this project.

Yours sincerely,

Sandra Nandi

.....
Please return to School Office

I agree ☐ do not agree ☐ to the participation of my child () in the research project conducted by S. Nandi/S. Baxt under the supervision of Dr. H.B. Ferguson (Psychology Dept. Carleton University).

Parent's Signature _____

Date _____

APPENDIX B**Kemler Hypothesis Formation Task****Instructions****Materials**

INSTRUCTIONS

GENERAL INTRODUCTION: (SESSION ONE)

I am conducting a reasearch project as part of my studies in Psychology at Carleton University.

The purpose of this study is to discover how much children/students know about the ways they learn and solve problems.

I will be asking you to do two thinking games. At the end of each game you will be asked some questions about what you have just experienced. Feel free, however, to talk during the game about what you are doing or thinking.

With your permission, I would like to taperecord your responses to help us not lose any important information. Would this be okay? I want to reassure you that your answers are only for this study and will not be discussed with your teachers or parents.

I will also be timing your answers with a stopwatch. It is not to see how fast you play the game but just to get an idea of how long it takes students to play this game.

KEMLER HYPOTHESIS FORMATION TASK INSTRUCTIONS

This game revolves around a story about two identical twins, Amy and Betty. These identical twins wore different clothes so their friends could tell them apart. For instance they had two different hats, necklaces, belts, hair ribbons, glasses, balloons, sweaters and wrist wear (Specific items are pointed out on the practise figures).

One day they decided to play a trick on their classmates and switch some of the clothes they were wearing at mid-day. That would be confusing wouldn't it? But each day the twins had a secret they told to their teacher. It was a secret about the one thing the twins promised not to switch the whole day. Your job is to figure out what Amy always wears and never switches. For the first turn, just guess which one is Amy and what you think is the secret item.

On each succeeding trial the student is asked which one is Amy and why? Feedback is provided by touching the top outside corner of the stimulus card and saying "This one is Amy".

As the number of attributes change (Three, Five, Eight attribute presentations), the children are told that this is a new day and reminded that the secret item changes from day to day.

APPENDIX C
Pattern Matching Task
Scoring Procedures
Materials
Instructions

PATTERN-MATCHING TASK INSTRUCTIONS

These instructions are reprinted from Stober (1983)

I. Instructions

Specific instructions or words to be emphasized are underlined. Parentheses or standard margins indicate demonstrations that accompany verbal instructions.

A. Training Problems:

Problem E-1: FOUR-DOT PATTERN IN FILE FOLDER/ FOUR-SOLUTION ALTERNATIVES

Now, I'm going to show you some patterns of dots like these. You see, here we have four patterns of dots with four dots in each pattern (pointing appropriately to the four-solution alternatives). Some of the dots are black; the rest are white. Behind the folder, there is a pattern of dots exactly like one of the patterns you see here (pointing), with one dot behind each of these four windows (pointing). The top dot in the pattern (pointing to the top dots in the solution alternatives) is behind this top window (pointing to the top window of the problem folder). This side dot (pointing to right side dot in pattern) is behind this side window. Which window would this bottom dot in the pattern (pointing to solution alternative) be behind? Right! Good! And which window would this (left) side dot be behind? Good!

If the child makes an error on one of these identifications, he is corrected and asked to point out windows corresponding to other positions until he can do this correctly.

O.K. Now for the important part. Your job is to figure out which one of these patterns (pointing) is behind this folder. To do that, you open these windows one at a time. The idea is to figure out which pattern is behind the folder opening as few windows as possible. It's important to remember that some moves are more helpful than others -- make the most helpful moves you can to figure it out opening as few windows as possible.

Let me show you how it goes. I could open this top window, for instance (opening top window). The dot behind the window is white. That means that the top dot in the pattern behind the board is white. Which of these patterns (pointing) might be behind the folder? Remember, we know that the top dot in the pattern must be white. Good! (Or correcting him if wrong). O.K., which ones are wrong -- which ones have the wrong colour dots? Good! (or correcting). O.K. We can forget about the ones that are wrong -- we'll just turn them over so we can really forget about them. (The experimenter demonstrates for the child how eliminated alternatives are to be turned over.) Now, we know that it must be one of these two. Our job is to figure out which one of these two patterns is behind the board. Which window would be most helpful to open next to figure that out?

If an informative window is opened, the experimenter opens a non-informative window as well and asks, "Was this window as helpful as the one you opened? No, it wasn't we couldn't turn any patterns over, so it wasn't helpful at all."

If a non-informative window is opened, the experimenter points out that this window is not helpful at all because no patterns can be turned over, and he then asks the child to select another window. When the child eventually opens the informative window, it is pointed out that this was a helpful move since a pattern could be turned over. (Note that this coaching serves to 'operationally define' helpfulness by indicating that a helpful move is one that leads to the elimination of alternatives. However, the way one decides in advance which moves will be helpful is never outlined -- i.e., the subject is not given an specific strategy for deciding which windows to open.)

**Problem E-2: FOUR-DOT PATTERN IN FILE FOLDER/
FOUR-SOLUTION ALTERNATIVES**

A second training trial, with four solution patterns of four dots each, is now presented and the child is asked to do this problem himself. The trial is introduced by the following instructions:

Now try this one yourself. Remember, you are to figure out which of those patterns is behind this folder (pointing) by opening the windows one at a time and turning over the patterns that are wrong. It's important to remember that the idea is to figure it out opening as few windows as possible and that some moves are more helpful than others.

Occasionally a child eliminates alternatives inappropriately (for instance, after opening the top window and exposing a white dot, some subjects will turn over patterns with a white dot at the top, rather than those with a black dot at the top). These errors are corrected immediately and subjects are reminded that they are to eliminate (i.e. turn over) the patterns with the wrong coloured dots at the top (or wherever).

Again, when a subject makes a non-informative move, the experimenter points out that that wasn't at all helpful because no patterns could be turned over. If no non-informative moves are made, the experimenter says "good", then 'undoes' the subject's last move and makes a non-informative move, pointing out that the move the subject made was helpful because he could turn some over, but if he had made this move (i.e., the non-informative move made by the experimenter), it would not have been at all helpful since no patterns could be eliminated.

**Problem E-3: FOUR-DOT PATTERN IN FILE FOLDER/
SIX-SOLUTION ALTERNATIVES**

Next, children are given a practice trial with a problem which has six four-dot pattern alternatives. This trial is introduced by the instructions used to introduce the previous training trial. After a subject opens a window, before he turns over any patterns, the experimenter says "Okay, be careful which patterns you turn over." If the subject makes an elimination error (i.e. if he unjustifiably turns over patterns or fails to turn over patterns which could properly be eliminated), he is corrected immediately

PROBLEM E-4 EIGHT DOT PATTERN IN WOODEN BOARD/
EIGHT-SOLUTION ALTERNATIVES

After a child has solved a six-pattern problem a problem with eight patterns, each problem having eight dots, is placed before him along with the corresponding eight-dot problem board. The child is then oriented to this more complex problem with the following instructions:

This game is just like the one you've been playing except there are more patterns and more dots in each pattern. This makes the game more interesting, but you still play the same way. Just to make sure you get off to a good start, I want you to show me which window you'd open if you wanted to see about this dot (pointing to a dot in the pattern alternatives) -- just point to the window you'd open to check on this dot. Good! (Or, no, look carefull-- Good!).

When the subject can correctly identify five target windows consecutively without errors, this is seen as evidence of his being oriented to the board. The subject is then given a training trial on this eight pattern problem. He is told, "Remember, the game is the same as before. You are to figure out which of these patterns is behind the board by opening the windows one at a time and turning over the patterns that have the wrong coloured dots. Remember, it's important to figure it out opening as few windows as possible and to remember that some windows are more helpful than others. Make the most helpful moves you can to figure it out opening as few windows as possible."

B. Test Problems

The test problems are then administered, the first being introduced by the following instructions:

"Remember, the idea is to figure it out opening as few windows as possible, and that some moves are more helpful than others. Make the most helpful moves you can to figure it out opening as few windows as possible "

The three remaining trials are introduced by the experimenter simply saying

"Okay, now I want you to figure out this one "

Materials for the Pattern-matching Task

Pattern-matching Board

Solution Alternatives

Pattern-matching Efficiency Score:

Expected Bits of Information

The formula for the expected bits of information per move, as used by Cameron (1976), is presented in Table C-3.1.

Table C-3.1

Formula for Expected Bits of Information

$$W1 (\text{Log } R - \text{Log } X) + W2 (\text{Log } R - \text{Log } Y), \quad \text{where:}$$

$W1$ = the probability the dot will be black

$W2$ = the probability the dot will be white ($W1 + W2 = 1$)

R = number of alternatives remaining before the move is made

X = number of alternatives that would remain if the dot at the opened shutter was black

Y = number of alternatives that would remain if the dot at the opened shutter was white

Note. Log tables are available in Attneave (1959).

The maximum expected information that can be obtained with a single move is 1.0 bits. This occurs only when the subject makes a focusing move (i.e. when the number remaining alternatives/number eliminated alternatives [NR/NE] would be either 8/4, 4/2 or 2/1). The minimum expected information elicited by a single move is 0.0 bits, with this occurring only when the child makes a noninformative move (i.e. NR/NE

would be either 7/0, 4/0, 3/0 or 2/0). Thus, the expected information score of any given move can range from 0.0 to 1.0 bits. The mean information extracted on each problem, or average expected bits of information score, was calculated by summing the expected information scores of each of the child's moves per problem, and dividing it by the total number of responses required to solve the problem. Table C-3.2 demonstrates the expected bits of information calculated for all possible moves.

Table C-3.2

Expected Bits of Information for all Possible Moves

Number Remaining/ Number Eliminated				Bits	Type of Move
8/4	4/2	2/1		1.000	Focusing
7/4	7/3			0.985	-
3/2	3/1			0.918	-
4/1				0.811 }	Gambling
8/1				0.544 }	
7/0	4/0	3/0	2/0	0.000	Noninformative

Source: Reprinted from Stober, 1983.

APPENDIX D
Metacognitive Interview Protocol

METACOGNITIVE INTERVIEW PROTOCOL

NAME: _____

DATE: _____

PATTERN MATCHING/KEMLER

SCORE

COMMENT'S

Define Problem

Planning

Strategy Selection

Monitoring

Evaluating

Flexibility

QUESTION

1a) If you are going to ask your friend to play the game you just-completed, tell me in at least six sentences, what would you tell him/her to do? Put it in your own words. (Tell me more; what else)

TASK: PM KEMLER

- 1b) If your friend was having difficulty understanding what to do, how would you describe what you did?

- 1c) Are there any important things you may have forgotten to tell your friend about the game?

2. Is there another way to solve the task? Yes ____ No ____
Take a moment, what other ways might you suggest?

3. Did you keep track of how you were doing on the game? Yes ____ No ____
How did you keep track of how you are doing on this game? How do you do it? How would you explain it to your friend?

TASK: PM KEMLER

4a) How would you rate your performance on this task? (1 - 10)

b) Did you do better or less well than you expected?

4c) If you had to play like this in a week's time, how would your performance compare? Would you do.....better
about the same
worse

5) How well do you think you did on this task compared to how your friend would do?

6) Is there any difference between the two games? Yes ____ No ____
If so please describe these differences.

APPENDIX E
Metacognitive Interview
Scoring Guide

Metacognitive Interview

Overview*

The Metacognitive Interview (MCI) was designed to assess the level of a student's metacognitive processes immediately following participation in a problem-solving exercise. The problem-solving tasks were counter-balanced to eliminate possible order effects.

The MCI was administered individually to each child twice in a single session; once following the Pattern-Matching test and again after the Kemler Hypothesis Formation test.

Six questions, orally administered, complete the interview protocol. Several of the questions have sub-sections intended to probe for more complete responses. Question 1 was designed to assess the metacognitive processes of Problem Definition, Planning and Strategy Selection. Flexibility of Strategy Use, Monitoring and Evaluating were measured by Questions 2, 3 and 4, 5 respectively. Question 6 was a supplementary question designed to assess the student's understanding of Problem Definition on both problem-solving tasks.

Student responses were scored on each of the six metacognitive processes according to a rating system designed as follows:

*See author for complete Scoring Guide

2 points - Superior response

1 point - Average response

0 points - Minimal or no response

In addition, each of the six processes were further evaluated as to Clarity, Specificity, Reflectivity, Organization and Conceptualization. Detailed descriptions of these categories and the point system are outlined in the MCI scoring guide.

The maximum number of points for each MCI is 88 points divided as follows:

Problem Definition	Qst. 1(a) & 1 (b)	20 points
Planning	Qst. 1(a) & 1 (b)	20 points
Strategy Selection	Qst. 1(a) & 1 (b)	20 points
Flexibility	Qst. 2	10 points
Monitoring	Qst. 3	10 points
Evaluating	Qst. 4, 5	8 points
	MCI Total	88 points

SCORING FORM

METACOGNITION STUDY

METACOGNITIVE INTERVIEW

Subject: _____

Task: Kemler/Pattern Matching

	Concurrent Interview	Clarity	Specif	Reflect	Org	Concept	Total
Problem Definition							
Planning							
Strategy Selection							
Flexibility							
Monitoring							
Evaluation							

Task: Kemler/Pattern Matching

	Concurrent Interview	Clarity	Specif	Reflect	Org	Concept	Total
Problem Definition							
Planning							
Strategy Selection							
Flexibility							
Monitoring							
Evaluation							

Problem Definition(6)

Total

APPENDIX F
Metacognitive Questionnaire

GENERAL KNOWLEDGE QUESTIONNAIRE**CARLETON UNIVERSITY****DEPARTMENT OF PSYCHOLOGY****STUDENTS QUESTIONNAIRE**

I am interested in understanding how students learn. The following pages contain questions which will help me in understanding what helps you to learn and to solve problems.

Please answer the questions honestly and try to answer every question, even if you are not sure of your response. There are no right or wrong answers, so whatever answers you give that really tell me how you would handle the situation, are O.K. Your answers will be for our research only, and therefore will be between you and me. They will not be seen by anyone else.

The results of this study will help others improve how they approach problems. Thanks for your co-operation in completing this questionnaire.

- 2 -

SECTION A

In this section, I would like you to imagine yourself in two situations. I would like you to tell me what you would be thinking about and what you would do as you try to solve the problems in these situations. There are two questions in this section, each requiring an answer in at least six sentences or statements.

1. Suppose you find yourself in the Rideau Centre and you have lost the person who was going to give you a lift home. Suppose you were counting on them to give you a lift and so you have spent all your money. How would you go about trying to find your way back home?

- 3 -

Now, I would like you to imagine yourself in another situation. Tell me what you would think about, and what you would do, as you solve this one.

2. Suppose you have an exam in math, tomorrow, but you have forgotten your math textbook at school. It is after 5:00 p.m. What would you do?

NOW THAT YOU HAVE FINISHED SECTION A, PLEASE LET ME KNOW BEFORE PROCEEDING TO SECTION B.

In the following questions I would like you to tell me what you would do in the situation I have described. Let's do one together....

Often, in the middle of doing a math problem, I find my mind wandering and then I

O.K., now continue on your own. Please answer every question. I am here to answer any questions you may have.

- 5 -

1. Let's suppose you have been given a large puzzle and it is all in pieces. How would you decide what to do?
2. With this puzzle in pieces, how would you decide if it is too easy or too hard for you to do?
3. Suppose the puzzle was very hard, what would you do next?
4. What is the first thing you would do to begin to put it together?
5. Suppose there are three programs on T.V. that you want to watch and they are all on at the same time. You do not have a VCR, (let's say) neither do any of your friends. What would you do?

- 6 -

6. Suppose you have been trying to decide between these three programs for about ten minutes and still can't make up your mind. What would you do?
7. Suppose you have a math test in school. You have finished all the questions. What do you do next?
8. If you have a story or book to read for class, do you do anything differently than if you were reading the same book at home, just for yourself?
9. What would you do differently, and why?
10. Suppose on this math test you are told that one problem has more than one way to solve it. You get points for the number of ways you can think of. Do you think you could

	<u>YES</u>	<u>NO</u>
a) find all of the solutions	☐	☐
b) some of the solutions	☐	☐
c) only one of the solutions	☐	☐

- 7 -

11. Do you think you could find as many solutions as most of the other people in your class?

	<u>YES</u>	<u>NO</u>
a) more	☐	☐
b) less	☐	☐
c) the same amount	☐	☐

12. Do you think your solutions would be as good as theirs?

<u>YES</u>	<u>NO</u>
☐	☐

13. Suppose there were a T.V. program which is directly related to one of your school subjects (e.g. history or english). Would you do anything differently when watching that program from watching, say Miami Vice, Bill Cosby, or Family Ties?

<u>YES</u>	<u>NO</u>
☐	☐

14. What would you do differently, if anything?

15. Suppose you have a math problem to solve and it is very hard. How would you start to solve the problem?

I would like to know which of these sentences applies to you. If you think it describes you, please put a check mark in the "TRUE" box. If you think it does not describe you, please put a check mark in the "FALSE" box.

Let's do the first one together.

	<u>TRUE</u>	<u>FALSE</u>
I always understand instructions about math problems at school.	☐	☐

Fine, now continue on your own. Please check an answer for each statement. I am here to answer any questions you may have.

TRUE

FALSE

1. When I am given a problem to do, I think that the sooner I begin answering it the better, since that way I won't forget the answers that are in my head.
2. When I can't solve a problem, the first time, I
 - a) stop
 - b) go on to something else
 - c) other
3. I read through the whole problem, at least once, before starting to answer it.
4. Even if I think my answer is not correct, I usually leave it, anyway and go on to something else.
5. If I try to solve a problem and it doesn't work, I try to see if there is another way to solve it.
6. When I am having trouble completing a problem, I often find myself daydreaming.
7. If I don't understand the instruction in class I try to do the problem, on my own, anyway.
8. I never have enough time to check my answers on a test.
9. I have a pretty good idea of how many of the answers on a test. I got right.
10. I am probably as good as my friends at solving problems at school.

☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐
☐

TRUEFALSE

11. I am better at solving some kinds of problems than others (for example, riddles, or puzzles, or math problems, or problems between friends).	☐	☐
12. I think that (basically) I would solve all problems in much the same way.	☐	☐
13. I don't think there is much difference between solving a math problem and learning a list of words in spelling.	☐	☐
14. I always listen when the teachers give instructions (in class) but I sometimes have trouble knowing what to do when I start an exercise.	☐	☐
15. When I am doing a test in school, I always check my answers after I have finished the whole test.	☐	☐

APPENDIX G
Metacognitive Questionnaire

Scoring Guide

Overview

Section A

Section B

Section C

Metacognitive Knowledge Questionnaire*

The Metaognitive Questionnaire was designed to assess a student's awareness and general knowledge of metacognition. Six theorised metacognitive processes (Problem Definition, Planning, Strategy Selection, Flexibility of Strategy Use, Monitoring and Evaluating) were used to structure the questionnaire.

In order to broaden the scope of this measure, namely (two types of problem-solving situations), questions were selected to elicit student responses on: 1) problems related to every day life involving social reasoning and 2) problems related to a school setting involving reasoning particular to academic subjects.

Questions and the subsequent scoring system were designed such that both the quantitative and qualitative aspects of student responses could be evaluated. For example, queries on the Strategy Selection process pertained not only to the number of strategies stated (quantity) but also to the level of awareness and sophistication of the use of these strategies (quantity).

The Questionnaire format consists of three sections as follows:

Section A: Two open-end questions

Section B: Eighteen short-answer questions

*See author for complete Scoring Guide

Section C: Fifteen true/false questions

The Metacognitive Knowledge Questionnaire can be either self-administered on an individual basis or group-administered. For children in Grade 3 it is suggested that the examiner consider reading and recording the answers, depending on the maturity level of the student.

Metacognitive Questionnaire

Section A

Overview of Scoring

Two open-ended questions were analyzed separately according to the following criteria:

(a) **Number of strategies**: The total number of strategies provided by the student to solve the problem were tabulated. Each strategy counted as one provided the stated strategies were at least minimally different from each other. For instance only one point would be given for a student who offered two approaches such as "get the clerk to call a taxi" and "wait for the taxi outside".

(b) **Awareness of metacognitive processes**: Student responses to each of the two questions were scored as to either the presence (yes = 1) or absence (no = 0) of each of the six metacognitive processes.

(c) **Qualitative Assessment of Metacognitive Process**: For each of the observed metacognitive processes, the degree of sophistication of the student's responses were evaluated according to a four-point rating system:

- (4) Superior evidence of metacognitive process
- (3) Average evidence of metacognitive process
- (2) Minimal evidence of metacognitive process
- (1) No evidence of metacognitive process.

A resolution test chart featuring various patterns of horizontal and vertical lines. The patterns are arranged in a grid-like fashion, with some patterns being larger and more prominent than others. Numerical values are placed next to the patterns, indicating the resolution or frequency of the lines. The values include 1.0, 1.1, 1.25, 1.4, 1.6, 1.8, 2.0, 2.2, 2.5, 2.8, 3.2, 3.6, 4.0, 4.5, 5.0, 5.6, 6.3, 7.1, 8.0, 9.0, 10, 11.2, 12.5, 14, 16, 18, 20, 22.5, 25, 28, 31.5, 36, 40, 45, 50, 56, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 225, 250, 280, 315, 360, 400, 450, 500, 560, 630, 710, 800, 900, 1000, 1120, 1250, 1400, 1600, 1800, 2000, 2250, 2500, 2800, 3150, 3600, 4000, 4500, 5000, 5600, 6300, 7100, 8000, 9000, 10000, 11200, 12500, 14000, 16000, 18000, 20000, 22500, 25000, 28000, 31500, 36000, 40000, 45000, 50000, 56000, 63000, 71000, 80000, 90000, 100000, 112000, 125000, 140000, 160000, 180000, 200000, 225000, 250000, 280000, 315000, 360000, 400000, 450000, 500000, 560000, 630000, 710000, 800000, 900000, 1000000, 1120000, 1250000, 1400000, 1600000, 1800000, 2000000, 2250000, 2500000, 2800000, 3150000, 3600000, 4000000, 4500000, 5000000, 5600000, 6300000, 7100000, 8000000, 9000000, 10000000, 11200000, 12500000, 14000000, 16000000, 18000000, 20000000, 22500000, 25000000, 28000000, 31500000, 36000000, 40000000, 45000000, 50000000, 56000000, 63000000, 71000000, 80000000, 90000000, 100000000, 112000000, 125000000, 140000000, 160000000, 180000000, 200000000, 225000000, 250000000, 280000000, 315000000, 360000000, 400000000, 450000000, 500000000, 560000000, 630000000, 710000000, 800000000, 900000000, 1000000000, 1120000000, 1250000000, 1400000000, 1600000000, 1800000000, 2000000000, 2250000000, 2500000000, 2800000000, 3150000000, 3600000000, 4000000000, 4500000000, 5000000000, 5600000000, 6300000000, 7100000000, 8000000000, 9000000000, 10000000000, 11200000000, 12500000000, 14000000000, 16000000000, 18000000000, 20000000000, 22500000000, 25000000000, 28000000000, 31500000000, 36000000000, 40000000000, 45000000000, 50000000000, 56000000000, 63000000000, 71000000000, 80000000000, 90000000000, 100000000000, 112000000000, 125000000000, 140000000000, 160000000000, 180000000000, 200000000000, 225000000000, 250000000000, 280000000000, 315000000000, 360000000000, 400000000000, 450000000000, 500000000000, 560000000000, 630000000000, 710000000000, 800000000000, 900000000000, 1000000000000, 1120000000000, 1250000000000, 1400000000000, 1600000000000, 1800000000000, 2000000000000, 2250000000000, 2500000000000, 2800000000000, 3150000000000, 3600000000000, 4000000000000, 4500000000000, 5000000000000, 5600000000000, 6300000000000, 7100000000000, 8000000000000, 9000000000000, 10000000000000, 11200000000000, 12500000000000, 14000000000000, 16000000000000, 18000000000000, 20000000000000, 22500000000000, 25000000000000, 28000000000000, 31500000000000, 36000000000000, 40000000000000, 45000000000000, 50000000000000, 56000000000000, 63000000000000, 71000000000000, 80000000000000, 90000000000000, 100000000000000, 112000000000000, 125000000000000, 140000000000000, 160000000000000, 180000000000000, 200000000000000, 225000000000000, 250000000000000, 280000000000000, 315000000000000, 360000000000000, 400000000000000, 450000000000000, 500000000000000, 560000000000000, 630000000000000, 710000000000000, 800000000000000, 900000000000000, 1000000000000000, 1120000000000000, 1250000000000000, 1400000000000000, 1600000000000000, 1800000000000000, 2000000000000000, 2250000000000000, 2500000000000000, 2800000000000000, 3150000000000000, 3600000000000000, 4000000000000000, 4500000000000000, 5000000000000000, 5600000000000000, 6300000000000000, 7100000000000000, 8000000000000000, 9000000000000000, 10000000000000000, 11200000000000000, 12500000000000000, 14000000000000000, 16000000000000000, 18000000000000000, 20000000000000000, 22500000000000000, 25000000000000000, 28000000000000000, 31500000000000000, 36000000000000000, 40000000000000000, 45000000000000000, 50000000000000000, 56000000000000000, 63000000000000000, 71000000000000000, 80000000000000000, 90000000000000000, 100000000000000000, 112000000000000000, 125000000000000000, 140000000000000000, 160000000000000000, 180000000000000000, 200000000000000000, 225000000000000000, 250000000000000000, 280000000000000000, 315000000000000000, 3600000000000

 

**Metacognitive Questionnaire
Section B
Overview of Scoring**

The fifteen short-answer questions were scored according to a four point rating system:

- (1) Minimal or no evidence of the metacognitive process.
- (2) Some evidence of the metacognitive process.
- (3) Average evidence of the metacognitive process.
- (4) Superior evidence of the metacognitive process.

This rating scale was designed to assess the qualitative aspects of the student responses.

Planning

- A. Let's suppose you have been given a large puzzle and it is all in pieces. How would you decide what to do?
(Question #1)

Two or more actions suggestive of planning

- (4) "I would sort the pieces by colour and edge pieces. Do the edge pieces first"; "I would do the edges then the familiar parts"; "Start to assemble the outer pieces by looking at the picture"; "put it together step by step and do a certain amount each time".

One action offered

- (3) "Read instructions"; "i would do the outside fist"; "sit there and think"; "try and remmeber what I did last time"; "I would put all the pieces together in groups".

- (2) "I would ask my mom to help me"; "Start building it and hope for the best"; "look at picture".

- (1) "nothing"; "start it again"; start to work at it"

**Metacognitive Questionnaire
Section C**

Overview of Scoring

All the True/False questions were justified so that a positive response could be coded as (2) and a negative response coded as (1). The following 15 questions are labelled according to the metacognitive process involved and an explanation as to why either a true or false response was considered positive.

True/False Questions

1. When I am given a problem to do....I won't forget the answers that are in my head (Strategy Selection)

False: A student who is using metacognition will take time to select strategies before answering.

2. When I can't solve a problem the first time, I
(a) stop
(b) go on to something else
(c) other (Flexibility)

(a) False; (b) True: Students aware of the process of flexibility will attempt other strategies in problem solving rather than stopping at the first difficulty.

3. I read through the whole problem, at least once, before starting to answer it (Strategy Selection)

True: Students who consider this an appropriate strategy may be demonstrating metacognitive awareness of this process.

4. Even if I think my answer is not correct, I usually leave it anyway and go on to something else (Strategy Selection)

False: Student who is using metacognition should attempt to select another strategy to solve the problem rather than quitting.

5. If I try to solve a problem and it doesn't work, I try to see if there is another way to solve it (Flexibility)

True: Student who is using metacognition should attempt to select another strategy to solve the problem rather than quitting.

6. When I am having trouble completing a problem, I often find myself daydreaming (Flexibility)

False: Student who is using the metacognitive process of flexibility will employ another strategy rather than daydream.

7. If I don't understand the instruction in class I try to do the problem on my own anyway (Problem Definition)

False: Student should not start problem until they understand fully what they are supposed to do.

8. Deleted

9. I have a pretty good idea of how many of the answers, on a test, I got right (Evaluating)

10. I am probably as good as my friends at solving problems at school (Evaluating)

11. I am better at solving some kinds of problems than others (for example, riddles or puzzles, or math problems, or problems between friends) (Evaluating)

True: Student indicating a true response to these questions demonstrates some awareness of the necessity to evaluate one's outcomes during problem solving.

12. I think that (basically) I would solve all problems in much the same way (Strategy selection)

False: A metacognitively aware student would solve problems using different strategies.

13. I don't think there is much difference between solving a math problem and learning a list of words in spelling (Problem definition)

False: Student should be aware of difference in problem definition between a math and a spelling problem.

14. I always listen when the teachers give instructions (in class) but I sometimes have trouble knowing what to do when I start an exercise (Problem definition)

True: Student who never has trouble starting an exercise is not aware of intricacies involved in defining a problem.

15. When I am doing a test in school, I always check my answers after I finished the whole test (Monitoring)

True: Checking is an indication of metacognition involving the monitoring process.

APPENDIX H
Mixed Kemler Task

Scoring Sheet

Scoring Guide

NAME: _____
 DATE: _____

MIXED
 KENLER
 SCORING SHEET

ATTRIBUTES CHOSEN

Five
 Attributes
 (8)

						Time	Repeats
81	C	(H)	bu		h b bo		
		br	pr		pr bg		
82	(C)	H	bo		h b bu		
		br	pr		pr bg		
83	h	m	bo		c b bu		
		br	(pr)		pr bg		
84	h	m	bo		c b bu		
		(pr)	pr		br bg		
85	h	b	bo		(C) m bu		
		pr	pr		br bg		
86	c	b	bo		h (H) bu		
		pr	pr		br bg		
87	c	b	bu		(h) m bo		
		pr	pr		br bg		
88	(C)	b	bu		h m bo		
		br	pr		pr bg		
89	h	b	bu		c (H) bo		
		br	pr		pr bg		
90	h	m	bu		(C) b bo		
		br	pr		pr bg		
91	c	(m)	bu		h b bo		
		br	bg		pr pr		
92	c	m	bo		(H) b bu		
		br	bg		pr pr		
93	c	(b)	bo		h m bu		
		br	bg		pr pr		
94	(C)	b	bo		h m bu		
		br	pr		pr bg		

K _____

1. Are there any comments you would like to make about this task?

2. How did you find it?

Mixed Kemler

The five-attribute Kemler problem was re-administered but the order of the attributes was randomized so no solution was possible. At the end of this task, students were asked how they found doing the task and if they had any comments. Their responses were analyzed according to the following categories:

Problem Definition

- 0 No definition of problem
- 1 Some attempt to redefine problem but not clear
- 2 Clear re-definition of problem

Monitoring

- 0 No awareness of need to monitor or unaware that task is in anyway different from before
- 1 Some awareness that something is different but can't articulate clearly
- 2 Definitely notices something is wrong with task or different

Evaluation

- 0 Evaluates task performance as same or better than before
- 1 Evaluates task performance with no clear statement as to whether better/worse or same
- 2 Evaluate task performance is poorer or worse than before

Appendix I
Validity Study
Measures

Overview
Planning
Strategy Selection
Monitoring
Evaluation

Validity Study**Planning****Preparation: Object**

Preparation: Object (Reprinted from Kreutzer et al. 1975)

Suppose you were going ice skating with your friend after school tomorrow and you wanted to be sure to bring your skates. How could you be really certain that you didn't forget to bring your skates along to school in the morning? Can you think of anything else? How many ways can you think of?

Each response was then assigned to one of four major categories (Skates, Note, Self, or Others). The Skates category referred to any proposed manipulation of the skates themselves that would help ensure their availability at skating time; in many cases this was accomplished by making the skates serve as their own retrieval cue. The subcategories of this category in the sample were: (1) putting the skates in the child's school bag or next to the things he plans to take to school, (2) putting the skates where he is sure to see them the next morning, (3) getting the skates to school or to his friend's house prior to the following morning, (4) attaching the skates to his body.

A response was categorized as Note if the child suggested using any external retrieval cue other than the skates themselves. The subcategories were: (1) any form of written reminder, (2) tying a string around one's finger, (3) the use of a tape recorder.

There were two rather different ways in which the Self was represented as a mnemonic aid: (1) through active,

internal efforts to facilitate recall, for example, deliberately thinking about the skates the night before, mentally checking off the next morning everything one is supposed to bring to school; (2) assertions that the excitement and pleasure associated with the prospect of going skating will almost automatically guarantee recall of the skates the next morning.

The category Others was scored whenever the child suggested that one or more other people could be asked to help him remember his skates.

Some responses seemed more explicitly preparatory, planful, and means-ends-oriented in tone than others. In most such responses, there were at least hints of a conscious separation in time between the act of preparation and its subsequent payoff in good recall. The child might specify that he would put the skates in his bag "that night", for example, rather than simply saying he would put them in his bag. Or he might say that he would put the skates by the door "so that" ("and then", etc.) he would be sure to see them in the morning. Protocols which seemed to contain such putative symptoms of a planful, means-ends orientation were scored as Preparation.

Validity Study
Strategy Selection

Question
Digit Task
Maze Task

Strategy Selection Question

You are asked to help someone like yourself to solve a similar type of problem as this set of problems. You can only tell them what they need to think about or, be aware of, while solving this type of problem. What are all the different ways you could tell them that you could have used in solving this type of problem?

Is there anything else you could tell them that they needed to be aware of?

Source: Reprinted from Ajchenbaum (1983).

Digit Task**Question:**

I am going to read some numbers and when I stop, I want you to say them backwards. Do you understand?

a) 5-7-4

b) 7-2-9-6

Scoring Guide: Digits Backwards

- _ 1. Repeat the numbers forward to yourself.
- _ 2. First learn the numbers forward, then reverse.
- _ 3. Picture the numbers in your mind and then reverse.
- _ 4. Picture the numbers of your fingers and then reverse.
- _ 5. Group the numbers into groups of two to remember them easier.
- _ 6. Concentrate on remembering the middle numbers and because the end numbers are easier to remember.
- _ 7. Close your eyes when working on the problems.
- _ 8. Listen well.
- _ 9. Don't go too fast.
- _ 10. Don't be impulsive.
- _ 11. Try to relax.
- _ 12. Other(s):

Score _____

Total score + + :

Source: Reprinted from Ajchenbaum (1983).

Name _____

Problem 2:

Find your way out.

Problem 1:

Find your way out.

Scoring Guide: Mazes

Check off on the sheet below the strategy factors that the student clearly relates in each of the interviews. If the subject describes a strategy factor which you feel is relevant to the solution but is not included in the checklist, please write it in below the other factors. Add all the relevant factors for each interview to obtain the score.

Interview 1 - Mazes

- ☐ 1. Look for the starting point.
- ☐ 2. Look for the finishing point.
- ☐ 3. Visually search the route before starting.
- ☐ 4. First trace the route with your finger.
- ☐ 5. Start from the end point and go back.
- ☐ 6. Look for blocked roads.
- ☐ 7. Don't just try the shortest way.
- ☐ 8. If you need to, turn the paper as you go.
- ☐ 9. Go slowly, don't be impulsive.
- ☐ 10. Always look ahead as you are drawing the line.
- ☐ 11. Be careful when drawing on long stretches.
- ☐ 12. If you make a mistake, trace your way back.
- ☐ 13. Other(s):

Score _____

Source: Reprinted from Ajchenbaum (1983).

Validity Study

Monitoring

Magic Trick Instructions

Probe Questions

Magic Trick: Instructions (Reprinted from Markman, 1977)

Instructions:

The experimenter first demonstrated the trick as follows: an ordinary cup, plate, penny and piece of paper were shown to the child. The cup, which was shown to be empty, was placed on the table and the plate placed on top of the cup. The penny was then wrapped in a piece of paper, placed on top of the plate, and pushed through the plate into the cup. (The penny could be heard dropping into the cup.) Then the empty paper and cup which now contained the penny were presented for inspection. While the trick was being performed, the experimenter gave a commentary which simply described what she was doing. After the demonstration, the following instructions were given.

"Here's the trick. When you wrap the penny you only pretend to wrap it. It really falls in your lap like this".

(The experimenter demonstrates, yet fails to mention how the penny, now in her lap, could end up in the cup.) After the instructions were given, 10 probes were used.

Scoring

When a child asked a clearly adequate question (or made a relevant statement), the procedure was terminated. A child was given a score which indicated at what point in the procedure he or she asked an appropriate question. The

scores ranged from 1 to 11. Scores from 1 to 10 correspond to the 10 probes in the procedure. An 11 indicated that the child never asked a question.

MAGIC TRICK PROBES

1. "That's it. Those are my instructions."
2. "What do you think?"
3. "Do you have any questions?"
4. "Did I tell you everything you need to know to play the game?"
5. "Did I forget to tell you anything?"
6. "Can you tell me how to play?" (The experimenter prompts if necessary.)
7. "Did I tell you everything you need to know to play the game?"
8. "Do you think you can play? Let's play, you go first."
9. "Did I forget to tell you anything?"
10. "Are you sure? Did I tell you everything you need to know?"

THE DRAGON'S TEARS

FAR AWAY IN A STRANGE COUNTRY THERE LIVED A DRAGON. AND THE DRAGON'S HOME WAS IN A DEEP MOUNTAIN CAVE. FROM THE CAVE HIS EYES SHONE OUT LIKE HEADLIGHTS. VERY OFTEN, WHEN THE PEOPLE LIVING NEARBY WERE GATHERED IN THE EVENING BY THE FIRE, ONE WOULD SAY: "WHAT A TERRIBLE DRAGON IS LIVING NEAR US." AND ANOTHER WOULD AGREE, SAYING: "SOMEONE SHOULD KILL HIM." WHENEVER CHILDREN WERE TOLD ABOUT THE DRAGON, THEY WERE FRIGHTENED. BUT THERE WAS ONE LITTLE BOY WHO WAS NEVER FRIGHTENED. ALL THE NEIGHBORS SAID: "ISN'T HE A FUNNY LITTLE BOY." WHEN IT WAS ALMOST TIME FOR THIS FUNNY LITTLE BOY'S BIRTHDAY, HIS MOTHER ASKED HIM: "WHOM WOULD YOU LIKE TO INVITE FOR YOUR BIRTHDAY PARTY?" THEN THAT LITTLE BOY SAID: "MOTHER, I WOULD LIKE TO ASK THE DRAGON." HIS MOTHER WAS VERY MUCH SURPRISED AND ASKED: "ARE YOU JOKING?" "NO," SAID THE LITTLE BOY VERY SERIOUSLY, "I MEAN WHAT I SAY: I WANT TO INVITE THE DRAGON." AND, SURE ENOUGH, ON THE DAY BEFORE HIS BIRTHDAY, THE LITTLE BOY STOLE QUIETLY OUT OF HIS HOUSE. HE WALKED AND HE WALKED AND HE WALKED TILL HE REACHED THE MOUNTAIN WHERE THE DRAGON LIVED. "HELLO. HELLO. MR. DRAGON." THE LITTLE BOY CALLED DOWN THE VALLEY IN HIS LOUDEST VOICE. "WHAT'S THE MATTER? WHO'S CALLING ME?" RUMBLED THE DRAGON, COMING OUT OF HIS CAVE. THEN THE LITTLE BOY SAID: "TOMORROW IS MY BIRTHDAY AND THERE WILL BE LOTS OF GOOD THINGS TO EAT, SO PLEASE COME TO MY PARTY. I CAME ALL THE WAY TO INVITE YOU." AT FIRST THE DRAGON COULDN'T BELIEVE HIS EARS AND KEPT ROARING AT THE BOY. BUT THE BOY WASN'T FRIGHTENED AT ALL AND KEPT SAYING: "PLEASE, MR. DRAGON, PLEASE COME TO MY PARTY." FINALLY THE DRAGON UNDERSTOOD THAT THE BOY MEANT WHAT HE SAID AND WAS ACTUALLY ASKING HIM, A DRAGON, TO HIS BIRTHDAY PARTY. THEN THE DRAGON STOPPED ROARING AND BEGAN TO CRY. "WHAT A HAPPY THING TO HAPPEN TO ME." THE DRAGON SOBBED. "I NEVER HAD A KIND INVITATION FROM ANYONE BEFORE." THE DRAGON'S TEARS FLOWED AND FLOWED UNTIL AT LAST THEY BECAME A RIVER. THEN THE DRAGON SAID: "COME, CLIMB ON MY BACK AND I'LL GIVE YOU A RIDE HOME." THE BOY CLIMBED BRAVELY ONTO THE BACK OF THE FEROCIOUS DRAGON AND AWAY THE DRAGON WENT, SWIMMING DOWN THE RIVER OF HIS OWN TEARS. BUT AS HE WENT, BY SOME MAGIC, HIS BODY CHANGED ITS SIZE AND SHAPE. AND SUDDENLY -- WHAT DO YOU KNOW? -- THE LITTLE BOY WAS SAILING BRAVELY DOWN THE RIVER TOWARD HOME AS CAPTAIN OF A DRAGON-STEAMBOAT.

SCORING GUIDE

THE DRAGON'S TEARS

1 Far away in a strange country	2.11	2
2 there lived a dragon.	3.41	4
3 and the dragon's home was in a deep mountain cave,	2.15	2
4 from the cave his eyes shone out like headlights.	1.26	1
5 Very often, when the people living nearby	2.07	2
6 were gathered in the evening by the fire.	1.67	1
7 one would say: "What a terrible dragon is living near us!"	2.44	3
8 And another would agree, saying: "Someone should kill him."	1.59	1
9 Whenever children were told about the dragon,	2.85	3
10 they were frightened.	3.11	3
11 But there was one little boy who was never frightened.	3.85	4
12 All the neighbors said: "Isn't he a funny little boy?"	1.44	1
13 When it was almost time for this funny little boy's birthday,	2.52	3
14 his mother asked him: "Whom would you like to invite for your birthday party?"	3.74	4
15 Then that little boy said: "Mother, I would like to ask the dragon."	3.67	4
16 His mother was very much surprised and asked, "Are you joking?"	1.70	1

2.

17 "No," said the little boy very seriously,	1.52	1
18 "I mean what I say;	1.59	1
19 I want to invite the dragon."	2.11	2
20 And, sure enough,	1.15	1
21 on the day before his birthday,	2.37	2
22 the little boy stole quietly out of his		
house,	2.67	3
23 He walked and he walked and he walked	2.44	3
24 till he reached the mountain where the		
dragon lived.	3.19	3
25 "Hello, Hello. Mr. Dragon."	3.04	3
26 the little boy called down the valley in		
his loudest voice.	1.82	2
27 "What's the matter?	1.22	1
28 Who's calling me?"	2.82	3
29 rumbled the dragon,	2.26	2
30 coming out of his cave.	1.52	1
31 Then the little boy said: "Tomorrow is		
my birthday	3.56	4
32 and there will be lots of good things		
to eat,	1.52	1
33 so please come to my party.	3.82	4
34 I came all the way to invite you."	1.85	2

35	At first the dragon couldn't believe his		
	ears	3.07	3
36	and kept roaring at the boy.	2.52	3
37	But the boy wasn't frightened at all	2.48	3
38	and kept saying: "Please, Mr. Dragon, please		
	come to my party."	2.41	2
39	Finally the dragon understood that the boy		
	meant what he said	3.26	4
40	and was actually asking him,	2.11	2
41	a dragon,	1.22	1
42	to his birthday party.	1.96	2
43	Then the dragon stopped roaring and began		
	to cry.	3.41	4
44	"What a happy thing to happen to me."		
	the dragon sobbed.	2.74	3
45	"I never had a kind invitation from any-		
	one before."	2.89	3
46	The dragon's tears flowed and flowed	3.22	4
47	until at last they became a river.	2.96	3
48	Then the dragon said:	1.82	2
49	"Come, climb on my back and I'll give you		
	a ride home."	3.37	4
50	The boy climbed bravely onto the back of		
	the ferocious dragon	3.04	3
51	and away the dragon went,	2.30	2

Appendix J

Metacognitive Interview (MCI): Composite Means and Standard Deviations by Intellectual Level and Grade

MCI	Average			Intellectually Gifted		
	3	6	8	3	6	8
Problem Definition	6.2	10.6	9.4	12.3	12.5	15.7
	(5.5)	(10.5)	(9.4)	(8.0)	(12.6)	(13.8)
Planning	5.7	14.0	13.7	8.9	22.4	20.2
	(5.9)	(6.2)	(5.9)	(5.4)	(7.1)	(5.3)
Strategy Selec.	4.8	13.2	13.6	9.3	25.4	23.4
	(5.4)	(5.7)	(7.4)	(6.1)	(7.4)	(8.0)
Monitoring	5.3	7.2	7.6	7.3	10.1	11.2
	(2.8)	(3.5)	(4.3)	(4.5)	(4.4)	(4.5)
Flex. of Strat. Use	2.2	4.4	4.9	2.1	9.2	8.3
	(2.8)	(3.9)	(4.5)	(2.6)	(4.0)	(4.0)
Evaluating	8.4	9.9	10.2	8.1	10.5	10.2
	(3.0)	(2.7)	(2.7)	(3.2)	(3.2)	(2.6)
Composite	32.6	59.3	59.3	48.0	90.1	88.8
	(11.4)	(14.0)	(18.8)	(15.3)	(23.4)	(15.6)

Appendix K

Metacognitive Interview (MCI): Qualitative Scoring System
Means and Standard Deviations by Intellectual Level and Grade

MCI Measure	Average			Intellectually Gifted		
	Grade			Grade		
	3	6	8	3	6	8
Clarity	8.3	14.6	14.4	12.5	20.4	21.3
	(2.4)	(3.3)	(4.0)	(3.4)	(4.6)	(3.6)
Specificity	5.5	10.3	9.7	8.6	16.0	16.8
	(2.3)	(2.8)	(4.7)	(2.8)	(4.9)	(4.4)
Reflectivity	10.1	15.8	15.1	12.9	20.5	20.1
	(4.2)	(3.9)	(4.8)	(4.0)	(5.1)	(4.2)
Organization	4.2	9.7	10.3	8.1	16.4	16.8
	(2.5)	(2.7)	(3.1)	(2.9)	(4.5)	(4.1)
Conceptualization	4.5	9.0	9.9	5.8	16.5	16.0
	(3.0)	(3.8)	(4.6)	(3.9)	(5.7)	(4.7)

Appendix L

Metacognitive Questionnaire (MCQ): Means and Standard Deviations by Intellectual Level and Grade

MCQ Measure	Average			Intellectually Gifted		
	3	6	8	3	6	8
Problem Definition	6.5 (.82)	7.1 (.83)	7.7 (1.3)	7.3 (1.5)	8.8 (1.3)	7.2 (1.3)
Planning	6.8 (1.5)	8.7 (2.6)	10.4 (2.1)	8.6 (1.3)	11.7 (2.2)	12.2 (2.1)
Strategy Selection	18.9 (2.1)	20.4 (2.2)	22.6 (2.4)	20.3 (2.7)	24.3 (2.7)	23.7 (3.2)
Monitoring	9.3 (2.1)	10.3 (2.0)	12.4 (1.9)	10.1 (1.9)	12.9 (1.6)	13.9 (3.1)
Flex. of Strat. Use	12.9 (1.9)	14.6 (2.3)	16.0 (2.6)	13.3 (2.2)	15.2 (2.0)	18.8 (3.4)
Evaluating	14.8 (2.3)	17.5 (2.7)	18.5 (2.5)	17.1 (3.0)	17.9 (3.8)	19.1 (3.3)
Composite	69.1 (5.2)	78.5 (8.7)	87.6 (7.5)	76.6 (6.3)	89.3 (9.4)	94.9 (10.0)

	$\bar{X}$ Average	$\bar{X}$ Intellectually Gifted
Problem Definition	7.1 (1.1)	7.1 (1.3)
Planning	8.6 (2.6)	10.9 (2.5)
Strategy Selection	20.6 (2.7)	22.8 (3.3)
Monitoring	10.6 (2.4)	12.4 (2.9)
Flex. of Strat. Use	14.4 (2.6)	16.1 (3.6)
Evaluating	16.9 (2.9)	18.1 (3.4)
Composite	78.2 (10.4)	87.6 (12.)

Appendix M

Metacognitive Questionnaire: Summary of Chi Square Analyses

<u>Question</u>	<u>Chi Square</u>	
Open-end Questions (Section A)	Intellectual Level	Grade
Lost at Shopping Centre (Presence/Absence of Process)		
Problem Definition	.24	.83
Planning	10.29**	13.75**
Strategy Selection		
Monitoring	3.40	6.88*
Flexibility of Strategy Use	2.31	14.50***
Evaluating	.69	2.09
Lost at Shopping Centre (Qualitative Ratings)		
Problem Definition		
Planning	12.41***	19.33***
Strategy Selection	8.00*	29.96***
Monitoring	3.52	11.64
Flexibility of Strategy Use	5.78	20.14**
Evaluating	1.47	5.41
Short Answer Questions (Section B)		
Planning		
How to decide to do a large puzzle? (#1)	15.10**	9.57
How to begin math test with more than one problem? (#18)	13.38**	28.79***
Strategy Selection		
What is first thing to put puzzle together? (#4)	3.44	10.55
How to choose between 3 TV programs? (#5)	7.22	13.85*
Different actions when reading for pleasure or school? (#8, #9)	5.89	13.97*
Different actions watching TV for pleasure or school? (#13, #14)	8.47*	3.23
Monitoring		
What to do after finishing math test? (#7)	5.31	42.09***
How would you know answer was wrong? (#16)	19.07***	14.84*

Question	Chi Square	
Section B (cont'd.)	Intellectual Level	Grade
Flexibility of Strategy Use		
If puzzle hard, what to do next? (#3)	7.79*	16.44**
If you can't decide re TV program, what to do next? (#6)	4.21	4.72
Evaluating		
How to decide if puzzle easy or difficult? (#2)	8.03*	14.7*
How many correct math solutions could you get? (#10)	2.67	17.13***
Do you think you can find as many solutions as others? (#11)	1.99	12.87*
Section C (True/False Questions)		
Is there a difference between a Math and a Spelling Problem?	6.71**	9.73**
I always listen to teachers instructions but sometimes have trouble knowing what to do.	11.45**	6.51*

Note: Remaining questions of Section C Chi Square analyses not statistically significant.

* p < .05
 ** p < .01
 *** p < .001

Appendix N

**Metacognitive Observations: Means and Standard Deviations by
Intellectual Level and Grade**

	<u>Intellectually Gifted</u>	<u>Average</u>
Grade 3		
Mixed Kemler		
Problem Definition	.19 (.51)	.05 (.22)
Monitoring	.90 (.89)	.50 (.76)
Evaluating	1.00 (1.0)	.80 (.95)
Self Corrections*	9	0
Elimination Errors		
Incorrect	1.33 (1.53)	3.30 (3.16)
Omitted	.762 (.768)	1.95 (1.60)
Grade 6		
Mixed Kemler		
Problem Definition	.40 (.75)	.05 (.22)
Monitoring	1.15 (.74)	.70 (.73)
Evaluating	1.50 (.76)	.90 (.91)
Self Corrections	4	1
Elimination Errors		
Incorrect	1.65 (1.53)	2.33 (2.61)
Omitted	.40 (.82)	.905 (1.30)
Grade 8		
Mixed Kemler		
Problem Definition	.40 (.68)	.55 (.75)
Monitoring	1.25 (.78)	1.25 (.78)
Evaluating	1.75 (.63)	1.45 (.75)
Self Corrections	4	1
Elimination Errors		
Incorrect	1.0 (1.7)	1.75 (2.55)
Omitted	.40 (.82)	.85 (.98)

***Number of Self-Corrections**

Appendix O

**Matched Mental Age Groups: Multivariate Analysis of Variance
Using Metacognitive Questionnaire Sub-process Scores as
Dependent Variables**

Effect	Pillais	F Approx	Sig. of F
Matched Mental Age (M.A. = 11 years)	.093	.343	.905
Matched Mental Age (M.A. = 13 years)	.324	1.594	.200

**Univariate F-tests for Effect of Matched Mental Age Group
(M.A. = 11 years)**

Problem Definition	.26	.61
Planning	.01	.90
Strategy Selection	.00	.96
Flexibility of Strategy Use	2.09	.16
Monitoring	.07	.78
Evaluating	.15	.71

**Univariate F-tests for Effect of Matched Mental Age Group
(M.A. = 13 years)**

Problem Definition	3.17	.08
Planning	2.26	.14
Strategy Selection	2.76	.10
Flexibility of Strategy Use	.81	.37
Monitoring	.55	.46
Evaluating	.19	.65

Appendix P

Kemler Task: Means and Standard Deviations of Problem-Solving Efficiency and Non-Informative Moves

	Grade 3		Grade 6		Grade 8	
<u>Group</u>	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>

Problem-Solving Efficiency

GIFTED

Three Attribute Problem	.700 (.28)	.822 (.30)	.813 (.25)
Five Attribute Problem	.782 (.25)	.855 (.22)	.861 (.25)
Eight Attribute Problem	.692 (.24)	.652 (.19)	.788 (.24)

AVERAGE

Three Attribute Problem	.521 (.35)	.808 (.21)	.738 (.29)
Five Attribute Problem	.437 (.27)	.631 (.26)	.739 (.27)
Eight Attribute Problem	.463 (.28)	.659 (.24)	.667 (.29)

Non-Informative Moves

GIFTED

Three Attribute Problem	1.10 (1.61)	.40 (.82)	.55 (1.36)
Five Attribute Problem	1.19 (2.20)	.60 (1.05)	.60 (2.01)
Eight Attribute Problem	1.57 (2.27)	1.20 (1.40)	1.20 (2.69)

AVERAGE

Three Attribute Problem	2.90 (2.47)	.52 (.98)	1.25 (1.97)
Five Attribute Problem	5.10 (4.06)	1.52 (2.22)	1.55 (2.56)
Eight Attribute Problem	5.05 (4.08)	1.57 (2.20)	2.35 (3.63)

Appendix Q

Pattern Matching Task: Means and Standard Deviations

	Task Efficiency	Focussing Moves	Gambling Moves	Non-Informative Moves
Grade 3				
Gifted	.871 (.19)	17.29 (.96)	3.52 (1.5)	.71 (1.6)
Average	.633 (.11)	16.45 (1.1)	4.65 (1.4)	12.70 (6.2)
Grade 6				
Gifted	.947 (.05)	17.40 (.88)	2.05 (2.0)	.45 (.76)
Average	.920 (.06)	17.29 (1.1)	2.90 (1.5)	.76 (1.3)
Grade 8				
Gifted	.972 (.04)	17.75 (.44)	1.00 (1.3)	.20 (.52)
Average	.886 (.08)	17.05 (.88)	3.15 (1.5)	2.0 (3.1)

Appendix R

Descriptive Statistics: Other Variables

	Average			Gifted		
	Grade 3	Grade 6	Grade 8	Grade 3	Grade 6	Grade 8

Socioeconomic Status (Blishen and McRoberts)**Mean SES**

Score	4.21	4.50	4.57	5.44	5.09	5.50
--------------	-------------	-------------	-------------	-------------	-------------	-------------

Motivation**Mean****Motivation**

Score	1.94	2.10	2.50	1.17	1.32	1.0
--------------	-------------	-------------	-------------	-------------	-------------	------------

High = 1**Low = 5**

Appendix S

Correlation of Validity Measures and Metacognitive Instruments

Validity Tasks	Interview				
	Problem Definition	Planning	Strategy Selection	Monitoring Flexibility	Evaluating Composite
<u>Planning</u>					
(Kreutzer et al., 1975)	.39*	.34*			.44*
<u>Strategy Selection</u>					
(Achenjbaum, 1983)					
Number of Strategies (Digits)		.64***	.67***	.63***	.42**
Awareness Level of Strategies (D)	.36*	.65***	.69***	.67***	.38**
Number of Strategies (Mazes)		.57***	.46**	.63***	
Awareness Level of Strategies (M)		.61***	.60***	.58**	.40**
<u>Monitoring</u>					
(Markman, 1977)					
Magic Trick Probes		-.41*	-.53**	-.49**	-.47*
<u>Evaluating</u>					
(Brown & Smiley, 1977)		.41*	.46**	.46**	.42*
					.49**
					-.58**

Appendix S cont'd.

Validity Tasks	Questionnaire				
	Problem Definition	Planning	Strategy Selection	Monitoring	Flexibility Evaluating Composite
<u>Planning</u>					
(Kreutzer et al., 1975)		.39*		.38*	
<u>Strategy Selection</u>					
(Achenbaum, 1983)					
Number of Strategies (Digits)		.61**	.34	.53**	.45**
Awareness Level of Strategies (D)		.55**		.50**	.41*
Number of Strategies (Mazes)		.53**	.36		.46*
Awareness Level of Strategies (M)		.55**	.48*	.49*	.57*
<u>Monitoring</u>					
(Markman, 1977)					
Magic Trick Probes		-.45*	-.43*	-.54**	-.36
<u>Evaluating</u>					
(Brown & Smiley, 1977)		+.41*	.78***		.39
					.58**

* $p < .05$ ** $p < .01$ *** $p < .001$

END

02-03-92

FIN